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A Study of the Think City Electric Car Development

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A study of the Think City electric car development

Karin Strzeletz Ivertsen

Doctoral School in Organisation
and Management Studies

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Partnership Drift in Innovation Processes:

A study of the Think City electric car development

Karin Strzeletz Ivertsen

Department of Organization

Copenhagen Business School (CBS)

October 2013

A thesis submitted in fulfillment of the requirements for

the degree of Doctor of Philosophy at the Copenhagen Business School

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Preface

This PhD thesis is structured as a monograph. The Monograph form has allowed me to aim narrowly within the topic of research 'technology innovation partnerships' and still pursue breath and depth. I found it to serve well as a vehicle for bringing and bridging extended accounts of contrasting theories, socio-technical maps, several empirical complementary stories, and for giving good room for analysis and clarification of positioning.

Ongoing dissemination and discussion of the thesis' idea, preliminary findings and argument have taken place to avoid quiet anonymity and improve the quality of the ongoing research. Thus, earlier versions of the project concept and some of the chapters have been presented in different formats to different audiences, including those present at CBS and McGill.

Project concept: The overall project concept has been presented at the individualized (mandatory) 'Work-In-Progress Seminar I' (WIP-1) at CBS' Department of Organization in February 2009, Denmark. Discussants: Peter Karnøe and Robert D. Austin.

Empirical stories: While developing the empirical storytelling, I presented Think's historical development at Oikos' PhD Summer Academy in July 2009, in Switzerland, focusing on Sustainability-Driven Business Models. Discussants: Oana Branzai, Jeffery S. McMullen and Christian Seelos.

Theoretical chapter – process view: In November 2010, this was discussed at the PhD Sustainability Academy, within the main theme of Markets and Movements for Sustainability, Canada. Discussants: Jay Barney, Tom Lawrence, Klaus Weber and Wes Sine.

Thesis story outline: This was first unraveled at the Strategy and Organization Student Research Presentation Series (with attending members of Faculty) at McGill, Desautels Faculty of Management in December 2010, Canada.

Overall project progress: Presented and discussed at the individualized (mandatory) Work-In-Progress Seminar II (WIP-2) at CBS' Department of Organization, in May 2010, Denmark. Discussants: Signe Vikkelsø and Kamal Munir.

Theoretical chapter – dominant design and open innovation: Presented at EGOS' 2011 Pre-Colloquium Strategy as a Practice Paper Development Workshop, in Sweden. Discussant: Richard Whittington.

The research aim and purpose are introduced in chapter one, where the general thesis outline is also presented in detail.

Glossary of terms

ACEA	European Automotive Association
ANT	Actor-Network-Theory
ATVM	Advanced Technology Vehicle Manufacturing program
BART	Bay Area Rapid Transportation project (in-text, referred to as the "BART-project")
CARB	California Air Resources Board
CEO	Chief Enterprise Officer
CFO	Chief Financial Officer
CMO	Chief Marketing Officer
CO_2	Carbon Dioxide
COP15	Fifteenth Session of the Conference of the Parties to the Climate Change Convention, part of the 2009 United Nations Climate Change Conference, commonly known as the Copenhagen Summit
CTO	Chief Technical Officer
DOE	Department of Energy in the US
EDF	Electricité de France
ETS	Europe's Emissions Trading Scheme
EU	European Union
EV	Electric Vehicle
EVC	Electric Vehicle Company
GBM	Global Brand Manager
GE	General Electric
GHG	Greenhouse Gasses
GM	General Motors
HRM	Human Resources Manager
JAMA	Japan Automobile Manufacturers Association
KAMA	Korean Automobile Manufacturers Association
KPCB	Kleiner Perkins Caufield and Byers
LOI	Letter of Intent
LowCVP	Low Carbon Vehicle Partnership
NAIAS	North American International Auto Show
NHS	National Health Services (UK)
NiCad	Nickel-Cadmium (batteries)
NTNF	Norges Teknisk-Naturvitenskapelige Forkningsråd (Science and Technical Research Norway)
OEM	Original Equipment Manufacturer
PCU	Power Control Units
PDD	Product Design and Development (Department)
PIVCO	Personal Independent Vehicle Company, which was later renamed as Think (referred to as "Pivco" in-text)

PL	Project Leader
PM	Product Manager
PSA Group	Peugeot SA Group
RWE	Rheinisch-Westfälisches Elektrizitätswerk AG
SCOT	Social Construction of Technology
SM	Senior Manager
SSM	Soft System Methodology
STS	Science and Technology Studies
T&E	Federation for Transport and Environment
UK	United Kingdom
US	United States of America
USABC	United States of America Battery Criteria
VAT	Value Added Tax
VEL	Véhicule électrique
WSPA	Western States Petroleum Association
WWI	World War I
ZEV	Zero Emission Vehicle

(author, year)*	References marked with an asterisk denote that the text has been translated by the author.

1 Introduction

This thesis is about a Norwegian car-development company's experience — Think's experience – of long-lasting periods of product ferment and how it endured these periods of ferment without failing. The thesis is also about the surprising dynamics of technology innovation partnerships in relation to complementary assets, competencies and electric car developments at Think. My empirical observations show a dynamic process that is characterized by changing and redefined partnerships throughout an innovation journey; indeed Think has been able to maintain its existence, not through stability, but through continuous transformations in partner-networks. The research studies these surprising dynamics by drawing upon and relating to debates within the technology lifecycle literature, open innovation literature and drift literature, with the purpose of contributing to a better understanding of the role of partnerships and partnership changes in technology innovation developments. The lifecycle and open innovation literature tends to have a relatively static view on what happens in partnerships when they have been established, whereas the drift-literature allows for dynamic shifts during the process, which characteristics of partnership reflect. Based on a close empirical study of selected car development projects at Think, the thesis presents four complementary stories about battery, drivetrain, headlamp and financial engineering. Each offers insights into the way partnerships are involved in and impact the innovation process. Built upon an analysis of these cases, the thesis argues that if partnership processes become understood as being premised on uncertainty and drifting relations, then partnership drift can be a productive learning element in technology innovation processes. In the following I elaborate on this, and present a general outline of the thesis.

1.1 A story about technology innovation development

This thesis analyses technology innovation development[1], although perhaps not in the usual sense. The analysis of car development projects in Think is used as a means of examining uncertainty and unpredictability in the innovation process whereby the aim is to advance our understanding of relative stability and changeability of partnerships in technology development processes.

Studying the context of Think (Chapter 2) I observed, for example, that political ambition was a driver of electric car development, but its practical realization was dependent on automakers' will and cost-effective car production change perceptions. Though partnerships between these two parties could be considered crucial, it remains that political, economic and environmental interests actively intersect and influence collaborative partnerships that are able to accept and endure unpredictable outcomes without drifting apart. Studying the four cases of Think (Chapter 5) I also observed how partnership shifts were influential in different ways, which may be summed up in five main points. First, Think's development process was slow and demanded change in the environment. Second, drift in the environment had a changing impact on Think's project activities in all cases, as it did on the overall Think City car project. Third, partner interests and expectations were important for how and with what purpose they could 'use' one another. Forth, Think's flexible approach to innovation played an important role in its ability to work with different partners and exist through time. Fifth, emergent learning, rather than time-to-market, was a qualifying factor for Think in its innovation journey and Think's ability to embrace emergent learning developed through different partnerships. All along partnerships seemed central and therefore I was

[1] Technology innovation development refers to the general process of creating and accomplishing new technology that solves existing problems and/or meets new requirements in relation to society over time. As such it is more encompassing than invention, which refers only to the creation of a new idea (Van de Ven, Polley, Garud & Venkataramen, 2008, p. 9). Often the term is interchangeably used with innovation pathways (Garud & Karnøe, 2001, 2003). When engineers set various path creation processes in motion, shaping socio-technical facets of an emerging technological field (Garud & Karnøe, 2001, p. 7), it is technology innovation development that is taking place.

surprised and puzzled by how little emphasis this topic had been explored by life cycle literature and open innovation.

To work this out, I have more specifically defined my phenomenon of interest as the interplay of partnerships, complementary assets, and competencies in an innovation process. This has also extended to include the study of what partnership relations develop as, without a priori assumptions regarding their role in an innovation process as it unfolds. The research question I have been guided by is therefore: how does the formation of partnerships interact with innovation processes?

Most innovations involve one or more forms of partnership or network and they are widely acknowledged as important to the 'dynamics of innovation'. This has prompted researchers to study partnerships and networks from an industry perspective, or what could be considered industry-level analysis. In this relation, my point of departure is the technological life cycle approach, sometimes referred to as the "dominant design" approach (Abernathy & Utterback, 1978; Utterback, 1994). These studies have focused on the question of how can we can better understand why certain technological frameworks or standards come to dominate or displace alternative solutions. The basic assumptions of this theoretical tradition is that companies must seek to 'master' the cyclical product and process development that characterizes the ripeness and mass of a product organization as this will help them choose the winning technology development trajectory. The technological life cycle approach has, through the concept of "collateral assets", recognized partnerships (Utterback, 1994, p. 27) and has begun to suggest that a partnership selection process is takes place at the micro-organizational-level of an innovation process. However, the literature does not offer further insights into micro-organizational-level processes. Similarly, this approach has pointed to the importance of complementary assets — for example, in relation to how electric cars and charging infrastructure together provide mobility service (Katz & Shapiro, 1994) — that can be used as a successful strategy for companies otherwise not able to compete after the emergence of a dominant design (Abernathy & Utterback, 1978). Further to this, competencies have been found as influential building blocks that are to be extended or replaced along with

technology innovations for a company to remain or become successful (Anderson & Tushman, 1990). But the technological life cycle does not openly engage with the complexities of the innovation processes, as its focus is not on "micro-dynamics of innovation", but rather on the larger development phases where partnerships are not dealt with in detail, nor is the very innovation process around a particular technology.

The new literature on "open innovation" (Chesbrough, 2003a; Chesbrough, Vanhaverbeke & West, 2006), in contrast, focuses explicitly on the micro-level analysis of an innovation process. The important contribution of these studies is that they point out the centrality of partnerships and partner access to external competencies in innovation processes. However, open innovation studies say little of how partnerships unfold in a context of endured uncertainty. The premise of this theoretical strand is that to survive in a time where the workforce is mobile and globally available, and skills, ideas and early stage technologies are commercially for sale, companies must seek to buy or license processes or innovations from other companies (Chesbrough, 2003a). The open innovation framework emphasizes the positive role that active outreaches for different types of complementary assets through research, suppliers, users, or other partners have on an innovation process (Chesbrough, 2003a; Chesbrough et al., 2006). Correspondingly, a care for and evaluation of different kinds of organizational competencies in relation to the innovation process has been stressed. However, despite its micro-organizational-level attention towards new partners in innovation projects, open innovation tends to take a relatively static view on partnerships after they have been established. Consequently open innovation does not to investigate how partnerships, complementary assets and competencies are involved in and shape innovation pathways. Rather, open innovation emphasizes the formulation and tooling of a deliberate strategy approach to reduce uncertainty and promote the alignment of partnerships to innovation activities in a company's business model. This approach therefore obstructs possibilities for digging deeper into details about what happens in the innovation process.

There are, however, other ways of exploring technology innovation development. What I will call the "drift perspective" (Kreiner, 1995; Van de Ven et al., 2008) on innovation processes regards innovation and uncertainty as inseparable and emphasizes the importance of embracing uncertainty by departing from the fact that unpredictable things may happens during the innovation process. If the previous perspectives emphasized thinking to the 'mastery' of a linear development path and planning to avoid uncertainty, authors from this perspective focus more on how we can understand why something surprising and unpredictable is unavoidable and unpredictable in the innovation process and how this can be considered useful to the innovation process itself. They emphasize that this 'something' cannot be controlled or planned out of the scope by good preparation and solid steering — obsessively trying to do so reflects the fear of uncertainty (Mintzberg, 1994, pp. 201-203). Still, the drift perspective expounders advocate for careful preparations through "projected conditions planned" (Kreiner, 1995) and a road map (Van de Ven et al., 2008). The principle idea is that because uncertainty cannot be avoided in the innovation process, nor can it be clearly predicted, it is important that managers of innovation projects learn to consider and continually take in what happens in the innovation process as learning occasions rather than threats. The drift perspective thereby fills another gap as it allows for exploration and analysis on an intermediary-level, or sociotechnical-level analysis — the level between the industry and company-specific — oriented towards interests and sensemaking.

In the analysis of the specific innovation processes related to car development at Think, I draw upon and discuss these three approaches in order to illuminate and contribute to the theoretical understanding of partnerships and their drift in technology development. The case in this thesis is unusual in the sense that it highlights an anomaly. My empirical data and analysis show how changing and redefining partnerships, complementary assets and competencies are assets in keeping innovation projects moving towards possible success. It seemed as if those at work developed an ability of fertile 'open-endedness' through changing partner relations. In other words, Think has been able to maintain its existence, not through stability, but through continu-

ous transformations in partner-networks as well as by redefining itself and the product idea. Think and innovation development in relation to the electric car are not likely to be unique in this respect; other great examples where experimentation, flexibility and re-identification were similarly important factors include the Sony Walkman case (Sanderson & Uzumeri, 1995), and the Nokia case (Giachetti & Marchi, 2010). But, Think may still be considered as especially important, because of its dynamic partnerships characteristics. As many new ideas in technologically oriented projects need ample time to become realized so synchronous studies on their processes of development help capture what is occurring as technology emerges and makes learning moments and analysis available throughout innovation processes, rather than solely in retrospect. Yet, these projects depend on competition along the dimensions of emergent learning rather than time, which doesn't meet the demands of flexibility and this struggle seems only to happen in networks of complementary resources. Indeed, relatively stable relations can be valuable, but in that case, what defines the relative stability that contributes to a successful evolving partnership?

In the thesis I take a process research approach, linking the notions of environmental drift and emergent learning through the ethnographic approach of Social Construction of Technology (SCOT) to form an understanding of the logics of open innovation: that endured uncertainty and unpredictability host future development possibilities and opportunities. Starting from a constructivist view, I move towards an increased analytical focus on partnerships forming, breaking and reforming, and collaborative socio-technical ensembles in emergent processes.

This approach allows three important observations to be made. First, this combination highlights the identification of critical events and turning points of the innovation project studied which convey the notion of overall direction, relevant actors and frame of reference for process connections. Second, it directs the lens of interpretation to concrete cues, social factors, action and talk, as well as communication across relations. Thirdly, it points to a potential extension of our understanding of open innovation by emphasizing socio-technical ensembles as mediating contextual factors and accentuates a

sensitivity to uncertainty and unpredictability. It is by integrating these approaches that I have developed a framework that enables me to undertake the research question of how does the formation of partnerships interact with innovation processes under endured uncertainty[2]?

This question implies continuous relative stability and changeability in open innovation processes. It includes the question of how a project organization has the capability of keeping these connections formable, breakable, or redefinable. I take the perspective that each of the partner-connections that are formed, broken or reformed is a composition of heterogeneous dimensions, referring to material, economic, interest and meaning dimensions simultaneously. I study how unpredictable changes in these dimensions (as well as in other dimensions) can lead to the breakdown or reforming of partner relations. In this sense, I decompose the dynamics of the socio-material ensemble that make up the existence of Think at any point in time.

I seek to build theory on the processes of innovation under endured uncertainty, grounded on empirical innovation research on Think. In 1991, Think was founded in Norway, nurturing the dream of developing an electric car. This venture is known today as the Think City car. Think forged its way ahead and has been tinkering with stuff over time to give direction, property and ingenuity to the idea. Think has endeavored to change the way people think about cars and with an electric and fully recyclable vehicle, play a role in the transformation towards clean and environmentally friendlier mobility. However, this innovation journey has not been directed by steady growth in sales; it was only recently that sales surged with expected sales of 2000-3000 cars in the US, and about the same number in Europe for 2011. So, Think has been able to maintain its existence, not through stability, but through continuous transformations in partner-networks as well as by redefining itself and the product idea. The company has changed and redefined its relations, it has developed the capability of emergent learning from partnerships in innova-

[2] This uncertainty may be endogenous or not, but that is not a point I seek to develop further — in fact, I cannot discuss it based on my approach, as this seems to require an industry level analysis.

tion processes. The case of electric car development constitutes an interesting context for investigating innovation processes, as it is a young, fragmented and unsettled market often characterized by eccentric organizational settings. Moreover, the scope for new ideas in electro-mechanics and motor drives has not yet been exhausted. The creative possibilities are continuing to surface in this special area, particularly in the ways in which innovation projects come to relatively concrete and short-term gains through changes and redefinitions of relations, while efforts towards intangible and long-term success remain intriguing.

I examine the research question by looking at the network of complementary resources that may be identified as surrounding components of an electric car: the battery, the drivetrain, the headlamps, and financial engineering. The battery was selected as it is the most critical component in an electric car. It counts for half of the total costs of production of one car. By in large, the safety, energy density and life span of the battery determine the overall performance of an electric car. The drivetrain was selected because it may be generally considered as the least understood component of an electric car. However this is where Think, dissatisfied with the available models in the market, went on to develop its own drivetrain from scratch, which opened-up new business opportunities for the organization. The headlamps were selected as these are one of the most critical power-consuming parts of an electric car, besides being a key, aesthetically defining element. They also represent a potential bottleneck for market release due to required focusing on legal compliance. As mentioned, I endeavor to include components and present examples that in different ways reveal material, economic, interest and meaning dimensions and possible similarities in Think's capability to keep connections across these dimensions – forming, breaking, or reforming.

1.2 Thesis outline

Partnership has been defined in many different ways and in different contexts. In this thesis I focus on technology innovation partnerships and how they evolved over a period of twenty years, in relation to Think. I do this by presenting a holistic, socio-technical view of Think's technology innovation partnerships from a series of four accounts on collaborative ensembles that are generated around the Think City electric car. These accounts offer windows into the socio-technical relational complexity of partnerships. Incidences of partnership forming, breaking, and reforming are described in rich detail, while other relations are covered, as revealed through the research, in reference to how they more or less successfully affect the process of technology innovation.

Chapter 2 establishes the empirical area of interest for researching technology innovation partnerships, which rests on observations from the automotive industry, especially focusing on the development of electric cars. I draw out relevant relations, obstacles and advances that aid to the purpose of setting a relational empirical frame for my research. This includes an analysis of some major exogenous factors that have had a direct impact on the electric car development environment throughout the past twenty years; linked are the California Air Resources Board (CARB) Zero Emission Vehicles (ZEV) mandate in America, and in Europe, the European Emissions Trading Scheme (ETS) and commitments to the Kyoto Protocol as well as the 1997 Asian financial crisis and the most recent Global Financial Crisis of 2008. The chapter is complimented by a short historical account of electric car development that points to increased public interest, despite continuous ambiguity, uncertainty and perceived failures in technology innovation development.

Chapter 3 examines the three different theoretical perspectives on technology innovation development in regard to their attention to and understanding of technology innovation partnerships. The perspectives are compared and the theoretical foundation of the thesis is set straight. First, the traditional dominant design perspective is examined as it highlights the period of ferment, which is useful to my case, but this perspective is found to take an

aggregated industry-level perspective on technology innovation, blackboxing partnership relations in detail. Second, the more recent open innovation framework is examined, which is found to address partnership relations, but assumes them to be purposeful and stable. Viewed through these lenses — both of which I consider deficient in terms of innovation process details, — I argue that the very relational uncertainty and unpredictability that Think has experienced is either bracketed out or overlooked, and that as a result, Think's technology journey is inevitably altered, misunderstood, or worse, rendered pointless. Third, in the partnership drift perspective I corral disparate literatures to draw a contrasting and multidirectional innovation development picture that can embrace the ideas that time-motion and complexity, emergent learning and the impact of relational interest and meaning are elements providing orientation for understanding Think's innovation journey. This is the socio-technical process perspective that I employ in my research analysis.

The partnership drift perspective is composed of three main ideas that all emphasize a process view that raises our awareness of technology and partnerships as being emergent and co-evolving in a complexity of processes. These two aspects never take final form, and remain only relatively stable. First, through the argument of drifting environments, the effect of change over time is introduced; uncertainty and unpredictability are presented as basic conditions in relation to resource potential because they insulate infinite opportunity. In practice, opportunity may be considered as a kind of raw material: only when usefully adjoined with other factors does it become appropriate — to find such a coalescence requires, in part, experimentation and learning. Second, the importance of experimentation, testing and demonstration events is introduced through my next argument of emergent learning. Technology innovation partnerships are considered as assignments requiring time so partners have the possibility to 'show up' and move consciously amidst different collaboration activities so that room is made available for the co-constructive change processes that create a drift in meaning-orientation. Meaning thus shifts from wherever it first was towards a greater focus on understanding and interpreting collaboration outcomes in terms of the new, successes or failures, and how this information might be useful. Third, I adjoin

the above two ideas to sensemaking as the meaning-term is already a part of drift. As partnerships engage in meaning-orientation efforts around collaborative activities, partners' actions can be considered as their means of seeking comprehension so as to also relate one innovation activity or set of innovation processes to others in a project and thereby create an impression – meaning – that can be guiding, if also only for a brief moment.

Finally, I conclude in this chapter by comparing and contrasting the three perspectives whereby the gradual move in understanding from a rather 'escaping' to a more 'openly engaging' process view of technology innovation development is emphasized.

Chapter 4 lays out the methodological approach I applied to research technology innovation partnerships in relation to Think, resulting mainly in socio-technical maps and the four individual cases on the battery, the drivetrain, the headlamps and financial engineering innovation technology development, which are presented and analyzed in the subsequent chapter. The case study activities and how data collections have been undertaken are also presented. Briefly I explain how I found SCOT's ethnographic research criteria and its analytical emphasis to provide a premise for research evaluation that is distinct from 'traditional' case study research. Furthermore, my main methodological ambitions and compromises based on my research process and analysis are highlighted. As such, the presented research process and analysis are described through three phases that reflect a constructivist view as a point of departure that leads towards an increased analytical focus on partnership forming, breaking and reforming, and collaborative socio-technical ensembles in emergent processes.

Chapter 5 presents four analyses in relation to Think's innovation journey. The first analysis investigates the collaborative socio-technical ensembles associated with the development of the electric car's battery, also over time and in detail, in order to understand the circumstances and conditions that structure forming, breaking and reforming partnerships. This analysis discusses the emergence of socio-technical relations that mold the frames of reference. I argue that socio-technical modularity helps explain the hetero-

geneity of forming, breaking and reforming partnership relations, but that as a strategy, it also has practice trade-offs.

In a similar vein, the second analysis investigates the electric car's drivetrain development but focuses on the emergence of innovation opportunity through exploration, experimentation and testing as something that wasn't considered a possibility, and yet became a reality and how economic partners thus became involved in radical innovation design. This analysis discusses perpetual, overly optimistic estimates and their associations relation to Think's bankruptcies and resurrections. The analysis argues that Thinks collaborative flexibility was valuable to help it pursue its own technology innovation interests over time.

The third analysis focuses on headlamp development and follows the same structure as the previous cases. However, this case centers on a component that is potentially — and not so apparently — strategically important, but which is nevertheless unstable and problematic. This analysis argues that because component complementarity has widespread impact on development process changes and emergent partnership learning, regardless of the technical complexity or strategic importance that was initially perceived in relation to components, all components remain uncertain and unpredictable.

Lastly, the fourth analysis captures the financial engineering development of Think, while focusing on the different relevant social groups, –such as economic, technological, political, environmental and media relations – and how these relations form collaborative socio-technical ensembles around Think. This analysis demonstrates the relevance and role of these ensembles in perceiving Think as a failure or a success. I argue that because it can be established that collaborative socio-technical ensembles are emergent and only relatively stable as they form, break and reform, value judgment and assessments are equally rendered relative. In this way, the analysis participates in the debate on what partnerships means in innovation technology development and how they unfold over time, in practice.

Chapter 6 recaptures the aim of the thesis and the contrasted theories before it presents and discusses points of what we have learned about the innovation process through the analytical lenses of dominant design, open innovation and the partnership drift perspective applied to each of the four accounts on collaborative ensembles of partnerships in relation to the electric car. In this sense, it addresses how something happened in the innovation process that was unpredictable, uncertain and in different ways gave room and life to emergent learning.

Chapter 7 provides concluding remarks specific to the insights from studying Think. It also expounds on the theoretical contribution that leads to discussions about what we can learn of practical relevance, and discusses the limitations of this research while providing an outlook for further research.

2 Empirical context of Think

In this chapter I introduce and explain the greater industry context related to electric cars and thereby address relevant relations, obstacles and advances with the purpose of setting a relational empirical frame for my research. This includes a short historical account of electric car development, an analysis of the California Air Resources Board's (CARB) Zero Emission Vehicles (ZEV) mandate's impact, and an analysis of the European Commission's strategy's impact to reduce CO_2 emissions from cars. These accounts all serve also to demonstrate that electric car technology innovation development is conceived and modified in this greater context through transformation in collaborative partnerships under endured uncertainty.

2.1 Observations from the automotive industry

2.1.1 Brief history overview of electric car development

The idea of developing electric cars for individualized mobility has been enticing for many, for more than a century, as the electric car history timeline demonstrates below.

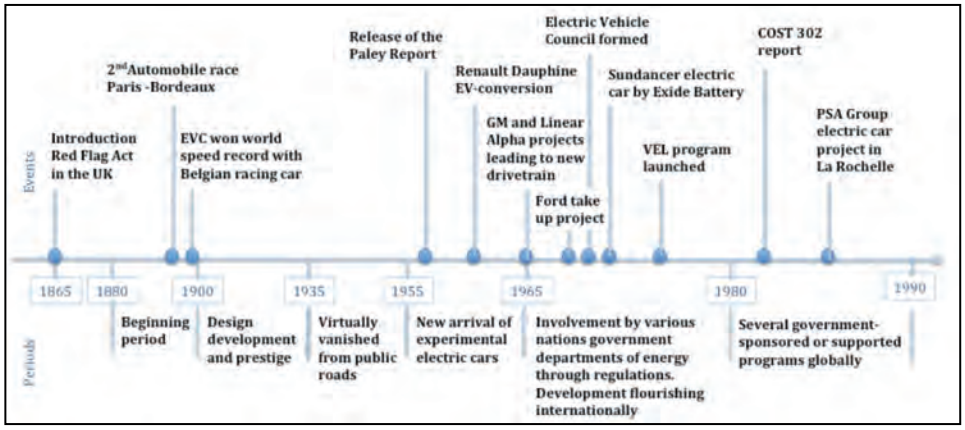

Figure 1: Electric car history timeline

Indeed, automotive literature, here particularly drawing on the careful writings of Wakefield (1994) and Mom (2004), accounts for many histories of

attempts to materialize and commercialize electric cars. Some development trajectories were more successful than others, as different contextual circumstances increased or decreased accession to electric cars. Some early breakthroughs that gave way to electric cars a century ago include electricity, bicycles, rubber-bearing wheels, free scientific thought environments, easy exchanges of information, and projects emanating from curious, playful and entrepreneurial engineers (Wakefield, 1994, p. xvii). At first, however, there was little public interest in replacing the horse as a means of local transportation with other awkward products – in later forms, these would be saluted as automobiles. Development began as creative experiments by engineers, carpenters and hobby-mechanics who were exploring how to build steam, electric and combustion engine machines for the road (Westbrook, 2007). From the 1850s entrepreneurs would test their vehicles and drive them in public, reaping recognition by mechanic professionals, while the public confronted them with fear — a fear that the vehicles would have a destructive impact on the traditional urban environment (McShane, 1994). Without the support of organized social groups, the technology's promotion remained weak (Struben, 2006, p. 38). In the earlier parts of the 1890s the attitude gradually shifted and with the second automobile race in 1895 from Paris to Bordeaux, public awareness and interest in all industrialized countries changed completely: the personal horseless carriage was recognized as the future (Wakefield, 1994, p. 1). Still, the transition to the horseless carriage would take more than two decades as consumer learning and socialization with the alternative technology emerged slowly (Struben, 2006, p. 36). While, "in 1900 there were about 18 million horses in the [US] and 8000 registered vehicles for a population of 76 million", twenty-five years later, 125 million [U.S citizens] drove 26 million combustion engine cars and held just 11 million horses" (Struben, 2006, p. 36).

The first vehicles assembled (c. 1880-1900) characterize a period when gasoline and a variety of electric cars were equally unreliable and only potentially successful (Mom, 2004, p. 98). Electric cars gained merit by virtue of their better design that didn't require gearshift or manual engine-start. They were also less noisy, smelly, and vibrational. During this period, electric

cars had also been adopted for the purposes of taxi services in New York, commercial delivery services, such as for the beer industry in the US, and as omnibus and royal transportation in Europe. There were several automakers of electric cars both in America and in Europe, while the Electric Vehicle Company (EVC) emerged as the first large-scale electric car producer (Wakefield, 1994, p. 112). Usability meant that both gasoline and steam-powered cars were being sold (Wakefield, 1994, pp. 41-119). Moreover, the EVC earned itself a world speed record, achieved by a Belgian racing car in 1899 (Wakefield, 1994, p. 242).

At the turn of the century, electric vehicles were perceived as reliable and prestigious, and in the first period of the century (c. 1900-1935), electric cars continued to develop mainly in design, though they were eventually overtaken by gasoline cars for long-distance travel on the ever-expanding road infrastructure (Mom, 2004, p. 197). Other factors also played important roles in displacing electric cars such as the Great Depression, mass production, lower gas prices, the invention of the electric starter and the army's choice of gasoline car usage during WWI (Wakefield, 1994, pp. 211-252).

In subsequent years (c. 1935-1955), electric vehicles had virtually vanished from public roads, taking up a lesser recognized role in the transportation system as industrial trucks or golf cars (Mom, 2004, p. 265); nevertheless, the technological knowledge was still being transmitted to subsequent developers of electric cars. However, the Paley Report to President Eisenhower in 1957 that revealed a scarcity of certain raw materials[3], paralleled by large investment in battery technology and the electric conversion of a Renault Dauphine in 1960 propelled a new, courageous and innovative entrepreneurial sector that would start organizing from 1955 to 1965 (Wakefield, 1994, pp. 261-267).

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[3] Though Wakefield refers to the report as being from 1957, it seems that according to the National Archives records that the President's Material Policy Commision was appointed on 1 January 1951 and delivered its final report on 2 June 1952, published as the "Resources of Freedom". However, it became known as the Paley Report, named after its Chairman, Willam S. Paley, President of the Columbia Broadcasting System ref: http://www.archives.gov/ research/guide-fed-records/groups/220.html#220.7.14

At this point in time, General Motors (GM) and a company named Linear Alpha embarked separately on development projects for battery-powered electric vehicles which led to the development of new drivetrain systems. Later, Ford Motors also got involved and by the end of the 1960s all three companies presented new experimental electric cars (Wakefield, 1994, p. 299). Other smaller companies began mostly experimenting with conversion models (Sperling, 1995; Westbrook, 2007). With the development of the high performing and designedly attractive Sundancer electric car by the Exide Battery Company in 1970 and the oil crisis of 1973, electric cars regained attention among electric car enthusiasts (Wakefield, 1994, p. 315). In a large number of other countries, developments flourished: Australia, Belgium, Brazil, Bulgaria, Canada, Denmark, France, Germany, Holland, Hong Kong, India, Mexico, the Soviet Union, Sweden, Switzerland, Taiwan and the UK (Wakefield, 1994, p. 331). In addition, a new form of car, the electric city car, tapping into a low-cost market, took stage both in America (Wakefield, 1994, p. 322) and in Europe (Westbrook, 2007, p. 20). The car gained broad media coverage, but failed by design and engineering to convince. As a result, production ceased in both cases within a few years.

With the exception of the Red Flag Act introduced in 1865 in the UK, setting back the development of electric cars until 1897 when it was withdrawn (Westbrook, 2007, pp. 10-13), government departments of energy in various nations became actively involved through regulations throughout this period (1965-1980). In 1968 the Electric Vehicle Council, including members from around the world, was formed in the US with the purpose of coordinating different commercial actors toward advancing the use of electricity in transportation (Lamm, 1977). At around the same time, a collaboration began between the larger energy suppliers of EDF, RWE and the UK Electricity Council that may have played an even greater role in promoting electric vehicles (Besse, 2006). One example may be the VEL (véhicule électrique) program launched in 1973 by EDF in France, through which Renault delivered 80 electric Renault 4 cars, where "a plan […] not only determined the precise characteristics of the vehicle it wished to promote, but also the social universe in which the vehicle would function" (Callon, 1986, p. 21) – an element that since

its inception has had a considerable impact on all future electric car developments (Husain, 2003; Wakefield, 1994; Westbrook, 2007). The Peugeot SA (PSA Group) in La Rochelle (Orsato, 2001) is another archetype which persisted for more than a decade and impacted the reintroduction of electric vehicles. During the 1980s governments gradually acknowledged the potential general benefits of developments in battery power and the environmental advantages of the electric car, which led to several government-sponsored or supported programs globally (Westbrook, 2007, p. 25). One outcome was the "COST 302" report, collaboratively produced by 11 European countries[4] between 1982 and 1986, in which the impact of introducing electric vehicles from various perspectives was studied (EU-Commission, 1987). Today, these considerations are increasingly dominating political, economic and environmental initiatives worldwide.

The brief historical overview presented above has touched upon the major events of electric car development up to 1990 for which there seems to be a general understanding. The subsequent 20 years of electric car development may bee seen in relation to two larger political initiatives: the US' CARB ZEV mandate and the European Commission's strategy, which both aim to reduce CO_2 car emissions. While the industry's development during this period will be addressed in detail through my chosen empirical focus on Think in Chapter 5, the impact of these two initiatives are analyzed hereafter.

2.1.2 De facto mandate for electric car mobility promoted from California

In 1990, an environmental regulation with the intended purpose of securing an increase in air quality in the long-term was adopted by the CARB (CARB, 2008, p. 798). The Board required that in 1998, 2% of the vehicles that large automobile manufacturers produced for sale in California had to be Zero Emission Vehicles. This affected the following companies: Chrysler, Ford, GM,

[4] Austria, Belgium, Denmark, The Federal Republic of Germany, Finland, France, Ireland, Italy, the UK, Sweden and Switzerland.

Honda, Nissan, Mazda and Toyota (Sperling, 1995, p. 38). The requirement increased to 5% in 2001 and to 10% in 2003. The detailed requirements implied that compliance could only be met by the sale of fully electric cars. This was the first version of a Zero Emission Vehicle Regulation (ZEV Regulation) in the world and it created a de facto mandate for a specific technology: battery electric vehicles (Bedsworth & Taylor, 2007, p. 1).

GM was prepared to follow the challenge and announced its plans to produce and sell electric cars by the mid-1990s (MacKenzie, 1994, p. 35). Commitments not only led other automakers to follow suit, but strengthened CARB's ZEV mandate, and thereby invited other states to also adopt the ZEV mandate (Sperling, 1995, p. 39). However, due to too high battery costs and unsatisfactory performance range results, GM moved away from its initial Impact electric concept car program[5] in 1993 and continued with a smaller electric car program (Wallace, 1995, p. 169). At the same time, GM joined forces with the other large automakers and filed lawsuits against the states that aimed to adopt the ZEV mandate. This raised a fierce public debate in California. Yet, the debate was not in favor of the automakers and CARB confirmed the ZEV regulation without making any changes in 1994 (Sperling, 1995, p. 40). Thus, once the automakers' voluntary endeavors encountered the uncertainty of technology development trajectories, they were met by regulatory persistence that was grounded in the certainty of the development efforts themselves (Lichtenthaler, 2011).

While the ZEV regulation has been vigorously criticized by the auto industry (Motavalli, 2000, pp. 32-39), it has propelled major auto manufacturers and suppliers to the automotive industry into technology development projects resulting in technological spillovers and changes to the market and infrastructure of the automotive industry (Bedsworth & Taylor, 2007, p. 9). On the other hand, CARB's mandate for the sale of new cars was expected to alleviate

[5] The GM Impact was a concept car which later inspired the design for GM's famous EV1 model program. The purpose of the Impact was to study customer reactions. GM assumed the would be demonstrations of public dislike for a car that due to technology development would "not allow production of a diserable car at a desirable price" (Wald, 1994).

barriers in the use of electric vehicles and the development of related components and infrastructure, and thereby achieve environmental benefits. Instead, it pressured automakers' existing competencies and led to competing designs which also led to advancements in cleaner conventional internal combustion engine vehicles and hybrid-electric vehicles, which have proportionately delivered a far greater contribution to a cleaner environment than what could have been expected from the number of electric cars defined by the sales mandate (Bedsworth & Taylor, 2007, p. 14). Moreover, although the larger auto manufacturers had increasingly been presenting electric car prototypes in their fleet, some had foremost been likely to partner in other types of auto development projects in order to meet environmental requirements. Contributing to this limited focus on electric car technology development has been the continuing impact of oil and energy companies lobbying against such activities, through organizations such as the Western States Petroleum Association (WSPA)[6] (Motavalli, 2000, p. 33), keen to protect their current industry income sources and jobs.

Since the introduction of the ZEV regulation in 1990, several amendments have been made, including some that also support improvements made to conventional internal combustion engine vehicles and hybrid-electric vehicles (CARB, 2008). Over time, the ZEV program had grown complex and in 2008 a redesign of the program was initiated in order to account for recent climate benefits and ensure an alignment with other streams of zero emission projects promoted by CARB (CARB, 2008, March 27). Although the ZEV mandate strongly pointed towards electric car development, which seems to have remained a part of the redesigned project, electric cars could also be substituted by other types of environmentally friendly cars (CARB, 2008, March 27). Overall, the ZEV program became less focused on the technology development for electric cars, and increasingly provided large auto manufacturers greater flexibility in terms of ways of developing more sustainable vehicles that pollute less.

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[6] The WSPA acts on behalf of oil companies in the western US states, such as California, including British Petroleum, Chevron, ExxonMobil, and Shell.

Though the new ZEV program was initiated in California, its debut and global impact in relation to the development of electric cars has been recognized by a wave of researchers in the field of electric car technology (Kirsch, 2000; Mom, 2004; Motavalli, 2000; Schiffer, 2010; Wakefield, 1994; Westbrook, 2007), and has arguably propelled a new era of electric car development. In the case of this research, it played a part in forming and breaking the partnership between Ford and Think, to which I will return in my empirical Think cases, in Chapter 5. In Europe, efforts that focus on the automotive industry's impact on improving the environment and air quality also initiated in the early 1990s.

2.1.3 Open technology emission reduction framework promoted in Europe

In 1995, the European Commission adopted its first strategy to reduce vehicular CO_2 emissions and improve the fuel economy (EU-Commission, 1995). This strategy was based on three pillars: "voluntary commitments from the car industry to cut emissions, improvements in consumer information, and promotion of fuel efficient cars via fiscal measures" (EU-Commission, 2007, p. 2); a strategy advocating for an integrated community approach.

In 1998, this led the European Automobile Association (ACEA[7]) to voluntarily agree to decrease CO_2 emissions to an average of 140g/km for new passenger cars sold by 2008, while the European Commission agreed to postpone the next target of 120g/km to 2012 (T&E, 2011). In 1999 the European Commission also made similar agreements with Japan Automobile Manufacturers Association (JAMA[8]) and Korea Automobile Manufacturers Association (KAMA[9]) (EU-Commission, 2007). In other words, the three associations had a

[7] At the time, the car manufacturing members of the ACEA were BMW AG, Daimler-Benz AG, Fiat Auto S.p.A., Ford of Europe Inc., General Motors Europe AG, F. Porsche AG, PSA Peugeut Citroën, Renault SA, Rover and Wolkswagen AG. These companies also included brands such as Audi, Opel, Saab, Seat, Skoda, and Volvo.

[8] JAMA included Daihatsu, Fuji Heavy Industries (Subaru), Honda, Isuzu, Mazda, Nissan, Mitsubishi, Suzuki and Toyota.

[9] KAMA included Hyundai Motor Company and KIA Motor Corporation.

decade to ensure compliance among their members. However, it is noteworthy that the partners appear to have agreed not to assess the outcome of the voluntary agreement in terms of costs and benefits (T&E, 2011). Moreover, the impact on the industry of this voluntary agreement would not be easily visible: requirement to share or document analysis of decision-making or related actions and reflection of demonstrated ideas, design opportunities and resource demands were not expected.

Fiat, Citroën and Renault, Ford and Peugeot were already proving to be relatively good performers with regard to CO_2 emissions as compared to other members in 1997, but during the voluntary agreement period, they managed to further reduce emissions significantly (T&E, 2006). However, in 2006 the Federation for Transport and Environment (T&E) stated in its report "How Clean is your Brand?" that "the commitment [of the car manufacturers] is not on track" (T&E, 2006, p. 3). T&E noted that car manufacturers would have to improve their products' CO_2 emissions by 4%-5% per year in order to meet 2012 emission targets. This meant a performance improvement rate of three to four times the rate of reduction achieved in preceding years. Furthermore, T&E pointed to the fact that the EU was the only major "economic region without legally binding rules for fuel efficiency of vehicles" (T&E, 2006, p. 8). In other words, T&E did not perceive the voluntary approach appropriate enough and called for legislation in taking cost and benefit scenarios into consideration, or say, business models.

Then in 2007, the European Commission adopted a framework to launch mandatory reductions proposing an integrated legislatively supported approach that "should ensure a competitively neutral and socially equitable and sustainable reduction" (EU-Commission, 2007). While the European Commission acknowledged the progress made voluntarily by automobile manufactures, it deemed mandatory reductions of CO_2 emissions necessary in order to meet the Kyoto Protocol that EU members had voted in favor of in 2002, whereby the EU also chose to commit to a fixed overall reduction of greenhouse gasses (GHG) to 8% below 1990 levels by 2008-2012 (EU-Commission, 2011, p. 3). This target increased in 2009 as the EU decided to augment its ambitions, aiming for a 20% reduction by 2020, as compared to

1990 levels (EU-Commission, 2011, p. 4). Later that same year a T&E report welcomed the European Commission's initiative, while emphasizing what it considered to be key issues for regulating fuel consumption: long-term targets by use of a utility parameter should be based on a car's "carbon footprint[10]"; penalties should be defined to ensure a robust compliance regime; biofuels should not be rewarded; and additional costs to car buyers should be understood as offsets to savings on fuel (T&E, 2007). As a result, T&E pushed for further details and directions in relation to auto manufacturers.

The next initiative came in 2008 with the "European Green Car Initiative" as part of the European Economic Recovery Plan. The Plan dedicated a total of €1 billion for research and development in the field of electrification (EU-Commission, 2009). In relation to this, it was pointed out that cost-based loans to car producers and suppliers would be provided to finance innovation and one of three major research and development areas were electric cars for road transport. On this account, more than 50 collaborative research projects initiated since, involving partners from electric car manufacturers, utilities, municipalities, universities and technology research institutions. Several European countries have introduced incentives for research, conducted pilot projects to demonstrate infrastructure feasibility, and stimulated electric car sales (Hockenos, 2011). And, in June 2010, the ACEA presented the first part of a joint recommendation (including the interests of JAMA and KAMA) for a standardized interface between electric cars and relevant infrastructure to ensure interoperability within EU member states (ACEA, 2010).

Large initiatives in Europe to improve air quality to date, focusing on the automotive industry, may be characterized by voluntary and fragmented activities, yet such efforts have also given rise to a priori electric car development. The Green Car Initiative is an event that demonstrates progress in this line of understanding.

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[10] A carbon footprint has been defined as "a measure of the total amount of CO_2 and CH_4 emissions of a defined population, system or activity, considering all relevant sources, sinks, and storage within the spatial and temporal boundry of the population, system or activity of interest, calculated as CO_2 equivalents using the relevant 100-year global warming potential" (Wright et al., 2001).

2.2 Summing up

With this portrait of the wider empirical context of electric car development I have brought forward several points which are noteworthy in relation to how technology innovation is conceived and modified in a wider context through transformation in collaborative partnerships.

First, historically, the idea of an electric car has never been abandoned since it was first conceived, but its meaning has depended on interests and an understanding of wider contextual environments and other technological ideas. Electric cars have depended on forming, breaking and reforming partnerships for their technological advancement and commercialization which has also been strongly linked to public awareness and relations. Electric vehicles have been considered a solution for technology experimentation and advancement and they have evolved into successful designs several times over the years, manufactured by both large and small automakers and energy suppliers. And, development has also meant progress within other industries where electric cars have been used as part of product realization, sometimes changing the characteristics of products. But at times, the electric car has also been considered a problem because of a lack in real-road experience and technology advancement, failing designs, and commercial and public reputation.

In the historic account, I referred to the delivery service of beers by electric cars around 1900. It is not difficult to imagine that the beer business changed itself, solving problems such as the amount of beer that could be transported in a single shipment and reducing bottle breakage during transport, which in turn, resulted in different costs and price options for beer suppliers. Though beer suppliers may not have perceived their existing business as being problematic, they certainly seized potential solutions in the use of electric cars. Thus, beer suppliers' interest in and understanding of how the electric car could be integrated in their business was important, and their experimentation with electric car use for delivery purposes helped build public awareness and relations.

I emphasized the Paley Report to President Eisenhower in 1957 that revealed a scarcity of certain raw materials, and as such brought forward a

problématique calling for technology innovation development. And, I mentioned investments in battery technology occurring around the same time that may be seen as providing solution opportunities. Both factors demonstrate that the ensuing electric car developments initiated by different entrepreneurs depended on problem-solving activities and partnerships. These examples also demonstrate that development may have been initiated by a perception of resource scarcity, but activities mainly led to successful innovation developments of new drivetrain systems, a small city car model and other complementary products that contributed to solutions but didn't solve the entire problem around the revealed scarcity.

Further, I also pointed to the purpose of the Electric Vehicle Council and partnerships among larger energy suppliers to target and advance the use of electricity in transportation, which led to the mapping of socially embedded and related innovation development expectations and aspirations for electric cars. Technology innovation partners aimed beyond tweaking existing contexts, towards the contextualization of an otherworldly environment pertaining to electric cars as the main means of transportation. Such players confronted the elements of unpredictability and uncertainty as part of innovation development.

Nevertheless, resistance to the electric car never ceased. Different technical, social, economic, and environmental obstacles challenged electric car development and its commercialization, at different times. I refer back to the horse carriage already accepted as a means of transportation in relation to which the electric car had to prove its advantages as it first came to market. The electric car development trials led to a defense and redefinition of legitimacy, as the gasoline car increasingly won favor, as the Red Flag Act in the UK government energy policy actively blocked electric car development among others. All along, not merely technical resistance, but interests, understanding and the individual choices of different people posed resistance.

Second, the CARB de facto mandate for electric vehicle development was driven by a US political ambition to change climate conditions by reducing urban pollution, but its practical realization was depending on automakers' will and perception of what was cost-effective car production change. In rela-

tion to electric cars, cost-effectiveness and automotive environmental improvements have so far mainly proved possible in the US where the electric car became the 'donor' of technological innovation and changes to the existing fossil fuel auto market. This is in part, as I noted, due to large US automakers and oil and energy lobbyists forming opposition partnerships, since the ZEV regulation was considered a problem for their current businesses. Paradoxically, change within the existing automotive industry and its energy consumption was part of the solution to counter uncertain energy use and unpredictable economic revenue from development efforts of electric cars. But it remains that political, economic and environment interests, still don't intersect because of a lack in collaborative partnerships.

Third, the open technology emission reduction framework promoted in Europe has been driven by an empowerment of the auto industry and consumer demands, as well as the political acceptance of unpredictable outcomes. While these conditions have granted auto manufacturers and their partners, such as energy suppliers, free hands on problem-solving and experimentation in relation to mobility, it has also left them without sufficient active promotional support from policies, or challenges in development expectations. But the advancements that have been made seem to be jointly desired by community partners.

Comparing the last two points reveals that, in recent years, the US and Europe have taken different, if not opposite, approaches toward changing climate conditions, gaining oil independency, and reducing urban pollution through policy changes and economic funds related to the automotive sector. While the US administered a de facto mandate in the development of electric cars, Europe set out with no detailed requirements relating to the improvement of any specific technology; rather, Europe provided an open technology policy. Meanwhile each side of the Atlantic developed strategic approaches that have changed. Currently the US is increasing flexibility in compliance, while Europe has embarked on a more focused strategy toward electric vehi-

cles, including country-specific initiatives such as Denmark's partnership with Betterplace[11].

Electric car pilot projects are emerging, as are activities that explore infrastructure, business models, incentive schemes and policy needs, more than ever (Reiner, Cartalos & Viljamaa, 2010). Furthermore, the general public is showing an increased interest in driving environmentally responsible cars, as people become increasingly conscious of the environment and carbon footprints. Yet, there is still uncertainty linked to many aspects such as auto manufacturers' recovery from the worldwide industry downturn following the oil price explosion and the associated financial meltdown from 2008-2009. There is also uncertainty as to whether there will be a prevailing technology guiding mass production, as to whether the perceived high public lethargy to transitioning away from conventional cars will change, and whether supporting regulation measures will be in place (Ewing, 2010; Vaughan, 2011). In addition, the historic lack of fulfilled expectations in the development of electric car components may result in dissatisfaction and perceived failure sooner than production series can reach customers and have a chance to prove their economic, social and environmental potential (Kirsch, 2000).

There is a long way from identifying these noteworthy points about the importance of: problem-solving activities, changing meanings, interests and expectations, confronting unpredictability and uncertainty, and redefining legitimacy in relation to how electric car technology innovation is conceived and modified in a wider context through transformation in collaborative partnerships; and, understanding the details of evolving technology innovation partnerships in relation to the emergence of innovation design. Still, Think has been forging its way somehow — but how? Our understanding today of this problématique depends in part on research literature on technology life cycle design. This is the focus of the next chapter.

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[11] The Betterplace project is highly contested (e.g. expensive concept and complex infrastructure design), but nevertheless, it is still an applicable example of a government partnership initiative that brings awareness and utility of the electric car to the general public, through the marketplace.

3 Three perspectives on the role of partnerships in technology innovation processes

Before reviewing and discussing the theoretical lines, I briefly highlight again the phenomenon of interest in order to explain why I found these theories useful, and also problematic. Focusing on the phenomenon of what happens with partnerships, complementary assets, and competencies in an innovation process, it was useful, in general, to study technology life cycle literature, open innovation and drift in order to compare and contrast their varying explanations of specific events and situations that occur during the periods of ferment. Through that, I could then find meaningful material that could help elucidate and explain the difference that my research case reveals. More specifically, the technology life cycle literature's determination that uncertainty and unpredictability terminate upon the emergence of a dominant design is problematic — continuous problem-solving through experimentation and emergent learning provides important material for explaining this deficiency. Open innovation's postulation that uncertainty and unpredictability culminate during periods of ferment through stabilizing partnerships is equally problematic — but drift and enduring ferment provide valuable insights that refine this notion. These tensions have led me to invoke drift literature, which presents a different view on uncertainty and unpredictability and thereby offers a distinctive way to understand what happens with partnerships, complementary assets, and competencies in an innovation process.

The emergence and development of the dynamics of technological innovation have been primary research focuses for decades and have been approached from diverse analytical perspectives. For our purpose, attention may roughly be divided between a macro-level or industry perspective, represented by the dominant design model, and a more micro-level perspective, represented by the open innovation framework, on technology innovation life cycle design.

Generally, macro-level research is good at tracing outcomes and patterns of interaction on a global level (Scott & Marshall, 2005, p. 374). Technology innovation studies with this level of analysis are typically concerned with how an industry evolves with some kind of technology, such as cars, mobile phones or computers, while paying less attention to — as this it not their focus — how the technology got there in the first place, what technology might have been replaced as a consequence and what companies took part in the development process. Therefore, what counts to the technology life cycle literature, which has this analytical focus, is that there is a dominant design, because it is necessary for a company to play a role in an industry. Still, the technological life cycle approach has, through the meaning of "collateral assets" recognized partnerships (Utterback, 1994, p. 27) and has also begun to suggest a partnership selection process that takes place at the micro-organizational-level of an innovation process. But the dynamics of partnerships are thereby not addressed, and while it may not be a fair expectation of the literature to do so given its macro-level analytical perspective, this ends up providing little input about partnerships and innovation processes. This becomes problematic for the present research, in which context there is no closure, and whereby it is crucial to understand the dynamics of partnerships.

Micro-level research seeks to engage with the small, the local and the individual in order to trace the construction of meaning (Scott & Marshall, 2005, p. 374). Technology innovation studies with this level of analysis are typically concerned with how structures, routines and material evolve and make sense within a company in relation to a technology and its commercialization, and due to this local focus these studies are less interested in how the technology may impact or be influenced by the 'world outside'. Having this analytical perspective, it is therefore important for open innovation to identify and deal with what a company finds good and efficient in terms of ways of using its ideas and skills, because this help the company survive. Nevertheless, the important contribution of open innovation framework is to emphasize that a company is not alone in the world and therefore considers the positive role that active outreaches for different types of complementary assets through research, suppliers, users, or other partners have on the innovation process

(Chesbrough, 2003a; Chesbrough et al., 2006). But the unpredictable emergent learning and interpretative flexibility of outcomes — their role and whether and why they are understood as positive or negative — that occur through collaborative experiments, tests and other partnership activities is not addressed, and neither is the dynamic impact of these factors on the partnership and the innovation project itself. While it can be argued that an understanding of the wider social partnership or network impact of partnerships cannot be expected by a micro-level analysis, it seems reasonable that open innovation could and should pay deeper attention to the questions raised above and when that is missing it seems to provide little insight for the phenomenon of what happens with partnerships in an innovation process, which is the focus of this research as earlier explained.

One alternative way of exploring partnerships in technology development is offered by alliance literature (see for example Gulati & Singh, 1998; Powell, Koput & Smith-Doerr, 1996). Studies focused on alliances tend to be oriented towards an actor-level or network-level of analysis and are typically concerned with how alliances are embedded in broader industry networks (Granovetter, 1985). For example, Schilling and Phelps (2007) studied 11 alliance networks at an industry-level and concluded that firms which are part of alliance networks that have dense cluster structure and broad outreach have greater learning and innovation output. Though this literature does not seem to settle on a macro-, micro- or other-level of analysis, overall it is found more aligned with an industry-oriented perspective as studies seek to link company motives for alliances to specific organizational governance structures and innovation project stages (Hagedoorn, 1993). Therefore, this literature suffers similar shortcomings to dominant design literature in terms of inadequately providing insights on the dynamics of partnerships that are relevant to the phenomenon in question. Therefore, alliance literature has not been given exclusive focus in this thesis.

Another approach is offered by intermediary-level or sociotechnical-level analysis (Geels, 2002; Pinch & Bijker, 1984) that is able to follow complex patterns of integration and adaptation that demonstrate how the macro and micro levels are connected. Technology innovation studies with this level

of analysis have demonstrated concern for how innovation processes may impact the conceptualization of and form repository for industry emergence by taking up detailed interest in how connections between different innovation elements, such as complementary assets, are created as a result of defining and redefining interests, collaborations and problem-solving activities that position the elements as related components in new temporary, stable, socio-technical ensembles. With this analytical perspective on innovation processes, the drift-perspective (Kreiner, 1995; Van de Ven et al., 2008) regards innovation and uncertainty as inseparable and emphasizes the importance of embracing uncertainty by taking an explicit focus on that 'something' unpredictable that happens as drifting environments impact technology innovation partnerships and the innovation process in general. The intermediary-level is also reflected in writings addressing emergent learning in technology innovation projects as part of an interactive act, which creates emphasis on why and how an understanding of learning from failure and learning from the innovation process itself (Ariño & Torre, 1998; Doz, 1996) is important in technology innovation projects as it adds to and changes partnerships. This dynamic in partnership meaning and sensemaking (Weick, 1995), which is related to unpredictable moves in economic, environment, social, and technical dimensions is why a partnership drift perspective is found to be a useful openly process-engaging view to investigating technology innovation partnerships in line with the ambitions of this research.

It is with this focus that I seek to line up my argumentation in this chapter by presenting the common perceptions of the technology life cycle design in the forms of the dominant design model (see 3.1) and open innovation (see 0), coupled with the main arguments and assumptions upon which they rest. By doing so, their limitations in relation to the context being researched will become clear. In addition, I point to their promises and limitations in explaining and motivating the progression of technology innovation development partnerships. I focus enquiry into what is particularly said about technology innovation partnerships – partnership duration, partnership forms and partnership interests – by both perspectives. Thereafter, I continue presenting the main assumptions and implications of a partnership drift perspec-

tive that contributes to an understanding of the era of ferment as forming-breaking-reforming technology innovation development partner relations (see 3.3).

Having presented the perspectives of dominant design, open innovation, and partnership drift on technology innovation development partnerships, and gradually completed **Table 1** below providing an overview of the three, I proceed to comparing and contrasting (see 3.4) the three perspectives, whereby I emphasize a gradual shift in understanding from a rather macro-level and distanced/evading analysis of how the formation of partnerships interact with innovation processes, to a more micro-level and openly engaging process view of partnerships and technology innovation development.

Table 1: Comparative perspective on technology innovation.

Innovation perspectives	Dominant design	Open innovation	Drift approach
General understanding of partnerships?			
How are partnerships initiated?			
Understanding of change during an innovation process?			
Understanding of project uncertainty?			
Understanding of project outcome?			

The summary at the end serves the purpose of drawing up which explicit constructs of the partnership drift perspective carry on into the empirical analysis of Think and its Think City car.

3.1 Dominant design perspective of the technology life cycle and partnerships

Studying technology life cycle literature I encountered a perspective that upheld the ambition of establishing innovation development as a dynamic model. Indeed, this dominant design does demonstrate – but only if observing the life cycle from the outside – design patterns of technology innovation for assembled and continuous products.

3.1.1 The technology life cycle model

Dominant design has long been introduced as a technology life cycle model that is concerned with how a certain dominant design may result from innovation processes in a new industry and how the industry market competition may be changed by emergent new design dominance (Murmann & Frenken, 2006). The model is based on the understanding that companies must seek assets that establish their product innovations as dominant designs and they must pursue a strategy that influences technology partners, policy makers, competitors, and users into perceiving said innovations as such. In other words, companies should seek to 'master' the cyclical product and process development, often referred to as a "life cycle" (Utterback & Abernathy, 1975), that characterizes the ripeness and mass of a product organization. This perspective assumes a linear development path where there is a period of fermentation, followed by different designs that improve on an initial idea and then compete with one another up until a final stage, where a dominant design emerges and is selected as a product is brought to market. Following this, only minor changes to the product likely occur as the product is assumed as optimal in terms of form and function; eventually, an attempt at a last 'facelift' transpires before the product is taken out of production and off the market. In other words, this path assumes a planned, orderly sequence of clearly identifiable moments of what may be called 'closure'. Since Utterback and Abernathy (1978; 1975) proposed this dominant design and product life cycle understanding of technology innovation, many studies have expounded these assumptions and refined the idea in various supportive ways. Markedly, domi-

nant design argues that as dominant design standards emerge, dictating forms and operation performance of technologies for competing companies, policy makers, and users also emerge. The frame of competition also changes while experimentation and learning shift to more specialized skills and incremental product innovations that seek incremental costs, scales and network benefits from particular technologies that have already been applied.

The important insight is that industry-level dominant designs emerge from an innovation process characterized by a complex interplay of technology, collateral assets, industry regulation and government intervention, and company strategy (Utterback, 1994, p. 27). However, the very micro-level socio-technical processes involved in gaining innovation-developing assets in the first place remained unexplored, along with what guides the different innovation engineering partnerships. In the technology life cycle partnerships are formed around a winning technology, but how they form or evolve over time is not explained in any detail. Effectively, this gap implores crucial examinations, such as that which is being questioned in this thesis, regarding the assumptions about partnerships being something internal, standardized, 'mastered', and requiring time, which in turn supports an argument for long-term relations.

Utterback and Abernathy (1975, pp. 643-644) proposed a dominant design and life cycle understanding which was further defined into three stages, each with a specific type of process, strategy focus and stimulus. Following an evolutionary perspective, radical innovations (mainly product-related) are assumed to happen in the early stage of a life cycle, followed by process innovations; the former increase as the latter decrease (Abernathy & Utterback, 1978). Based on both types of innovation, a dominant design is perceived to emerge, giving stability and direction in the market. It is this approach to design that I argue reflects a linear, progressive accumulative and irrevocable approach, also in terms of relations, and where I find strategy to be considered as a matter of planning: at some point in time, innovation design is considered 'task-done' and that also impacts partnership considerations. The following model illustrates a dominant design's general perspective

on technology development and can be used to illustrate an ideal product life cycle model:

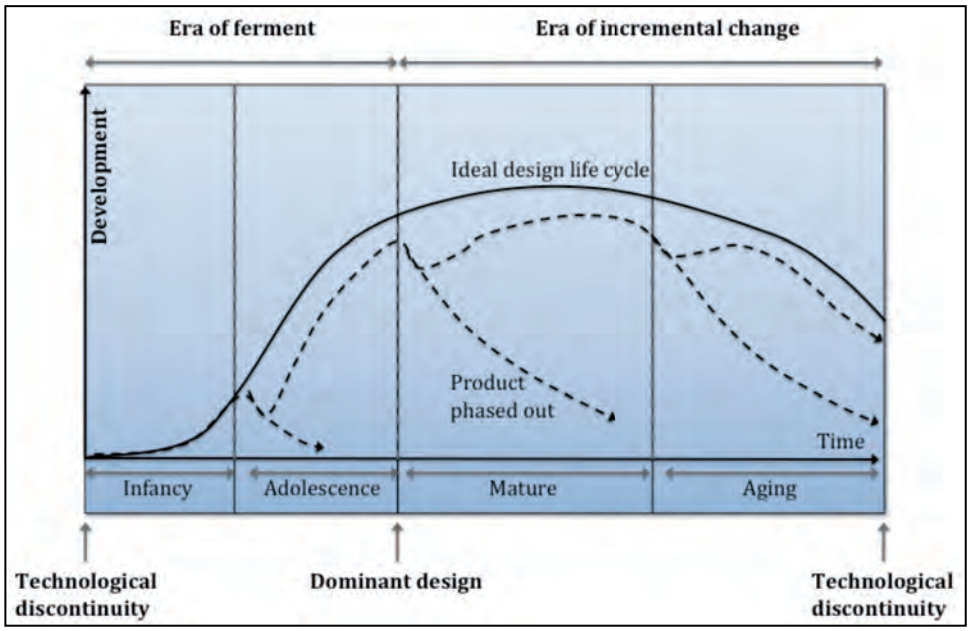


Figure 2: Technology life cycle model example

Later, a sense of temporality and importance of activities outside the project organization became integrated into the model of dominant design, as product design was also deemed to be affected by changes in customer demands, technical options and government policies (Abernathy & Clark, 1985, p. 18). These factors were found to have a stabilizing effect on product design with destabilizing technological, economic, environmental and social implications. Although literature in relation to this began engaging with and searching for micro-level ways of questioning the broader role of technology innovation development, Abernathy and Clark's focus remained tied to the macro-level "patterns of technology development and competition rivalry over time" (1985, p. 5), whereas again, factors such as material resources, skills and relations, collective knowledge and understanding remained unexamined and unexplained in detail. However as a positive element, I argue, Abernathy and Clark's life cycle perspective demonstrates that uncertainty and history have also become recognized as affecting the pattern of technological change and innovation. Uncertainty had already been inscribed in innovation literature by Rosenberg, who also related the notions of "technological uncertainty" and

"learning by using" and experience, arguing that underlying development problems may only surface after years of experimentation and learning (1982).

Around the same time as Abernathy and Clark's presented their life cycle perspective, Clark (1985) investigated the logic of problem solving in relation to dominant design. He asserted that technology becomes dominant as a result of a larger, complex process, involving several competing variants of core technologies (both materialized and non-materialized) and their physical application, that occurs in conjunction with other technologies. Ongoing selection and deselection evolves until a preferred technological 'hierarchy' emerges in the form of a particular design (Clark, 1985). References to dominant technology 'hierarchies' or 'trajectories' were also found in technology development literature (Dosi, 1982; Sahal, 1982) and in studies on innovation from an economic perspective (Nelson & Winter, 1982) at the time. I argue that this partly explains why external partners still seem to play little importance in terms of dominant design considerations and as meaning is bestowed to technologies prior to any project engagement. This 'missing' element is presented as 'technology against technology' and as a matter for partners to try and 'fit' into a context.

The notion of dominant design and its discontinuity is an idea supported by Tushman and Anderson (1986), who identified innovations as either enhancing or destroying the competencies and technologies of both organizations and industries and could thereby also be considered as affecting skilled and unskilled labor (Anderson & Tushman, 1990; Tushman & Rosenkopf, 1992). Through their research, Anderson and Tushman (1990) concluded that new companies are not any more likely than existing companies to successfully compete with competence-destroying innovations; to them, its was a question of whether the technology was competence-destroying or not. Nevertheless, existing companies are more influenced by their internal knowledge resources, whereas new companies seek to compensate for a lack in competences with resource complementarities. From a micro-sociologic perspective, while research increasingly emphasized learning and know-how in relation to dominant design, in part by recognizing the work

of Pinch and Bijker (1984), these factors were still being considered as individual constructs, strictly related to technology, and only organizationally relevant once a dominant design had been achieved (Anderson & Tushman, 1990). Therefore, I contend that a rigidity embedded in the dominant design idea progressively revealed itself, while research based on a process view began demonstrating how innovation could be understood and explained in more useful terms and detail and thereby filling some of the gaps from dominant design.

3.1.2 Assumptions about partnerships in the technology life cycle model

While it is understood that partnerships matter and much is known about fruitful partnerships (see for example alliance literature or open innovation), less is understood about their dynamics in innovation processes. As Utterback (1994) returned to the dominant design in his book "Mastering the Dynamics of Innovation" he argued that,

> The idea of a dominant design is conceptually broader than technical competition and progress. Factors other than technology come into play; chief among these are collateral assets, industry regulation and government intervention, strategic maneuvering by individual firms, and communication between producers and users (Utterback, 1994, p. 27).

Utterback's emphasis on "collateral assets", which he also called "co-specialized assets", is, as I have found within dominant design, what comes closest to acknowledging the need for partners and emergent learning (Utterback, 1994, p. 27), and an attempt to work a way out of a rigid approach to innovation. A couple of examples from the book support this conjecture. First, in relation to technical and capital matters, Utterback touched on the case of the development of typewriters and stated that "a good hand with mechanical gadgets was what was required, and partners [...] to handle the technical and capital-intensive business of manufacturing that new design" (Utterback, 1994, pp. 23-24); but he did not explain this need further. Second, Utterback noted that during periods of increased market and technical uncertainty "a productive unit must be focused to make progress; for a group to be

successful in an uncertain environment, individuals in the organization must act together" (Utterback, 1994, p. 84). He referred to innovation organizations as "organic structures" and "organic connections" emphasized by "frequent adjustments and redefinition of tasks, limited hierarchy, and high lateral communication" (Utterback, 1994, p. 84). But instead of explaining this unrest of connections in-depth, he pushed forward the importance of having "a production process, and a set of market relationships and expectations [that] become highly developed with respect to specified and standardized product, [and] organizational control […] provided through structure, goals, and rules" (Utterback, 1994, p. 85). Third, in relation to stabilizing a dominant design in a competitive environment, Utterback explicitly emphasized,

> Another hallmark of stability is the emergence of a set of captive suppliers of equipment and components. Although such suppliers can be an initial source of innovation and growth, they may ultimately become a conservative force, further stabilizing the competition and change within the product market segment and creating yet another barrier to entry (Utterback, 1994, p. 89).

Utterback's argument grants not only suppliers a co-creating role in technology development and organizational growth, but he also cites them as a collaborative group that may be either considered helpful or obstructive in the face of competition and change, depending on whether the collaborative group is partnering with an organization or not. Also, it is either a macro-evolution or micro-partnership that is presented, and from the macro-level dynamics of dominant design literature it is inferred that partnership evolution is very progressive, but is this (always) the case? And if not, is that necessarily a problem? I argue that these three examples demonstrate that dominate design began to consider, more specifically than previously, 'what' in the innovation development partnerships mattered, associating partnerships with technical and capital matters, market expectations, organization growth and stability, and change, though the 'how-questions' were still not being approached. In addition, Utterback was found to make almost no comments about how partnerships are related to the different phases of the dominant design model, but the hints that I found in relation to the era of ferment are what I discuss next.

3.1.3 Partnership contributions in the era of ferment

The life cycle approach still widened with contributions from Tushman and Romanelli , for instance, who investigated how both internal and external sources impact organization inertia and change. In developing their model of organizational evolution (1985, p. 182), they described, in relation to the era of ferment, which they referred to as short periods of "reorientations" that, "executive leadership mediates between internal and institutional forces for inertia and competitive forces for fundamental change. It is executive leadership which initiates, shapes and directs strategic reorientations" (Tushman & Romanelli, 1985, p. 173). In terms of defining the external forces, Tushman and Romanelli referred to political and economic structures and processes associated with gaining "legitimation" and "effectiveness" through the development of a role in the close and wider environment and with "regulatory agencies", in particular (1985, p. 175). Though Tushman and Romanelli focused on a need for achieving consistency with the environment, they considered this a one-time act of adaptation that a partnership does at the initial stage of its existence to fit into and survive within a predefined "resource space", also referred to as a niche (Tushman & Romanelli, 1985, p. 183).

As Utterback attempted to capture the dynamic processes of the life cycle model, still with the interest of understanding the patterns of innovation, he noted, in relation to the era of ferment, which he referred to as "the fluid phase" in his own slightly adapted model-presentation (Utterback, 1994, p. 92), that,

> The first personal computers were also crude and relatively expensive versions of what would emerge over the following decade, but dedicated lead users were undeterred by these drawbacks and stayed with the new technology through its many early forms (Utterback, 1994, p. 93).

Though a more specific description lacks of who the "lead users" Utterback referred to were, the comment reveals, I think, something about partnerships and the innovation process: that an innovation may exist in its early forms, partly supported by some form of dedicated and friendly partnerships beyond the project group, which does not necessarily involve direct con-

tact. Further, Utterback stated that "Custom designs and user-adapted designs are common during the fluid phase, and we see them essentially as experiments in the market place" (Utterback, 1994, p. 93). What can be inferred from this is that Utterback acknowledged, or at least ascertained, some form of interaction that takes place between customers/users and manufacturers while technology is in a stage of development. It also posits that partnerships are observed in relation to the perceived pattern of dominant design, which essentially is what Utterback aims to explain. Another point is the relationship between a company and its founder. Utterback noted that during the era of ferment the entrepreneurial character of a company "often reflects the personalities of their founders, who are generally technical entrepreneurs" (Utterback, 1994, p. 95). Founders are considered to bring both hard and soft skills into the innovation project, but how this happens is not explained. The final point I can discern from Utterback which pertains to partnerships concerns patenting. Utterback described that companies "worked feverishly to acquire and protect patents to their innovations to assure their technological superiority against a field of imitators" (Utterback, 1994, p. 95). The word "acquire" implies some sort of collaboration with intellectual property offices, but this is not explicitly mentioned and the process details that were involved are also left out of Utterback's considerations.

So, however much was left to the interpretation – if not, imagination – of innovation researchers and industry experts following dominant design, based on the references mentioned above, including references to lead users/customers, company founders, and patent offices, Utterback had indeed considered the occurrence of partnerships in the dynamic processes of the life cycle model, in the era of ferment. Nevertheless, I argue that these mentions and associations reflect a random engagement with the relevance and importance of partnerships.

For the era of ferment, where the primary focus lies on the types and degree of technical variation, few contributions have been made thus far explicitly focusing on partnerships and its potential importance for variation. As Gort and Klepper (1982) made a major contribution to the academic literature

by documenting 46 products over time in terms of volume, price, producers, output, and sales, they concluded,

> The structure of markets (in terms of the number and composition of producers) is shaped, to an important degree by discrete events such as technical change and the flow of information among existing and potential producers (1982, p. 651)

As such Gort and Klepper's statement pointed out that partnerships could be considered sources of variation in technology innovation development both individually and when composed in groups, though there was no mentioning of the origins of these relations between producers, and whether experimentation would be an important aspect of figuring out what opportunities partnerships may hold. But this links the macro dominant design to micro studies on organization and alliances, and the variation referred to here links up nicely with the important experimentation that I present under the partnership drift perspective later in this chapter.

3.1.4 Input for a comparative perspective on technology innovation

Summarizing the main input of dominant design's contribution to understanding technology innovation development and the role of partnerships, I lay out my view in relation to the aspects I mentioned in the introduction. Overall, I have found a rather limited perspective due to its macro-level focus: partnerships predominantly being considered as internal, something to standardize, and at best be 'mastered'. When reference was made to external partnerships, they were random. Design approaches were viewed upon as standardized, linear, and irrevocable. Strategy was presented as a matter of planning a direction that should lead to a dominant design. Change was considered as coming from exogenous or endogenous shocks. Project outcomes were deemed predictable possibilities that are measurable and controllable, while uncertainty was presented as the main opponent – too complex, and at best, handled through risk management as listed on the next page in **Table 2**.

Table 2: Dominant design perspective on technology innovation

Innovation perspectives	Dominant design	Open innovation	Drift approach
General understanding of partnerships?	internal, long-term, standardized, 'mastered'		
How are partnerships initiated?	through standardized selection criteria, following detailed plans of direction for the collaboration		
Understanding of change during an innovation process?	exogenous or endogenous shocks		
Understanding of project uncertainty?	considered an opponent, too complex, risk management		
Understanding of project outcome?	predictable possibilities, measurable and controllable		

This perspective was clearly neglecting the variety of different dimensions of innovation, variant partnerships and perceptions that I found in relation Think. With this in mind, I was persuaded to look beyond the prevalent traditions. One of the challengers of the dominant design perspective is the open innovation framework and that is the focus in the next part of this chapter.

3.2 Open innovation framework for technology value and partnerships

In investigating open innovation literature I found a framework that aspires to be the new open perspective on technology innovation development catering for the knowledge landscape of the early 21st century[12]. This is a time when open innovation is understood as being characterized by a workforce that is mobile and globally available, the commercialization of financial engineering skills, companies, consultancies and research institutes that are selling technology development ideas and early stage technologies, which also holds suppliers as obvious partners in the development and production of improvement activities. This is a time that stands in contrast to the previous century in which dominant design was introduced, and from which open innovation distinguished itself (Chesbrough, 2003a, pp. 34-39). Indeed, the perspective on innovation is widened in relation to partnerships, a little.

Open innovation promises that managing internal and external knowledge, that is meeting company business model requirements, will create innovation success, and this focus does seem to bring open innovation a step closer to an understanding of external technology innovation partnership processes. Therefore, a sense of speculation seems to follow through open innovation's argumentation. It is the notion of "value networks" by Chesbrough and Rosenbloom (2002) that I find slightly touches on how complementary knowledge in some way may be useful for technology innovation. Thereby it relates, though vaguely, to partnerships as part of socio-technical ensembles, as I have encountered them in Think. But overall, I did not find that open innovation provided new explanations about partnerships, which is why the contribu-

[12] Chesbrough refered to "the unique relationship between the public university system and corporations that developed in the United States in the first half of the twentieth century. Unlike the higher education system in European nations, the US system was decentralized, even among public universities. [...] Private universities were neither accountable to a national authority nor responsible even to a state authority and were thus free to pursue their own science and technology agenda" (Chesbrough, 2003a, p. 25). This may also explain why the innovation development approaches I touched upon in relation to dominant design are likely to differ not only globally, but also nationally and even regionally, besides differing by industry.

tions discussed in the following review, still reveal a rather limited frame for partnerships and their role and relationship to technology development.

Typically, alliances and networks are considered to be built based on a motivation for access to complementary assets that could enable the commercialization of an innovation product, and for a company to match up to or differentiate itself from competition (Teece, 1986). Therefore, the reason for most companies to seek some form of complementary assets through alliances and networks in relation to an innovation technology project, Teece argued, rests upon the actuality that "no company can keep pace in all of these [different technology] areas by itself" (1986, p. 293). However the notion that uncertainty will have an impact, in relation to the development pace of the different potential complementary assets, is not examined. Open innovation studies are problematic because they do not look into the processes of forming alliances or networks. They rather focus on trust and time-to-market. They also do not address why partnerships fail. Open innovation does not question why it is beneficial that a partnership is stable over time. The activities expected that partners do together over time are neglected by open innovation as it focuses on exchanges of already existing innovations and action on predefined agreements. Such insights are missing for the phenomenon I am trying to explain.

3.2.1 The open innovation framework

Open innovation is a recently introduced model that focuses on how organizations may create technology innovation that advance their business value and how they may also gain additional value from selling off any innovation that is underutilized in relation to business activities. The model is based on the understanding that companies must seek access to, combine and exploit both internal and external knowledge resources in order to develop product and process technology that creates business value, and instead of discarding internal underutilized innovations, it should at some point in time decide to sell them off. Chesbrough (2003b, 2003c) first proposed this notion, which has since gained attention by researchers and practitioners alike. The following

model illustrates open innovation's general perspective on knowledge input and output flows in relation to technology development:

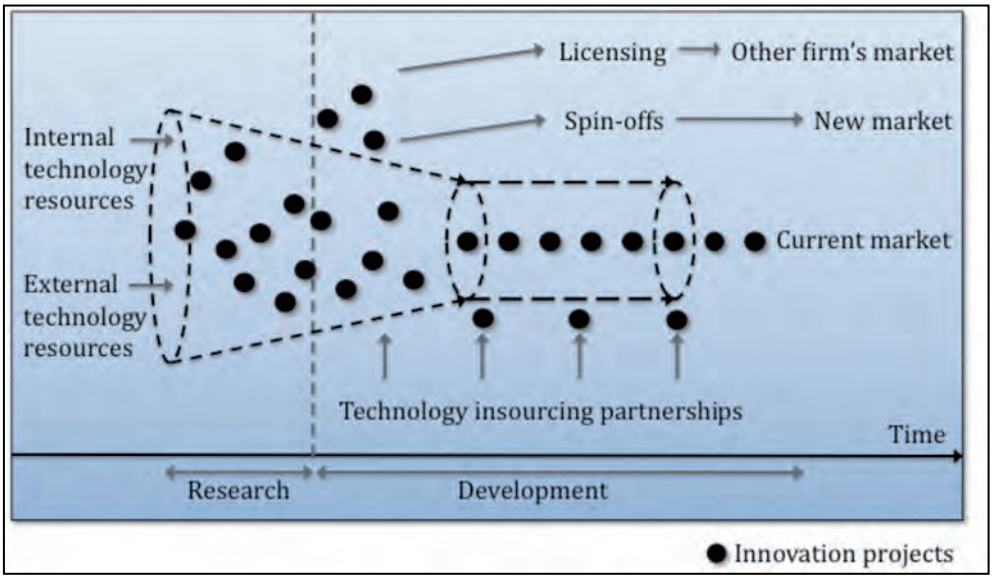


Figure 3: Open innovation model example

The common argument of open innovation is that social and market changes have led to the closed innovation model, posing a design efficiency problem for innovation development: an increase in the mobility of knowledge workers; greater information access; an increase in the marketability of technology as an asset, depending on the business model; and new financial structures have forced the boundaries of innovation processes, causing them to start breaking. Hence, it is companies that are able to structure their organizations in order to leverage both internal and external knowledge, in a creatively focused and timely way, that will stand a chance of surviving (Chesbrough, 2003b, 2003c). Indeed, it may be argued that open innovation has become appealing and useful to business managers in technology-driven organizations in a way that innovation management and technology literature have previously been unable or unwilling to. Still I found, open innovation shares the assumption, with life cycle literature, that knowledge resources pre-exist somewhere, and that business value is a known factor (Chesbrough, 2003a). How innovation processes are breaking, I argue, is not elaborated on by open innovation, and whether this is due to the low efficiency of existing

development practices, a lack in flexibility of established ways of commercialization, limited variability in financing structures or uncertainty of intentions in partnerships, remains speculation. This is important to understand because breaking processes may launch companies into uncharted and uncertain territory where processes or even everything that was previously in place has become disrupted — what had value is worthless and knowledge resources are no longer accessible, outdated or none-existent — and there is a lot to learn for the innovation process from these experiences, for example, in examining the usefulness of exploring new interests, forming new partnerships and redefining the innovation project. Nevertheless, I agree that the closed innovation model, which is based on the assumption that organizations should strive to be in control of innovation processes, while considering knowledge spillover as an inefficiency and favoring internally secured environments, as Teece explained "is likely to be unnecessary as well as prohibitively expensive" (1986, p. 293). Throughout past decades, however, this is the strategy that many companies have aimed to pursue by employing the best people, defining proprietary knowledge and protecting both. This is not surprising, as "most approaches to strategy are based on a closed model of innovation" (Clegg, Carter, Kornberger & Schweitzer, 2011, p. 203).

Today, companies should rather open-up their innovation processes in order to benefit from the combination of both internal and external knowledge resources (Chesbrough, 2003b, 2003c). In a thought experiment, Chesbrough noted a couple of different options to develop mechanisms to do so. First, he mentioned that there is an "abundance of well-educated workers […] readily available for hire and [who] need not require extensive internal training or the inducement of lifelong employment" (Chesbrough, 2003a, pp. 48-49)[13]. Second, companies he suggested buying ideas like buying other commercial off-the-shelf products from "venture capital firms developing useful technologies" (Chesbrough, 2003a, p. 49). Third, companies could be stimulat-

[13] For example Chesbrough suggested the employment of professors over their summer periods, or the even more cost-saving option of hiring students (Chesbrough, 2003a, p. 50).

ing collaboration with "capable suppliers" (Chesbrough, 2003a, p. 49). Fourth, Chesbrough suggested that funding external research, in for example universities, could gain early access to knowledge by having a "well though-out program" for innovation (Chesbrough, 2003a, pp. 50-51). Different types of partnerships besides those formed with an end-user/customer or supplier, as noted by the dominant design model, are entering the innovation arena. Nevertheless, and as equally applicable to many thought-experiments, great assumptions on how to 'get things done', I argue, entail absurd speculations about partnerships – as reflected in the greater implications of the open innovation model.

3.2.2 Assumptions about partnerships in an open innovation framework

In general, open innovation literature refers to partnerships in a variety of ways: as interorganizational ties, as parts of value networks, as parts of geographical networks, as interpersonal relations (Chesbrough et al., 2006), and as co-development relations (Chesbrough & Schwartz, 2007), to name a few. In turn, these terms refer to customers, governmental and non-governmental relations, start-ups, suppliers, universities, venture capitalists, and other innovation technology developing companies. However, this typology work on partnerships, naming of meta-structures and partner types, offers no new insight that innovation literature has not already recognized.

As Chesbrough, Vanhaverbeke and West positioned open innovation as a new paradigm for innovation endeavors, the following definition was presented:

> Open innovation is the purposive use of inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively. Open innovation is a paradigm that assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as the firms look to advance their technology (Chesbrough et al., 2006, p. 1).

Their promise of open innovation in this definition reflects a deliberate management strategy approach as it is only focused on deliberate uses of in-

flows and outflows of knowledge, deliberate directions of internal innovation plans, and deliberate uses of defined and existing ways to an equally defined and existing market. That may not be surprising as formalized partnership agreements are highlighted rather than fortuitous encounters that could also lead to partnerships. Moreover, the definition reflects a limited innovation process understanding, which not only conceals pragmatic accounts about how open innovation works in practice, but also how companies could aim to make it work in the first place.

All the same, the open innovation model has emerged as the one demonstrating that a company's internal and external technology and resources may be combined in innovation projects. It emphasizes that the innovation process may take its offset from either side; that new technology may enter during the course of the process, and that there are a variety of channels leading a product to market, apart from traditional sales channels (Chesbrough, 2003c).

Definitely, innovation has gained high priority after it was overshadowed by the 1990s' dedication to optimal resource allocation from resource providers for a desired market positioning (Gant, 1991) — a focus that was about top-down management control and centralization, which offered poor conditions for innovation. As reflected on by Chesbrough and Appleyard,

> Traditional business strategy has guided firms to develop defensible positions against the forces of competition and power in the value chain, implying the importance of constructing barriers to competition, rather than promoting openness. Recently, however, firms and even whole industries, such as the software industry, are experimenting with novel business models based on harnessing collective creativity through open innovation (Chesbrough & Appleyard, 2007, p. 57)

But, in my view, as appropriate as it is to discuss and define new innovation models, it is also as inappropriate that open innovation does not reflect, test and adapt more explicitly to the uncertain and unpredictable business environments, which have provoked increased importance in companies' openness and flexibility also in relation to their technology innovation partnerships. For example, due to a convergence between traditionally separate industries such as consumer electronics, computers, entertainment and tele-

communications, which has broken down traditional hardware and software logics for product and service development, many technology providers have been left with no market and no core knowledge competence to fall back on, only but a chance to think anew and transform through partnerships. Leaving such debate out, open innovation ends up saying little about what happens to complementary assets and competencies in this new business environments.

Instead, Chesbrough consistently directed attention to the business model and explained how this would help companies succeed in commercializing technology innovation, which suggests that the success or failure of a technology innovation is to be understood in relation to a company's business model (2007a, 2007b, 2010). As Chesbrough further emphasized, "technology by itself has no single objective value. The economic value of technology remains latent until it is commercialized in some way via a business model" (2010, p. 354). As such, he argued that a company could gain value from the innovation of either one or both parts. But, I argue, he left users and partners as receivers of a pre-defined value understanding and did not consider them to be contesters and contributors through their technology learning and usage processes.

A common definition of what a business model is, I should like to note, has not been found, but there seem to be agreement about this relatively new concept in terms of describing the expected value chain for a product production, expected value proposition to customers, and an expected revenue model (Amit & Zott, 2001; Chesbrough & Rosenbloom, 2002; Osterwalder, 2004). Decisive, however, is that the business model is, like open innovation, a concept composed by static design elements that explain what is to be the business of a company from a transaction cost perspective, and thereby, I argue, the business model remains limited in its explanations of how the effective technology innovation comes to be through partnerships and how it is brought into play with an emerging market under conditions of uncertainty and unpredictability.

Describing types of openness in relation to open innovation, Gassmann and Enkel (2004) refer to "coupled processes" that leverage well-established relationships with innovation network partners by working with complemen-

tarities profoundly. Collaboration is in this case considered an improvement of knowledge and learning interaction, competitive position and ability to minimize risk (Gassmann & Enkel, 2004, p. 12). While this infers that relations can be assets and necessary preconditions for innovation progress, it also infers partnership stability over time, and the authors don't explain how "coupled processes" get coupled, and unfold as one.

Within innovation literature a critical scientific discourse has developed around the open innovation framework[i]. But though empirical research is emerging, drawing on open innovation theory, I did not come across empirical research pinning down the robustness of open innovation in relation to the present research[ii]. The ongoing debate related to the open innovation model points to a missing link between its postulated theoretical construct of openness in partner relations and the practical product development staged model that it remains committed to. A play on the business model may be a step towards creating that link. However, the approach to understanding the business model described above by open innovation seems to indicate that work on the business model should remain, at least partially, subject to closed innovation, within and outside the company. This, I found, further elucidates open innovation, liking it to a stand-alone technology development and commercialization process, rather than an embedded part of a company's ongoing external relations strategy.

In relation to the business model concept as defined by Chesbrough and Rosenbloom (2002) there is, however, one assumption of particular interest to my study as they did consider the term "value network" by their business model in relation to a company's use of complementary assets to strengthen the business model and value creation by implementing partnerships between said company and its customers and suppliers. Next, I will present and discuss examples of such partnerships as described by open innovation.

3.2.3 Examples of partnerships in an innovation value network

In relation to the "value network" description that consists of different external partnerships that occur in relation to a particular business innovation, open innovation remains distanced. Although Chesbrough and Rosenbloom (2002, pp. 534-535) used the term "value network" in their article, there were no details found concerning the process of how the supply of complementary goods comes about in a partnership, what partnership complementary goods may be and the effects they may bring to the value network, the partners and the individual partnership, and not the least to the innovation project the partnership encircles. Chesbrough and Rosenbloom emphasized that "positive alignment" of partnerships with the value network means greater success in harvesting potential value (Chesbrough & Rosenbloom, 2002, p. 535), but what positive alignment means was not explained. And how a partnership that is part of a value network must at the same time align with that very network was puzzling, as a seeming regard for the network as a stable and independent entity. However, "positive alignment" may be related to an alignment of business models, as Chesbrough and Schwartz (2007, p. 57) emphasized this as what innovation partners should aim for. Chesbrough and Schwartz explained that, "to sustain co-development relationships, one must carefully define the business objectives and align the business models of each firm" (Chesbrough & Schwartz, 2007, p. 55), They further stated,

> Aligned business models are complementary; if you execute your model well, your partner will benefit, and vice versa. Such alignment increases the chances that the co-development partnership can be sustained over time and perhaps even expanded (Chesbrough & Schwartz, 2007, pp. 57-58).

This concept is similar to that of "co-opetition" (Nalebuff & Brandenburger, 1996) that intends to explain competition and cooperation in networks by applying game theory to problems in partnerships. In co-opetition collaboration around complementary assets and competencies is perceived as creating a value, that if it's jointly created, must be divided between the partners through negotiation. This value-division shifts not only the role of the value from being fundamentally complementary to a source of

competition, but it also shifts the role of the very partnership. What impact those shift are likely to have on the relationship long-term and how the value can be split up, is not explained. Second, Chesbrough and Schwartz' (2007, pp. 57-58) statement refers to only one partnership alignment, and as such, I argue, it neglects other partnerships that open innovation encourages companies to engage with in order to use the distributed knowledge landscape. It does not explain how one can go about aligning several business models, which should be possible. And second, it favors sustained partnerships, over time, without explaining why partnerships should be stable and whether a long-term relationship impacts the quality of different complementarities.

In Chesbrough's (2003a) book, *Open Innovation – The New Imperative for Creating and Profiting From Technology*, I found, one explicit reference indexed to value networks, which led to a brief passage providing, what may be considered to be, open innovation's approach to a definition of what a value network is:

> The value network created around a given business shapes the role that suppliers, customers, and third parties play in influencing value captured from [the] commercialization of an innovation. Besides increasing the supply of complementary goods on the supply side, the value network can increase the network effects among consumers on the demand side. Building strong connections to a value network can leverage the value of a technology. Failure to construct such a value network can diminish a technology's potential value, particularly if that technology competes with a rival technology that does enjoy a strong value network (Chesbrough, 2003a, p. 68).

Surely, the message raises importance to external technology innovation partnerships, but in essence, it only confirms known limitations of open innovation leaving similar questions unanswered as already pointed out above. However, it draws attention to the notion of "complementary goods" again, as well as to the importance of building "strong connections" in relation to partnerships.

Referring to complementary goods, Chesbrough noted that, "even very good technologies will flounder if they do not connect effectively to outside complementary technologies" (Chesbrough, 2003a, p. 60), and two examples were found touching on how an effective connection to outside complemen-

tary technologies by open innovation is considered possible (Chesbrough, 2003a, pp. 52-57). First, Chesbrough remarked that, "Managers may apply different paths of promotion and may give their researchers rotational assignments in areas of their interest with external participants outside the company, such as business development" (Chesbrough, 2003a, pp. 52-53) and this with the purpose that researchers "don't just create excellent science in their own lab, rather, they identify and build connections to excellent science in other labs, wherever those labs may be" (Chesbrough, 2003a, p. 54). In other words, it is suggested that partnership forming is incentive-driven internally and based on assignments tailored to an employee's technology interests, but how this could be coordinated in relation to a company's technology innovation project was not explained. Thus, the open innovation approach does not address the way that aspects other than 'incentives' can drive collaboration, such as could be considered with mutual learning and knowledge exchange.

Secondly, as Chesbrough stated that venture capital groups span over connections to new companies experimenting with new combinations of technologies often applied to new markets (Chesbrough, 2003a), he also noted,

> These novel combinations provide learning opportunities for established companies to monitor, and potentially leverage, if and when they prove valuable. As evidences of the visibility of these "lessons" emerges, Open Innovation firms may actually change their own technology strategies as a result. They learn faster and adapt their own strategies more rapidly, as a result of coexisting with an environment filled with venture capitalists and their start-up firms (Chesbrough, 2003a, p. 55)

In this case, the benefit of partnership learning and the prospect of change seem to exclusively rest on the side of the established company. The interest and meaning of such partnerships to independent start-ups or companies represented by venture capitalists are ignored. How start-ups prove valuable is not unfolded further; only the nice results of change are stated. As such, the statement leaves the impression that open innovation is only defined to help larger, established companies and not companies pursuing innovation in general. An added observation I make is, in relation to other studied articles

(Chesbrough, 2007b, 2010), that the concept of open innovation is also neglecting the role of external partners in trials and experiments.

Regarding the importance of building strong connections, open innovation considers partnerships as having different qualities in terms of representing deep or wide ties (Simard & West, 2006), which in open innovation literature has also been associated with explorative or exploitative ties (March, 1991) and formal or informal ties. I found open innovation to favor the building of "deep networks in relevant areas" which is claimed to be achieved successfully through the "align[ing of] metrics and incentives" (Chesbrough & Crowther, 2006, p. 233), and repeated interactions which also lead to an increase in trust and faster knowledge exchanges (Simard & West, 2006). In contrast, wide ties are considered useful for "small bets on early stage unproven technology" (Chesbrough & Crowther, 2006, p. 234) or to prevent overembeddedness with long-term partnerships; but too many wide ties are considered damaging to the trust and ability to recognize relevant knowledge (Simard & West, 2006). It is noticed that companies need to build both forms of ties, however, they must ensure that "the value of knowledge flowing into the company is greater than the value of knowledge outflows" to external partners, who may prove to be potential competitors (Simard & West, 2006, p. 229). However it is not explained how these ties come about, which relations one should 'keep strong' and which one should rather 'hang loose' with, or how partners might be tied together in the greater value network. I found the qualities of external relations to be judged by perceived transactional value, and the approach to collaboration as opportunistic and defensive. Another limitation I found is that the question of whether and how external relations might be useful in themselves, beyond an exchange or creation of knowledge, for example as an innovation asset contributing to framing and assembling, seems to be overlooked. This is a problem because it ignores the greater relational dimension of partnership. Indeed, there are also constraints that could be associated with this kind of innovation asset, though the idea is not new (Granovetter, 1973).

The greater relational dynamics of partnerships is neither emphasized in other open innovation contributions about value networks and complemen-

tary assets that focus on the commercialization of new technology (Vanhaverbeke & Cloodt, 2006), which in Chesbrough's few comments, are related to what may be considered an era of ferment. These, I now turn to.

3.2.4 Partnership contributions during the era of ferment

I have not found Chesbrough to point explicitly to the era of ferment. Perhaps this is due to the term being less known or used nowadays, particularly since it is difficult to determine in which phase an innovation can be precisely located, as I also demonstrate in relation to Think. But the lack of explicit reference to the era of ferment is also noticeable, since open innovation seems more apt in accounting for an organization in which more stability and certainty are present. For Think, uncertainty prevailed and partnership selection and design were completely different from what can be explained through open innovation insights. However, Chesbrough has referred a few times to "early-stage technology" and how relations between component technologies at such a time are plentiful (Chesbrough, 2003a, p. 58), but left the topic by stating that,

> This technical uncertainty is compounded by market uncertainty, when early-stage technology projects also address an uncertain market. How a technology might be used by customers, and what benefits it might provide them, are also not well understood (Chesbrough, 2003a, p. 11).

Another example in relation to this is, as Chesbrough described the search for a useful business model, that may also be influenced by funding:

> The search for a viable business model happens quite regularly at many early-stage technology companies in the commercialization process funded by venture capitalists. Venture capitalists necessarily invest to commercialize technology in environments of significant technical and market uncertainty (Chesbrough, 2003a, p. 89).

With this lack of attention to detail and transparency, open innovation literature exhibits a limited ability to contribute to the quest for understanding the innovation process in its open form which is imbued with uncertainty. This means that in practice, organizations struggle to translate the message of partnership in and beyond the early stage of product development In other

words, the awareness in literature of options and an ability to consider product and process innovation through partner relations throughout the innovation project remain limited. And still, to ensure "the purposive use of inflows and outflows of knowledge" (Chesbrough et al., 2006, p. 1), partner relations are often guarded by extensive documentation regarding information or solution proposals (in practice, referred to as 'RFx') upfront, by all parties, in the early stages of product development.

Again, open innovation does not provide new explanations about driving interests or activities that contribute to or explain the importance of openness during innovation development processes: There is no recognition of the usefulness of complementary knowledge for problem-solving activities, or for example new insights about the use of different financial partners according to technology innovation learning contexts; and there is no attempt at deciphering investors in general, legal, and media-content relations as innovation-value-creating partners. Indeed, open innovation literature misses explicit explanations as to how shared objectives in complex technology development projects could be framed so as to ensure openness throughout a given innovation process (Chesbrough et al., 2006). This is a need that has been expressly documented, but is yet to be meet (Dahlander & Gann, 2010).

3.2.5 Input for a comparative perspective on technology innovation

I contend that the open innovation summary takes the same focus as that of dominant design in more than one sense, as the open innovation perspective, despite its efforts, remains rather closed: partnerships were being considered as both internal and external, but still predominantly standardized based on predefined agreements and exchanges of already existing innovations that are motivated by incentive and favored as long-term and strong; design approaches were perceived as static making use of pre-defined elements; strategy was about the deliberate use of in-flows and out-flows of knowledge and plans to increase business value; change was also considered as a deliberate act that is based on verified learning evidence; project outcomes were resolved as being predictable and they were measured against the perceived

success and failure of a pre-defined business model; while uncertainty – again – was too complex and not well understood. **Table 3** is used to illustrate the summarized input from open innovation:

Table 3: Open innovation perspective on technology innovation

Innovation perspectives	Dominant design	Open innovation	Drift approach
General understanding of partnerships?	internal, long-term, standardized, 'mastered'	**internal and external, standardized, network incentive driven'**	
How are partnerships initiated?	through standardized selection criteria, following detailed plans of direction for the collaboration	**through deliberate use of inflows and outflows of knowledge and plans**	
Understanding of change during an innovation process?	exogenous or endogenous shocks	**deliberate, based on verified learning evidence**	
Understanding of project uncertainty?	considered an opponent, too complex, risk management	**too complex, not well understood**	
Understanding of project outcome?	predictable possibilities, measurable and controllable	**business value measured by business model success or failure**	

Indeed, open innovation challenged dominant design's closed view of innovation, but open innovation is limited by its deliberate strategy approach that leaves the complexity and uncertainty of the innovation process unmentioned: open innovation is accessing, combining and implementing what it expects already exists. The partnership drift perspective that I present next has proven to shed light on the technology innovation process and contributes to an understanding the era of ferment as forming-breaking-reforming technology innovation development partner relations.

3.3 Embracing unpredictability and uncertainty: a partnership drift perspective

In this part, I begin with presenting the overall ambition of a partnership drift perspective, suggesting that researchers and technology innovation development projects should not treat technology innovation development process and socio-technical ensembles as predictable and stable in need of deliberate approaches to concerting innovation efforts. Instead, research should seek to understand how unexpected and ongoing problematizing contribute to the existence and openness of innovation projects over time. In this relation I point out how the partnership drift perspective has roots in previous studies. Next, I bring into play three notions about technology innovation development reality that together represent pillars for the dynamic socio-technical process perspective on innovation development, which comprises the partnership drift perspective. First, I present how drifting environments impact innovation projects. Second, I demonstrate how emergent learning adds to or changes innovation partnerships. And third, I expound on how a socio-technical ensemble helps identify the various heterogeneous dimensions of a technology innovation development vision through chosen problem-solving. I subsequently bridge these notions, laying out a more integrated theoretical foundation that will be used for analysis, pointing out the main assumptions and implication of a partnership drift perspective, which I have found contributes effectively to an understanding of the era of ferment, with considerations for forming-breaking-reforming partner relations. Finally, I also present examples of research advantages that have been evidenced by research broaching on an understanding of technology innovation from some or all of these directions.

3.3.1 Partnership drift ambition

The partnership drift perspective considers that technology innovation relations are multidimensional, interrelated and only temporarily stable because of uncertainty and unpredictability (Pinch & Bijker, 1984; Van de Ven et al., 2008). It finds innovation project opportunities and outcomes to be no less unpredictable in part, because they are related to different partnerships, and

because emergent learning is likely to appear throughout the development process (Van de Ven & Polley, 1992). This learning is an advantage but without demand on a particular solution-reality about the usefulness of that learning. The core insight of the drift perspective — which does not explicitly address partnerships — is that something unforeseen may happen in the process that initiates after the negotiation and hand-shakes of the seemingly stable partnership deal. The process-acts may shake partnership understandings of minor or larger tasks and goals and as this happen they impact individual company and partnership sensemaking (Weick, 1995), likely to result in redefinitions of technology problem-solving. Thereby, the technology framing (Bijker, 1995, pp. 122-127) is also impacted, as is the potentiality of the partnership itself. Thus, the partnership drift perspective argues it is better to be prepared for an unexpected and ongoing problematizing socio-technical ensemble, involving forming, breaking and reforming partnerships, that will maintain the existence and openness of innovation projects over time. It thereby confronts not only the pitfalls of planning but the assumption that formal planning is equally emergent and forming (Mintzberg, 1994).

The partnership drift perspective draws on a literature, which emphasize organizing processes as multifaceted social processes that do not follow a narrow technical-rational logic. It is rooted in social psychological perspectives emphasizing human activity as directed by sensemaking and negotiations. In particular it draws upon the decision theory of the Carnegie School, which describes decision-making as a non-linear process, drawing on concepts such as bounded rationality and satisficing to describe how individuals and organizations act in the face of "the uncertainties and ambiguities of life" (March & Simon, 1993, p. 2).

3.3.2 Uninvited change – Organizational projects when environments drift

Uncertainty and unpredictability disturb project order, but even with theoretic attempts that avoid and omit confrontation, as demonstrated in the previous parts of this chapter, uncertainty and unpredictability claim their place as uninvited change. The idea of uninvited change is developed as I engage

with Kreiner in his article "In search of relevance: "Project management in drifting environments" (1995) and Van de Venn, Polley, Garud and Venkataraman through their book *The Innovation Journey* (2008). Kreiner (1995, p. 18) referred to such change as "environment drift", and thereby he highlighted that the project environment is not pre-given and likely to remain unstable over time. 'Drift' is not a term used by Van de Ven and colleagues, they referred to "unanticipated environmental events" (Van de Ven et al., 2008, p. 10) as they explained how projects frequently are subject to "shocks" and "setbacks" triggered by external or internal sources during the period of project initiation and development — but the similarity in argumentation about project change is striking and leads me to argue and both defend a non-linear progression of technology innovation, for which Kreiner may be considered a forerunner, anteceding Van de Ven and colleagues.

Kreiner distinguished between the "projected environmental conditions, the premise of which the project was originally designed and planned" (Kreiner, 1995, p. 338), and the ongoing project's environment — reality — throughout which, a situation may occur "where something diverges from its project course" (Kreiner, 1995, p. 338). This 'something' is exemplified as, but not limited to, change in commitments of corporate management, customer preferences or competition strategies (Kreiner, 1995, p. 335). As such the drift affecting the project may be driven both by internal and external events, and could therefore derive from changes in the commitments of technology development partnerships.

The argument of "environmental drift" assumes that project design, planning and contracting is professionally executed in order to meet the needs, desires and requirements of the various interested parties (Kreiner, 1995, p. 338). At the same time the argument raises sensitivity as to how fast-fading this organized picture of the environment is by marking-out the problems of tacitness of knowledge, equivocality of experience, and systemic complexity (Kreiner, 1995, p. 338). Tacit knowledge matters as stakeholders, such as external partners, are unlikely to be aware of all aspects that are relevant for their commitment at a project's outset. Only as they gain experience about the 'real' project during the project's process may their tacit knowledge sur-

face and change their relation to the project (Kreiner, 1995, p. 339). Equivocality of experience has an impact since project partners may experience the same project-related events differently, and as they make sense of their feedback towards the project they construct different images of the project and its environment (Kreiner, 1995, p. 339). And lastly, systemic complexity is important as every project is carried-out in relation to a wider context in which "events far away from the project may ramify in their consequences, and ultimately change the very foundation on which the project and the environment originally negotiated their relationship" (Kreiner, 1995, p. 340). Thus, as technology development processes evolve, partnerships may be perceived as uncertain and unpredictable despite contractual agreements.

Following the notion of drifting environments, Kreiner captured the essence of the type of inherent uncertainty and unpredictability in a project process which, at any point in time, may "undermine the relevance and ultimate success of a project" (Kreiner, 1995, p. 344); thus, changing commitments to a design, a plan, a project, or a partnership in technology development. According to Kreiner's research several internal and external project aspects evolve and change throughout the development process. Thus, to theoretically avoid and omit the unplanned, coincidental, and also emerging aspects in the environment that contribute to forming, breaking or reforming a project and its relationships, seem to flatten the experiences of the innovation journey. In that case, moving the focus from drifting environments onto drifting partnerships in open innovation processes could help explore what actually happens. Through this slight new shift in focus of analysis, some of the features and characteristics of partnership processes and transformations throughout time can be elucidated, as with their impact on innovation development as such.

Van de Venn, Polley, Garud and Venkataraman take a similar approach to Kreiner as they distinguish between the "road map" of how to undertake an innovation journey, and the innovation process in real time (Van de Ven et al., 2008, p. 21) – throughout which "shocks" and "setbacks" may often occur (Van de Ven et al., 2008, p. 10). Based on their extensive longitudinal case studies they found that "none of the innovations developed in a simple linear se-

quence or stages or phases of activities over time" (Van de Ven et al., 2008, p. 23). As such Van de Venn, Polley, Garud and Venkataraman also found systemic complexity like Kreiner (1995) did, but they went on to develop an emerging process model of innovation: "the fireworks model" (2008, p. 25).

The fireworks model combined 12 common elements in the innovation process that Van de Venn, Polley, Garud and Venkataraman (2008, pp. 23-24) identified as 1) gestation 2) shocks 3) plans 4) proliferation 5) setbacks 6) criteria shift 7) fluid participation or organizational personnel 8) investor/top management involvement 9) relationships with others 10) infrastructure development 11) adoption and 12) termination. It is especially the second "shocks" and the fifth "setbacks" characteristics that I focus on in this discussion. This model was based on the understanding that technology innovation development was far more complex and fluid than previously perceived: numerous events involving many and different kinds of people over extended time, years of gestation, shocks, complex bundles of ideas and divergent paths, setbacks, innovation receptiveness, learning and adoption speed, and varying odds of success became dynamic factors to consider (Van de Ven et al., 2008, pp. 10-11). **Figure 4** below illustrates the fireworks model of technology development:

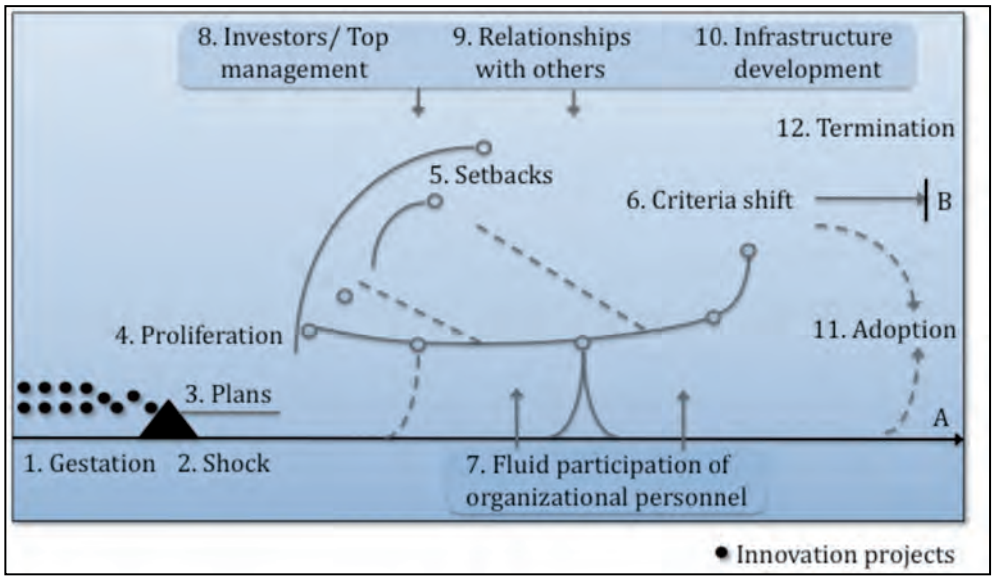


Figure 4: Fireworks model of emerging innovation process example

Shocks and setbacks are not specifically qualified by Van de Ven and colleagues as something positive or negative to the innovation development; rather, they are identified as having an impact on the technology development process, as being derived from internal and external sources, and are explained as happening because of different actions.

Shocks are considered "triggers of innovation" and exemplified by "new leadership, product failure, a budget crisis, loss of market share", but are not limited to these forms (Van de Ven et al., 2008, p. 29). The importance of shocks is described to be a way of letting technology innovation projects "gain currency" with various potential stakeholders, as stakeholders driven by an urge to resolve dissatisfaction with their conditions gain their own special "insight" about the innovation project (Van de Ven et al., 2008, p. 29). In this way I found that shock is like drift, changing stakeholders' working conditions and priorities, and as stakeholders sense a problem of some sort and address it they may become aware of and willing to assess innovation projects to progress their interests and a new understanding of technology innovation development potential may follow. A project then begins to be considered valuable if it has problem-solving potential in the changed environment of the stakeholders.

Setbacks are rather associated with failure or rejection of innovation and explained as happening when development "plans [that] go awry or unanticipated environmental events significantly alter ground assumptions of the innovation [in work]" (Van de Ven et al., 2008, p. 10). Ground assumption may have been tacit and implicit but at once come to the attention of the actors involved (Kreiner, 1995, p. 341). As examples of impact, slipped schedules, overrun budgets, unsuccessful product launches, and deferred sales revenue are mentioned (Van de Ven et al., 2008, p. 37). Setbacks are important because they are likely to occur frequently the more complexity a project entails and they therefore offer "opportunities for learning through reinvention" (Van de Ven et al., 2008, p. 37). How well the professional organization responds to these learning opportunities was found to depend on the project's ability to filter organizational noise, listen to critical voices, maintain a course also when facing minor or correctable problems, and converge success criteria along the

process (Van de Ven et al., 2008, p. 37). On the other hand, "best practice" project management formulations were identified as frequent disablers (Kreiner, 1995, p. 336).

Both the "shock" and "setback" arguments assume process uncertainty and unpredictability as ongoing conditions of technology innovation project approaches and this leads me to argue that shocks and setbacks — like drift — may also derive from changes in the commitments of technology development partnerships. Second, I argue these events not only offer a learning opportunity as a "reinvention process" is initialized, but in themselves, shocks and setbacks offer opportunities for emergent learning about the technology innovation development. This is a matter I will return to in the next section.

First, through the arguments of drifting environments (including now, an understanding of shocks and setbacks), the affect of change over time is introduced bringing with it uncertainty and unpredictability as basic conditions with resource potential because they insulates infinite opportunity. In practice, opportunity may be considered like a kind of raw material: only when assembled in a useful way with other factors does it make sense and to find such a way requires in part experimentation and learning. Second, the role of management in technology innovation as a controlling function of success, which it traditionally is ascribed, is pulled apart. Because of environment drift "entrepreneurs and managers cannot control innovation success, only its odds" (Van de Ven et al., 2008, p. 65). Rearticulated, the role of management becomes more that of facilitating and tolerating than controlling the process, providing what Van de Ven called "enabling conditions" (2008, p. 65), that allow for learning and assembling-trials that can build competences into partnerships and thereby increase the odds of innovation success. This emphasizes that no plan, "no criteria, no algorithm, can ensure success a priori" (Akrich, Callon & Latour, 2002, p. 205). But at the same time, it highlights that unpredictable consequences can be managed when management adapts to shape and follow unknown pathways. The importance of emergent learning and conditions for learning is highlighted and this leads to presenting the second pillar in the partnership drift perspective, which is the focus of next section.

3.3.3 Unpredictable outcomes – When emergent learning appears

In examining the literature supporting the idea of emergent learning I found value in the applicability of two different inputs, namely the idea of "learning from failure" (Ariño & Torre, 1998) and "learning processes" (Doz, 1996), which I have used to describe how partnerships may be considered as assignments that create emergent learning opportunities as part of the technology innovation process. That means partners have to be working with a sense of 'being present'. This involves conscious engagement and making room available for the co-constructive change processes that create a drift in meaning orientation from wherever it originally was situated, to then become focused on understanding and interpreting any collaboration outcome as to what seemed new, successful or failed, and how this information may be yielded and harnessed as useful.

3.3.3.1 Learning form failure

By now it may seem obvious that learning from failure is important in technology innovation projects where experiments and trials are deliberate activities initiated to identify failures with the purpose of analyzing and improving the odds of some form of successful development, for example through crash-testing experiments at Think, and that work in partnerships undertaking such activities could increase task complexity and therefore bring about a greater variety of an frequency to failure moments that they must in turn pay attention to. But despite the increased awareness about the importance of collaborative partnerships, as earlier described in relation to open innovation, Ariño and Torre's (1998) study, taking a process perspective on how partners learned from failure, was found to stand alone with this focus. In their work Ariño and Torre traced initial conditions for collaboration as an"outcome of preliminary negotiation and commitment" [...and that] "as commitments are executed, learning processes unfold that result in [a] re-evaluation of those initial conditions" (1998, p. 307). These processes of negotiation and re-evaluation were then found to take place anew, again and again, shaping and seeking a balanced direction. Changes in external conditions were found to

follow similar processes (1998, p. 307). These findings led Ariño and Torre to argue that partnership failure can be attributed to three different factors:

> (1) Initial conditions that are inconsistent with economic efficiency requirements or which hamper learning; (2) environmental changes that modify the efficiency or equity conditions to a nonremediable degree; or (3) a breach in performance that results in a deteriorated relationship (1998, p. 307).

While these factors are interesting and seem helpful to direct my analysis, it is not explained whether they refer to general and initial or project-specific conditions. Ariño and Torre's moved on to focus on efficiency and equity which they explained as being based on partners' relation to expectations about future environmental conditions, which in turn were rooted in their past experiences and perceived as "quality of the relationship between partners" (1998, p. 307). As relational "quality", the authors took to mean trust, reputation, and partnership commitment to venture contribution (1998, p. 307), and they saw these elements defined, to a great extend, in relation to specific task-responsibility, administrative procedures, and functional decision rules. Details about the scope of a venture were missing in their analysis. To Ariño and Torre uncertainty is related to the expectations of the future environment and a partner's behavior, but is assumed to "resolve through processes of learning" about factors (1998, p. 308). As such, partnerships' learning from failure is not taken further, but remains a matter of something to aim for while trying to restore balance in a given relationship; a partnership break-up is considered a last resort, but whether events such as this one could become a form of learning from failure is not explored. Consequently, I found the authors too narrow in their interpretation of change and learning from failure, which might not only have an impact on the ongoing forming of relations, but could also be examined in terms of impact on the breaking of partnerships engaged in development activities. Furthermore, as their focus was on contracts and individual partner behaviour, I did not find detailed arguments about how partnerships' learning from failure was related to technology innovation development processes and the wider socio-technical context.

3.3.3.2 Learning from processes

While Doz also pursued an examination of initial conditions in relation to partnerships, it was with the attempt to analyze "the conditions fostering or blocking inter-partner learning in collaborative projects" (1996, p. 56). In a broader scope Doz' aim was then to "asses the relative contributions of initial conditions and of evolutionary learning processes to the outcomes" (1996, p. 56). When innovation projects were considered to be successful, Doz observed "sequences of interactive cycles of learning, reevaluation and readjustment" of project goals that reflected an emergent process view (1996, p. 55). In these cases the partnership learning cycles were observed as "cumulating over time", as improvements to initial conditions were found (Doz, 1996, p. 64). And all throughout, these cycles were also considered by partners as opportunities for building and testing trust (Doz, 1996, p. 64). Thus, further analysis confirmed that partnerships must go through transforming learning cycles in order to move their technology innovation projects forward.

Less satisfying projects were governed by inertia, little or divergent learning and frustrated expectations, and in these cases, process stability and planning ruled over perceived progress opportunities (Doz, 1996, p. 64). Doz regarded these factors as important obstacles in the evolution of a partnership and its ability to learn from collaborative processes (1996, p. 67). He stated that in these cases there were "little joint sense-making and little learning about how to interact successfully" (Doz, 1996, p. 68). Nevertheless, something was being learned in these partnerships about the collaboration, the project tasks and priorities, but rather than creating trust, the learning created doubt (Doz, 1996, p. 68).

The comparative case studies led Doz to conceptualize the initial phase of collaboration in strategic partnerships as,

> The interaction between four initial conditions (task definition, partners organizational routines, inter-partner interface design, and partners expectations) and five learning processes or learning dimensions: environment, task, process, skills and goals (1996, p. 70).

He followed up on this by defining that a first step to developing an evolutionary path for a partnership is to recognize that learning takes place in

tandem to "partners that learn on board, and move away from the initial conditions to establish new conditions in light of the lessons drawn from that learning" (Doz, 1996, p. 70).

Based on these empirics Doz concluded that partnerships may fail in several ways as initial conditions: "block, or at least delay, learning"; enable an understanding of how the collaboration 'should unfold' which however makes partners aware of the difficulties rather than the possibilities; or, give way for successful learning that unfortunately is followed by negative reevaluation (1996, p. 74). This places further importance on sensemaking which was found already as a part of the environment drift notion and which therefore is the last pillar in the partnership drift perspective.

3.3.4 Unsettled understanding – when meaning dimensions drift

Sensemaking, a term introduced by Weick (1995, 2001), is a meaning-term that refer to what partners do when they try "to comprehend, understand, explain, attribute, extrapolate, and predict" (Starbuck & Milliken, 1988) and frame what is new or seem uncertain and unpredictable. Thereby the aim is to grasp the ongoing technology innovation complexity of their surroundings and create a "situation that is comprehended explicitly in words that serve as a springboard into action" (Weick, Sutcliffe & Obstfeld, 2005, p. 409).

I introduce sensemaking explicitly because I find it to already be a part of drift and emergent learning (not to forget SCOT, see page 111). The relation to drift is through its obvious focus on the uncertain and accepting it is part of any process and because meaning also drift as interests and understanding of existing ideas change. While the relation to emergent learning is through its information-collecting search that takes managers forth and back between technology innovation overview and detail. Thus, as partnerships engage in meaning-orientation efforts around collaborative activities, partners' actions can be considered as their means of seeking comprehension so as to also relate one innovation activity or set of innovation processes to others in a project and thereby create an impression – meaning – that can be guiding, if also only for a brief moment. But with every technology innovation development

activity meaning shifts from wherever it first was towards a greater focus on understanding and interpreting collaboration outcomes in terms of the new, successes or failures, and how this information might be useful.

3.3.5 Summing up

It was several factors that rendered the three different approaches, combined in this partnership-drift perspective, relevant to my research case. But perhaps most important was their heterogeneous process focus and their way of keeping this focus dynamic. As I noted, these approaches emphasize that this that happens during the innovation process 'something' cannot be controlled or planned out of the scope by good preparation and solid steering — obsessively trying to do so reflects the fear of uncertainty (Mintzberg, 1994, pp. 201-203). However, the aim is not to encourage overly excessive emergent organization styles, but advocate for careful preparations through "projected conditions planned" (Kreiner, 1995) and a road map (Van de Ven et al., 2008). The principle idea is that because uncertainty cannot be avoided in the innovation process, nor can it be clearly predicted, it is important what happens in the innovation process should be embraced by managers as a learning occasion rather than a threat.

The partnership drift perspective has demonstrated quite a different focus on technology innovation development and the role of partnerships to the previous two approaches of dominant design and open innovation. Though I note that the drift-perspective, as introduced by Kreiner (1995) and Van de Ven and colleagues (Van de Ven et al., 2008), did not refer explicitly to the importance of partnerships for technology innovation development. However, as I found drift, coupled with emergent learning and sensemaking provided a better foundation for discussion I moved the focus, as noted earlier, from drifting environments onto drifting partnerships. This slight new shift in focus of analysis helped study some of the features and characteristics of partnership processes and transformations throughout time. It is also through this creative use of the drift-perspective that is has come to fill another gap as it allows for exploration and analysis on an intermediary-level, or sociotechni-

cal-level analysis — the level between the industry and company-specific — oriented towards interests and sensemaking.

Through its persistence of the inescapable relation of emerging partnerships to an ever-changing context it has placed openness right at the center: partnerships are considered as distributed and unpredictable and they are furthermore 'free' to change in meaning and are likely to do so upon sensemaking in relation to problem-solving activities; design approaches are viewed upon as irregular and subject to interpretative flexibility which may entail set-backs as activities are halted, to make other experiments, or adapted to make use of emergent learning; strategy is deemed as a process, to be conditioned by the messy process of variation and selection of products and problems that ensue in any development activity; change is considered to be incessant and a result of transforming relations – partnerships forming, breaking, and reforming; project outcomes are seen as unpredictable and uncontrollable and only subject to temporary notions of success or failure through the impact of time and different kinds of drifts; and this is all in part because uncertainty is tolerated and even embraced. **Table 4** page 71 illustrates the summarized input from a partnership drift perspective.

Table 4: Partnership drift perspective on technology innovation

Innovation perspectives	Dominant design	Open innovation	Drift approach
General understanding of partnerships?	internal, long-term, standardized, 'mastered'	internal and external, standardized, network incentive driven'	distributed, around temporary problem-solution, sensemaking-oriented
How are partnerships initiated?	through standardized selection criteria, following detailed plans of direction for the collaboration	through deliberate use of inflows and outflows of knowledge and plans	through relation forming, projected conditions and careful planning, irregular, interpretative, and flexible trials and experiments
Understanding of change during an innovation process?	exogenous or endogenous shocks	deliberate, based on verified learning evidence	systemic complexity, emergent learning, Incessant transformation of relations
Understanding of project uncertainty?	considered an opponent, too complex, risk management	too complex, not well understood	embraced, tolerated, potentially beneficial
Understanding of project outcome?	predictable possibilities, measurable and controllable	business value measured by business model success or failure	unpredictable alternatives, drift and uncontrollable interpretative

Having individually presented and discussed the three perspectives on technology innovation development partnerships that I have engaged with through my Think research journey, attention is directed towards drawing out comparative and contrasting points of interest. This serves as a theoretical 'acid test' that both solidifies and critically nuances the argumentation of the partnership drift framework I later use in the empirical analysis of Think.

3.4 Contrasting the views on technology innovation partnerships

3.4.1 General trends of three perspectives

The three theoretical perspectives on innovation and innovation development presented above are all reasonably persuasive taking into consideration their different foci and knowledge interests. Each of them are used and defended as relevant for the topic of innovation by different scholars; however, regarding the role of partnerships, they cannot and do not offer enough insight. They differ in their emphasis and sophistication, with the two first tending towards the macro-level, and the newer micro-level being the least clear and appreciative of partnerships. In this part I compare and contrast the three perspectives, drawing up and discussing what may also be seen as significant differences that separate the three. Next I present my own position and how each of the three first discussed has increased my knowledge and understanding throughout the research, while provoking me to search beyond the limits of initial explications.

Having studied the technology life cycle and dominant design theory, I will characterize this theory as taking an aggregated — or macro-level perspective on technology innovation. This theory recognizes patterns and phases of innovation development over time and assumes linearity in the progression of events. In addition, the theory acknowledges a number of factors, resources and relations as drivers of successful or less successful product developments such as: collateral assets, governmental action, strategic maneuvering, and user-interaction (Utterback, 1994). But a detailed investigation of their role and meaning in technology development is not pursued because, I suppose, it is found to be in conflict with the expectations of a macro-view understanding, which adds too much complexity. This results, however, in an understanding that things in the innovation process are 'coming and going', as predefined inputs and outputs without continuing influence. This loss of continuity also means that there is little need and room for experience transfer or emergent learning. I find that this dilemma, which focuses on development patterns as opposed to development processes, exemplifies why the dominant

design theory doesn't support this thesis' enquiry into the understanding of the role and meaning of partner relations in innovation projects to any amount of detail that could be deemed valuable or interpretive.

Historically, partners and other technologies have not been considered as having a co-creating impact in the dominant design view, in the sense that these may also be sources of value creation and support for competitive advantage. Despite perhaps Teece's note on "co-innovators" in relation to mutual risk exposure between Apple and Canon (1986, p. 294), and his concern for the broader understanding and promotion of the term and condition of "strategic partnering" (1986, p. 294), this perspective oversees the nuances of process relations in which history and uncertainty take dynamic forms, studied from a micro-sociologic perspective (Garud & Rappa, 1994; Munir, 2005; Pinch & Bijker, 1984).

In other words, dominant design ends up focusing on product versions and process efficiency over time. Nevertheless, dominant design does not actually 'enter' the innovation process in which partners act, and where the dynamics of innovation are formed. I have not come across explanations within technology life cycle literature that penetrate the complexity of the innovation process in detail or reveal how the dominant design of products and processes are created in the first place in terms of knowledge, functionality, partnerships and other aspects. Again, this may be deliberate due to its macro-level perspective. However, it can be inferred that dominant design points to certain assumptions on a micro-level about partnership duration, selection, and benefit in relation to innovation development, which is relevant to the current research and of my particular interest; that is, companies make the choices. The emphasis on "collateral assets"' by Utterback (1994, p. 27) is what I found came closest to describing how technology innovation development in some way depends on external complementary relations in the era of ferment. But this complements Tidd and Bessant's assertions (2011), who as proponents of dominant design in innovation processes, still primarily situate partnerships internally, within the lab, maintaining a closed frame on their role and relation to technology development, as the following discussion reveals.

Although the framework of open innovation addresses partner relations, it assumes they are purposeful and stable and fails to explain the dynamics throughout the innovation journey to any depth or detail — here the drift perspective has something to offer. So where the dominant design theory appears to characterize the entirety of the innovation journey as uncertain and unpredictable, it also seems to ignore the uncertainty and unpredictability.

While the dominant design perspective is largely silent about the role of partnerships in the technology development process, the importance of partnership contributions is the very foundation of the open innovation perspective. However, the way in which the argument of open innovation is currently presented leaves somewhat unclear the nature and role of (socio-technical) relations and how they can be studied. There is no explicit assumption of how specific elements or actors operate throughout innovation processes and thus add to, or change partnerships. It is what influences at the outset of a partnership that counts: the selection criterion for a partner, available patents and knowledge flows to buy or sell, and perceived success of the relation. But there is no mention of how or the way in which the process-part impacts a partnership. Thus the dominant design comes to marginalize the role of the people forming partnerships, who are, accordingly, provided little room for action. This is a heavy limitation because it is evident — if not, intrinsic — that 'something' does happen throughout the course of an innovation process, otherwise the very idea of partnerships seems absurd. Without regard for the dynamics of partnerships, academically insisting on investigating design, plans, and other tangible deliverables such as contractual agreements of partnerships — overlooking the unplanned, coincidental, tacit and emerging aspects that contribute to the forming, breaking or reforming of a project and its relationships — effectively flattens the experience of the innovation journey. Such limited focus creates if not illusions, then perhaps too strong a trust in the stability of technology innovation development and the ideal that full transparency can be achieved through modeling, analysis and simulation. The problem is not that these ideas are downright misleading, but that they are incomplete; they don't investigate the innovation process itself, only what is

designed to be an instance of innovation. As such, shifting focus from drifting environments to drifting partnerships in open innovation processes provides the opportunity to explore what happens.

Both perspectives do focus on partnerships as complementary assets with competence developing and migrating ability. However, given their level of analysis, none of the two perspectives have been taking up detailed interest in how technology innovation development partnerships evolve in relation to the emergence of innovation design. With respect to my interest in the role of partnerships, this poses a number of weaknesses. First, the silence regarding how partnerships are formed and how innovation design emerges has led to a lack of empirical awareness of and attention to these dynamics. Maybe it is not fair to argue that dominant design and open innovation should address these dynamics, because of their analytical level, however, they indirectly contribute to the silence and flawed assumptions by omission. Second, stable long-term partnerships are predominantly assumed to serve innovation projects. Third, relevant and suitable partnerships are by trend assumed as identified in the market upon careful comparison and selection of their existing resources. Forth, a related assumption is that potential benefits of partnerships may be predetermined based on planning and control. I am concerned about the limiting impact of these assumptions on the field's ability to intellectualize on a conceptual level, as well as management implications of technology innovation development projects and partnerships in relation to several aspects: innovation project design approaches, strategy, change, outcomes, and the projection of uncertainty, especially in the era of ferment.

The partnership drift approach to study technology innovation partnerships and processes can follow, as I found, in terms of individual companies, much more complex patterns of adaptation. The idea is that a strategy cannot only simply be designed, planned, and executed, but also emerges as drift pushes it further, particularly in relation to other actors. As such strategies can be *formulated* as well as be *forming* during a process (Mintzberg, 1987, p. 68), and that also indicates how partnerships are initiated. Further, uncertainty and unpredictability are not just random. They can be studied in relation to political, economic, and technological factors and thereby can be

approached in differentiated ways: however, they do not fit into a stage model that assumes a reduction progress from total uncertainty and unpredictability that can be reduced through customer segmentation, appropriate technology selection, political policies, and other factors. Such selections assume a move towards a predictable and stable world. It is important to note that the drift-perspective, as introduced by Kreiner (1995) and Van de Ven and colleagues (2008), did not refer explicitly to the importance of partnerships for technology innovation development. However, as I found that drift, coupled with emergent learning and sensemaking provided a better foundation for discussion I moved the focus, as noted earlier, from drifting environments onto drifting partnerships. This slight new shift in focus of analysis helped me to study some of the features and characteristics of partnership processes and transformations throughout time. Therefore, partnership drift assumes no stages, and it considers socio-technical development uncertainty as something that remains present and influential, which makes socio-technical ensembles and innovation processes repositories for industry emergence.

Researchers in this tradition offer a micro-sociological perspective in which they open technical development processes, and that makes them able to build a nuanced understanding of how processes are linked to interests and outcomes through context-experiences and context-learning that reach beyond matching technical features with defined needs and conceptual frameworks for evaluating existing competitive offerings and the making of purchase decisions (Garud & Rappa, 1994; Munir, 2005; Pinch & Bijker, 1984).

3.4.2 Summary

The contrasting review of research on technology innovation partnership is organized in relation to the three theoretical perspectives of dominant design, open innovation and partnership drift, which have been discussed individually earlier in this chapter. Each, these are also understood to represent examples of what macro- (dominant design), micro- (open innovation) and intermediary-level (partnership drift) analysis are able to reveal about innovation partnership and innovation processes. The overview is admittedly rather rough as

some overlap may be identified and internal variation exists. Still, these three perspectives broadly describe how the formation of technology innovation partnerships has been perceived to interact with innovation processes to date. At the same time, the overview points to ways that current and future research may complement the general understanding. **Table 5** summarizes some relevant aspects that have been identified throughout the theoretical presentation.

Table 5: Contrasting the theoretical perspectives model examples

Innovation perspectives	Dominant design	Open innovation	Drift approach
General understanding of partnerships?	internal, long-term, standardized, 'mastered'	internal and external, standardized, network incentive driven'	distributed, around temporary problem-solution, sensemaking-oriented
How are partnerships initiated?	through standardized selection criteria, following detailed plans of direction for the collaboration	through deliberate use of inflows and outflows of knowledge and plans	through relation forming, projected conditions and careful planning, irregular, interpretative, and flexible trials and experiments
Understanding of change during an innovation process?	exogenous or endogenous shocks	deliberate, based on verified learning evidence	systemic complexity, emergent learning, Incessant transformation of relations
Understanding of project uncertainty?	considered an opponent, too complex, risk management	too complex, not well understood	embraced, tolerated, potentially beneficial
Understanding of project outcome?	predictable possibilities, measurable and controllable	business value measured by business model success or failure	unpredictable alternatives, drift and uncontrollable interpretative

All three perspectives describe and explain something about innovation partnerships and the innovation process. Contrasting the concepts of technology life cycle, dominant design and open innovation with the partnership drift perspective, reveals how each approach also offers important contributions to our understanding of partnership formation, not least in relation to how partnerships may intend to and do act in the face of uncertainty and unpredictability. How these perspectives offer different insights exists in part because they analytically approach technology development in very different

ways. The concept of dominant design focuses on the pattern of technology development over time (Abernathy & Utterback, 1978); open innovation also takes this perspective, by analyzing snapshots of what happens inside or outside an organization (Chesbrough et al., 2006). However, partnership drift breaks down this stylized framing that isolates technology innovation from the contingent flow of things and "the common knowledge about it" (Latour, 2005, p. 144), and enters the process of technology development itself (Pinch & Bijker, 1984). The unit of analysis also differs among these concepts: the technology life cycle concentrates on phases of development; open innovation is focused on knowledge flows; and partnership drift is concerned with — in addition to a multitude of actors — other aspects such as relations between partners, the formation of partnerships, and the social boundaries involved. As a result, different actors are identified and the challenge is not so much in understanding the complexity of innovation development as learning to be open to learning and navigating under uncertain conditions in the innovation process. The technology life cycle and open innovation perspectives tend to be used to analyze macro-level factors in large companies or micro-level factors in isolation of the wider context, whereas partnership drift reveals intermediary-level factors and is often used in analyses of smaller companies, as shown in **Figure 5** on the next page.

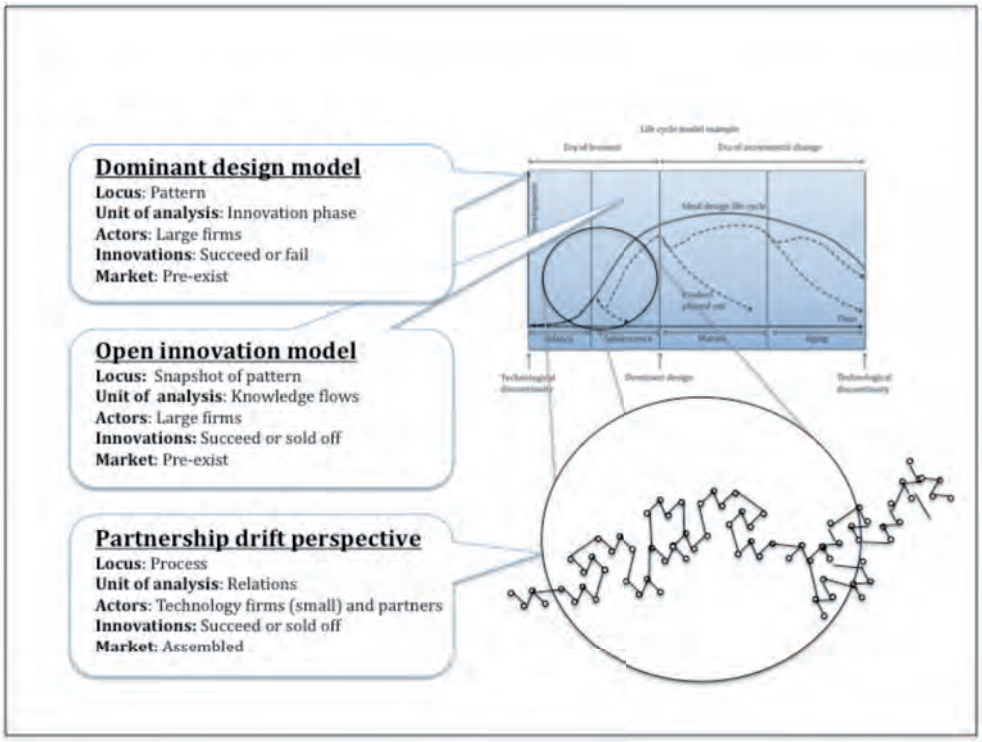


Figure 5: Clarifying the notion of Dominant design and Open innovation vs. Partnership drift

This contrast also highlights that although collaboration, third-party enablers, and government and university influences may be seen as current innovation management trends, these three components have long been solidly embedded in organizational innovation processes (Callon, 1986; Latour, 1987; Law, 1992). However, there is indeed an emerging trend regarding the way we understand organizational innovation processes. A non-linear perspective on innovation management that embraces uncertainty and contingencies has taken root as academic research challenges conventional thinking about linear and stable innovation management.

Thus, the dominant design and open innovation views on technology innovation aim at offering advice for developing a well-defined design, while the dynamic view of partnership drift makes no such promise. The latter offers the potential of in-work design that remains relatively stable — it never fully stabilizes, but it may break apart. Therefore, the notion of a period of enduring ferment or even a certain open-endedness is presented. Here, the promise is that with all its uncertainty and unpredictability, the dynamic part-

nership drift view demands creativity over perfectionism, and innovation over standardization. The socio-technical ensembles are fragile: partners denounce one another in relation to design, financing and commercialization, whereas technology explodes, is weak or doesn't work — so the innovation process is a constant struggle. Technology innovation is therefore both the result as well as the premise of action.

This thesis seeks to complement these findings, from studying socio-technical ensembles, by exploring how partnerships experience uncertainty and unpredictability in the innovation process and the relative stability and changeability of partnerships. My goal is to investigate what happens with partnerships, complementary assets and competencies in an innovation process that will in turn elaborate on the notion of partnership formation.

Methodologically this suggest an intermediary-level analysis approach, one that captures how partnerships experience process openness, flexibility, sensemaking, testing and experimentation to assemble opportunities and possibilities in innovation projects (Geels, 2002, 2005).

The following chapter describes in detail the research methodology — how I have been attending to technology innovation partnerships and processes — before the four empirical cases are presented. Thereafter the thesis returns to the contrasting table presented in this chapter in order to discuss the findings in relation to the phenomenon of interest. (Tidd, 1993; von Hippel, 1986)

[i] Studies critically examining the concept of open innovation are appearing and raising questions as to its novelty and limited contribution thus far (Dahlander & Gann, 2010; Lichtenthaler, 2011; Trott & Hartmann, 2009). A general argument is that neither the concept, nor the model of open innovation is explicit as a management model: openness in innovation has been addressed with the perspective that innovation processes have always been open to some extent as to partner for patents (Tidd, 1993; von Hippel, 1986). Trott and Hartmann (2009, p. 715) determined that the concept of open innovation was repacking that which has already been presented as findings from within the body of research on innovation management. To them, open innovation merely describes the inherent limitations of closed innovation principles, but doesn't provide a novel framework for innovation. As an example, Inkpen and Dinar (1998) have emphasized that alliance partners represent a particular source of new external knowledge. However, Oxley and Sampson (2004) pointed out that R&D alliances have demonstrated a difficulty in achieving openness in terms of knowledge flow which could enable the realization of collaborative objectives, while retaining what is perceived as sensitive knowledge and technologies. To overcome this challenge, these researchers suggested focusing on and making use of governance structures and relationship management instruments or reducing the scope of alliance activities that would enable one to match the readiness of knowledge sharing (Oxley & Sampson, 2004). In relation to the present research on Think, a rather limited use of deliberate governance structures and relationship instruments were found to make those working on innovation technology collaborate around the same ideas.

[ii] Ongoing contributions that aim at developing the open innovation model are emerging. Since knowledge resources are central to open innovation in terms of sketching ideas out, problem-solving, and examining solutions as part of any innovation process, empirical open innovation research has concentrated on determining how collaboration with external partners has been beneficial in problem-solving, and how problem-solving has often been observed as occurring in the periphery or outside a given industry (Lakhani, Jeppesen, Lohse & Panetta, 2007; Laursen & Salter, 2006). Based on their research from an IBM case study, Enkel and Gassmann (2007, p. 10) suggested that ideas and knowledge creation from external sources are likely to flow into an organization through customer and supplier integration and technology partnerships. Reciprocally, an organization may contribute outwards, from its internal side, with licensing of company patents, the globalization of innovations and cross-industry applications of innovations. In cases of strategic alliances and innovation networks of co-creating technologies, products and services are likely to develop (Enkel & Gassmann, 2007). Lazzarotti and Manzini (2009) have studied modes of open innovation that occur through the phases of innovation with the aim of identifying different approaches to partnerships in open innovation. They have undertaken this through examining a number of different Italian companies from a variety of industries including mechanical, chemical, textiles and other industries. Within this study, they considered partner variety and the number of phases of a given innovation process that an organization leaves open to external collaboration, and they derived four basic modes of open innovation partnerships: closed innovators, open innovators, specialized collaborators and integrated collaborators.

4 Attending to technology innovation

In this methods chapter I describe the way I have gathered and connected qualitative, empirical case-related research data and have analyzed it, which has contributed to crafting socio-technical maps and integrated accounts on collaborative partnerships around the Think City car. In the two-way traffic stream between theory and practice (Law & Urry, 2004), I have turned direction and steered based on practice towards theory. The basic empirical setup has been one inspired by ethnographic field studies (Barley, 1986; Van Maanen, 1988) and more especially the SCOT approach (Bijker, Hughes & Pinch, 1987; Pinch & Bijker, 1984), which challenges the idea that technology innovation development occurs independent of social needs, as it follows a self-guided and linear trajectory. Instead, SCOT explains the way technology is developed as an on-going process in socio-technical ensembles involving actors, ideas, interests, material, and negotiation. Thus, my objective has been to engage with a thought-process and a language of research-writing that form technology innovation process-consciousness and reality-making in order to mediate a wider socio-technical environment pertaining to partnerships: when economic, social, technical and environment factors come together.

4.1 Case study research

This thesis builds on case study research with a focus on the Norwegian electric car company, Think. Case study research can develop in-depth understanding about a contemporary phenomenon and its unclear context boundaries, and in its usefulness for descriptive or exploratory enquiry, case study research is able to draw on a wide variety of data (Yin, 1989, p. 11). As such, and as expected, case studies are intensive, comprising of a lot of detail, richness, completeness, and variance (Flyvbjerg, 2011, p. 301). A basic trust in case study enquiry is that the kind of description it yields may stress an understanding of "dynamics present within single settings" (Eisenhardt, 1989, p. 534) and more general developmental factors as the case study itself evolves

in time (Flyvbjerg, 2011, p. 301). The purpose of case study research is, through context-experience and context-learning, to build a nuanced understanding of how processes are linked to interests and outcomes. This sensitivity can produce knowledge about the sensemaking of history and conceptual applicability which are embedded in a given context (Flyvbjerg, 2011). This may be valuable for organizations wanting to increase awareness regarding their innovation processes.

This thesis is essentially a study of processes – not in the abstract, but through the study of how specific relationships are enacted to connect actors over time and space and how the unfolding of specific relationships can be empirically determined by longitudinal observations on a set of dimensions and then analyzed in terms of potential differences over time (Van de Ven & Poole, 1995). I have combined a longitudinal, three-year case study of Think to a complementary retrospective analysis of technology development processes in its history. According to Leonard-Barton (1990) this dual method – one longitudinal case complemented by several retrospective cases – is likely to have several scientific advantages, as it enhances three kinds of validity: construct, internal and external. However, my use is a bit different as I, through the retrospective analysis, provide antecedents for the case study.

The selection of case research was related to its potential generalizability in relation to the guiding research question. Think seemed to have the quality of being both an extreme and critical case: in light of its history with forming, breaking and reforming partnerships, Think seemed especially problematic, yet also exhibited an especially flexible innovation journey. If Think's process dynamic could be revealed, it could explain or at least elucidate parts of other cases as well, which therefore elevates the value of a solid and critical understanding of the case. Through a dedicated study of Think, emerging observations and analyses could provide an understanding of the limits of existing theories, and also permit logical new findings about technology innovation as a process struggle (Flyvbjerg, 2011, p. 307). At the heart of the case selection, there was an intuitive justification that was based on my educational background and work experience with technology innovation projects, reflections provided by the scholarly community, and the knowledge

that the research outcome itself could provide a meaningful answer to the problématique.

The general methodological challenges that the Think case presented may be expressed as the advantages and disadvantages related to a study of innovation partnership processes. Gaining access to meetings with partners, internal discussions, or email-history concerning ongoing partnerships while I visited Think was clearly a challenge. While I did my field research I saw this as a disadvantage that blocked possibilities of having direct exposure to the constructs of partnership processes. To solve this problem, I began observing ongoing interactions through the public domain, and to my advantage Think and its partners were in recent years often posted in dedicated online news or communities, and posted press releases itself providing insights to partnership processes. Drawing boundaries around partnerships and in relation to partnership processes was another challenge I encountered. Innovation partnership processes were related to context, culture, language, leadership, learning, strategies, trust, values, and work routines to mention some of the more prevailing factors. I found that not only to me, but also to Think, it was difficult to uncover the detailed nuances in partners' ways of prioritizing, their values, principles and ways of working. It was difficult to define when 'something' was happening within a partnership or in a wider open context including other partnerships. And, it was also difficult to understand which of the many factors relevant to a partnership contributed to its progress and how. To deal with this problem, I sought contact with key people and pursued a deep examination and exploration of the critical Think City car components. I also began using communication to challenge most aspects of what happens with partnerships, complementary assets, and competencies in an innovation process. In this regard, the relatively small size of Think's closer organization was an advantage to me.

This has taught me that innovation process research is not so much about connecting important events, partnerships and outcomes across time, as it is about how the people involved in those events and partnerships recall actions, artifacts, problems, discussions, decisions, and solutions — that actually realized or hampered outcome possibilities. It is about seeking to recog-

nize and address the complexities of what people knew and how these actors made sense of different technologies, components, and practices at different moments in time, and how they "had to commit themselves to a course of action despite and even because of such ambiguity and with the knowledge that their efforts could not fully determine emergent outcomes" (Garud, 2011, p. 3). Through this understanding, innovation process research builds intimate knowledge of socio-technical ensembles as the four cases in this thesis demonstrate.

This has also taught me that being a process researcher means developing the ability to think processually. I draw on Langley's specification of process thinking in relation to strategy process research as "considering phenomena dynamically – in terms of movement, activity, events, change and temporal evolution" (Langley, 2007, p. 271). Similar to my learning about process research, I found that process thinking is not developed alone through the work of organizational innovation process mapping, with inputs and outputs traced back-and-forward in time, feedback circles, technologies, changes, decisions, — all the details that people recall and share with the researcher. Rather, process thinking leads to concise theorizing as it emerges out of an ongoing problematizing of what seems relatively stabilized — be it relations, technology, processes, concepts, or terminology — and it also delays judgments about the studied context through the consideration of interpretative alternatives to sensemaking that all in all generate researcher-owned endogenous insights (Garud, 2011).

In summary, case study research and processual focus have been the primary methodological and analytical shaping attachments I have chosen to guide my enquiry. Next, I will describe the different data sources I collected, how I got access to these and what inspired me in that process.

4.2 Data collection

Data has been collected for this thesis over the course of three years, from September 2008 to August 2011, during 16 days of observation at Think's Oslo headquarters, the 2009 United Nations Climate Change Conference (COP-15[14]) in Copenhagen, and through ongoing online archival research over the Internet. Qualitative data was amassed from various sources: face-to-face and telephone interviews, of which most were digitally recorded, observations that have been video-recorded at meetings and press release events, and Think-life photo snapshots which had been developed for researching technology innovation partnerships in relation to Think's innovation development process. Publicly available written material related to various aspects of the research objective had also been collected: predominantly, press releases, news articles, company presentations, commercial photos, and reports which had been written by Think or others in the industry who focused on Think, the electric car industry, referring to Think as an example, or electric car technology development processes.

In the process of gathering empirical data I have been inspired by the ethnographic approach of SCOT. The basic idea is that in order to understand the multiple relations being forged through an innovation process, the researcher should follow the actors and materials as they meet and form relations, bearing in mind that technologies do not succeed or fail because of some self-guided and linear trajectory (Bijker, 1995, pp. 14-15). Clearly, the SCOT approach stands in contrast to the compartmentalized and linear approaches used in many mainstream innovation studies (Pinch & Bijker, 1984, p. 28) and provides a researcher with four described and exemplified elements to be used for data collection, sorting and analysis: "relevant social groups", "the artifact", "meanings" and "closure" (Pinch & Bijker, 1984). How-

[14] "The formal name of the COP-15 meetings is the Fifteenth Session of the Conference of the Parties to the Climate Change Convention. COP-15 was held concurrently with the Fifth Session of the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol (CMP5 – the meeting of countries, including Canada, that have ratified the Kyoto Protocol)"(CANC, 2009).

ever, I endeavored to use SCOT creatively, by way of using the four SCOT elements as temporary conditions (as drift may appear anytime) so that an entirely new analysis of technology innovation projects could ensue, using the Think case of this study. At first I paid attention to all partnerships in relation to Think and all parts of the Think City electric car, but as data gathering progressed, a focus on partnerships in relation to battery, drivetrain, headlights and financial engineering emerged. By focusing on individual partnerships across time in the development of these technology innovation components, I also aimed to integrate and operationalize, as a unit of analysis, the notion of socio-technical ensembles (Bijker, 1995) in a new way. I used the notion of 'socio-technical ensembles' as an empirical metaphor that I should enquire into and seek to describe; in other words, I considered the selected components as socio-technical ensembles. I did not attempt to apply the wider analytical framework of this metaphor[15], but simply used it as an empirical gathering device.

The traced events, technologies, problems, solutions, engineering experiences and engineering lessons learned were used to craft realistic accounts on collaborative partnerships concerning the Think City car and originate from pieces of data related to these four parts of the Think City car and their close contextual relations. Focusing on the discourses created in relation to different problem-solution puzzles related to these four parts elucidates understandings of Think's partnerships in technology development as achievements based on contingent properties (Bijker, 1995, p. 15) and how their relations are negotiated and interpreted. In this way, SCOT provides multiple perspectives on Think partnership situations of innovation development. SCOT helped realize and demonstrate that technology innovation is a problem-solving journey that evolves in relation to different socio-technical ensembles with different interests and expectations that are affected by contextual drift and emergent learning about innovation's potential outcomes. This

[15] If I should have used the wider analytical framework of socio-technical ensembles, I should have dealt more generally with industry or the Norwegian national-orientation of electric car technology as a socio-technical ensemble, or in other ways, I should have maintained less of a firm-level perspective.

holds back the expectation that Think could or should be responsible for everything that happens in its innovation journey. But it also helps emphasize another important point: the ongoing debate about worth. I hereby refer to both economic and environmental worth and this is important as technology innovation activities are also interpreted with an aim to defining how their outcomes should be valued. With regards to data sorting and grouping, this means that while an interview may be carried out with a focus on the innovation journey of a particular person from Think – the one being interviewed – interviews in this research are collectively about technology innovation at Think, involving different people in and around Think, and different parts of its technology innovation process. In relation to publicly available written material, this means that although an article's focus may be on a particular matter, for example a new partnership between Think and another company, considered as part of a larger context, this same article is also about different partnerships and technologies related to Think. Similar reasoning applies to Think-life photos and video-recorded observations. In sum, collecting and analyzing these different data sources and data inputs helped expand my thinking and helped me achieve important insights about partnership evolution and the uncertainty and unpredictability attached to their processual development. It has benefitted the level of information nuance and quality in case studies, and the sensemaking within one and across the four case studies. It also challenged the analysis process by increasing complexity, raising new questions, blowing up temporally-constructed relational boundaries as cross-data comparisons seemed to confirm or discard cues, which demanded a significant time commitment as cross-data comparison necessitated a 'play' with the data. The field accounts I have written individually draw on and refer to collaborative partnerships forming-breaking-reforming around a particular part of the Think City car and specific technologies. However, data units coincide and are rarely cut-off specifics around these processes, which is why dedicated grouping has been difficult. In relation to the four analyses in Chapters 5.3 to 5.6, I have found it relevant to account for the data in terms of the number of active partnerships and technologies, as delineated in **Table 6** on

page 127 that enumerates data units related to partnerships and technologies in the four cases.

Interviews with people are of various durations depending on the time an interviewee could spare. They range between 15 minutes and one hour in length, with a few exceptions that went on for more time. The observation data recorded at meetings or press releases covered durations of 3-35 minutes, depending on the length of a speaker's time. All recordings of interviews or observations were transcribed in their original languages (Norwegian, English or German). Using HyperResearch qualitative coding software, interviews were coded for the case examples in this thesis: the battery, the drivetrain, the headlights, and the financial cases. Then, the data were examined for external drift. The business model stage in which an event seemed to take place was noted, as were the relational modes (forming, breaking, reforming), relationship type (investor, supplier, political, research network, societal group, users, etc.) and whether they were perceived as successful or unsuccessful. In addition, data were coded based on their relationship to the version of the Think City car. I got access to interviews with all managers at Think, except for the Purchasing Manager, whose schedule and time out of the office did not permit a meeting. All managers had been working at Think since the early 1990s, except for the Chief Financial Officer (CFO). The Human Resources Manager (HRM) who arranged my interview schedule had also booked time for me to interview one long-term employee, and with this exception, I was asked to obtain approval of the manager in charge, if I wanted to talk to specific employees. However, Think did not have some kind of organizational chart to guide me and during the managerial interviews there was reluctance to give me names and interview time with non-executive employees without knowing what I wanted to specifically interview them about. As a result, employee contact with those not on my roster of pre-scheduled interviews was made by through networking, over lunch or by the coffee machine.

Observations from meetings or workshops, focusing on technology component matters, did not take place during my two visits at Think, apart from when I attended the All-Team-Meetings. I attended two of these meetings.

Informed consent was ensured in relation to all interviews and meeting attendance. Preliminary versions of the battery, drivetrain, headlights and financial engineering cases were also shared with the person in charge of each component area so as to ensure their consent for the use of quotes I had selected out of interview data transcripts.

Publicly available written materials (i.e. press releases, news articles, company reports, etc.) were sorted by year and documented in an electronic matrix to facilitate future searches. Most materials were published in English, but some records were only available in Norwegian, German or other languages. Collected materials include 574 items: 318 online news articles from the period 1999-2010; 112 press releases from the period 2006-2010, of which 67 derive from Think, with the balance being Think-related press releases published by, for example, a technology innovation partner; 13 company presentations, of which 10 are Think-presentations, including the founding management presentation; seven industry reports referring to Think as an example of an electric car, often in relation to sustainability matters; and lastly, seven academic papers university theses[16]. It was not possible to locate Think's early press releases in electronic form. It may be possible that these were lost due to changes in organizational ownership. Norwegian news agencies were contacted, however all replied that earlier press releases were not available electronically; hard copies of the materials were available locally, but I chose to spend my limited time in Norway at Think.

Photos were sorted according to image, mainly based on versions of car development and context, and were listed and briefly described in an electronic matrix. The collection counts 397 photos and comprises of both Think-life commercial photos and research photos. While the commercial photos taken by others tend to tell a story on their own and were often captured with the purpose of selling and marketing a story, the research photos I took rarely captured enough to represent stand-alone stories and work as data. The latter are rather documenting work or places as I could observe them and they

[16] This included four research reports, one PhD thesis, and two master thesis (see Appendix 2).

served as timestamps of my research process. However, I found commercial photos to help me become creatively productive and sharpen my insights about Think and its partnerships. I experienced how these pictures could say something about the design development of the Think City car and also how they could convey stories about various partnerships and how they progressed over time. In this way, photos became complementary support for my analysis of information procured from interviews or written materials, which I found useful for the research. Thus, photos have been included in this thesis as complementary study objects of partnerships, rather than as study objects in their own right.

Other data, including field notes based on observations of employee presentations and work life at Think as observed during my two-week visits, three interviews with Think partners, the car sharing company MoveAbout and the supermarket Migros, and video recordings from the 2009 COP-15 have also informed the research, but fell out of my final analysis scope. The usefulness of the documented observations turned out to be limited as direct data input, but somewhat valuable as part of my in-depth knowledge gain about Think and partnerships in general. More than anything they reported how I observed Think office settings, people coming and going, intimate face-to-face conversations taking place, coffee break moments and people absorbed in computer tasks. I could feel a tension related to the fact that I was physically present where technology innovation was happening and partnership processes were making meaning, yet I also self-identified as an observer, detached from constructing lines of communication, tests and performance experiments that took place in designated meetings to which I had no access. My notes also reflected the thoughts I had while at Think about the interviews I conducted, where I experienced how knowledge was assembled in meaningful relations through interview conversations. The partner interviews also drifted out of scope, as they proved to focus more generally on expectations of a growing EV market, component technology and collaboration with Think in the future, than on reflections of specific past or current collaborations with Think. As such, the partnership interviews were helpful in my ongoing boundary seeking efforts. Finally, video recordings from the 2009 COP-15 were

made at a time when I was still considering whether and how to explicitely address the issue of sustainability in relation to Think. Attending the COP-15 events helped frame a wider socio-economic picture of technology innovation in my mind, but I also found that sustainability was such a potent issue that it easily could steal attention from the partnership matter I was interested in and create more confusion about the research goal.

A full listing of created and collected fieldwork is provided in the appendices.

4.3 Methodological ambitions and compromises

In this part I will point out what, in retrospect, may be considered to be my empirical, theoretical, methodological, and analytical ambition and compromises that emerged in relation to research resources, challenges and results.

My empirical ambition is to demonstrate a constructively consistent and persistent deep-dive into one empirical delimited field, conveying technology innovation development enthusiasm and unfolding technology relations based on a broad-minded understanding of technology. In retrospect, my intention was to contribute to an understanding of technology innovation development as impacted by political and symbolic interests and expectations in the close and more distant environment of the technology innovation. Today, I also think that the project brought forward noteworthy attention and insights on the socio-economic processes of technology innovation. Placing emphasis on partnerships has allowed me to work strategically in both arenas. It may be considered a weakness that I did not attempt to include more interview accounts from Think partners to compare Think's view on events and partnership development. One reason was that Think was not very helpful in providing direct contacts and as I tried going through official channels with some partners, I was politely declined interview time due to their customer confidentiality policies.

My emerging theoretical understanding and position directed attention to how technology innovation developments happen in unstable social conditions, where uncertainty and unpredictability of actions prevail. While

analyzing through an analytical focus on drifting partnerships what gave directionality to technology innovation in such an environment, I directed attention towards the importance of relations between external partners and a technology innovation project: expressions of interests and expectations for a partnership, efforts of deliberate design and planning of activities, exchanges and the creation of resources for complementarities and change, the role of partnerships as connections to a larger cause and context, as well as other aspects. At a moment in time, and in later parts of my PhD research steps, I sensed how this theoretical partnership drift process analysis mediated amidst interactions between partnerships and certain technology development components over time. Focus on technology innovation partnerships enabled me to theorize about the development, role, and meaning of partnerships in technology innovation contrasting my findings to the common perceptions about partnerships such as those held by dominant design and open innovation theory. Using SCOT as a main resource was a benefit through its focus on social groups and problem-solving processes, but it had weaknesses in explaining how actors passed from one problem-solving situation to another. This was where I found notions of environmental drift and emergent learning helpful. However, it may then be considered a weakness that I maintained a focus on technology innovation development rather than learning among heterogeneous engineers per se, but from a social-constructivist perspective, this is just another way of looking at learning. The strong empirical focus of my thesis may also allow others to test their theorizing and thereby this research may contribute in a broader way to academic research than what I alone may be able to facilitate over time.

My methodological ambition is to convey presence, closeness, and intimacy with technology development processes to the reader. To create such an empirical awareness and insight I build on interviews, observations, articles, photos, mapping and narrative accounts. These methods complemented one another, while they also contributed to the research in different ways. While interviews and articles were important ways of accessing process accounts and managerial understanding of the Think City car innovation, pictures supported the empirical which could not be captured in language and

thereby helped compensate for the inaccuracy and insufficiency of language of the empirical world in its interactions with me. Also in this thesis, pictures helped me, when faced with the inaccuracy and insufficiency of language as a tool to communicate my heterogeneous view on technology innovation to the reader. Triangulation has been performed through the combining of different unobtrusive methods (Webb, Campbell, Schwatz & Sechrest, 1966) such as voice recordings, video recordings, photography, and archival records. With different methodological weaknesses in my research design, I have aimed to cross-validate sources of qualitative data and my interpretation thereof. Thereby, some research inappropriateness and irrelevancies have been identified and diminished along the journey.

Looking back over a company history of twenty years was meaningful because it enabled a kind of diachronic analysis (Ruspini, 1999) through which I traced dynamic process characteristics, conditions, events and technologies relevant to partnership change. It gave a coherent understanding of Think and partnerships, grounds for making sense of both and demonstrated socio-technical processes, within the limits of the enquiry. But dealing with information dispersed over such a long period of time was also a challenge in the sense that it demanded a lot of time. The approach depended on the willingness and perhaps more importantly, the memory of interviewees to recount events and actions in the past in more than general terms.

My method contributed back to Think, especially since it contrasts how Think has worked it way through relationship processes throughout the years. My mapping of external relations gained particular interest with several managers as it presented them with an overview of their actions, which is something they had not generated themselves in understanding Think's history. Although I observed white-board work as a common method used by Think's project teams to map known and assumed partner relations, a consolidated view of prevailing business relations had not been undertaken by Think and was not available.

This methodological work-process shifted my analytical focus from a general curiosity about Think and its innovation journey to a new focus on its organizational existence – how innovations could have a better chance of be-

coming, surviving with partnership drift, success, failure and interpretative flexibility.

In principle, my analytical ambition is two folded: to identify elements that contradicted the traditional innovation perspective on partnerships, and to identify elements that would direct a process perspective on innovation development further through an understanding of partnerships. But in detail, it is the notions of drift, emergent learning and the SCOT analysis method that in the thesis analysis helped me to tease out the economic, technological, environmental and social aspects that are found to change technology development partnerships: Why would Think seek out partners and vice versa?; How did initial contact happen between partners and what happened next?; What kind of helping tools did partners invoke to collaborate?; Were there defined contracts, project plans or other coordinating frameworks in place?; How could they determine if a partnership was functional or dysfunctional?; How did they dealt with problems and solutions in their partnerships?; Why and how would partnerships break?; and, Why and how would partners get back together?

Focusing analytically on partnerships made it apparent that I could not explain Think's ability to maintain existence through its innovation journey by exclusively looking at Think, because in essence, that is not where Think, with all its economic, social, technological and environmental complexity, could be found in the process. I could only examine Think in relation to a relative wholeness. Therefore the socio-technical ensemble in which I found Think expanded and became as important as Think itself, analytically. My interest is that which is constructed by the socio-technical ensemble, the way in which it is constructed, how solidly it is construed, how it is valued and how it changes. I have aimed to work this out of the cases in such a way that the knowledge gained will be accepted as socially robust (Nowotny, 1999) in relation to the social research process I have undertaken, and the criticism and trust currently associated with technology development research.

4.4 Research process and analysis

In this part I follow up on my overall explanation of the empirical, theoretical, methodological, and analytical ambitions and compromises that may be considered as outcomes of the research process, by explaining in more detail how my research focus and questions have developed and sharpened through my contact with the field of research and literature. In retrospect, it makes sense to talk about three research process phases: the first, driven by a general orientation within the automotive industry, around Think and within innovation literature; the second, concentrating on narrowing the focus around Think partnerships and theories allowing a socio-technical perspective to form; and the third, occupied with crafting qualitative data accounts and analytical insights, as illustrated in the following model:

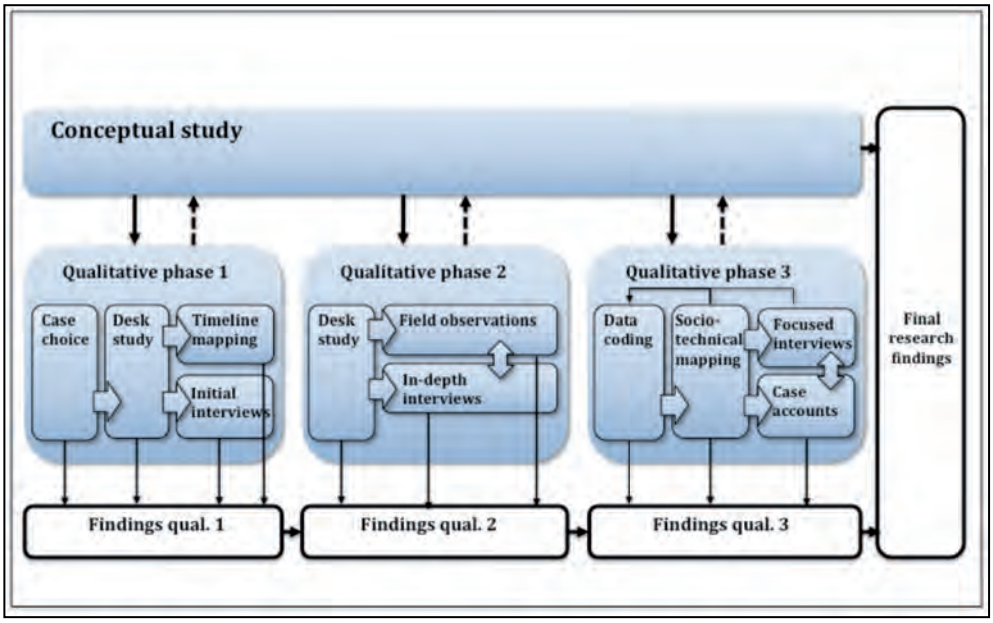


Figure 6: Emergent research design defined in retrospect

4.4.1 Understanding the Think City car as a contemporary mobility alternative – First qualitative phase

Enrolled in the PhD program at the Copenhagen Business School, my early qualitative research activities focused on choosing a case study topic, conducting desk research to locate materials in the public domain, and revive my con-

tact with Think, through reconnecting with people I had first meet during the Geneva Auto Show in March 2008. In **Figure 6** above, the emerging research design, referred to as the first qualitative phase, is demonstrated. My level of analysis in this phase was directed towards the automotive industry and Think as an organization. My research questioning focused on how Think was part of making an industry for electric cars and how Think, as company, could maintain existence with only one car model in its program and without any noteworthy sales across the years, as well as how Think managed to resurrect from bankruptcies again and again. These questions led me to recent publications on organizational innovation (see for example Kessler, 2004; Lam, 2006), small business innovation (Laine, 2008), and knowledge in innovation (see for example Basadur & Gelade, 2006; Enberg, Lindkvist & Tell, 2006) that in turn led me to focus on Van de Ven's work on managing innovation (see for example Van de Ven, 1986; Van de Ven & Garud, 1993; Van de Ven & Polley, 1992). This early phase yielded my increased understanding of the electric car as a contemporary alternative means of mobility and my preliminary understanding of the various 'real' partner relationships (professional, economic, political and technical) that Think had been forming-breaking-reforming over time. I chose to use a timeline as a map that could reveal the various constellations and developments over the history of the company in order to enable the interpretation of several collaborative networks and the generation of several initial research sub-questions (see **Figure 8** and **Figure 9**, page 114-115). Mapping was a form of visual interpretative work that I returned to several times, which is described in more detail later in this chapter. This early research in the public domain also prepared me for my first site visit, which took place over a period of two days in October 2008. Despite the fact that Think's Founder, Jan Otto Ringdal, no longer had an active role within the company, I was fortunate to have been invited to his office in downtown Oslo, where he recounted his story with Think during a three-hour interview. Clear-spoken and inspiring, he told an entangling story. This conversation was not recorded, but extensive notes were taken, which provided me with significant data pertaining to Think's overall history. The day after I met with Ringdal, I had spoken to Think's CEO, Jan Olaf Willums, and his secretary, who was responsible

for human resources. Willums had also taken the time to bring me to another closeby office location and had introduced me to the people working on what was to become Moveabout, a zero emission car sharing company. These conversations focused on Think's dire financial situation and the stressed organizational work situation that existed at the time of my visit, Think's business and technology innovation development efforts since its resurrection in 2006, and the importance of initiatives such as MoveAbout to growing Think's commercial activities. Besides this, I introduced my research aim, as the primary purpose of the visit was to gain Think's support for my research, which as explained, would take the form of documented materials, observations, and interviews with staff. Due to corporate restructuring, I was asked to refrain from contact with the company until the summer 2009; these conversations were not recorded and no materials were given to me at that point in time, but I did leave with the impression of having been in a working environment that was in a state of transformation: cables were hanging loose from the ceiling, provisory workstation were set-up, building material were in piles on palettes, and few, but intensely active people were working. I understood that it was uncertain and unpredictable whether Think would exist in 2009, and that my research set-up would have to be flexible in terms of ways of collecting data, but I did not consider changing my case company.

Almost a year later, in August 2009, I made a second visit to Think after respecting the request made by Willums and the HRM. In the meantime, a kind of restructuring had also taken place around my research project. I had changed supervisor, I had turned my literature attention to dominant design (Utterback, 1994) and open innovation (Chesbrough et al., 2006), and I had begun teaching and taking courses: I had learned and gathered my initial experiences about my research field from a distance and from working in academia, but I found myself no more clearer in terms of my specific empirical research focus: I was uncertain of which external relations I should focus on, whether any parts of the Think City would be considered more central than others by Think, and what I would be able to understand about technology innovation by being physically present at Think. I was longing to be thrown into my field. During this second visit, I had spoken with the new CEO, Richard

Canny, his secretary, a sales representative and the HRM. These conversations focused on the burden of financial restructuring that Canny faced when taking over as CEO of Think and how problem-solving revealed to him a "need for more discipline, focus and real car manufacturing skills" at Think (Think visit notes, 08/2009). Fortunately, Canny was supportive of my sketched-out research idea — that important lessons may be drawn from a small entrepreneurial organization's managerial experience of connecting to other actors and dealing with uncertainty and unpredictability — so he approved the future visits I made in the spring of 2010. However, this was not without an unspoken supposition of reciprocity; there was a hope or even an expectation for me to contribute to Think's ongoing restructuring process. For example, the HRM said,

> "Yes, I think we can profit from having you around here. We are going through a transition phase where it is important not to be hindered by the history. So for many employees it can be helpful to be talking about it" (Think visit notes, 08/2009)

This example shows how I experienced unclear expectations of the forming relation and found relational uncertainty and unpredictability between Think and I. It emphasized the need for my detachment, if I were to critically study matters in Think innovation processes without developing conflicts of interest.

On this one-day-visit, I had been offered a desk in an area dedicated to management offices, where building materials were still laying around, and where, as I walked about, I could see a lot of people active in discussions around whiteboards, car material parts, and computer screens. The office entry area increasingly took on the look of a Think electric car exhibition platform, yet, as a whole, the space did not seem to have settled into a final form, which was still the case during the second qualitative phase of the research.

4.4.2 Narrowing the focus to Think as an organization and partnerships in relation to the Think City car – Second qualitative phase

The second qualitative research phase included attending the COP15 events on electric cars, two one-week field visits to Think's Oslo headquarters in

2010 and further desk research. In this phase, the level of analysis was broadened beyond the automotive industry to include the general environment as it pertained to electric cars. At the same time, I narrowed my focus on Think as an organization and its partnerships, especially those impacting the Think City electric car. In relation to the general environment, I was questioning how the electric car as an innovation could play a role in larger networks (see for example Granovetter, 1973, 1983; Owen-Smith & Powell, 2004). I got inspired by notions of technology escaping lock-in (see for example Cowan & Hultén, 1996), the duality of terms such as homogeneity and heterogeneity (see for example Granovetter, 1973; Law, 1992), and actor network theory through reading, for example Callon's (1986) case on electric vehicle development in France. In relation to Think as an organization I questioned how to strategize with partners when facing continuous change (see for example Brown & Eisenhardt, 1998). And finally, to develop my processual thinking, instead of reading innovation literature with a static perspective, I read about deconstructing static ways of thinking (Dürr, 2009; Knapp, 2008). This phase yielded in-depth interview accounts, observation notes and photos providing details on Think's 'real' relationships. These data were used to identify the relevant constructs impacting the coding approach and theoretically relevant insights.

In my first one-week visit to Think in January of 2010, I spent time interviewing members of the Think management team and one selected long-term employee, the Founder Ringdal, the then newly appointed CEO of Moveabout, and I attended an All-Team-Meeting at Think. In addition, I received a copy of the most recent Think company presentation and audio files and photo materials from an off-site workshop that the purchasing and product management groups held that same week. Prior to my arrival, Think had requested a short briefing presentation about my research (see Appendix. 3), which was passed on to all managers in order to inform them of who I was, including my background, and the initial idea of why I would visit. I had conducted three to four interviews per day, which did not all take place in the old airport area of Oslo, Fornebu, where Think's office was located; some were carried out in downtown Oslo. Thus, I largely relied on the same interview

approach for all. For the interviews, I asked interviewees to tell me their individual stories with Think, emphasizing on projects and external partnerships they had been engaged in or aware of, and I would only interrupt to ask for elaboration on what happened in relation to partners and events and broadened explanations of problems or opportunities as they became mentioned. As my analytical focus at this time was on Think and its partnerships in general, and not exclusively in relation to the later selected four cases, interviewing was not as much a matter of steering as it was about listening attentively for cues to relevant questions and themes particular to Think that I could bring up in case-focused interviews. In that sense, I applied mainly an anthropologic perspective on innovation development. The CFO was the only manager who had not been with Think for several years. As with my other interviews, I also asked him what he thought of Think and what he thought of its way of developing and working with partners and it was through the diversity of answers to questions like these, that a constellation of themes and connections of flexibility and acceptance started to emerge as a thought in relation to 'how to characterize innovation development processes and the relationships that shape them'. The interviews focused on various aspects of Think. While the problem-solving related to technology innovation and assembling was a central and recurring point, design development, work organization, sales and distribution efforts, impact of financial distress, partnerships, collaborative expectations and disappointments, as well as personal hopes and beliefs about Think also played important parts. In relation to the Think City car components, the battery, the drivetrain, the headlamps the aluminium space frame, and the thermoplastic body panels were often referred to.

The Moveabout interview was by-in-large guided by the same approach employed in interviews with Think managers. What differed was that this interview provided both an internal-Think and external-Think perspective on things, as the CEO of Moveabout had been a former Think employee. I noticed that a number of expectations had been voiced concerning Think's City car's maintenance provisioning, general exterior design, and updates of various accessories, of which I wondered whether Think was aware of and working on.

My interview approach was different with the founder of Think as he already had told his story in our first meeting (see Appendix 1 for an overview of research interviews, page 263). In the recorded interview, our conversation was structured around his initial management presentation, which he explained to me, had developed as his learning and experience had increased, as in discussions with potential partners, he was confronted with partner expectations and what the public would be interested in knowing about the Think City car project. I then began looking at the Think company presentation as a conceptual development sketch, iterated over time. It represented a way of keeping a dialogue going around ideas, revealing partner interests, gathering requirements, making promises, and so on. In the evenings, I compared the founding Think presentation to more recent ones I had and then I came to think about the car as an expression of where Think and its partners were at in their technology development journey. In this way, I began tracing a narrative infrastructure, that also played a part in establishing an account that gave Think contextual bearing at the time. The account further developed into somewhat of a tale, where different factors played a part, were given a past, present, and future: an actor-world. I had a sense that these insights were important, however, I couldn't sort them into my research at that time.

Attending the All-Team-Meeting gave me a glimpse into how staff shared new information about problems and solutions that related to technical, economic, and social factors and how one partner could be mentioned by different managers in relation to different updates on development processes.

For the little time I had left that week, I lingered in different parts of the open office environment watching and listening to employees' interactions. I did not really know what I was looking for that week, but I clearly felt the newness of 'hanging out' in such a casual way in an office environment. As earlier mentioned earlier, I felt detached from the lines of communication I had come to study though I was physically present. At the same time, however, I understood it would be a challenge to detach myself from my former role as project manager in this kind of work environment were I to have stayed at Think for a longer period of time.

The second one-week visit to Think took place in February 2010. I got access to Think's commercial contract filing cabinet. I spent time interviewing the Head of Product Management whom I had not talked to on my last visit. I spoke with the selected long-term employee again, and the Project Manager who had coordinated activities in relation to moving the production from Aurskog in Norway to Valmet in Finland in the autumn of 2009. I also attended another All-Team-Meeting at Think. During this visit I adopted a socio-technical perspective to innovation development (Bijker et al., 1987), which means that I paid increased attention to decision-making related to the Think City car development and the particular historic contexts in which development took place. Equally, the perspective helped acknowledge that things could have turned out differently. This was important because it helped open up more nuanced debates and analyses of Think's partnerships development.

The archival search in Think's commercial contract filing cabinet had been granted because I signed a non-disclosure agreement. I seized this as a chance to gain insight on Think's intended collaborative development processes, including collaborative policies, collaborative communication, work quality expectations, and so on. I found binders bursting with paper, and binders yawning empty, and everything in-between, but no apparent useful system. I got the sense I was pursuing a dead-end, but then I thought that this could be telling me something about what did not work well at Think or perhaps, what was not important to Think: formalized procedures seemed to have a hard time getting – well – formalized. Perhaps this indicated a need for informal settings in technology innovation partnerships; so as to let interactions take place by also involving a wider context. To me, the examination yielded a list that covered various partnerships, which I could then classify in relation to different Think City car component areas, and which could serve me in future focused interviews and online document investigation.

Of the remaining activities, it is the interview with the Head of Product Management that deserves highlighting. I had asked him to describe his collaboration with external partners, elaborate on what he thought about his work with external partners, what changes he had experienced over the years in his approach to external collaboration, what he did when external partners

contacted Think, or when Think contacted external partners, his thoughts on collaboration break-ups and collaboration reformations. I noticed how he was very good at providing concrete examples, typically starting off his sentences with, "Okay, here is an example" – perhaps he was so good at that because he did so regularly on the job. Towards the end of the interview, he suddenly paused and said, "There will be this trip to the US soon, where we will meet potential partners." He looked me straight in the eyes and said, "Well, there we will be engaged in exactly what you are interested in. Let's talk to Canny [the CEO]!" I got all fired-up by the suggestion that I could join the road trip and envisioned the unique data I could get my hands on. It was an ideal solution for getting access to partner meetings: to observe, listen, learn and look for partnership processes' cues. Unfortunately, back in Copenhagen, I encountered some financial problems, which meant this opportunity didn't materialize. I was very disappointed and became even more determined to find ways to succeed in my research – an igniting spark between experiencing opportunity and uncertainty seemed to have accelerated my learning and flexibility. The reason why this is important to tell here is that all of a sudden, I realized how important learning and flexibility are in innovation. I had been looking for partnership relations, identifying the who's and the what's, but I had not paid careful attention to the how's. That had changed right then. There was something more to know about partnerships beyond their connections and interrelations. With new insight at that moment, I could somehow visualize innovation partnerships and all the 'stuff' about it floating around and about its processes: expectations, interests, negotiations, solutions, contextual changes, opportunities, flexibility, learning, etc. I sensed I was ready to narrow my analytical focus further, which I did in the third qualitative phase.

4.4.3 Revealing partnership processes in relation to assembling batteries, drivetrains, headlights and financial engineering – Third qualitative phase

The third qualitative research phase included interview transcription and coding, socio-technical mapping, crafting case accounts and further focused interviews and desk research. In this phase, I narrowed the level of analysis to

Think partnerships closely related to the development of batteries, drivetrains, headlights, and financial components. My focused research questioning turned to how partners formed relation to Think and the Think City car, how they collaborated in projects, how their partnership broke again, and how sometimes Think and a partner got back to working together again. This analytical focus on forming-breaking-reforming made me notice uncertainty and unpredictability as positive aspects of technology innovation, and this became central to finding out how these aspects could be more deeply understood. I also more closely analyzed relations between sustainability discussions and the development of electric cars. This meant that also in this phase I adopted a socio-technical perspective a long the way, but as the writing advanced, I coupled it with a narrative perspective. This phase yielded socio-technical maps, case account story outlines, and per-case timelines that revealed forming, breaking and reforming processes in relation to Think's 'real' relationships. These data were used to establish early drafts of the theorized storyline. In my reading process, I found useful support for my analysis approach from Bijker and Law that I explain in more detail later in this section, and I went on to read various contributions that draw on socio-technical (see for example Geels, 2005), socio-cognitive (see for example Garud & Rappa, 1994), socio-material (see for example Orlikowski & Scott, 2008) or otherwise socio-driven (Barley, 1986) approaches in understanding innovation. I also read about experimenting and testing (Thomke, 2003), and capabilities (Atkinson, Crawford & Ward, 2006), and organizational decision (March, 1994) and sensemaking (Weick, 1995, 2001).

It was not interview transcribing, but the process of transcription-reading that made a difference for me. During the various interviews and meetings, I had noticed that some electric car component parts seemed to attract more attention than others. In the transcriptions I began 'looking' for components and I saw that battery, drivetrain, headlights and financial assembling stood-out, based on my newly gained understanding of partnerships. Focusing on these four components gave me an empirical hook and directed my understanding. In **Figure 7** page 107, the emerging framework for identi-

fying and analyzing technology innovation partnerships processes, is demonstrated.

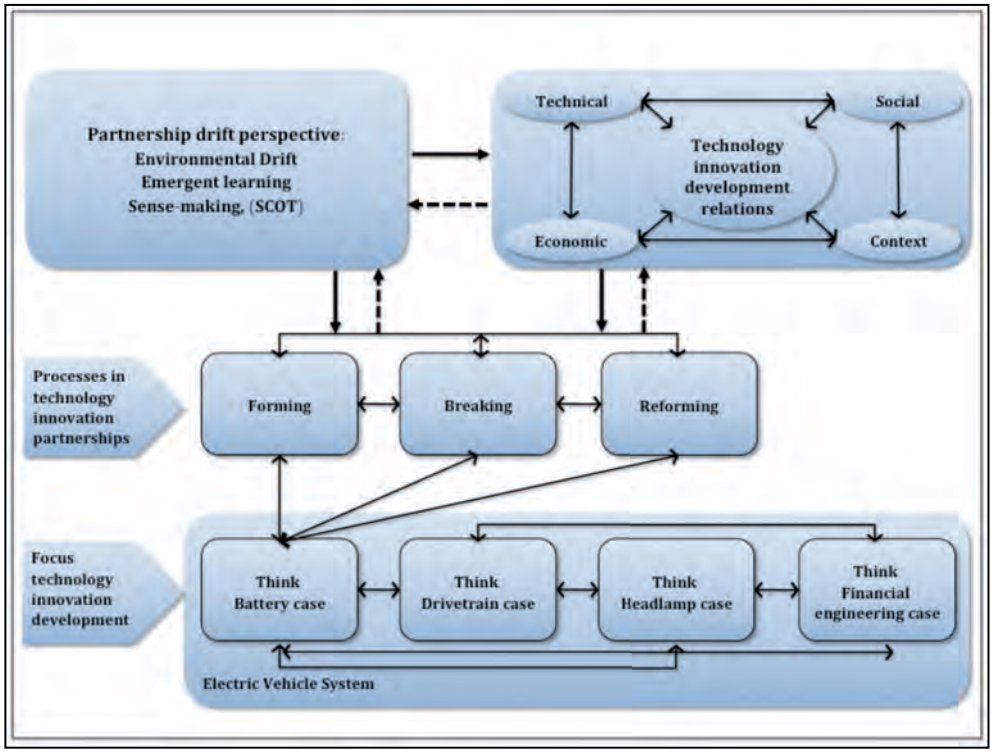


Figure 7: Framework for identifying and analyzing partnerships processes

Focused interviews were set up as I had selected these four components to be thesis cases. This time it was possible for me to interview over skype the CTO, the Headlamp manager and the CEO. I had planned to also collect information on the aluminium space frame, so as to ensure I had four cases. I was uncertain about the depth to which I could draw out of the headlamp case, but although I got referred to the person to speak to about the aluminium space frame development, I didn't hear back despite several attempts of contact. Consequently, I stayed with the headlamps. In each of the focused interviews it was the story of the particular technology component that was central, about which the interviewee would tell without much interruption. However, when I would speak, I would do so to ask for elaboration on specific technologies, partnerships, events, problems, solutions, or expectations mentioned by the interviewee. Throughout all research interviews I had been aware that retrospection has limitations because people may recall things a little more "rosy" than they would care to admit, or a little more

"black" (also depending on the mood of the person being interviewed). Nevertheless, especially through the focused interviews, I came to understand how retrospective also has a strength in that storytelling stimulates some learning for the interviewees and sometimes and they seemed to get a better sense of 'what actually happened' because they too became somewhat 'removed' from the situations they were telling about, by the very fact that they were telling about them in a 'separate' space and time to the events. Subsequently these interviews were also transcribed and coded although on the way to the written case accounts it was socio-technical maps that played a greater role.

The goal of crafting socio-technical maps was to gain a sense of following the road Think had, finding a way of thinking about Think by catching up with it. Reconsidering the retrospective view that I had gained from understanding Think's experiences provided me with grounds for further application of singular events related to the cases of battery, drivetrain, headlights, and financial engineering that I had decided to focus on. It became my way of "following the actors themselves" (Latour, 2005, p. 12) as the ANT slogan supports. My approach to crafting socio-technical mapping was based on the desk research and interview output I had collected throughout the years. At my disposal, I had a vast amount of physical and virtual data representing the 'stuff' that made up Think. When I first began mapping, I used it as a way of interviewing and sensitively observing my desk research material. I experimented with listing things in a spreadsheet matrix to see if it could be as useful, aware of the possible advantage I could have at a later stage, in terms of already having notes electronically, but I found myself preoccupied with grid-order and structure, writing descriptions that had a strange theoretical twist, and contriving types of relations because they seemed realistic to me. I felt like a judge in this process, and not like the conscientious engineer I felt I had become when mapping. I used mapping to make some of the complex interactions and connections visible, tactile, analyzable and debatable. This way my understanding emerged from distributed connections of different material. I focused on identifying partnerships and the problems and solutions with which Think was explicitly associated. Also, explicit interests and expectations were captured. This led me to think about and focus on events such as the

1994 Winter Olympics in Lillehammer, participation at automobile trade shows and public car races, Think's bankruptcies and other events around which partnerships of various kinds became apparent in socio-material ensembles. I noted the reference that actors made to the greater context such as the Oil Crisis in 1973, the Asia Financial Crisis in 1997 and the more recent Global Warming Focus from 2006. The organizational formal constellation, in terms of company name and location of offices and production facility, was also taken into account, which gave a sense of the geographical spread of Think. But otherwise, I observed how the socio-technical mapping allowed me to move across boundaries of institutionalized organizational structures and thereby, had been helpful in conveying a sense of wholeness – to me, at least. Lastly, the different versions of the Think City car were mapped alongside other products such as the Think Public Omnibus. However, it became more clear that attention to other product developments was to mostly waver the potential impact of relationships on the Think City car.

Mapping was, to me, like returning to the field, being close to the Think City car and being close to Think's people – seeing the two as one. In this way and through this process, I also realized that being physically distanced from Think did not mean that I got disengaged, or that I could not follow Think. Often, when going through the material I had, I could travel back in time and feel a oneness with the car and the people making it, even if I focused on events several years back. In those moments there was an intimate and sensitive relation that emerged which provided me with a deeper understanding of my object of study. However, I believe that in part, I had understood the value of these moments because I had my own local embedded experiences at Think. It had been a messy process, and I had to draw several maps, until one map, to me, represented a fair translation of the experiences I had had thus far in investigating the data. The whole looked like a story in itself and conveyed to me that I had reached the point of data saturation for my case stories. From that point on, it was 'the map and I' discussing. This was when I began to 'mind-walk' between my emerging sense of theoretical argumentation about the case and the "theoretical multivocality" (Golden-Biddle & Locke, 2007) of the study's object. It was both an inspiring and demanding process to close in on

explanations, as the map was "talking back" (Flyvbjerg, 2011, p. 310), revealing the misfit of theorizing attempts and reminding me what I had left out and that there was a clear heterogeneity in the cases. To avoid misunderstandings, let me point out that I did not assume any of the representations to be complete in a real-world sense.

My socio-technical mapping approach to capture interconnected partnerships may be associated with the Soft Systems Methodology (SSM) (Checkland, 2000). On the one hand, it shares the rationale "that the complexity of human affairs is always a complexity of multiple interacting relationships; and pictures are a better medium than linear prose for expressing relationships" (Checkland, 2000, p. 22). On the other hand, the socio-technical mapping has served as a research sensemaking process, as Checkland (2000, p. 33) exemplified that the SSM might have, in relation to his work with the NHS (National Health Service, UK). Beyond these two arguments, the relation to the SSM lies in the assumption "that the process of inquiry into the world can be a consciously organized learning system" (Checkland, 2000, p. 44). It is process thinking – on display – which was articulating the socio-technical process that is the makeup of Think. The fact is that I did not use the SSM as a methodological inspiration; rather, I employed mapping as a research tool intuitively, based on my prior work experience as a technologist. As a specific socio-technical analysis tool, it was SCOT (Bijker, 1995) that I found useful in helping me get closer to the socio-technical ensembles as I became increasingly aware of what I was interested in observing.

Using SCOT means applying a method which does not assume a priori knowledge of different scientific, technical, social, cultural or economic factors (Bijker, 1995, p. 15) in innovation. Instead, SCOT recognizes the richness of work performed by people in innovation – in this research, they are the engineers at Think and Think's partners. SCOT highlights a good technology engineer as a "heterogeneous engineer" (Law, 1987) who struggles with various kinds of situations laden with instability, controversy and change (Bijker, 1995, p. 124). In this way, SCOT also handed me an analytical process perspective, making me look for what the actors make out of the artifacts through their sensemaking. SCOT ignites curiosity as to why something is chosen as a

problem or solution over its alternatives and why the effects of choices change related artifacts into something other than what they were at the onset. However, while SCOT is concerned with the identification of problems and the selection of solutions, which helped me explain in part how partnerships collaborate in technology innovation processes, I found it useful to create a link between the notion of interpretative flexibility and sensemaking, as found in research on new media (Gephart, 2004). Weick (1995) addressed sensemaking, as he used the term to explain the process that occurs when organizations, faced with uncertain and ambiguous situations, try to find explanations and provide structure to make the inexplicable explainable. Sensemaking is likely to be conveyed into some form of materiality such as designed car components and financial investments, as it becomes part of the environment. Events demonstrating sensemaking and interpretative flexibility could thereby be used to analyze how partnerships unfold in relation to Think. Looking at the data through this perspective does not feed associations to grand design and powerful craftspeople; rather, it reveals connections where otherwise defined work discipline categories, or perhaps job descriptions, may become blinding lenses. As such, examining my interviews or data, such as media articles, with the view that Think engineers are a heterogeneous group, led me to identify and describe relevant groups (Bijker, 1995, pp. 45-46) that were not necessarily realistic groups to me, but that have nevertheless been real in their relation to one or more versions of the Think City car – the artifact. Think engineers signaled and spoke of such relations themselves and thereby mapped temporary group boundaries that became revealing for my research. For example, the Bergen Think Fan Club was a group I did not consider on my own, but one that Think brought to my attention and that later I could consider as a dynamic connection. Bijker (1995) examined the notion of "disturbances" that are led by problems and solutions that allow a researcher to see an artifact through the eyes of relevant social groups. Leading from this idea, I often thought of the connection between a relevant group and Think as an electric cable capable of transmitting several kinds of problems and solutions through it, in both directions, simultaneously, making different kinds of electric friction at each end and, which could sometimes cause very serious electric shocks

that would stop transfers. Sometimes due to friction entering from the greater mesh of interconnected cables, these metaphoric cables would have to be replaced, and that could take time.

In drafting and crafting accounts I aimed at developing a narrative framework that coupled the description of Think's technology innovation developments directly to my theoretical argumentation about drifting partnerships, in a meaningful way. That meant, while my initial case-drafts followed a time-chronologic flow, that allowed me to gather my learning and experiences about each case, a complete rearrangement was made in my second case-drafts to follow the analytical problématique of partnership uncertainty and unpredictability and a forming, breaking and reforming emphasis. This follows Eisenhardt's argument about selecting categories or dimensions as a key to good cross-case analysis (1989, p. 540). I also aimed to follow her second advice, though more loosely, in the case summaries, about drawing out case similarities and differences (1989, p. 540). Through this process of decomposing and rearranging Think development experiences I developed a reflective mind-set as to Think's innovation journey. It was then that I had identified the emergent learning and sensemaking aspects as closely related to the problem-solving technology innovation matter. As I worked on tightening and rounding the case-drafts the 'empiric voices', theoretical signposts and analytical questioning were strengthened in meaning, realness and credibility. By then, inspired by Van Maanen (1988, pp. 25-33), I had a roundtable of general technology interested reading partners in mind as my audience and that influenced not only the ethnographic accounts, but the entire thesis.

To me, to have only worked with what caught my immediate attention would have been like only acknowledging what the front headlights on a car reflect. All the rest, which is picked up by my awareness, would never have found its way into my research. In order to have the essentials and the meanings that things have for me flow into the research, I have had to work with the less illuminated impressions as well. Retaining richness and conveying wholeness in the accounts while also unfolding information and intuition has been a struggle; and this struggle continued again later, when combining the dualisms in a sensemaking way. Studying the implicit, the intangible and the

tacit poses a difficulty in itself, but when it comes to articulating and expressing the associations, I find vocabulary is missing. This is not new, but it is part of a scientific writing struggle, and much support has been found in work on how to use the writing as a way of developing theory (Glaser & Strauss, 1967) and analyzing qualitative data (Eisenhardt, 1989), on how to use literary and rhetoric devices to craft tales from the field (Van Maanen, 1988), and on how to demystify science and technology in writing (Zinsser, 2006, pp. 147-164) in relation to which a vocabulary-oriented read of socio-technical studies is also carried out (see for example Bijker, 1995; Garud & Munir, 2008; Grandclément, 2009). Thus, throughout the research I have constantly been searching for the 'right' words that could tell the story about Think and the aspects that I have perceived as intriguing and novel in relation to technology and partnerships. I settled, for example, for the forming-breaking-reforming analytical handles to give me focus and direction and keep movement in the thesis. At times, I have been a person waiting for words and have tried with patience and willingness to sit and live the situation out to its fullest. I am not sure whether my imaginary-self will find this work, with all its words as striking in years to come, as I do now, but when I read through the work then I will know what I thought at this stage. I will know that this was what I knew about the answers I was trying to find and about the forms of navigating in research; these words will help me understand a little more about where I had come to stand in my research endeavors and its puzzles, and then those moments of effort and seeking more meaningful words will make sense, though they might not suit the impatient, perfectionist and doubtful side of me today. This thesis embodies information in transformation. As Gregory Rabassa (2005) expressed it in *If This Be Treason*, "Every act of communication is an act of translation".

Thus, in the last section of this chapter I have described the research process including the different data, tools, techniques and methods I picked up, worked with and applied. Meanwhile, I have tried, throughout the entire chapter, to explain my developing interests and engagements with the empirics, and my ways of gaining distance and perspective to then analyze and theorize about the empirical in this PhD research. The methodological process

demonstrates that I have sought interaction, challenge, and advice during the research process through different work practices, in literature and in discussions with people to evaluate and reflect on my production and my thinking. The discussions about technology innovation partners that I present in this thesis are therefore to be understood as a combination of the fieldwork material, insights from other people studying technology innovation partnerships and my experiences and emergent learning about the topic.

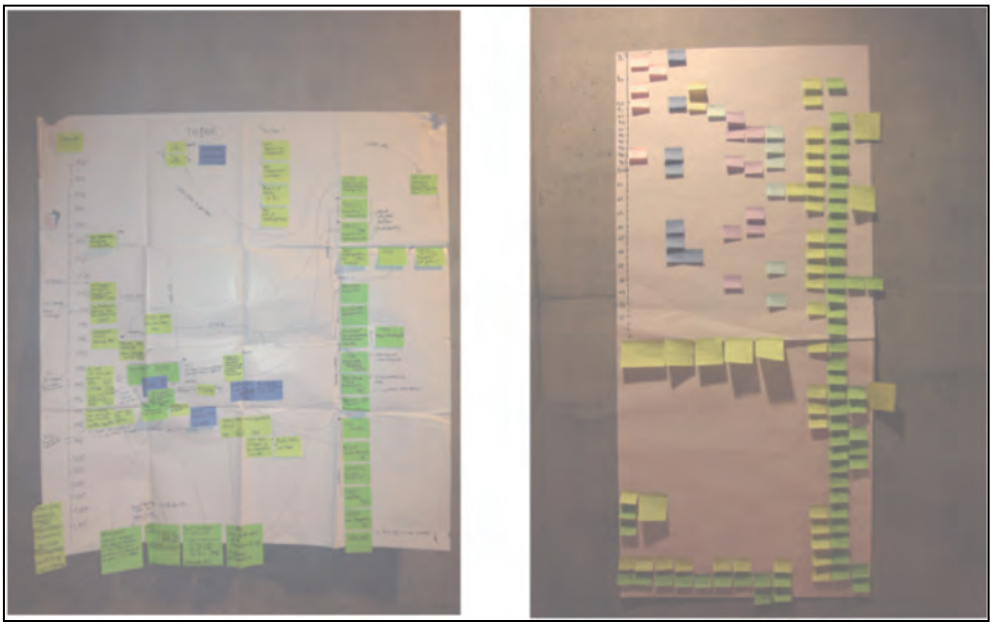


Figure 8: Socio-technical timeline maps no. 1-2 over history of the company Think

Figure 9: Socio-technical timeline map no. 3 over history of the company Think

4.5 Drawing on observations from other studies based on Think's innovation process

In this section I draw attention to other Think-related studies, which similar to this research deal with organization and innovation aspects. These studies are relevant as their findings underscore the difficulty of predicting the future success or failure of radical technology innovations. Furthermore, they confirm that electric car development, and that more particularly, Think as a different and interesting player in the automotive industry, has attracted scholarly attention over the years, alongside growing interest in the development of environmentally friendly product design, production methods and processes, distribution and marketing approaches. As such it may be argued that studies focusing on electric car development may impact and benefit debates among electric car engineers, managers and advisors, and other fields with interest in innovation technology development. In the following, attention is given to the studies[17] of Schwartz (2002) on "Strategies for developing new environmentally adapted cars", Nieuwenhuis and Wells (2003, pp. 45-48) on "Environment technology and the creation of new market segments", and Orsato and Wells on the ecological modernization of the automotive industry (Orsato, 2001, 2009; Wells & Orsato, 2004). A brief literature review will ensue, followed by my critical observations that Think-related studies remain silent about details of partnership processes in relation to Think's technology journey.

4.5.1 As a new environmentally adapted car – Schwartz

In a study of how the different roles and strategies of actors are important for a project to survive, Schwartz (2002, p. 1) defined Think as a network organization and went on to examine and describe the interests and motivations of

[17] During the research process I came across a number of interesting studies including academic theses and strategic market reports drawing on Think (see Appendix 2, p. 266 for an overview), however this discussion has been limited to academic papers and book chapters.

Think's owners, large users, suppliers, research and development partners, and other parties who were closely engaged in the project from the early beginnings. The study described how technology know-how, technology expertise, organization status and financial support mattered from Think's point of view. According to Schwartz (2002, p. 1) different strategies had been employed in order to create public opinion, increase the importance of environmental issues, and develop new business opportunities by the different partners. In this way, Schwartz argued that Ford's engagement with Think represented a break from "the traditional resistance in the car industry to new technical solutions" (2002, p. 2) and that Think allowed prospects with Ford to "easily fulfill the ZEV mandate" (Schwartz, 2002, p. 16). The relation to Ford also appears to be what rescued Think financially at the time. Schwartz noted that, in general, partners' readiness to collaborate with Think which was in part premised on the Founder, Ringdal, who was perceived "as a charismatic person and someone to trust" (2002, p. 4). Schwartz further highlighted the support of large companies as a necessary condition for creating less restrictive access to public funding (Schwartz, 2002, p. 4) and with that, Think's organizational existence and possible success: "This strategy has given the TH!NK *city* project stability, status and financial strength" (Schwartz, 2002, p. 9). Furthermore, Schwartz referred to the "timing" (2002, p. 9) of the project as an important factor, working both for and against the project, also affected by an increasing environmental awareness in society and the larger car manufacturers' learning needs. The latter was especially perceived as important for competition, as learning would enable competitors a greater chance of innovation in developing electric cars. While Schwartz analyzed Think through the lenses of institutional theory and primarily focused on the notion of actors gaining legitimacy in terms of their environmental awareness through their involvement in the Think adventure (Schwartz, 2002, p. 16), Schwartz' empirical accounts support the empirical findings in the present research.

4.5.2 As a viable business model or not? – Nieuwenhuis and Wells

Studying the relation between the environment, technology and the creation of new market segments, Nieuwenhuis and Wells (2003, pp. 45-48) considered the case of Think. Convinced that technology was not enough in itself for electric cars to succeed, the authors primarily questioned the viability of Think's business model based on the "Th!nk @bout London" project launched on September 11, 2001 that Ford had engaged in. This project involved the collaboration of leading businesses outside and within the Ford group (Hertz, Kwik Fit and Ford with 15 Think City cars), environmental groups and the UK government. Nieuwenhuis and Wells found that Ford, in their process of product creation, appeared to "combine market testing with public relations [and] sought to be inclusive, to gain support of key stakeholders in advance of putting the cars onto the streets of London" (2003, p. 46). This was also reflected in the partners chosen to drive the vehicles, who were selected from a list of 50 applicants according to usability and environmental profile. In addition, Nieuwenhuis and Wells noted the project illustrated "how markets are shaped, and even designed" (2003, p. 47). They identified how Think's product concept made it to market through even more open and intentional ways in order to create the necessary support to "overcome perceived performance disadvantages" and build political and business coalitions vital to the creation of such a context (Nieuwenhuis & Wells, 2003, p. 47) – Think's government support in relation to this project was not attracted by accident; it was based on a process of political consensus-forming that resulted in a general sense-making about the contributions of participation, which also served as the condition for marketing activities. However, as Ford eventually sold-off Think, Nieuwenhuis and Wells questioned whether Think was "another false down – or possibly an illustration of the inability of the established automotive industry to create a viable new business model" (2003, p. 48). They concluded the situation could at least be considered as a case exemplifying the many challenges the automotive industry faces when introducing new technologies seeking to meet environmental needs.

Later, Wells (2009) returned to the study in his article "Think: The end of strategy?" and applauded Think for its "rather well-finished and professional electric car [and] intriguing strategy premised on low-volume production, Internet-based sales, and the location of small factories in the markets they were to serve"(2009, p. 1). Thus, Wells recognized Think's business strategy capabilities on paper, but concluded that, "the problem really has always been price"(2009, p. 1). Wells also concluded that the project had lost its innovative edge in terms of distribution, marketing and design, and doubted its success given the loss of "original elegance of the manufacturing system"(2009, p. 1).

4.5.3 As a practical bypass for large-scale manufacturing – Orsato

Studying the ecological modernization of the automotive industry leading to greening as a core competence, Orsato (2001, 2009) investigated the production paradigm of Think. He found several processes and operations that "entailed a minimal environmental impact, as compared to the production system of traditional car manufacturers" (Orsato, 2009, p. 10). In relation to this, Orsato referred to the use of aluminum for the space-frame, the way the body was being produced, and the low-volume production series. Orsato deemed Think to be an example of a company trying to "cover the wider possible scope of corporate environmentalism, represented by the win-win zone" (2009, p. 14), but showing "the vital importance of obtaining returns from eco-investment that present a competitive nature" (2009, p. 16). In this regard, Orsato (2001, p. 259) emphasized the positive role of environmental policies and programs used to increase a national competitive advantage (Porter, 1990). Though he considered Think as having suffered the fate of market failure, its production paradigm represented "the practical viability of bypassing the imperative of large-scale manufacturing" (Orsato, 2009, p. 170). In part, Orsato attributed Think's accomplishments to the concept of Micro Factory Retailing (Wells & Orsato, 2004), which "is in essence a business model for the automotive industry in a distributed economy: in this sense it is an attempt to

define a business model that allows the transition to be made from the current condition to some (more sustainable) future" (Wells & Orsato, 2004, p. 376).

4.5.4 Summing up

Indeed, looking into this earlier research related to Think, I found resonance for some of my observations and inspiration for ways of perceiving Think's roles in general and in relation to strategic, automotive and environment discussions. Nevertheless, I found little hold in terms of understanding how any such role originates through Think's collaborative actions and partnerships.

In her paper, Schwartz' (2002) engages with the notion of partnership and the recognition that partnerships are of importance, but how partners were closely engaged, how they provided support, or how they created opinions, was not explicitly explained, but seemed to be more accounted for unintentionally. However, Schwartz (2002) identified Ford as a potential solution to Think's situation at the point in time they were forming their partnership. Thereby, the author hinted at the problem-solving need as a premise for forming partnerships. Further, the importance of Founder Ringdal and larger organizations as actors who embodied trustworthiness was deemed an element that impacted partnerships in a positive way; for example, access to public funding became less restricted. Schwartz (2002) also hinted at how the notions of success and failure have context attachments as to the importance of timing, partners public media exposure and own driving and testing experiences in relation to Think. These were identified as elements that impacted the perceptions of Think's usefulness as a partner and as a car manufacturer, more than what production figures could reveal. These insights were helpful in my partnership analysis process to support my developing partnership drift argument.

Though I found Nieuwenhuis and Wells (2003) talked about 'partners' in relation to their analysis of the "Think @bout London" project, their focus remained on levels of partnership, selection, role, reputation, and on noticing some of the tasks partners were expected to be carrying out during the collaboration. But also these authors failed explain how these partnerships un-

fold in detail: what the actual doings were when carrying out tasks, how expertise was enacted, what it meant to be 'inclusive' or create support, and how the partnerships participated in market-shaping and design were all questions left unanswered. It was merely noted that the "Think @bout London" project was an "important lesson"' (Nieuwenhuis & Wells, 2003, p. 47), which alluded to the possibility that the authors were concerned with some form of learning and partnership sensemaking. Another point that stood out, as I read, was the authors' attempt to conclude on Think's fate: either a success or failure, able or unable to create a viable new business model. Nieuwenhuis and Wells (2003) expressed that Think represented an example of the many challenges that occur when introducing new environmentally friendly technologies; on the one hand, they made no judgment on the future that lies ahead for Think, but on the other hand, as Wells (2009) later stated, the future would be dependent on a price-factor on which partnerships had no direct impact.

Finally, Orsato (2001) also engaged with the notion of partnership and the recognition that partnerships are of importance. Nevertheless, how some partners are perceived more important than others, how partners collaborate, define their commitments, competences and constraints in the partnership, was not explicitly explained, perhaps because Orsato substantially relied on Schwartz and Maruo's (1998) report[18]. However, Orsato approached Think as part of a socio-technical ensemble with this figure "The Evolution of the *PIVCO-Th!nk* Venture" (2001, p. 259) (see Appendix 4, page 279) and considered Think as a potential solution to environmental policies and programs at the point in time in which it was initially founded. Thereby, the author addressed technology innovation development as a context-specific act, and hinted at a need for theoretical analysis of technology innovation development to attend to the wider environment of partnerships. I found these insights helpful in my analysis of the uncertainty and unpredictability of partnerships and they further helped me reflect on my own mapping approach to analysis.

[18] In relation to this research it has not been possible to trace Schwartz and Maruo's report — neither through different academic online services, the library service of the University of Twente, or through direct contact to the authors (email correspondence 5 April 2012 with Schwartz).

5 Technology innovation development through problem-solving in socio-technical ensembles

This chapter introduce briefly the Norwegian electric car manufacturer, Think, focusing on how the initial idea was sketched out and what the company has become known for. This introduction is followed by another brief introduction to the thesis' four analytical cases on battery, drivetrain, headlamp and financial engineering that demonstrate technology innovation development through problem-solving in different partnerships across time as part of temporary socio-technical ensembles. Subsequently, the four cases are presented.

5.1 Introducing Think and the electric Think City car

The Think City[19] car, which once was sketched out by the Norwegian Bakelite factory owner Lars Ringdal and later built as a prototype by his son Jan Otto Ringdal, has continuously been drawing attention for the past twenty years. Lars Ringdal got the idea for the Think City during the 1973 oil crisis[20]. In Norway, as well as in other countries, the oil crisis imposed strict limitations on the driving of cars in order to ration oil reserves. Internationally, the oil crisis also resulted in measures to reduce the dependency on oil and drive for environmental technology solutions. An electric car could make private mobility possible without limitations, as Norway was self-sufficient on electric power at the time. Lars Ringdal wanted to create something small and atypical solving an urban mobility need. He thought of applying a plastic production

[19] The initial prototypes of the Think City car were called PIV1, PIV2, and PIV3, which stood for Personal Independent Vehicle. PIV3 was also called the "CityBee". The name "Think City", which was often commercially referred to as the "Th!nk City", was conceived during the Ford period of ownership between 1999 and 2002. For reasons of simplicity I refer to all versions of the car as the "Think City" car througout the thesis, while I also associate it to the relevant development versions in my illustrations.

[20] Information based on interviews from 2008 with Jan Otto Ringdal.

method enabling the use of the technology he already had. He figured that if he could build the chassis of the car in thermoplastic material it would neither become rusty or scratched. Thus, a compact plastic-bodied vehicle was conceived. However, as the oil crisis subsided, the relevance for and interest in electric vehicles declined and the electric car idea found a place in Lars Ringdal's work desk drawer. His son, Jan Otto Ringdal (Ringdal), later opened that drawer in 1981 and began work on a conceptual model of the electric car. Ringdal found that increasing public environmental concern could indicate a social readiness for electric cars. This interest was expressed partly with concerns for greenhouse gas emissions and partly with concerns for city traffic congestion. In addition, he was aware of the ZEV mandate and the United States of America Battery Criteria (USABC) partnership. In 1991 he founded the Personal Independent Vehicle Company (Pivco) and soon after, in 1992, a first driving prototype was produced with financial and technical support from Norwegian companies such as Statoil, Hydro and Oslo Energy.

Today, the company has become known as Think[21], and the Think City car has continued to draw attention not only through the vision of clean urban mobility, but also due to its technology development. Think has aimed to change the way people think about cars, and with an electrical and fully recyclable vehicle, Think has come to play a part in the transformation towards a cleaner and environmentally friendlier mobility (Think, 2010). The Think City has been developed as a modular car, maintaining a focus on clean recyclable materials, non-polluting production processes and optimal uses of materials. It has been conceived to meet the demands of urban mobility: convenient for work distance, shopping and other activities. As there is no market standard set for batteries, they are subject to intensive turbulence, and continue to be a high-cost component; batteries are leased to the car owner and returned to the supplier at the end of their usable lifetime. Silent and small, the Think City

[21] Initially the company name was "PIVCO" (1990-1999). As Ford bought the company, it became part of the "Think Goup" (1999-2002). During the ownership of the Kamkorp Group the company was called "Think Nordic" (2002-2006), and as Norwegian investors took over in 2006, the name shifted to "Think Global". For simplicity reasons I refer to the company as "Think" throughout the thesis.

also contributes to reducing noise and congestion problems in urban environments. The overall ecological balance of the Think City depends on the type of electricity that it is charged with. But, even when it is dependent on mixed energy sources, it is still three times more energy efficient than a fossil fuel car.

Despite its long innovation journey, it was only recently that sales grew. According to an interview with Head of Sales Richard Waitz, Think expected to sell 700 units of its cars in 2010 in Norway alone – a country, which today has about 3000 electric cars on its road. In addition, Think expected to sell another 2000 cars across, Austria, France, the Netherlands, Spain and Switzerland. Compared to sales in 2008, when 350 cars sold in Norway, and 2006 sales, when 50 cars sold, Think seemed to be doing well. In 2010 Think sales comprised of deals with several hundred retail customers in Norway, as well as fleet and municipal customers all over Europe including the Austrian Vlotte project and the European car sharing group MoveAbout. Teaming up with strong distributors like Migros, which is a grocery and department store in Switzerland, and Norauto in France, it became evident that Think was willing to take new routes to market.

Throughout its innovation journey, Think has been able to maintain existence, not through stability, carefully selected and standardized technology, best-practice project routines and organization set-up, long-term development partnerships, regular sales to a defined and loyal market segment, a successful reputation, or other elements I could list that would give a sense of development predictability and certainty. Think has maintained existence through transformations in partner-networks, problem-solving experiments and trials with different technologies, being used as showcase platforms that allow for the interpretation of other developing technologies, the construction of and gain in access to public events, picking-up emergent learning opportunities from collaborative failures and successes, and through an ongoing process of redefining itself and its product idea. As founder Ringdal explained,

> It was a bit of a dilemma. We had to discover our way forward with partners who were willing to work with us, but at the same time gave us freedom. […] We had to be very open about our agenda and try out something without making standard

> commitments and agreements to ensure we had flexibility. Clearly, if we would get a larger supplier, who had a greater possibility of testing, developing and perhaps wanted to invest in parts of the motor, testing or something similar, then it would be different. But then we would also have joint interests in the project idea and we would share the experience that we gained along (JOR, interview 09/2008).

This ability and capacity to maintain existence will be further elaborated in the empirical analysis and discussion of the research.

5.2 Introducing the four Think cases

The following four cases on battery, drivetrain, headlamp and financial engineering are different, but have several interdependencies. The cases are related as they all focus on the technology innovation development of the Think City car, from the first development experiments in 1990 to the latest activities in 2011. By following the problem-solving that takes place during the ongoing development process, all cases draw in and describe the external partnerships that form, break, and sometimes reform around the subject component the particular case addresses. Similarly, all cases emphasize individual partners' interests and expectations of collaboration. In fact, some partners are involved in more than one of the cases, creating another dimension to the interdependency.

The case differences are defined by their different detailed focus on development of the Think City car, respectively through battery, drivetrain, headlamp and financial engineering. Therefore partners, technologies, problem-solving ways and what create emergent learning opportunities, define success and failures and affect the unpredictability and uncertainty in different ways. Another difference is that while the battery, drivetrain and headlamp cases only address their closer environment of the greater project, the financial engineering case involves company management and strategizing from the overall project perspective.

The cases are structured to highlight the matter of partnership transformation as well as the redefinition of itself and the product idea by the arrangement of, firstly forming, then breaking and reforming partnerships,

which is then followed by an overall case synthesis. The following table provides an overview of the number of transformations that have been identified across the cases:

Table 6: Number of forming, breaking and reforming partnerships in the four cases

Think cases	Battery	Drivetrain	Headlamps	Financial
Forming	9	10	5	19
Breaking	7	8	2	5
Reforming	4	0	1	2

All four cases present their own development timeline overview emphasizing all forming and reforming relations in historical, chronological order and their relations to a Think City car version and relevant technology or events. However, the following large histo-graphical multi-attributional timeline in **Figure 10**[22] presents upfront, the un-narrated complexity of the Think City technology innovation process overview.

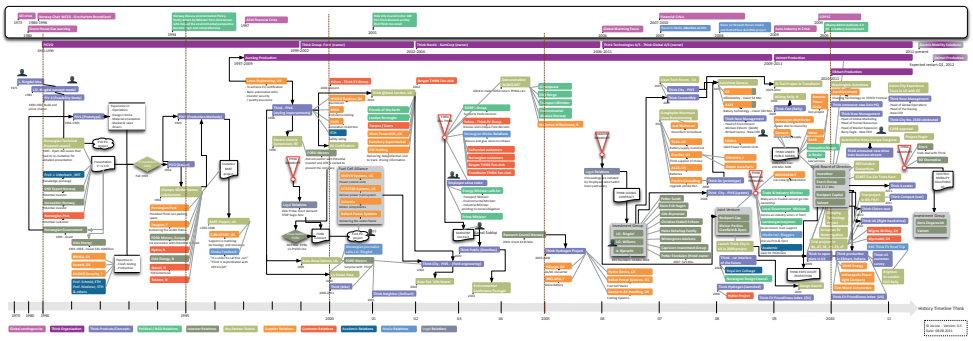
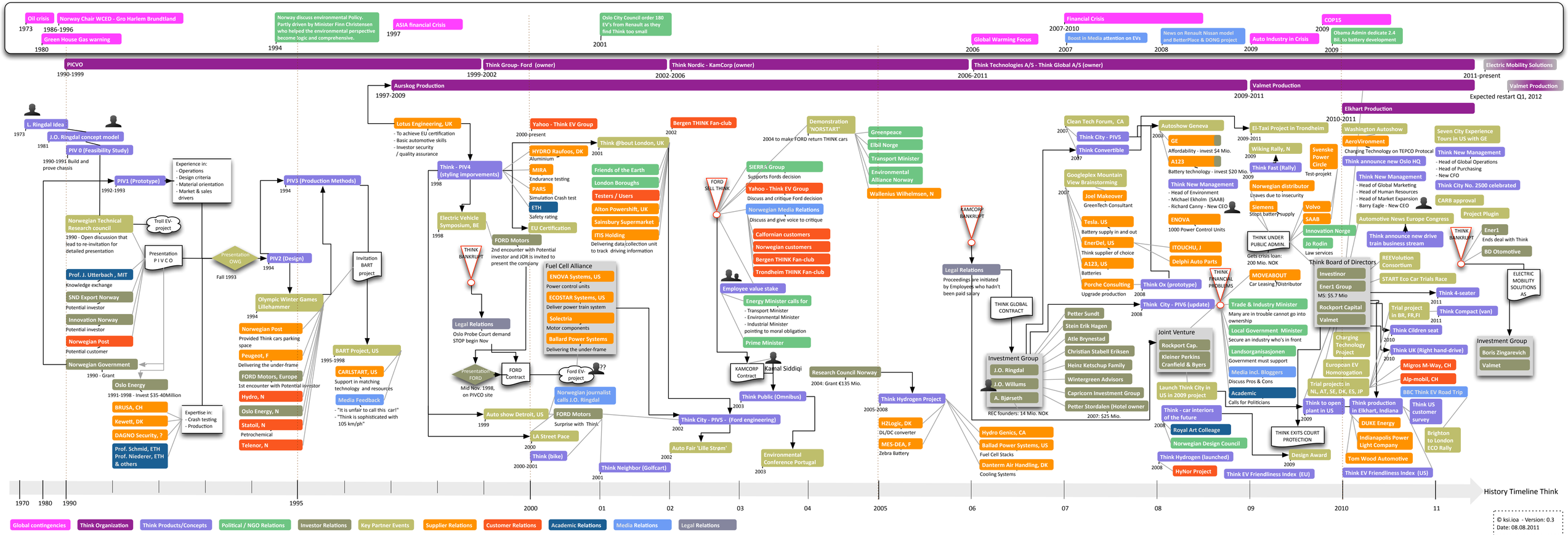


Figure 10: Large histo-graphical multi-attributional Think-timeline

[22] Please fold out the following double pages for a readable version of the this timeline.


Oil crisis
1973
Norway Chair WCED - Gro Harlem Brundtland
1986-1996
Green House Gas warning
1980
Norway discuss environmental Policy. Partly driven by Minister Finn Christensen who helped the environmental perspective become logic and comprehensive.
1994
ASIA financial Crisis
1997
Oslo City Council order 180 EV's from Renault as they find Think too small
2001
Global Warming Focus
2006
Financial Crisis
2007-2010
Boost in Media attention on EVs
2007
News on Renault Nissan model and BetterPlace & DONG project
2008
Auto Industry in Crisis
2009
COP15
2009
Obama Admin dedicate 2.4 Bil. to battery development
2009
PICVO
1990-1999
Think Group- Ford (owner)
1999-2002
Think Nordic - KamCorp (owner)
2002-2006
Think Technologies A/S - Think Global A/S (owner)
2006-2011
Electric Mobility Solutions
2011-present
Aurskog Production
1997-2009
Valmet Production
2009-2011
Valmet Production
Expected restart Q1, 2012
Elkhart Production
2010-2011
L. Ringdal Idea
1973
J.O. Ringdal concept model
1981
PIV 0 (Feasibility Study)
1990-1991 Build and prove chassis
PIV1 (Prototype)
1992-1993
Experience in:
- Operations
- Design criteria
- Material orientation
- Market & sales drivers
Norwegian Technical Research council
1990 - Open discussion that lead to re-invitation for detailed presentation
Troll EV-project
Presentation P I V C O
Presentation OWG
Fall 1993
PIV2 (Design)
1994
Prof. J. Utterbach , MIT
Knowledge exchange
SND Export Norway
Potential investor
Innovation Norway
Potential investor
Norwegian Post
Potential customer
Norwegian Government
1990 - Grant
Oslo Energy
1991-1998 - Invest $35-40Million
BRUSA, CH
Kewett, DK
DAGNO Security, ?
Prof. Schmid, ETH
Prof. Niederer, ETH & others
Expertise in:
- Crash testing
- Production
PIV3 (Production Methods)
1994
Invitation BART project
Olympic Winter Games Lillehammer
1994
Norwegian Post
Provided Think cars parking space
Peugeot, F
Delivering the under-frame
FORD Motors, Europe
1st encounter with Potential investor
Hydro, N
Oslo Energy, N
Statoil, N
Petrochemical
Telenor, N
BART Project, US
1995-1998
CARLSTART, US
Support in matching technology and resources
Media Feedback
- "It is unfair to call this car!"
- "Think is sophisticated with 105 km/ph"
Lotus Engineering, UK
- To achieve EU certification
- Basic automotive skills
- Investor security / quality assurance
Think - PIV4 (styling imporvements)
1998
Electric Vehicle Symposium, BE
1998
FORD Motors
2nd encounter with Potential investor and JOR is invited to present the company
THINK BANKRUPT
Legal Relations
Oslo Probe Court demand STOP begin Nov
Presentation FORD
Mid Nov. 1998, on PIVCO site
FORD Contract
Yahoo - Think EV Group
2000-present
HYDRO Raufoss, DK
Aluminium
MIRA
Endurance testing
PARS
Simulation Crash test
ETH
Safety rating
EU Certification
Think @bout London, UK
2001
Friends of the Earth
London Boroughs
Testers / Users
Alton Powershift, UK
Sainsbury Supermarket
ITIS Holding
Delivering data collection unit to track driving information
Bergen THINK Fan-club
2002
Fuel Cell Alliance
ENOVA Systems, US
Power control units
ECOSTAR Systems, US
Deliver power train system
Solectria
Motor components
Ballard Power Systems
Delivering the under-frame
Ford EV-project
Norwegian journalist calls J.O. Ringdal
Auto show Detroit, US
1999
FORD Motors
Surprise with Think
LA Street Pace
2000
Think (bike)
2000-2001
Think Neighbor (Golfcart)
2001
Think City - PIV5 - (Ford engineering)
2002
Auto Fair 'Lille Strøm'
2002
Demonstration 'NORSTART'
2004 to make FORD return THINK cars
Greenpeace
Elbil Norge
Transport Minister
Environmental Alliance Norway
Wallenius Wilhelmsen, N
FORD SELL THINK
SIERRA Group
Supports Fords decision
Yahoo - Think EV Group
Discuss and critique Ford decision
Norwegian Media Relations
Discuss and give voice to critique
Calfornian customers
Norwegian customers
Bergen THINK Fan-club
Trondheim THINK Fan-club
Employee value stake
Energy Minister calls for
- Transport Minister
- Environmental Minister
- Industrial Minister
pointing to moral obligation
Prime Minister
KAMCORP Contract
Kamal Siddiqi
2003
Think Public (Omnibus)
2003
Environmental Conference Portugal
2003
Research Council Norway
2004: Grant €135 Mio.
Think Hydrogen Project
2005-2008
H2Logic, DK
DL/DC converter
MES-DEA, F
Zebra Battery
KAMCORP BANKRUPT
Legal Relations
Proceedings are initiated by Employees who hadn't been paid salary
THINK GLOBAL CONTRACT
Investment Group
J.O. Ringdal
J.O. Willums
A. Bjørseth
REC founders: 14 Mio. NOK
Petter Sundt
Stein Erik Hagen
Atle Brynestad
Christian Stabell Eriksen
Heinz Ketschup Family
Wintergreen Advisors
Capricorn Investment Group
Petter Stordalen (Hotel owner
2007: $25 Mio.
Hydro Genics, CA
Ballad Power Systems, US
Fuel Cell Stacks
Danterm Air Handling, DK
Cooling Systems
Clean Tech Forum, CA
2007
Think City - PIV5
2007
Think Convertible
2007
Autoshow Geneva
2008
GE
Affordability - invest $4 Mio.
A123
Battery technology - invest $20 Mio.
Think New Management
- Head of Environment
- Michael Ekholm (SAAB)
- Richard Canny - New CEO
ENOVA
1000 Power Control Units
ITOUCHU, J
Delphi Auto Parts
Think Ox (prototype)
2008
Think City - PIV6 (update)
2008
Joint Venture
Rockport Cap.
Kleiner Perkins Cranfield & Byers
Launch Think City in US in 2009 project
Think - car interiors of the future
2008
Royal Art Colleage
Norwegian Design Council
Think Hydrogen (launched)
2008
HyNor Project
Ei-Taxi Project in Trondheim
2009-2011
Wiking Rally, N
2009
Think Fast (Rally)
2009
Norwegian distributor
Leaves due to insecurity
Siemens
Stop: battery supply
Volvo
SAAB
Innovation Norge
Jo Rodin
Law services
Svenske Power Circle
Test-projekt
Googleplex Mountain View Brainstorming
2007
Joel Makeover
GreenTech Consultant
Tesla, US
Battery supply in and out
EnerDel, US
Think supplier of choice
A123, US
Batteries
Porche Consulting
Upgrade production
THINK UNDER PUBLIC ADMIN.
Gets crisis loan: 200 Mio. NOK
MOVEABOUT
Car Leasing Distributor
THINK FINANCIAL PROBLEMS
Trade & Industry Minister
Many are in trouble cannot go into ownership
Local Government Minister
Secure an industry who's in front
Landsorganisasjonen
Government must support
Media incl. Bloggers
Discuss Pros & Cons
Academic
Calls for Politicians
Think to open plant in US
2009
THINK EXITS COURT PROTECTION
Design Award
2009
Washington Autoshow
AeroVironment
Charging Technology on TEPCO Protocal
Think announce new Oslo HQ
Think New Management
- Head of Global Marketing
- Head of Human Resources
- Head of Market Expansion
- Barry Eagle - New CEO
Automotive News Europe Congress
Think announce new drive train business stream
Think Board of Directors
Investinor
Ener1 Group
MS: $5.7 Mio
Rockport Capital
Valmet
Charging Technology Project
European EV Homologation
Trial projects in NL, AT, SE, DK, ES, JP
Think production in Elkhart, Indiana
DUKE Energy
Indianapolis Power Light Company
Tom Wood Automotive
Think EV Friendliness Index (US)
Seven City Experience Tours in US with GE
Think New Management
- Head of Global Operations
- Head of Purchasing
- New CFO
Think City No. 2500 celebrated
CARB approval
Project Plugin
THINK BANKRUPT
Ener1
Ends deal with Think
BD Otomotive
REEVolution Consortium
START Eco Car Trials Race
Think 4-seater
2011
Trial project in BR, FR,FI
2011
Think Compact (van)
2011
Think Cildren seat
2010
Think UK (Right hand-drive)
2010
Migros M-Way, CH
Alp-mobil, CH
BBC Think EV Road Trip
Think US customer survey
Brighton to London ECO Rally
ELECTRIC MOBILITY SOLUTIONS AS
Investment Group
Boris Zingarevich
Valmet
History Timeline Think
1970
1980
1990
1995
2000
01
02
03
04
2005
06
07
08
09
2010
11
Global contingencies
Think Organization
Think Products/Concepts
Political / NGO Relations
Investor Relations
Key Partner Events
Supplier Relations
Customer Relations
Academic Relations
Media Relations
Legal Relations
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Date: 08.08.2011

5.3 Partnerships around battery systems in the electric car

This part focuses on the forming, breaking and reforming of relations between the Think battery system, battery system developments' partners and the electric car. Analysis of these aspects leads to vital understandings of partnership evolution. To use a simple analogy: the battery system can be considered as the 'heart' of the Think City, and the rest of the car, as the 'body'. Essentially, the battery system is physically interlinked with the rest of the car. The choice of battery has consequences for how the drivetrain is tuned as the battery is what powers the Think City electric car; without the battery the electric car cannot move. And, as the main cost-driver, the battery plays a critical role in determining the electric vehicle's viability. Combined, these essential car parts also influence the character of partnerships and the chosen directions for research and development.

Battery suppliers explore electrochemical active materials, component raw materials and their integrated configurations in order to excel in battery storage capacity. Balancing, cooling and monitoring systems ensure energy-release control and cell life-span, which is essential to all battery solutions. Paralleling this, Think engineers and automotive partners explore how battery system modules may be combined and integrated into the Think City in order to power functionality such as the drivetrain, headlights, radio, ventilation, and provide a long-range use of the vehicle. Together, these partners make use of hands-on approaches, assembling and testing as they work on ways to overcome the compromises in battery technology that pose safety, performance and cost-challenges to battery systems which are applied in the Think City.

All battery partnerships that Think engaged in were at some point in time formed and later broken and in some cases, partnerships reformed. To date, Think has worked with six different battery technology development partners: SAFT, Ford, FZ Sonick, Tesla, EnerDel, and A123. Different people formed battery partnerships in different ways and around different battery technology and different versions of the Think City. **Figure 11** page 129 shows the relations over time.

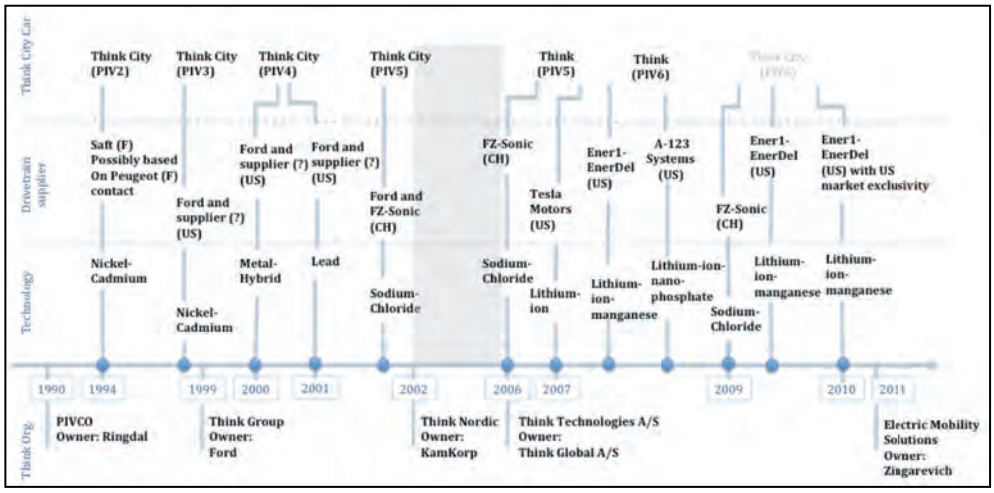

Figure 11: Think battery development partnership overview

The partnerships are part of the technological frame and they are driven by interests and expectations related to problems and potential solutions appearing in the innovation process. In each partnership there was uncertainty and unpredictability making them only relatively stable as analyzed in the following partnership examples.

5.3.1 Forming partnerships based on flexibility and adaptability

Think was built on the philosophy that it couldn't and shouldn't make batteries itself. Think kept in close dialogue with potential suppliers in the sense that it tested different alternative battery systems and tried to implement those it considered to have a potential winning application for the future of battery technology in the Think City car. Thereby, Ringdal deliberately drew up where to capture value, develop competencies and who to seek partnerships with in relation to the battery component — a strategy to establish relations with necessary complementary assets (1986). Founder Ringdal explained,

> We said that we should not develop batteries ourselves. It was not part of the idea that we should develop our own batteries, drivetrain or other components. I always said that we should seek to use existing components. When giving a presentation I would be asked: "How do you think you are able to build an electric car? Do you have batteries?" And I would explain that

> we should find the batteries in the market; there where we find those who are willing to support us and who develop the best "state of the art" batteries, drivetrains and energy. We would seek to find the specialists in these areas (JOR, interview 09/2008).

This buy-decision affected Think's approach to partnership forming in the first place as it led battery partnership flexibility and adaptability to be considered in the way the Think City car related to the battery system. Think CTO Mollestad confirmed: "This means that we are making the Think City [car] accept any new battery technology in an easy-to-replace, modular way" (EM, interview 11/2010). What he referred to was an important feature of the Think City car, placed in the middle of the car, removable from underneath, a rectangular battery box that carried measures that basically allowed any battery part to fit inside[iii]. In partnership relational terms, this means that Think understood battery technology would continue to develop, and it saw the possible technology constraints in relying only on one supplier, which led Think to deliberately to pursue a kind of technology partnership-hedging strategy. Think PL Feltheim explained,

> We roughly know where we are today, but nobody knows where we will be in five years' time, because development on battery technology is ongoing. Therefore it has been our philosophy that it should be easy to insert a battery and connect a battery. Besides this aspect, we have considered risk-avoidance by working with several suppliers. Without a battery an electric car won't work, right, so if we are too dependent on a battery supplier – and we know batteries are difficult and things happen – so if the battery supplier has problems, we automatically have problems too. Lastly, we are pretty ambitious about the volume and as it is today, there are no battery suppliers that can deliver the entire volume (OF, interview 01/2010).

Think's battery-agnostic reflected an openness to possible future partnerships in battery technology as well as the development of its own battery concept as shown in **Figure 12**[23] page 131.

[23] The source is Think presentation, 2010.

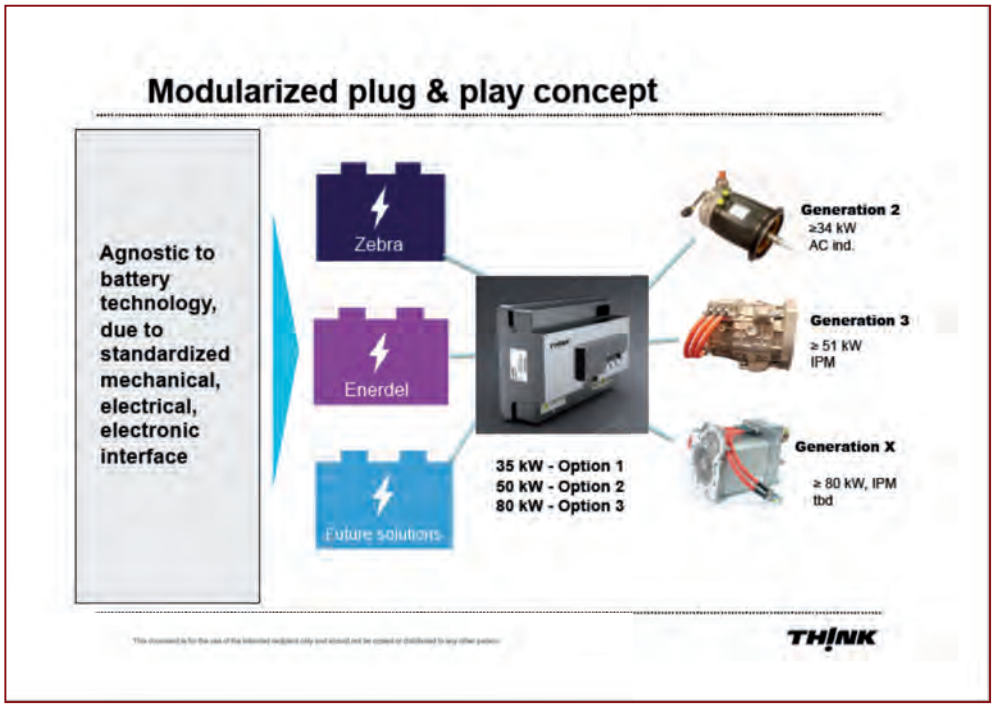

Figure 12: Think modularized battery plug-and-play concept

But the buy-decision attached to battery parts also affected the individual forming battery partnerships in both good and problematic ways. To partners simply seeking to learn from testing and demonstrating their technology the buy-decision offered advantages and Think itself remained in a flexible position in terms of its overall project: any company that was able to meet Think's battery criteria[iv] was of interest and partners could draw on dispersed knowledge and emergent learning. Meanwhile partners aiming for supply exclusivity and a tight collaboration with their other technology investments found Think's buy-approach meaningless and Think was often left with operational rigidity and a lack in technology innovation learning opportunities.

5.3.2 Battery partnerships forming

5.3.2.1 SAFT partnership forming around NiCad batteries upon initial search, 1994-1999

Think's team had selected battery technology prior to searching for its first battery system partner. When Think first sought out battery partnerships in 1994, nickel-cadmium (NiCad) batteries were common and had a majority share of the rechargeable batteries' market. Compared to other options, these batteries had a low internal resistance and a longer lifetime; characteristics that were advantageous for electric cars.

Think's CTO Mollestad recalled, "Through market research we had found that electric car developers such as Peugeot, Renault and Citroën would seek to develop their own interface specifications for nickel-cadmium battery systems" (EM, interview 11/2010). Think also chose to pursue this technology and engineering approach. The technology was chosen because other interested development groups had deemed it a suitable technology solution for electric cars at the time. As interface specifications are pieces of illustrations, tables with figures and written text, specifying as precise and verifiably as possible the user requirements, design, performance and other system characteristics – what to combine with what, what has been done to do that, and what not to do – they are critical engineering tools which follow the development process. As such, Think solved its problem of battery technology selection and information storage and focused on the procuration of battery supplier relations. Was Think thereby trying to learn from development standards of big firms to identify its own way of working with battery technology?

Think had formed a partnership with SAFT; though the initial contact between the two is unclear. Think SM Brown recalled,

> It's fun being there at the start and having to be creative at how you do and get things because you don't have the money, you don't have the name, you don't have the brand, and you don't have anything! But you still have to deliver a product after twelve months (DB, interview 01/2010).

The French company SAFT was one of the world's five largest makers of rechargeable NiCad batteries, providing state-of-the-art batteries for electric vehicles. According to Brown, it is likely that Peugeot – who delivered the

underframe for the Think City car at the time, and also worked with SAFT – played a role in establishing the partnership. Sharing second-tier suppliers is not uncommon in the automotive industry. But why should SAFT work with Think? Think had demonstrated it could build a chassis and had defined a technical concept, which was about all that made them appealing as partners. However, Think CTO Mollestad recalled,

> In this first battery partnership SAFT would supply their existing NiCad battery modules and we would work on connecting the battery modules and develop our interface specifications for the battery system and the car (EM, interview 11/2010).

Hence, SAFT batteries powered the drivable Think City cars at the 1994 Winter Olympics in Oslo and the 1995 BART-project in California. These two events served Think and SAFT in invaluable ways. Firstly, the Think City could be tested in public and Think could also stimulate interest within the automotive scene, political arenas and the greater community. The public presentations of Think City cars also served SAFT in demonstrating the applications and use of SAFT technology — which is something would have been much harder to do without the Think City car serving as a showcase.

To SAFT, however, a partnership formation with Think represented a relatively small deal in terms of volumes. That being so, NiCad technology development was of high importance and Think's developments could only increase SAFT's knowledge-base without the costs of financial investment or development resources. SAFT supplied a standard product without adaptation or engineering consulting and also made reservations in terms of product guarantees – it anticipated Think's experiments with the battery modules beyond the tolerated range SAFT was delimiting. Financially, a partnership with Think represented an 'easy catch' for SAFT. There was little risk attached and a lot of potential benefit. As such, the initial partnership conditions did not reflect long-term expectations in terms of partnership impact, rather it reflected the huge upside – and challenge – around understanding the future market battery standards (see overview of macro trends in appendix 5), and SAFT and Think's timing made the flexible partnering model viable for each.

To Think, this collaboration indeed ignited its first drivable vehicles. It allowed Think to become aware of integration issues demonstrating how

powerful this technology could be: a weak processor, loose connections, a lack of quality control and burnable material too close to the electric connections could all lead to instability. In September 1998, the flawed battery system got hot during use and also loosened which in turn, had once caused a notch that set off a fire which burned down a whole car. Think CTO Mollestad recounted, "I was driving that car that burned so I know this very well, and I think [...] that taught us that this is dangerous stuff" (EM, interview 11/2010). This battery system development learning experience strengthened Think's relationship with SAFT, NiCad battery technology, and battery interface specifications. Think learned how critical it was to communicate and negotiate a common understanding with partners to reduce ambiguity of what either of them was intending; to identify relevant technical automotive skills and thereby ensure the appropriate people would be involved, and to document design assumptions, interpretations and what went wrong during tests. A total redesign and quality control was necessary (after the fire) in order for Think to forge ahead. This is what shifted the direction of Think's actions towards other partners.

5.3.2.2 Ford partnership forming around a NiCad battery system redesign, 1998-2000

The burned car was a problem that led Think to a new partnership with Ford, which began in 1998, and redesigning the whole battery system was part of what prompted Think's relationship with Ford engineers. In 1999, the flawed battery system gave structure to the partnership. Together, Ford and Think worked out solutions: how to seal everything, remove all flammable materials and build process controls into the battery system so as to avoid car fires. Solutions were not found through planning, but work took place on the factory floor between paper drawings, battery components, wires, measuring instruments, soldering irons, other craft tools and the Think City 'body'. Think CTO Mollestad recalled,

> A lot of weekly cross-Atlantic telephone meetings, a lot of back-and-forth. Project management of the Think City always remained in Norway, but a part of the electric system and battery system was made at Ford in the US (EM, interview 11/2010).

The battery system influenced the development process by enabling design validation and showing weaknesses and opportunities in relation to modularity, performance, quality, and cost, while the two partners cooperated: searching, combining, assembling, testing, and discussing to find out what worked with what in order to make suitable adaptations. Through this process, Think learned the importance of finding partners willing to specialize and co-develop with it when engaging with Think's battery technology development needs. An intimate socio-technical interaction, where partners and technology are specializing towards one another, formed the partnership and the construction of a new design. The redesigned system was like the previous system based on NiCad batteries and delivered relatively robust battery systems that in some cases still run today. The partnership entailed a careful work process that may help explain why Think hasn't had any car fires since – in relation to NiCad battery systems or other battery systems.

However, Ford's intention of forming relations with Think, also in terms of battery systems, did not center around the battery system developed for the Think City. Initially, Ford wanted to develop a battery system solution with Think which would allow it to benefit from the resources it already had. It was a struggle to make Ford realize that its approach was not so feasible. Think PL Feltheim explained:

> Ford wanted to go to market as soon as possible with an affordable product and that was the beginning of a parallel run. In one case it was the aim to convert a Ford car into an electric car and the alternative case was to continue building on the Think product. This clearly proved that the structure of design was very different. Our product was designed from the start to have a big space in the middle of the car giving room for a heavy battery. A much more flexible structure and a compressed steel chassis. But Ford was very determined: they had a car, which was being produced in volumes. The framing, the investments, the production tools, suspension and everything were in place – it just had to be made electric. I think they made simulations and crash-tests, but it turned-out, as Think had said, that they didn't manage to get good driving conditions in this vehicle, because they didn't manage to balance the weight of the battery in this car. It wasn't designed to be an electric car from the start. So they returned to Think and said: "Okay, you can develop the car based on the development project you had lined-up". This

> was a success for the Norwegian environment over the big Ford machinery (OF, interview 01/2010).

Time-to-market, product liability and low production costs were important to Ford and it considered a partnership with Think as one possible way to market Ford's version of an electric car. Ford had a car it could produce in high volumes and it wanted to convert a part of this volume production into electric cars. That seemed not to be a problem. Think was perceived as a small organization unit that could speed-up the development of Ford's conversion car model. Think could complement Ford's lack of resources in terms of electric circuit and battery system experience with fully electric cars and, not least, Think could contribute with its efficiency in low-volume production. To some extent Think was aware of these intentions, but Think's team thought Ford also had an interest in the Think City. Founder Ringdal recounted,

> It is difficult to see how Ford values us, but in addition to the car, I think Ford has an interest in our methodology for reasonable costs at low volumes. Ford tells me they are interested in [Think] as an organization, to use as a swift development center where things can be done quicker than in a large organization (JOR in Kobe (1999)).

Forming the partnership may have seemed straightforward to Ford, but not only did Think remain skeptical during the collaboration around the Ford conversion car model, it also maintained its focus on innovation development and an awareness about how organizational size may impact the speed of development. In an interview with Think PL Feltheim, it was revealed that Think voiced its concerns about the difference in design structure: an electric car needed more structural flexibility. Think found it problematic to form a partnership around the conversion car model with Ford since there was a lack of trust in the Ford design. Founder Ringdal explained,

> You know, many tries to redesign, taking a normal car, removing the back and inserting a battery. But all they prove is that driving electric cars is possible. If you want to design an electric car, you have to design it from the ground up starting with the battery system. If you suddenly insert a 200-kilowatt battery in a normal car, that vehicle looses its characteristics (JOR, interview 01/2010).

While Ford remained technology-oriented in its development approach, Think had, through driving experience, been convinced that the design had to be radically different to that of a conventional car: to achieve convincing driving experience characteristics, main requirements had to relate directly to the battery system and its realization would in turn provide input for other vehicle design aspects. All the same, Ford persisted, not having expected the integrated design structure to be as decisive as it turned out to be throughout the course of the development process. Ford did not predict the difficulty in balancing the battery weight in the conversion model and the difference in driving experience. The battery system that had developed was not conforming to the conversion car model and with too much adaptation to the car, Ford would loose its cost benefit.

The partnership between Ford and Think seemed therefore to be forming rather because of the way Think appeared to work with and think about technology, and its accumulated experience – especially in relation to battery systems; Ford was interested in the same battery technology as Think and this was made evident from when they began working together. However, Ford seemed to only become committed to the Think City project once it had been convinced about the idea of building an electric car from scratch – having failed in its own trials with a conversion model. These failures worked to reinforce Think's success and Ford's return to collaboration on Think's project idea.

5.3.2.3 Ford and Think exploring metal-hybrid batteries for Think City platform, 2000

Subsequently, Ford and Think began forming their partnership by developing a next-generation Think City platform, which positioned the two partners more around the Norwegian idea. However, by now it had become known that from 2008, the NiCad would be banned from automotive use due to the battery's poisonous character. Upon this regulatory drift, this battery type was no longer an option and together, Ford and Think agreed to shift to metal-hybrid batteries. With the new development direction, new problems and solutions were emerging and forming the partnership. Metal-hybrid batteries had much

in common with NiCad, but had better energy density and didn't consist of the poisonous cadmium. Unfortunately, these batteries turned-out to be too expensive, as an expected price reduction did not transpire during the year 2000. Think CTO Mollestad recalled this problem, "So after a year, whatever, everyone recognized that this battery was not feasible from a business plan, business case point of view" (EM, interview 11/2010). Maybe the partnership was increasingly forming around a battery system fitted to the Think City, but through associated business case exercises, Ford brought the finances and market considerations close to battery engineering. Think learned how cost and revenue interests should be taken into account in battery design as part of heterogeneous needs.

5.3.2.4 Ford and Think's design controversy surfaces around lead battery technology, 2001

Anew, Think and Ford were considering how to change the battery systems, approaching the problem in different ways. An important design controversy in the partnership, as Think PL Feltheim explained,

> Ford was focused on that the solution should be reasonably priced, so they wanted to use lead batteries. The Think environment was firmly opposing, saying: "This won't work: poor range, poor battery lifetime, and lead batteries won't work in the Nordic climate". But Ford insisted and decided that development of the drivetrain, gearbox [...] and the whole system should be developed in the US, by an American team (OF, interview 01/2010).

Think defended the ideal that the car should function properly – and not just be cheap. Recalling discussions, Think CTO Mollestad revealed,

> Ford claimed to have some good experience with lead-acid batteries, which are basically the best technology below nickel-cadmium batteries. But we have been of the opinion that those batteries are not good enough for EV usage. Lead-acid batteries don't have the required energy density, and don't have the required 'livage GPS'. You don't need a cheap battery if the car won't work properly! (EM, interview 11/2010)

The partners were debating intensely about what to do, the scope of development goals and which battery technology to go for. In dialogue, they were exploring and evaluating technical options. Both partners were uncer-

tain: none of them seemed to have enough experience with other battery technologies to document or demonstrate design direction and production scalability that could overcome constraints, in a convincing way for the other. Despite Think's skepticism related to lead-acid batteries, Ford claimed to possess some good experience from its other programs and prompted Think into working with lead-acid batteries in 2001. Ford enforced its role as financial investor and owner and directed development activities to take place in the US. Founder Ringdal recounted,

> As an outspring, the situation demonstrated the dilemma of big versus small companies. Nobody takes the risk in a big company. Their investors ask many questions. Investors want to comprehend and know a lot of details (JOR, interview 09/2008).

If the uncertainty prolonged, Ford would risk loosing its investors' support and create panic about the battery innovation and technology development, as the investors wouldn't know what to expect in terms of specific results from the project – besides a reasonably priced battery system. When project teams don't know the answers to the questions, stakeholders ask about what they are going to develop, because they themselves will only find out as they try out different things, or perhaps experiments in parallel in order to be able to gain a sense of answers. They draw on company experience; Think's skepticism wasn't of much help in providing investor an understanding as compared to the experience Ford had, however uncertain that may have been too. In this way, investors' understanding was created by the project team through the stimulation of the investors' sense of certainty by relying on Ford's experience-sharing in discussions and presentations of predicted achievements.

For a period of about two years, Think worked on lead-acid battery systems. Think CTO Mollestad recalled,

> A lot of testing and research went on with these battery systems well into 2002, however forecasted achievements and improvements didn't materialize, at which point I think we all agreed, including Ford, that the technology would not work – not then and there (EM, interview 11/2010).

The partnership evaluated actions and faced unmet expectations and development efforts on lead-acid batteries were stopped.

5.3.2.5 Ford and Think develop successful Think City prototypes with sodium-chloride batteries, 2002

In early 2002, Think brought forward its initial proposition of working with fibered batteries: high-temperature sodium-chloride batteries. With high energy density, high charging efficiency, a long lifetime and low material cost, it had many of the desired characteristics for an electric car.

The existing Ford-Think partnership was forming around this new initiative because both partners took risks and trusted one another. This time it was Ford that was having reservations due to its experience with sodium-sulfur batteries. Think CTO Mollestad explained,

> Ford had some bad experiences with a similar battery back in the early 1990s, where it had a car, the Ecostar, that took [caught] fire and a lot of material burned down in a lab. So it was a hard job to convince Ford management that this is different, this cheaper battery is safe and what happened in their lab couldn't happen with this system because that was a sodium-sulfur battery and this is a sodium-chloride battery, and there are some notable differences in safety between those two batteries (EM, interview 11/2010).

After long discussions, Ford understood that the problem of corrosion, which posed a severe fire-risk in case of battery leakage, was particular to the sodium-sulfur battery. As interest in safety grew alongside other interests, Ford agreed to develop prototypes of the Think City with the sodium-chloride battery system, and in the early summer 2002 the first prototypes were developed. They were also convincingly working. This was a successful moment for Think and its partnership with Ford.

5.3.2.6 FZ Sonick partnership forming for performance, 2001-2002[24]

The partnership between Think and Swiss FZ Sonick was forming during the period of Ford ownership. FZ Sonick supplied the sodium-chloride battery system – called Zebra[25] – that was used in the prototypes that were developed in the early summer 2002, which were convincingly working. The research data provided no elaborate details about this partnership – neither from archival or interview resources. Why are details about this partnership forming less recalled? In an interview in 2001 with the *Norwegian Technical University News* Think CTO Mollestad, said,

> The two main problems today are that [the] Think [City] has short range and the price is very high. But a lot of exciting things are happening in relation to battery technology and we see the challenge in reducing price through larger production. We are optimistic. Think is a fun car to drive, it is a smart and future-oriented concept, and we have a good status in the Ford-system. They are impressed with what we have created, and they don't disturb us too much (Asphell, 2001, p. 10)*.

Think's organizational focus at the time it was forming its partnership with FZ Sonick may have played a role during the interviews for this research. First, Think became interested in price- and production-scale for the Think City, which indicated a stronger focus on sales. Second, Think was comfortably nested in corporate Ford, and consequently, Think sensed less existential uncertainty with such a strong partner. However, what could have contributed to forming this partnership besides the battery technology is not very clear. In relation to Think, a hunch may be FZ Sonick's European position. In relation to its early prototypes, Think had created good connections in the Swiss automotive technology arena and it possessed good experiences from working with different partners there. To Ford the partnership motivation seemed again to rest on it being a cheap low-risk way to experiment with battery technology. To FZ Sonick the partnership was an opportunity not only to demonstrate and

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[24] Before it was named FZ Sonick in 2010, this supplier was known as MES-DEA, an Italian company founded in 1988. However MES-DEA merged with FIAMM in 2010 and formed FZ Sonick S.A. Though research sources refer to both company names in relation to Think, this thesis only applies the latest.

[25] Zebra stands for Zero Emission Battery Research Activities.

test its technology, but to also gain international, and in particular Ford's attention. But as Ford sold Think, the partnership work in relation to the Think City car stopped. It was later revealed that FZ Sonick remained a loyal partner and Think remained interested in sodium-chloride batteries.

5.3.2.7 Tesla and Think partnership forming around promises of lithium-ion batteries, 2007

Think was back in business after the Kamkorp Group (Kamkorp) period. In this partnership, the plan was that the American electric car manufacturer Tesla Motors should supply Think with a battery of about half the size of the one it made use of in its electric sports car, the Roadster. A contract to that effect was signed in the spring of 2007. The development agreement announced that Tesla would sell US$43M worth of battery systems to Think over a period of 12 months. Tesla's battery system was based on lithium-ion batteries, another technology that had a demonstrated potential for electric vehicle battery systems. This technology was especially interesting due to its high energy density, allowing for faster acceleration.

Forming a partnership with Tesla enabled Think to pursue its strategy of battery modularity, as meanwhile, its partnership with FZ Sonick had also reformed (see page 154), and it had several promising prospects. In an interview with the REVA Electric Car Club at the time, CEO Willums gave examples. He stated,

> People have different needs and different requests. This is why we choose to collaborate with Tesla, in addition to our current supplier of Zebra batteries [FZ Sonick]. Our customers will now get the choice of whatever battery that suits their driving patterns (Boxwell, 2007).

Offering a Tesla battery would not only be an advantage in terms of current customers, but it would also make Think appealing to potential new customers interested in driving with the newest technology. It was clear to Think that customers would also develop a relationship to their battery system once they purchased a car, and that consequently, car design had to take that relation into account. The battery system did not simply relate to numbers on a technical fact sheet, which were of course relevant to a buying deci-

sion process. Its performance would be part of what constituted a customer's driving experience. Furthermore, customers buying the Think City would lease the battery. In that sense, the battery stood-out from most other car components for the customer. Think was challenging traditional understandings of car-sales and customer-relationship with its sophisticated business model.

Another similarly attractive aspect about Tesla was its organization and its geographic location. CEO Willums stated, "This is an important agreement for Think. The collaboration gives us [the] opportunity to cooperate with one of the most innovative car companies in the US" (Boxwell, 2007). Tesla had been founded only four years earlier in California and was bound to release its first sports car model in the US market. Partnering with Tesla enabled Think to collaborate with another promising niche player and pursue its strategy of re-entering the US market. Supported by a Paola Alto private equity company, the Capricorn Investment Group (Woody, 2007), that had invested in both Think and Tesla and intended to launch a battery-leasing company, the partnership seemed like a plan that had the necessary hold for development.

5.3.2.8 EnerDel and Ener1 partnership forming in the place of Tesla in relation to lithium-ion batteries, 2007

As the partnership with Tesla broke in the summer 2007, due to Tesla's organizational situation drifting as uncertainty about its home market forced its production resources to be focused, Think arranged a US-wide battery system road-trip, during which it visited a number of potential battery supplies. In this case, Think's flexible specialization seemed well aligned with the market drift it also may have experienced. Think ended-up considering EnerDel, a lithium-ion-manganese battery system manufacturer as the most promising potential partner they had encountered. EnerDel was 80.5% owned by Ener1, 19.5% owned by the Delphi Corporation, and it was at the development stage where it had a pilot production facility. Following the road-trip, a development contract was negotiated between Ener1, EnerDel and Think that would entail fitting EnerDel's battery system into the Think City, delivering first prototypes by March 2008 and pre-production parts by July 2008 – all to Think's

satisfaction (Kanellos, 2007c). Subsequently, EnerDel could expect battery sales of US$70M between 2008 and 2010. According to Think's growth plan, it was estimated that the total value of battery sales could exceed US$200M. In a press-call at the time, the Chairman and CEO of Ener1 stated,

> The Ener1 team has meet its goal of signing a Li ion [lithium-ion] battery development contract with an automotive customer in 2007. This contract with Think is the commercial breakthrough that will provide the investment community with a clear picture of the substantial revenues and cash flows that are possible in the Li ion market. […] At the same time we believe that timely execution on this contract is critical to sustaining the competitive advantage we believe we have in the marketplace (Ener1, 2007).

Clearly, Ener1's interest in partnering with Think was to serve its own investors and address potential new investors. This specific problem had been solved simply by securing operational financial support, all of which was based on the revenue outlook Ener1 had provided in the paper-contract. The problem of executing the contractual agreement and scaling the production was in the hands of EnerDel CEO Grape who welcomed this first customer agreement, stating,

> Supplying batteries to Think gives EnerDel the opportunity to work with one of the most exciting and market-ready EV products today. It is truly rewarding to be working on this technological breakthrough with such an innovative company (Ener1, 2007).

Again, Think itself was being perceived and used as a complementary asset in terms of its battery expertise, test markets and reputation. This comparison to complementarities can be made because to attract the investment community to lithium technology, Ener1 needed to demonstrate the potential gains by lithium's production and implementation through economically specific and contextual appropriate use. The agreement to use Ener1's lithium batteries in the Think City, which at the time was considered a strong EV partner in its market, was a strategic response to investor contractual hazard on behalf of Ener1, but it also sent a helpful risk-pricing statement to the broader investment and automotive community. This was matched by Think CEO Willums, who expressed trust in that same press-call,

> We are confident in EnerDel's capabilities to deliver this safe, reliable and high-energy battery system that will power the electric vehicles in the future. While this is the largest lithium-ion battery contract in the automotive history to date, we expect demand for our vehicles and the resulting battery supply requirements to increase substantially from these levels (Ener1, 2007).

As planned, EnerDel's prototypes of battery systems were successfully tested by Think during the spring of 2008 (Ener1, 2008). Though there was still a lot of testing and evaluating to be done, EnerDel announced in the beginning of June 2008 that its development activities were proceeding to schedule and the likelihood was that targets for pre-production parts would also be met, placing Think with good prospects for sales production around September 2008. "We are very pleased with the progress EnerDel and Think have made on the lithium-ion battery solution for the Think City vehicle", assured Think CEO Willums in June 2008 (Ener1, 2008). However, as Think's next CEO Canny took over in October 2008, a different situation seemed to come about. He recalled,

> The most immediate challenge when I came in was to get the car finished but, although there have been a great deal of efforts, the reality was that unfortunately the car was neither legally nor practically saleable. You know a combination of issues. […] I think a hundred cars were built during the summer of 2008 that in turn could not be sold. […] The first production cars were finally built on October 27th, 2008 (RC, interview 01/2010).

Had Think management previously been too optimistic about the market readiness of the Think City car or had the market needs drifted? Though Think and its partners managed to solve many of the electromechanical, legal requirements and production roll-out problems, Think was also in a dire financial situation for which it would take much longer to find a solution.

5.3.2.9 A123 and General Electric partnership forming to hedge risk, 2007

During their road-trip in the US in the late summer 2007, Think had also initiated a relationship with A123, another lithium-ion-nanophosphate battery supplier (founded in 2001). Since Think was aware that lithium-ion battery technology was new, it sought-out another supplier besides EnerDel to hedge

financial risk and avoid potential problems of long-term dependency. Think CTO Mollestad recalled,

> Still we wanted, because… as I said, this is new technology. You never know if these battery suppliers are successful or not. A lot can happen… they can go bankrupt. They can have technical issues, difficult things… whatever. So we wanted a further battery supplier to hedge risk, and we then negotiated with A123 Systems, one of the best-known players, which we also had identified during this road-trip […] and we also entered into agreement with A123, and developed the contract and then it was supposed to go into delivery contract. So they developed about 15 prototype systems for us, which we retrieved and did a lot of testing on, and there were issues, but basically, that was quite okay (EM, interview 11/2010).

This commercial supply agreement was signed in relation to another partnership that General Electric (GE), A123 and Think were forming in which GE invested US$20M in A123 to help A123 roll out batteries for Think, and US$4M in Think. Both agreements were announced at the 78th Annual International Motor Show in Geneva in March 2008, which enabled all three partners to increase industry interest around the agreement.

To GE this was a venture capital investment whereby it offered its engineering, process and commercial expertise to bring forward A123 and Think's innovative technology. The agreement was an opportunity to attract other innovative companies to its newly-expanded venture capital group. To A123, an agreement with Think resolved its problem of showcasing its technology and enabled it to move into production through GE's investment, and as such it became a far more appealing partner to other automotive manufactures: experienced technology in production. For Think, it became connected to another industry giant which abled it to offer its customers three different battery systems: the FZ Sonick sodium-chloride battery, the EnerDel lithium-ion battery, and the A123 lithium-ion battery.

Throughout 2008 these partners continued collaborating until December 2008, when Think had to close production, lay-off employees and admit publicly that it was financially broken. What happened later in relation to Think's battery system development is explained in the section of Think battery reforming partnerships (see page 154).

5.3.3 Battery partnerships breaking

5.3.3.1 SAFT partnership breaking as Think's organizational situation drifts, 1999

Battery partnerships had been forming around NiCad batteries since the beginning of 1994 and in 1998, total redesign and quality control was necessary in order to continue the development of batteries for the Think City. However, Think's financial resources had run dry – its overall organizational situation had drifted. Think Founder Ringdal said, "The car was certified for sale in [the] EU, but due to the Asia Crisis the venture capital market was dry and we ran into money problems" (JOR, Interview 09/2008). The impact of the 1997-1999 Asia Crisis had not been foreseeable and Think's future had become uncertain, and it became difficult to find investors. As such, it doesn't seem that the problem of battery redesign influenced the breaking of the SAFT partnership. Prospects of resuming collaboration with SAFT were only fully broken as Ford took interest in Think, despite the fact that it had later chosen to work with its preferred battery suppliers in the US. This too had not been foreseeable. While Think got back together with some other battery partners after the Ford-period there is no record of SAFT reforming a partnership with Think. Could there have been other less perceivable but, more closely related reasons to the battery collaboration? In my interview with Ringdal (01/2010), he acknowledged the relevance of working with French partners in the early days, referring to SAFT and other companies, but he made it clear that his trust was fading in Think's "ability to overcome the language barriers" that it had encountered in these collaborations. This particular statement may help explain why the partnership hadn't been reforming.

5.3.3.2 Ford-Think partnership breaking as Ford corporate interests drift, 2002

Earlier, the Ford and Think battery partnership had been forming around four different battery technologies: in 1999, the redesign of NiCad batteries foreseen for the Ford conversion car model; from 1999 to 2001, the metal-hybrid batteries in relation to a new Think City platform; then in 2001, the unfolding of the design controversy around lead-acid batteries; and lastly, between 2001 and 2002, with the successful production of Think City prototypes that housed

the convincingly working sodium-chloride batteries. Through continuous problem- and solution-finding processes, the partners had managed to elevate battery technology development related to the Think City well.

Then, in August 2002, Ford decided to sell-off Think and the battery partnership was breaking (Maynard, 2002). In October 2000, Bill Ford had underlined, "We are the world's leading producer and seller of electric vehicles. We've just launched an entire new brand – Think" (Vasilash, 2000). And Global Brand Manager (GBM) of the Think Group, Palmer expressed his expectations about getting "thousands of people to try a Think during the first eight months" when the new model was to be launched in 2002 (Vasilash, 2000). Less than two years later, Ford's spokeswoman Tatchio said, "It was a business decision, based on the market" (Maynard, 2002). Ford would subsequently focus on hybrid electric and fuel cell-powered technology. Think CTO recalled,

> We were in many ways very disappointed that Ford chose to sell Think, and we felt they couldn't do it, by then they had… I mean the car was almost done, and they had placed millions of dollars into the development, which they actually just offered for free, and we were so many years ahead of the competition. We were disappointed to see Ford didn't proceed to production, complete the car and so on (EM, interview 01/2010).

Disappointment and frustration spread throughout the Think battery development team, where the sodium-chloride battery had passed diverse tests and trials and had worked convincingly in Think City prototypes. This part was considered ready for production just when all development activities had come to a stop.

By selling-off Think, Ford seemed to claim there was no market for fully battery-electric vehicles and this was a change in corporate interest and market perception that was unforeseeable to Think. But the sale also demonstrated how Ford seemingly had difficulties in enduring uncertainty around and within system technology standards (e.g. type of battery) and systems (hybrid or electric or other), and how these conditions were part of Think's important role. However, several events, which had no direct relation to Think, caused Ford to face troubled times, and that rather seemed to have broken Ford's general commitment to Think. First, between 2001 and 2002

Ford lost about US$6bn due to the Firestone tire scandal and the long-term partnership between Ford and Firestone ended (Moore, 2002). This meant that Ford was in financial trouble. Second, its US market share had fallen and its stock ranking sank as Jacques Nasser, who had been Think's number-one internal ambassador, stepped-down from CEO in October 2001 (Moore, 2002). These signaled that Ford's organizational situation had drifted. Third, with the CARB agreement on hold, pressure on Ford to offer electric cars in California had drifted (Maynard, 2002). As Bill Ford, who took over as CEO, embarked on a turn-around plan for Ford that entailed a review of all parts of the company, Think fell short of the demands that were placed on it as a business in comparison to other parts of Ford and it was sold to Swiss Kamkorp in December 2002.

5.3.3.3 FZ Sonick partnership breaking with the Think City, as Kamkorp focuses on the Think Public omnibus, 2002

FZ Sonick was the supplier of the sodium-chloride battery technology that was working convincingly in the Think City in the summer of 2002, as part of a collaboration between FZ Sonick, Ford and Think. When Ford sold Think to Kamkorp in December 2002, FZ Sonick's prospect of moving to production with the battery system for the Think City soon, became uncertain. FZ Sonick's partnership with Think around the Think City battery development seemed to be breaking as Kamkorp decided not to pursue the Think City car development, but shifted resources to the development of an omnibus. Kamkorp may have chosen to work with FZ Sonick in relation to the development of the Think Public omnibus; however, this has only been mentioned vaguely in one data source (TU.no, 2004) therefore this research assumes the relation was broken.

5.3.3.4 Tesla partnership breaking as Tesla's organizational situation drifts, 2007

The partnership with Tesla initiated in the spring of 2007, after Think had resumed its activities in Norway and had overcome the Kamkorp period. The plan was for Tesla to sell US$43M worth of lithium-ion battery systems to Think over a period of 12 months. However, this never materialized as Tesla

decided, already in the summer of 2007, to cancel the contract based on the argument that it needed the resources to resolve its own production needs. In an interview with the online magazine *Green Car Congress*, Tesla's Vice President of Sales, Marketing and Service said,

> After Michael Marks became CEO of Tesla Motors, one of the first actions he took was to inform Think that we would not pursue the development of battery packs for them at that time because we had to be focused entirely on [our] own vehicle programs. We hope to work with Think in the future, but for now it is important that we stay focused on our own vehicle programs (GreenCarCongress.com, 2007).

Tesla was leaving the possibility for future collaboration open, but the CEO succession at Tesla resulted in an immediate organizational drift that in turn, placed Think in a difficult situation. Think CTO Mollestad recalled,

> This was an unpredictable situation. Our volumes were based on [the fact] that this deal in the future could happen, and its consistency. So that ended-up with the Head of Purchasing Erik and myself, we took a road-trip around the United States and we visited a number of potential battery suppliers (EM, interview 11/2010).

The promising prospects of working with Tesla lithium-ion batteries and the Tesla organization, coupled with the benefit of Tesla's geographic presence in the US and Tesla's contacts to early adapters and target audience, were broken for Think. It became uncertain to know how long Think would need to identify a new partner, negotiate a new contract, get access to prototype batteries, develop the new interface and get the other necessary things done in order to sell Think City cars with new batteries. Therefore, it was also uncertain whether Think could meet the promises of sales in Norway and the UK by the end of 2007 – a claim it had made earlier in the year to the press (Kanellos, 2007a). Partners tried to conceal the breaking and uncertainties from the public for a while. It wasn't until Think communicated its new battery agreement with EnerDel that the press got a clue about the change (Kanellos, 2007c). Thus the shift in battery partnership may not have seemed to be as critical to operations from outside Think, as it was. The partnership drift was not just to be considered as the move of one independent relation

alone, but as the drift of a collection of interrelated technology, battery system and market possibilities.

5.3.3.5 EnerDel and Ener1 partnership breaking as Think's financial situation drifts, 2008

In 2007, Think began forming a partnership with EnerDel around lithium-ion batteries for the Think City. By the end of October 2008, the partnership had worked on battery system prototypes, made tests and proceeded to the production of battery system models. These had gone into Think City vehicles that had finally rolled-off the production line. "It's a great launch customer for us", said EnerDel CEO Grape, who was then preparing to ramp-up production and expand the workforce (Hromadka, 2008). EnerDel's owner Ener1 later supported this statement. Ener1 CEO Gassenheimer recounted,

> When Ener1 signed the largest automotive grade lithium-ion battery contract with Think Global in 2007, we were forced to get our products and facilities to manufacturing ready-status within a compressed time frame. This contract helped lead to the EnerTech acquisition, and affected the advancement of our energy dense cells and modular pack design that have become our building blocks for today (SeekingAlpha.com, 2011).

How helpful the Think-partnership had turned-out to be for Ener1 and EnerDel was unpredictable. Maybe, despite battery development efforts, Ener1 and EnerDel had taken more advantage of Think in that period than they had fully committed and contributed themselves to mutual partnership benefits? However, Think's financial situation had drifted during the collaboration and it was not in a position to launch the Think City. Consecutive delays of production start-time between 2006 and 2008 – also related to the battery system situation – had delayed possibilities for Think City car sales that would have generated revenue for Think. Think was out of money and was told that it would not be bankable before being in production (E24.no, 2008). Thus, money to get the production up to speed had to come from equity sources, but due to the global financial crisis that began in 2007, it was uncertain how long Think would need to raise the estimated US$40M it required. By then, the automotive industry crisis had also hit Think's suppliers who demanded payment for open invoices. Think was struggling throughout the autumn months,

but in December 2008, Think saw no other possibility than to commence lay-offs and close production.

Think had made a bold assumption about how fast the Think City production would be up-and-running when signing the battery contract with EnerDel, and for Think, the impact of the global financial crisis had been unpredictable. The situation also put EnerDel in a precarious situation as much of its planned launch activities had depended on this deal.

5.3.3.6 EnerDel partnership breaking as Ener1's battery investment interest drifts, 2011

As it is described later in this chapter, Ener1, EnerDel and Think were reforming their partnership in 2009 around the problem of refinancing Think, where Ener1 became a major shareholder in Think, and in 2010, when the partners decided that Think's US assembly facility should be located in Indiana, like EnerDel's battery production. The reforming helped Think get its battery program and the Think City production up-and-running again. The first cars were sold, making use of EnerDel batteries in the US by December, 2010 (Think, 2010h). However, part of the deal also meant – upon Ener1's request – that Think would have to give-up its battery supplier independency. It was a partnership where problems seemed to be related to the marketing of a battery-car package rather than a battery-to-car development, which had been the focus in the previous partnership between these companies. At least, this was the focus of Ener1 as recounted by Ener1's CEO, Gassenheimer,

> Ener1's subsequent investment in Think in 2009 followed the same logic [as in 2007]. It was important for us to demonstrate that lithium-ion battery systems were not just an R&D project. […] We also believe that our work with Think helped us gain rapid market entry in a way that established not only industry presence, but also industry leadership for Ener1 (SeekingAlpha.com, 2011).

But in May 2011 the partnership was breaking as Ener1's investor interests and market expectations drifted. Ener1 was facing financial losses and the EV market increase was slower than Ener1 had predicted, which it related in part to the lack of charging infrastructure. The expected delivery of US$200M in batteries to Think hadn't taken place. Faced with this problem

Ener1 wrote-off the entire investment in Think and ended the partnership with Think. Think's main source of capital supply had been terminated. Ener1 decided to return its 31% share to the company and write down US$73.3M on the investment it had made. One of Ener1's public comments was that Think had disappointed due to its inability to raise further capital (McDonald, 2011) while Think's former CEO, Canny noted,

> Think didn't get a US Department of Energy loan because the combined entity of Think and Ener1 was not credit worthy. […] So it was a symbiotic relationship that was more negatives than positives in marketing (RC, interview 07/2011).

Think's inability to raise capital seemed from this point-of-view closely linked to the partnership with EnerDel and Ener1, who had insisted on closeness. Think's future had again become uncertain.

5.3.3.7 A123 partnership breaking as Think's financial situation drifts, 2008

With the A123 supply agreement for lithium-ion battery technology Think had signed in early-2008, the possibility to hedge financial risk associated with the new lithium-ion technology and avoid problems of long-term dependency surfaced. A123 considered Think as a showcase for its product and enabled Think, through investment by GE, to move into production.

Think's delivery contract with A123 Systems was hindered by the financial crisis that had ensued in the autumn of 2008, which led Think to the brink of bankruptcy once again. Though Think and A123 lost the possibility of entering a continuous production process following a promising collaboration, A123 seized the chance to use the knowledge it had gained through the partnership to improve its battery system. In the relatively short period of time the partners had been collaborating, accumulated battery system information had passed from one technology innovation project to another: from Think's to A123's development project as Think would later learn. However, it was uncertain whether A123 would have been able to share its battery system improvements with Think.

As Think had been refinanced in 2009 it was very interested in reconnecting with A123 as it became aware of the battery development progress

A123 had made. However, Ener1 – who had become a major shareholder of Think – objected. Think CTO, Mollestad recalled,

> Ener1 told us to stop the work with A123, which we believe is a little shame, because A123 have done more improvements on their battery system on themselves, and it had come-up with a new version of Think's battery systems, which was very promising. […] Ener1 isn't too keen on us working on that [battery systems] together with their competitors, because they will, of course, like us to promote their battery and that is also the main battery we have today. But, from a technical point of view, we would also like to work with other suppliers and promote competitors of Ener1. So this is an internal discussion we have together with our main shareholder. Will we be allowed to do that for the future? We have to speak with EnerDel and the operation. This [only working with EnerDel] will be a shame, because then we give away basically one of the biggest advantages we have in our vehicle because, as I know no others that have this very, very flexible platform as we have. […] But as of today, we have basically been stopped and there are now high-level discussions (EM, interview 11/2010).

While it was clear to Think that Ener1 wanted it to work with and promote EnerDel's battery system, it was a problem from a technical perspective that Think couldn't work with A123's new designed version of the Think battery system. EnerDel's supplier exclusivity not only broke Think's ability to benefit from its own flexible battery platform, but given the unpredictability of rapid battery technology developments, it also seemed to be breaking Think's market advantage – to spread its risk by working with several cutting-edge battery technology suppliers in parallel.

5.3.4 Battery partnerships reforming

5.3.4.1 FZ Sonic partnership reforming around the same technology and contact people, 2006

When Think resurrected in 2006, the sodium-chloride battery program reopened and the first cars that were sold in Europe carried the sodium-chloride batteries. FZ Sonick, the company Think worked with on developing sodium-chloride batteries in 2002 had shifted owners, but Think managed to reconnect with the company through its contacts to the people working with bat-

tery development at FZ Sonick, who had been transferred from the previous company. Thereby, Think enjoyed the benefit of previous positive collaborative experiences which led its FZ Sonick contacts to help create the opportunity for reforming the partnership, by convincing the new FZ Sonick owners. Think kept on offering the sodium-chloride battery system to its customers and the supplier, who during the partnership was bought-out by an Italian company, continued to supply Think with limited volumes up until Think's bankruptcy in 2011. Think CTO Mollestad recalled,

> It [the sodium-chloride] is a good battery when it's properly made. [...] Unfortunately this technology is patented by this company [FZ Sonick] so there hasn't been many other battery suppliers investigating into this because there is quite a lot of improvement potential in this technology (EM, interview 11/2010).

FZ Sonick battery technology wasn't the newest, but it worked, was in production, was affordable for Think and the people working in this partnership knew who they were collaborating with, so trust and familiarity were present. Think CTO Mollestad said, "We have been working with them for close to 10 years" (EM, interview 11/2010).

5.3.4.2 FZ Sonic partnership reforming as a non-direct competitor of EnerDel's technology, 2009

In contrast to A123's technology, FZ Sonick's Zebra sodium battery was no direct competitor to EnerDel's lithium-ion battery, which may explain why Think wasn't hindered in reforming with FZ Sonick as it resumed activities after being refinanced in 2009. This partnership was able to reform and pick up production activities, which they had had prior to the financial problems. This continued until Think's bankruptcy in 2011.

5.3.4.3 EnerDel and Ener1 partnership reforming in relation to Think's refinance, 2009

In December 2008 Think had closed its production and laid-off personnel and came under public administration while searching for new investors. Ener1, the primary investor of the battery manufacturer EnerDel, came into dialogue

with Think, about taking on a major shareholder position. During a visit to Think in January 2009, Ener1's CEO, Gassenheimer said,

> We have a goal about getting the Think [City] to the road as fast as possible and we have to ensure the necessary financing gets in place. We are here to see that a descent business plan and financing is worked-out. We are serious and see a leading role in the refinancing of the company and thus we are carrying out a due diligence on Think. It is not a problem to sell 10,000 Think City cars in the US, a year. I just came from the Detroit Motor Show. There is a lot of talk about EVs, and many think they have solutions. But nobody has come as far as Think. The batteries are half the car, and we have the production capacity ready (Gran, 2009)*.

Ener1 was confident about the US market demand and the January 2009 Detroit Motor Show may have had a reassuring influence on Ener1's investment interests in relation to a Think partnership. Ener1's subsidiary had a battery system developed for Think and a production waiting to supply exactly this battery system. The partnership that was reforming between Ener1, EnerDel and Think was not focused on developing a battery system that fitted Think as much as it was focused on the problem of bringing the Think City, powered by an EnerDel battery system, into production and out to market.

In August 2009 it was announced that Ener1 had negotiated a 31% stake in Think, and that EnerDel and Think agreed to enter a long-term battery supply agreement as part of the transaction. The contract also defined an intent to combine the companies' complementary resources towards the development of drivetrains (Think, 2009b). This was an agreement that gave Think the much needed refinancing options to recall employees, make progress on its sales campaigns and restart production with – among others – EnerDel batteries, while at the same time, providing Ener1 with a controlling shareholder position.

5.3.4.4 EnerDel and Ener1 partnership reforming in relation to Think's US assembly facility, 2010

In January 2010 the partnership got further enforced as Think announced that its US assembly facility would be located in Indiana where EnerDel also held production (Think, 2010g). Shortly after, Think also announced that EnerDel

would hold battery supplier exclusivity for Think City vehicles sold in the US through 2012, and it would supply at least 60% of the batteries for Think City vehicles sold in Europe (Think, 2010n). Think was letting go of the battery supplier independence it had aimed for in order to ensure the financial support it had been promised by its battery partner, Ener1. Ener1's confidence in Think was increasing, as its CEO, Gassenheimer said, "Think's transformation into a company ideally placed to translate product advantage into market access is undeniable. Ener1 fully intends to invest further resources in Think" (Think, 2010a). However, success of the partnership plans for the US depended in part on Think receiving the low-interest federal loans it had applied for in order to finance its assembly facility and Think City sales in the US (Chambers, 2010).

5.4 Partnerships around drivetrain systems in the electric car

This part shows how relations between the Think drivetrain system, drivetrain system development partners and the electric car have been forming, breaking and reforming and it follows the same analysis principles as the battery analysis did – though it is an entirely different story. In this case, Think chose to build the development competence inside the organization and drivetrain development became a new business stream Think would pursue; a success story that reveals further understandings of technology innovation partnerships. The art of drivetrain systems lies in a seamless integration of several mechanical components: an electric motor; a control module; a charger, an inverter; and a transmitter. Opening-up the floorboards in the electric car, it is found that the drivetrain system enables the transmission of power and provides way, through high-voltage cabling, for energy to get from the battery to the components that make the electric vehicle move, enabling cabin heating or other electronic functionality. Even the most advanced batteries seem useless if the drivetrain's torque doesn't get relatively constant to the wheels': without a dynamic performance it's no fun driving. This makes the drivetrain the second most important component in an electric car, next to the battery, and explains the special attention it gets in comparison with other car components.

Drivetrain suppliers explore friction material, electromechanical material and material combinations in order to reduce power consumption while advancing a faster, lighter and more effective power distribution that will improve handling and stability characteristics under changing driving conditions. Similarly, Think engineers explore how different components work in combination, and how drivetrain systems may be assembled and integrated into the Think City car in order to enhance aerodynamics while meeting testing and validation requirements. Materially, the Think City car creates a point of connection; it frames drivetrain system partners with drivetrain problems and possible solutions, allowing for more information about their relational

setting to appear and thereby, drivetrain partners can more readily identify what kind of problems they are struggling with.

Since its beginning, Think has been related to more than ten different drivetrain technology development partners: first Brusa Elektronic, then Siemens, Ford-Ecostar, Continental, Leroy-Somer, Enova, Ricardo's UK Engineering, Semicon, Eltek Velere, Itochu and Ener1, and Delta. Different partnerships emerged around different problems, in the pursuit of different solutions around different drivetrain technologies and different versions of the Think City. **Figure 13** shows how relations evolved over time.

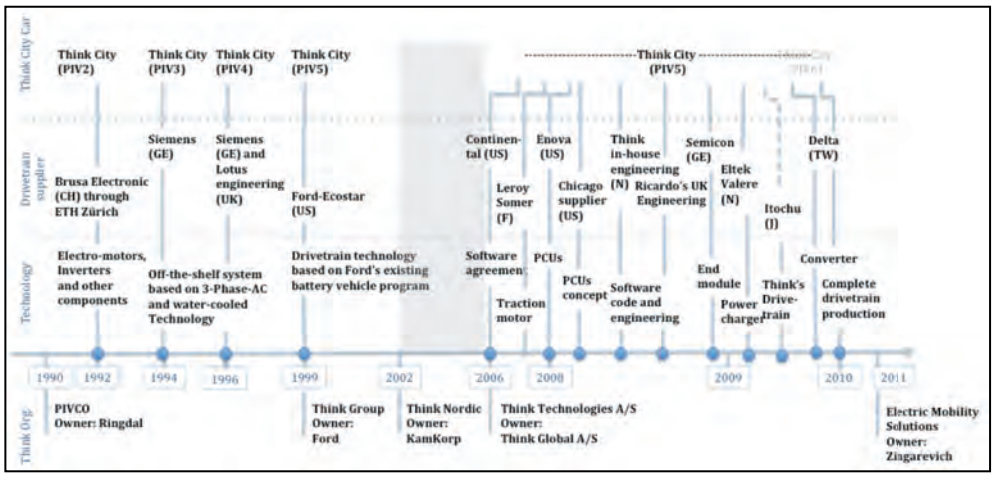

Figure 13 Think drivetrain development partnership overview

In the following, I analyze how drivetrain partnerships, as collaborative socio-technical ensembles, negotiated their interests and expectations while gathering drivetrain technology development experiences in relation to working and non-working drivetrain systems.

5.4.1 Forming partnerships without standard commitment terms

Initially, Think was seeking drivetrain partners who would both be willing to work with it on Think projects and be willing to provide Think with the freedom to explore other drivetrain products. For as long as Think was working with smaller suppliers, who themselves had very limited resources, this was

the main interest, although Think was aware that this approach had trade-offs in terms of confidentiality. As Founder Ringdal explained,

> It was a bit of a dilemma. We had to discover our way forward with partners who were willing to work with us, but at the same time gave us freedom. If we had tied ourselves to certain partners to begin with, then we would perhaps have been in trouble the year after, when we would see that Siemens had come with a product that we found interesting. How could we then ignore an agreement with Brusa? So that would have been a problem. We had to be very open about our agenda and try out something without making standard commitments and agreements to ensure we had flexibility. Clearly, if we would get a larger supplier, who had a greater possibility of testing, developing and perhaps wanted to invest in parts of the motor, testing or something similar, then it would be different. But then we would also have joint interests in the project idea and we would share the experience that we gained along the way (JOR, interview 09/2008).

The way forward with partners was not static; the journey was forged through an intentional pursuit of emergent learning. Moreover, when collaborating with smaller partners, Ringdal revealed that he considered standard agreements as hosts of potential problems, rather than devices that aid at ensuring and securing relationships when collaborating with smaller partners. However, he did not seem to assume the same loss of freedom and need for discovery among potential partners once Think was tied to a larger partner, as he counted on joint interests and experience-sharing. Getting a larger partner, he viewed, was as a solution in itself.

5.4.2 Drivetrain partnerships forming

5.4.2.1 Brusa Elektronic partnership forming through ETH relations, 1992-1994

When Think started developing the initial Think City prototypes it made contact with Brusa Elektronic (Brusa), a Swiss company focusing on developing components exclusively for solar and electric vehicles, as well as solar energy systems. This contact came about through Founder Ringdal's relations at ETH, the Swiss Federal Institute of technology, where he had studied mechanical engineering. From Brusa, Think got its first drivetrain models of electro-

motors and inverters, along with other components. It was considered a solution to get a handful of Think City cars developed, based on Brusa technology, in order to prove the initial prototype and design concepts of the car. However, during the emergent learning Think noticed that Brusa would only be able to supply a few models at a time, as Brusa didn't have the production platform for assembling anything close to a hundred motors. This was a production scale envisioned by the optimistic expectations of Founder Ringdal. He recalled,

> So to start with, as an example, we had some Swiss motors, which worked very well from Brusa. But we saw that they could only deliver one to five motors, while we wanted to reach 100 or more – perhaps 1000 – so they didn't have the production capacity (JOR, interview 01/2010).

Although Think wasn't interested in formal agreements and rather preferred to buy samples in order to build them into the Think City car and test the collective effectiveness, the company did consider the future potential of the partnership. However Brusa's limited production capacity was a problem, and that was the impetus underlying Think's search for other partners. Perhaps Ringdal was overly optimistic in expecting Think's drivetrains needs to be at the level of 1000 in the near. At the same time, Brusa failed to consider that the partnership with Think could bring opportunities for production facilities' expansion, because Brusa's main focus was on stability.

5.4.2.2 Siemens partnership forming in relation to an off-the-shelf drivetrain system, 1994-1999

Brusa's limited production capacity was a problem and led Think to its solution, Siemens in Germany, for an off-the-shelf drivetrain system: primarily based on so-called 3-Phase-AC and water-cooled technology provided by Siemens Simotion. Think CTO Mollestad recalled,

> I think the motor and most of the power electronics came from Siemens, basically everything except the charger, because Siemens couldn't make chargers, so we had to go somewhere else for the charger. That [Siemens components] has been a very robust and good system – very, very little problems. We had a number of cars on the roads and there have hardly been any issues with these components at all. They're [the components] very, very, good quality from Siemens (EM, interview 11/2010).

It was not considered a problem to integrate the charger with the brand name 'Actia Energia', of which no further record has been found for the present research. And as no other major issues were encountered with respect to the technology itself, the focus of attention in the retrospective interviews with Think seemed to be elsewhere. What mattered was the good and safe quality of Siemens' components and units of technology, as well as the collaboration that would move the drivetrain system development forward, Siemens' favorable global position, its name and production scalability. Founder Ringdal recalled,

> Yes, Siemens was important, because it was now we began developing the PIV3 [Think City car]. This was the one that should become a conventional vehicle. And this was when PL Feltheim said we should emphasize on safety and airbags (JOR, interview 01/2010).

To Siemens, Think represented part of its solution to testing Siemens technology. Siemens' interest in Think related to its role as showcase platform. In other words, identifying both problems and solutions related to Think's drivetrain system would provide solutions back to Siemens of where and perhaps how to improve its technology. Founder Ringdal explained,

> You may ask why Siemens, which is a large international company with relations to Mercedes and Chrysler and other big automotive manufacturers were interested in us. But they were very interested, because we were the only ones who offered a medium-size platform where they could test drivetrain technology. So there was no real down-side for them to work with us. They were also very involved, because we had a serious project. It was not just "let's try a little here if it goes wrong and it says Siemens on the motor, then that is just another mistake too". They wanted it to succeed. To us it was important to be able to relate our name with a company that had a global position and had the potential to supply and industrialize. This was one of the problems with the small companies – supply and industrialization – who actually were in the same position as us (JOR, interview 01/2010).

Siemens also seemed to be appreciative of the attitude towards technology development that Think had. Together, the partners confronted their inexperience and unpredictability with regards to development of drivetrain systems systematically and with the mutual ambition of success.

5.4.2.3 Siemens, Lotus, and Think partnership forming around EV Symposium events, 1996-1998

On the basis of a mutual ambition towards success, the collaboration continued between Siemens and Think around the Think City car (PIV4), which was exhibited in Brussels, at the Electric Vehicle Symposium of October 1998. This was an important event, through which Think hoped it could meet large investors. However Think saw an emergent problem. Siemens could not support Think in securing the automotive quality assurance of the drivetrain system required for EU certification, which Think wanted even prior to the symposium in Brussels. This was one of the reasons why Lotus Engineering in the UK was brought-in as a recognized automotive consulting company (a partnership that will be further elaborated on in the financial engineering case). But Siemens' interest in Think would remain and as Think later began work on a new generation of Think City cars in 2000, it received a new bid for the drivetrain system from Siemens, who was interested in continuing its supply for Think.

5.4.2.4 Ford partnership forming in relation to a new drivetrain system by Ecostar, 1999-2002

However, as Ford took over Think it was in its interest that Think collaborate with Ford's partner called Ecostar Electric Powertrain and Power Conversion Systems (Ecostar). Ecostar was founded in 1998 as part of the Fuel Cell Alliance formed between Ford, Ballard Power Systems Inc. (Ballard) and DaimlerChrysler (PRNewswire, 2000). The Ecostar drivetrain system was based on technology developed for use in Ford's existing battery vehicle program, prior to its acquisition of Think. In this program Ford had worked on an experimental electric car called the Ford Ecostar. Founder Ringdal recounted,

> Ecostar was a project that Ford had, which had been developing electric components and the like for electric cars. But I think you could have Think CTO Mollestad confirm that it was our wish to continue with Siemens – I mean those of us working in Norway wanted that. But it was clear that when Ford came in they wanted to use their own. I remember I was up meeting the Head of Siemens Norway, because I also wanted an offer from them. But he took me aside and said that they would have found

> it great to give us an offer, but Ford is smart; it was clear Ford would chose their own system (JOR, interview 01/2010).

How did it become clear to Siemens that Ford would choose their own system? Was this a special technology life cycle condition in Ford-partnerships, a common condition of large companies or did Siemens understand something about Ford's political interests that Think wasn't aware of? In the Fuel Cell Alliance, Ford owned 62% of Ecostar, which meant that Ford was likely to have several interests at stake for a partnership between Ecostar and Think. On the one hand, the location of Ecostar – across the street from where Ford's people were working on the Think City played a part – and they already knew each other. On the other hand, this priority was related to Ford's agreement with Ballard, who on Ford's behalf had acquired shares in Ecostar. This way, most of the technology development could stay within the Ford group, not least, the capital. Through the collaboration, Think realized that Ecostar's main technology achievement was the development of configuration software. Think CTO Mollestad explained,

> Ecostar's approach was that they would buy a motor from another sub-supplier, a tier-two supplier called Enova and then, use a software, which they had developed themselves during the years. We started out that work and it went quite okay (EM, interview 11/2010).

However, in public, it was announced that Ecostar had the goal of developing the entire drivetrain system especially for Think, and thereby contribute to the car's improved performance, quality and cost structure, as the President of Ecostar, Witschonke explained,

> Ecostar's goal is to create an electric system for Think City that will integrate electronic functions, improve performance and quality, and reduce overall cost. We are confident that the electric powertrain [drivetrain] that we are developing for the Think City vehicle will provide improved performance and function for the growing electric customer base (PRNewswire, 2000).

Think's collaboration with Ecostar seemed to result in a setback in its drivetrain technology innovation. Although Think CTO Mollestad didn't directly confirm Founder Ringdal's comment about supplier preference, he was

far less excited about the solution with Ecostar than he was with respect to Siemens. Ecostar's work was okay.

5.4.2.5 Continental partnership forming around a limited agreement for the software part, 2006-2008

When Think resurrected again in 2006 it seemed like a good idea to reconnect with Ecostar. However, Siemens was in the process of acquiring the Ballard Power Systems Inc. company and sold-off Ecostar to another supplier; Continental Automotive. Could there have been an opportunity to reform with Siemens, and if so, why didn't Think and Siemens seize that opportunity? It was a turbulent situation for Think drivetrain partnership-forming. As a result, it became unpredictable for Think to know how open to collaboration Think's contact people would be. While Ecostar's engineers might have been transferred, enabling Think to reform its previous working relations, the decision-makers were not the same. Eventually, a partnership with Continental began to form. Think CTO Mollestad recounted,

> And then Continental said, okay, we can work with you, but you have to go and make deals. They wouldn't deliver the whole thing, but they could deliver the software part and they said, you have to go to our tier-two suppliers and make deals for the hardware. So, we went to the motor suppliers, but they wouldn't deliver to us (EM, interview 11/2010).

Trouble emerged out of the situation. The collaboration with Continental turned-out to be complicated as well as time-consuming. All software changes that Think had to the source code had to go through Continental's approval and that slowed down communication processes and took time. And, Think couldn't draw on Continentals' network to access other necessary drivetrain components. There were a number of problems that influenced the drivetrain system's development and Think's partnership with Continental.

5.4.2.6 Leroy Somer partnership in relation to the liquid-cooled-AC traction motor, 2006-2011

The lack of openness Think experienced in the tier-two network of Continental led it to seek partners elsewhere. It is not known whether this collaboration barrier was due to tier-two suppliers' relations to other partners, system

interdependencies, or a lack of suppliers' skills and experience. Think's partnership focus drifted. But Think had a difficult time finding the right partners for the motor and other drivetrain components. Think Head of PDD Neal explained,

> An example will be our electric motor supplier. When we were looking for an electric motor in 2006, we had troubles finding people that were interested in being suppliers for the electrical vehicle industry. We went to an industrial motor firm making motors for plant machinery. They said: "Well, we can sell you this motor. It is purely a commercial thing we are not interested in getting into the EV-space". Now, four years later, they are very interested in getting into the EV-space. They are employing people that have worked in the automotive industry to teach them about the needs of the automotive industry. So in the space of four years, that one supplier has really started to think this is a space we ought to get into. I think we are going increasingly to be seeing people looking to use us as their sort of opener for other OEM [Original Equipment Manufacturer] and EV projects (CN, interview 03/2010).

Think had to accept that the interest of the motor supplier was purely commercial to start with and so it began to train its own engineers. Only years later would the partner begin to consider its development and innovation potential in relation to electric cars and Think would begin to understand that it could play a decisive role as a showcase platform for other EV technology development innovation projects. Something had happened and changed the landscape of the 'EV-space'. But what exactly had changed? And how, had it shifted to Think's favor? However, recalling the quest as less complicated, Think CTO Mollestad described, "We went on to find another motor supplier – that was not an issue. We got the motor from Leroy Somer in France, which was okay and that worked fine" (EM, interview 11/2010).

Leroy Somer had been involved in the development of the Peugeot 106 in 1995 and had a strong global position. Would this supplier become a long-term, stable partner for Think? In light of the other problems with the drivetrain components, that company was a good solution: it was based in Europe, had a global position and experience with electric car development.

5.4.2.7 Enova partnership forming around drivetrain hardware, 2008

Think also had to find itself a hardware partner and in February 2008, it was announced that Enova, who had been a tier-two supplier to Ecostar during Think's time with Ford, was going to provide a minimum of 1000 power control units (PCUs) to Think throughout 2008. But was this component sale possible without an agreement involving discussions with Ford, and if so, how? Future production ambitions for the Think City were expected to be a minimum of 10,000 units in 2009 (GreenEnergyNews, 2008). Enova viewed this as a privilege and placed high expectations in Think. To the Green Energy News, President and CEO Staran said,

> Enova is privileged to be working with a visionary company like Think Global. We are pleased to be awarded this high volume production contract from them. Our belief is that the Think City vehicle will revolutionize the passenger electric vehicle market in Europe, and ultimately [in] North America (GreenEnergyNews, 2008).

At first Think was optimistic about the partnership with Enova, but soon a concern emerged about the effectiveness, quality and work-attitude. Think CTO Mollestad revealed,

> We went to Enova for the hardware. However, we started with this work and we thought that Enova in Los Angeles was not doing their job. Very soon we got concerned about the progress, the quality of the component and the way they were working (EM, interview 11/2010).

A difference had emerged in what Enova imagined Think should become and what Enova was actually doing to move drivetrain technology development forward, together with Think. Problems concerning communication responsibility, and intellectual property and ownership in relation to drawings, coupled with a poorly engineered product, overshadowed the collaboration. Think suspected Enova was in financial trouble. Though Think brought in additional help to review the design[26], there were problems Think

[26] The research interview does not reveal whether the help came in the form of a third company or additional Think-internal engineering source, therefore I have chosen to omit the idea that there was an individual partner acting, and have not counted this as a separate partnership in the drivetrain case analysis.

could not go about lightly, Alongside, as well as a result of the problems Think had also experienced with other partnerships, it had to reconsider its approach to drivetrain technology innovation development.

5.4.2.8 Think starts building-up internal competence in drivetrain technology, 2008

As Think had bought the software code from Continental, this led the company to recruit people and build-up internal competence in code writing and programming. Think had transferred the whole concept from Enova to a supplier in Chicago, but soon after it realized that the Enova system was merely a very expensive product with questionable quality. This learning also meant that Think was facing consequences of past management decisions. Think CTO Mollestad recounted,

> The reason why we didn't have this [drivetrain] knowledge before was that when Ford owned us, we had an agreement between our management and the Ford management that this EV drivetrain [development] should stay within Ford and we should basically draw on their resources. So when we split we basically didn't have the resources in-house… at all! (EM, interview 11/2010).

As Think did not have the skills to assess the PCU concept in-depth and didn't pursue a third-party assesment, it purchased an unpredictable product component. Indeed, collaboration with Enova — and with Continental — had also been conditioned by Think's lack in drivetrain competence, due to decision making in relation to Think's overall company situation back in 1999, what in this new context now could seem a failure of management. Nevertheless, on the basis of the Enova conceptual model, Think had then designed its own, first drivetrain with an inverter module, a charger module, a divider module and a vehicle controller, and coupled this with software developed on Continental's source code. Instead of a unit in which everything was integrated as Think had received it from Enova, Think kept the design modularized allowing it to make use of the best technology available from specialized companies, for each of the four modules. Think had recombined drivetrain technology.

5.4.2.9 Ricardo's UK engineering partnership forming in relation to the reconstruction of the drivetrain, 2008

To help put its own resources together, Think contracted Ricardo's UK engineering (Ricardo) division and this collaboration went very well. The various components were bought from different suppliers. Semicon, in Germany, supplied an end module, which was based on the technology that it had launched itself, two years earlier. Eltek Valere in Norway delivered the power charger. Delta Electronics in Taiwan delivered the converter. Think also entered into an agreement with Delta about production of the entire drivetrain, which was introduced in May 2010.

The reconstruction of the drivetrain and the modular design was a successful way Think could move forward. Overall, the reconstruction saved Think a lot of cost compared to what it estimated it would have had to pay Enova, had that agreement continued. The drivetrain was of much better quality and had a longer lifetime which improved the functionality of the Think City in general, and in the process, Think had become an OEM, carving yet another role within the EV space for itself. Indeed, it was a favorable development partnership with promising outcomes, not as the result of a planned path, but new opportunities that emerged through collaboration diversity.

To Ricardo, who's business it was to deliver technical engineering services in different automotive projects, the partnership with Think was certainly also of interest, as it was through projects like Think's that it gained special practical engineering experience, which enabled the company to later provide differentiated technical expertise in other projects.

5.4.2.10 Itochu partnership forming around a sustainability project involving Mazda, 2009

The reconstruction of the drivetrain had also enabled Think, as an OEM, to create relations with Japanese companies. Think and Itochu began to cooperate in 2009 through projects in association with Ener1, one of Think's investors. As part of their relationship, Think's drivetrain technology had been used in a fleet of Mazda 2 vehicles in the 'Tskukuba Green Crossover Town' sustainability project, during a three-months trial. Itochu, had a minority-stake in

Mazda and had been equity investor in Ener1 since 2003, and in 2010, it had also taken a stake in Think, which thereby earmarked past collaborations as successful. A partnership became formalized with the purpose of developing opportunities for the Think City and Think's drivetrain in Asia (Think, 2010b). Due to this initial relation, Think's drivetrain is still currently being used in some Japanese postal cars. But at the onset, there was no arrangement put in place between the two partners, as Think Head of PDD Neal explained,

> This Japanese contract came sort of via the board [of directors]. So we are in this sort of interesting relationship, which now seems to become better and better and stronger and stronger. But one of the products of that sort of relationship was this product demonstration happening in Japan. And what you sense is we do not have an organization to deal with this – but nor do they. So, what you see is we are running around – arms and legs. A good indication of this is a mail going around to 15 people, 'cause you are not really… I see this on our side. I do not know who to talk to, I just shotgun gun [shout out]: "Somebody just pick it up, and make this happen, whoever!" But on their side it is exactly the same. So they really… I get the same questions from two or three of their guys, you know. It is just chaotic and sort of so inefficient, but everybody understands that this is just really what we've got to make through of work, but if at the beginning we had sat by and considered and said, "Fine this is a project let us allocate some resources". I allocated one of my guys to this but the rest of the organization didn't step up and say: "Fine we're going to make this happen". And that was a problem. And I think on their side it was sort of the same. So the dialogue has been like that… and like that… and like that… [gestures pointing in different directions] many one-to-one emails with copy to different people each and every time, because we are not organized to do it. It is just organic and you do it; and you just do it and you do not really organize to do it! (CN, interview 3/2010).

It was all but through a carefully planned development cycle that Think and Itochu had been introduced to one another and began to collaborate. To begin with, board relations established this and then situational attentiveness and emergent learning engineers continued the process. The demonstration project in Japan was created because Think and Itochu could openly share problems broadly and throughout their entire organizations. They could also endure working together through tedious problem-solving processes,

changing sensemaking and still kept focused on the will to make the idea of technology development innovation happen.

5.4.3 Drivetrain partnerships breaking

5.4.3.1 Brusa Elektronic partnership breaking as Think focuses on production scalability, 1994

Though Brusa's limited production capacity was a problem and led Think to look for new suppliers, no record was found evidencing that Brusa's products and Think's electric car tests with Brusa products were deemed unsatisfactory for either of the partners. In fact, under Brusa's company history webpage, it states that within the period 1992 to 1995,

> Some new products are developed. Among them is a high efficiency microprocessor controlled battery charger. The induction motor control unit now delivers more power (up to 34kW at 180V DC), and is now also controlled by a microprocessor (Brusa.biz, 2012).

It seems plausible that both partners benefited from emergent learning in relation to technology innovation during the collaboration, but that different perspectives on individual company economic and environment growth ambitions and predictions hampered the partnership continuity. An equally plausible unfolding could have been that their mutual inexperience in supply and manufacturing had actually discouraged the future of their collaboration.

5.4.3.2 Siemens partnership breaking as Ford takes over Think and chooses Ecostar, 1999

Siemens had provided Think with satisfying components, support, and it had also demonstrated a like-minded approach to the development of drivetrain systems. However, as Ford bought Think, the collaboration with Siemens became uncertain. Ford introduced Think to Ecostar, which supplied Ford with drivetrains for other products, such as the mini version of the Ford Ranger. In a bidding competition between Siemens and Ecostar, Ecostar put-in a cheaper bid and Ford was most interested in giving the mandate to it. The partnership

with Siemens was then broken and there is no record of the collaboration around drivetrain systems later reforming.

5.4.3.3 Ford-Ecostar-Think partnership breaking as Ford's corporate interests drift, 2002

The partnership between Ecostar and Think had been based on Ecostar's software development and tier-two supplier Enova's motor – an 'okay' drivetrain system from Think's point-of-view. Until the summer of 2002, when Ford basically stopped all development activities in relation to the Think City, as Ford had taken the decision to sell-off Think. Ecostar had also been sold, whereas Ford still continued with the Fuel Cell Alliance (FuelCellsToday, 2004), which was aligned with its strategic development direction. What Think learned from the partnership with Ecostar was something about what type of resources it wished to have in-house. Think CTO Mollestad explained,

> So when we split from Ford, we basically didn't have the resources in-house at all to develop drivetrains. And you know, now we have it, so I think the story around this drivetrain is quite a good story because, what was available in the market was not good enough. So we built our own competence and developed our own competence and now we are one of the leaders in this area (EM, interview 11/2010).

Think realized that the 'little guys' do win sometimes. Through the process related to discovering a satisfying drivetrain system, Think discovered it would be a problem to stick to the idea of not developing any parts in-house, as Founder Ringdal had set as a frame for technology management for the company to begin with.

5.4.3.4 Continental partnership breaking due to a lack in network openness, 2008

As Think wasn't able to benefit from Continental's tier-two supplier network and Continental's handling of Think's software change-requests was slow and problematic, Think's focus drifted. Finally, Think was able to buy the software code from Continental and from there on, execute all changes itself. This was when Think began to recruit people who had expertise in electric car power electronics and control electronics, as well as people who had the software

development skills required to build-up Think's internal competence and experience.

5.4.3.5 Enova partnership breaking as Think's development focus drifts and it buys the PCU concept, 2008

The Enova partnership had turned into one long discussion about communication responsibility, intellectual property and ownership, and it had not resulted in any noteworthy technology advancements according to Think's expectations. Think CTO Mollestad explained,

> So, we had a lot of meetings and a lot of discussions and it ended-up with us actually buying off the whole technology from them. We had to take over this to make it happen (EM, interview 11/2010).

Think had transferred the whole PCU concept from Enova to a supplier in Chicago, but soon after it realized that Enova's system was merely a very expensive product of questionable quality:

> We understood that this Enova system was basically not good enough. You could improve, try to take away the worst quality issues, but it was very expensive – basically old technology – and it was not the right way to go (EM, interview 11/2010).

To Think, a better solution was to "basically make a complete new drivetrain system", since what was available in the market also couldn't meet its expectations (EM, interview 11/2010). At the time, there was no expectation or forecast that this technology development would become an important independent line of business for Think[27], though Think eventually became one of the leaders in the area. This shift also represented an important and intentional move beyond the founding principles of Ringdal that precluded the production of a car's parts in-house.

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[27] Software development skills required in relation to technology innovation development of electric cars may be considered similar to those necessary for developing combustion engine cars. However, the traditional automotive industry is not recognized for competence in the area of power electronics, which means is was difficult at the time to find engineers with the appropriate skills and overall, Think had to create its own expertise through experiments and tests. Efforts in doing so later proved build valuable experience.

5.4.3.6 Leroy Somer partnership breaking as Think's financial situation drifts, 2011

The Leroy Somer partnership continued until Think went bankrupt in 2011. Several advancements were made to increase the efficiency and robustness of Leroy Somer's liquid-cooled-AC motor in relation to its function in the Think City car. It was a satisfying collaboration and therefore Leroy Somer was also considered as a possible partner in relation to Think's next generation of Think City cars, which were being planned for 2011. But whether Think would have chosen Leroy Somer after examining other technology options was uncertain, as Think CTO Mollestad explained,

> And for the next generation [Think City cars], we are now in the bidding process to see if we should continue with that company or if we would like to go somewhere else because there have been quite a lot of motor technologies in the past few years. And there is room for both improvements and, yes, specifications in efficiency and also production and cost… it probably changes. Maybe we will replace some of the modules and that is one of the beauties of this new [drivetrain module] approach that from now on, when technology is coming for inverters or chargers then we'll quite easily just replace the modules without redoing the whole thing (EM, interview 11/2010).

Think's focus was on using the new drivetrain module approach it had developed for the next generation of Think City cars with the best available technologies. Its focus was not on stabilizing its partnership with Leroy Somer at any cost — Mollestad seemed to consider the new approach as an enabler for partner choice flexibility. However, it is not known whether the bidding process for motor technology for Think's next generation of Think City cars was ever completed before Think's activities had stopped in the summer of 2011, and so the outcome of technology choice remains uncertain.

5.4.3.7 Ricardo's UK engineering partnership estimated breaking as Think's financial situation drifts, 2011

From 2008 onwards the partnership with Ricardo's UK Engineering had helped Think build up its own drivetrain innovation development team, conduct experiments, test its first drivetrain module, and prepare itself for the role of OEM supplier. However, there is no record of the collaboration pro-

gress until Think officially stopped activities in 2011. Perhaps while Think's internal drivetrain team increased its different drivetrain-engineering skills and experiences leading it to less explicitly draw from Ricardo's competences, the partners drew from other intentions in the continuation of the partnership, such as political or market opportunities. For example, in 2009, Ricardo's Technical Director Jackson had been appointed chair of the Low Carbon Vehicle Partnership (LowCVP)[28] program, a UK government-sponsored partnership that had the aim of encouraging adoptions of reduced carbon emission vehicles (Ricardo, 2009). In relation to this, it was mentioned that Jackson "brings with him a wealth of experience gained at the cutting edge of this sector and will help the partnership [LowCVP] accelerate progress to low carbon vehicles" (Ricardo, 2009). As such, Think could be a useful partners in promoting this politically important agenda. In 2010, it was announced that Think became part of a UK electric car consortium called REEVolution, which was also part of the LowCVP program, and as such, this provided Think with a chance to showcase its own developed drivetrain modules (Think, 2010k)[29]. To the Edmunds Auto Observer Think CMO Lock explained,

> We have visibility for the controller because we have a finished vehicle, but selling electric cars is not the only strategic goal of the company, we also have an advanced and proven drivetrain technology, and if we have an advantage at the moment it is more in our technology than in finished vehicles (O'Dell, 2010).

Think's engagement in the REEVolution consortium was thereby not only a demonstrative gesture that put Think's technology at the forefront, but it also confirmed Ricardo's UK Engineering competences.

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[28] The LowCVP was an integrated program of the UK Government involving its Technology Strategy Board, the Department for Business Innovation and Skills and the Office for Low Emissions Vehicles.

29 To realize the ambitions of low carbon technology expansion and enhancing, the LowCVP had awarded a consortium of automotive partners about £9.5M towards learning and feedback for supply chain and technology development through 'on the road'-demonstration projects. The consortium partners consisted of Jaguar Land Rover, Lotus Engineering, Nissan Motors, Think, Axeon, EVO Electric and Xtrac. These partners contributed with another £11M to the program, of which the first three mentioned partners may are expected to have contributed the most (Think, 2010k).

5.4.3.8 Itochu partnership breaking as Think's financial situation drifts, 2011

The Itochu partnership had marked Think's debut as an OEM supplier of drivetrain technology. Through this, Think had been given the chance to showcase its technology and later benefit from demonstration projects and experiences that had taken place in Asia. These not only contributed to the improvement of the drivetrain technology, but also served the Think City car as a whole. The focus of Itochu had been in line with Think's ambitions as both were trying to connect potentials between Mazda, Ener1, Think and beyond. As Ener1 CEO Gassenheimer explained, "Itochu has the vision and resources to connect the whole value chain, [...and] Ener1 and Think's technology are at the heart of everything Itochu is looking to achieve within the energy efficiency sector" (Think, 2010b). There were no accounts found reporting any change in the positive progress of collaboration up until Think's bankruptcy in 2011. Therefore, this partnership is likely to have been considered an asset to potential new investors.

5.4.4 Drivetrain partnerships reforming — or the lack thereof

In this drivetrain case, the partnerships with Ecostar and Enova may be considered as reforming partnerships since Think had contact with both companies during the Ford period. Partnerships from 2008 were formed based on the initial collaboration that was established during the Ford period, despite the fact that they had been mediated by Ford. Still, data from the period of Ford – both data related to my research interviews and from other sources – does not feature or point out that there had been direct contact between Think and Ecostar, or between Think and Enova. For that reason this research explores only the drivetrain relations as forming and breaking regarding Think's explicit and documented partnerships from 2008, though it acknowledges the possibility that its the partnerships with Ecostar and Enova may be considered as reforming partnerships.

5.5 Partnerships around headlamp systems in the electric car

This part shows how relations between the Think headlamp system development partners and the electric car have been forming, breaking and reforming. In this case, Think began to consider headlamps as non-standardized products and develop variations of headlamps to meet different local needs and keep different headlamp partnerships in work at the time. It is a story that reveals how strategic importance may be related to any partnership.

The foremost role of the headlamps is a functional one: to produce and distribute light to illuminate a road ahead when there is low visibility and thereby provide a car driver with traffic overview. The component consists of a lens, a reflector, and a light bulb related to a headlamp leveling system. Headlamps are compulsory equipment on cars and they have to meet engineering and performance requirements and tests, which may differ from one marketplace to another. This makes them important, as seen from the outside of an innovation project. For example, a headlamp system must produce a low and a high beam, achieved by single or multifunctional lamps, which must not blind or dazzle oncoming drivers. Thus, headlamps are a performance safety component to both the driver and fellow drivers on a road.

Headlamp makers explore how to avoid blinding, strengthen optical precision and headlight output, extend bulb life, and keep power consumption to a minimum. In tandem, Think had to explore headlight integration with the Think City car design, where headlamps are focal components; they are the eyes of the car's face and an important factor in the car's front area's styling characteristics. Think's aim has been to select headlights that meet legislation and to select them early in the development process so as to allow the styling influence to be integrated into the design; however, legislation criteria, material quality and cost have maintained priority.

In relation to this particular component, names of partnering headlamp manufacturers and Think manager – and to some extent, the technology – were kept concealed by Think. To respect this discretion, I will refer to Think's partners as the HLM1, HLM2 and HLMx partnerships, where HLMx will represent the collaborative development of several headlamp manufacturers, as they occurred simultaneously. The case does not

trace the headlamp development process during the first ten years as no account could be collected for this period. However, it is assumed that headlamp components may only have gained development importance in relation to the Think City model developed in 1998 that focused on styling improvements. **Figure 14** shows how relations evolved over time.

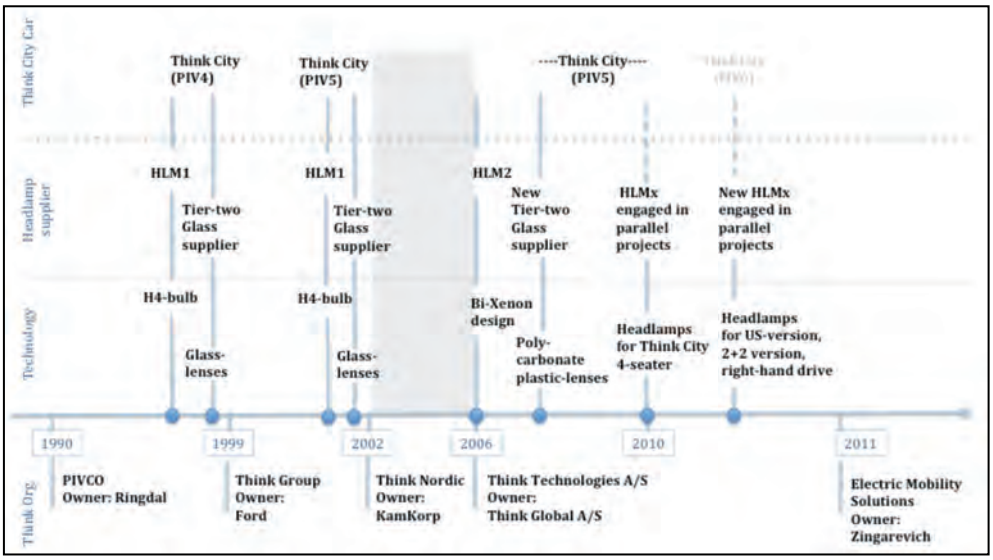

Figure 14 Think headlamp development partnership overview

5.5.1 Headlamp partnerships forming

5.5.1.1 HLM1 partnership forming around the design intent and the H4-bulb, 1999-2002

The headlamp partner HLM1 that Think was working with during the Ford era had received Think's specified design intent and notification of the legislation requirements that Think needed to comply with. The company provided Think with a headlamp model that made use of an automobile industry standard bulb – the so-called halogen headlamp 'H4 bulb' that could produce both a low and a high beam. There seemed not to be any strategic problems related to the headlamps as Think viewed headlamps as something that needed to be inte-

grated as a requirement and so the system had to simply work satisfactorily in the Think City car. Think PM of Headlamps[30], explained,

> Headlamp business is not a very strategic one. It's merely to meet legislation and of course the styling influence that has to be integrated into this design. I don't see a headlamp as something strategic like perhaps our core competences today in drivetrain and battery technology (PM of Headlamps, interview 10/2010).

However, this headlamp model failed to meet legislation criteria for all markets, which was a strategic problem to Think's overall technology innovation project. What had prompted Think to consider headlamps to be less subject to technology development problems than batteries or drivetrains? Was it their size, Think's lack of experience with detailed skills involved in headlamp development, or did it come from a traditional automotive perception that Think and its partners had somewhat blindly followed? Moreover, this issue only surfaced at a later moment in time, as Think resurrected in 2006.

5.5.1.2 HLM2 partnership forming around design of Bi-Xenon projectors, 2006

The partnership between Think and HLM2, who bought the order book from HLM1 as it went out of business, embarked on the development of exploring a headlamp design solution that could make use of the new intelligent 'Bi-Xenon' or 'Bi-Halogen' projectors.

Initially Think thought it could incorporate the aforementioned H4 bulb, most especially as a solution for headlamps in smaller cars and lower-end family cars.

> A key realization is using a standard in the industry, we called it H4 bulb, that's a standard bulb which most headlamps, not high profile vehicles but certainly the domestic sort of ABC category of cars the cheaper model [make use of], and they have a standard bulb (PM of Headlamps, interview 10/2010).

However, Think realized in 2006 that it could not pass regulation requirements in the US with this type of bulb[31]. It was a tough learning curve for

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[30] The name 'PM of Headlamps' is used to respect interviewee anonymity. The term refers only to one person.

Think to discover that this headlamp could not serve its envisioned purpose. Was this a sign that Think's ambitions had drifted more strongly towards the US market? In addition, in 2006, the body panel of the Think City car defined an enveloped hexagon space which Think wanted the headlamp to parallel in shape and dimensions. Still, besides the legislation requirements and the Think City body panel design changes, a redesign of the headlamp model posed other design-legacy challenges. Think PM of Headlamps, explained,

> Impregnated, I would say was the design legacy of the previous company so, you know, they (HLM2) inherited a very poor performing design. The design would not meet legislation for all kinds of different reasons. We have had to tune up every single component part of the lamp for it to be resold (PM of Headlamps, interview 10/2010).

In technical terms, this new design involved removing the bezel, putting in a Bi-Halogen projector and getting this tuned into the right level of output light to meet legislation. In terms of cost, however, this became a problem-item: it led to a ten-times more expensive assembly solution. Still, to be able to sell the Think City, Think had to solve this bottleneck problem and adjust for the increase in material cost per vehicle, as Think PM of Headlamps further explained,

> It became a major bottleneck because we didn't want to take the decision to go with a projector unit, which is typically ten times the cost of the standard bulb where we're just doing the assembly, so it's a high-cost item. This is a cash-sensitive business and headlamps are a material cost that should be monitored, which now run at such a high cost per vehicle, it was unsatisfactory. However, as this specifically was required to pass the car to sales and sell it in the market then of course, we took the decision that we had to do it (PM of Headlamps, interview 10/2010).

This legacy of poor design, a development program led by a company (HLM1) that didn't deliver what it was paid to do, and the shortcomings of Think being in a learning process, also in terms of customer experience, kept

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[31] Since its introduction in 1971, the H4 bulb had become one of the most popular bulbs for automotive use, but still in 2006 it was the only European-designed and internationally approved bulb that the US Department of Transportation did not deem as having an acceptable filament variance (Candlepower, 2003).

on having implications on the partnership with HLM2 as Think regularly would return with change requests. Think PM of Headlamps recounted,

> Development and production has never been stable (with HLM2), we've always come up again for tuning or quality levels that are not satisfactory and made compromises both in cost and quality and of course this would always impact delivery. And we still suffer that today – everyday (PM of Headlamps, interview 10/2010).

The suffering had centered more on achieving different satisfying levels of variance for different models of the Think City car.

5.5.1.3 Tier-two partnerships forming around glass and polycarbonate lens-design, 1998-2008

The lens-design will be used to exemplify how Think began to work with two suppliers on many different headlight piece parts. Within the headlight's assembly there are an average of one hundred pieces and each supplier has about thirty to forty tier-two suppliers providing them with small pieces that assemble into components. Think worked with tier-two suppliers directly. Maybe that was unique for headlamp development or Think's HLM1 partner didn't want to take the coordination role, but this gave Think a substantial logistic-task, considering its organizational size. To add to the complexity, the glass supplier that used to supply Think with lenses had gone bankrupt, so in turn, supply became unpredictable, and the responsibility of finding a solution became Think's. Ten years ago, Think worked with glass lenses – although this lens-technology is no longer practiced today, as polycarbonate plastic lenses have become the standard – so Think didn't only have to change from glass lenses to polycarbonate plastic lenses, it has had to work on retooling the entire production process to fit this new material. Further to this, Think's direct supplier didn't produce the polycarbonate plastic lens, which is the front of the headlight that looks like glass; the supplier produced a plastic molding in-house and then shipped it out to be naturalized it order to obtain its high shine appearance. So while Think tried to stabilize the larger assembly parts, the company was still in a learning process with its suppliers, who in turn, were also trying to industrialize and optimize the manufacturing of the components and assembly tools. Think PM of Headlamps reflected,

> Lots of things in the supply chain can go wrong and have gone wrong. And the suppliers, if they were smart, and we can't afford them to be so, should say: "Go away, we cannot produce what you want to assemble in six months. We need time to industrialize this production". We haven't allowed them that time, and time and time again we are pressuring them with a product that doesn't fit the purpose of their production facility, but because of the demands on the sales of the car, we push them to produce (PM of Headlamps, interview 10/2010).

The headlights may, for the current fifth version of the Think City, be re-defined within the area of variance provided by the body panel. However, to ensure a robust alignment, too much interface playroom cannot be left unused. As both the body panel and the headlights are subject to development changes this is an ongoing puzzle and play with materials, mass, machines and minds. A time consuming and collaboratively draining process for all parties is involved. Necessary changes are not perceived as improvements on a desirable technology, rather, they are considered as problem-fixing of a chronically problematic technology and what are only relatively successful partner relations. Think PM of Headlamps explained,

> You know, if two years ago whilst we had some downtime, we had lifted the tools to make the founds which we hone and placed them in a molding manufacture, I'm sure our life would have been a lot easier, so that's one way, don't change the design or the style of the lamp. But it would have taken us away from a supplier who is not necessarily engaged in focusing on us as a key customer. Therefore our leverage in our ability to influence them day to day is a struggle and we recognize that. Our opportunity is when we are developing the next platform (PM of Headlamps, interview 10/2010).

Think had not predicted that the difficult financial period at the end of 2008 would be a useful period it could use to focus on assessing headlamp partnerships. The uncertainty of Think's general future had become the company's major concern, including headlamp development dilemmas. As a result, Think was looking for ways to improve the Think City car headlamp development by drawing on its other projects and thereby increase its headlamp supplier independency.

5.5.1.4 HLMx partnership forming in relation to the design of headlamps for the 4-seater vehicle, 2010

As Think began developing variants of headlamp design for a 4-seater vehicle, its tests of various headlamp options with regards to the use of material, assembly tools, and design were also intended to advance the Think City car's headlamps. Since a 4-seater vehicle is larger, the weight is different and therefore the headlights behave differently. As an effect, legislation requirements for headlights on that type of car are also different. The result of this is that Think was running several projects – "at least two or three" – with its headlamp suppliers, at any one time, which required close coordination within Think. But this also allowed Think to remain less dependent on tier-two suppliers whose situation often drifted, as PM of Headlamps, explained,

> We've had so many things that have happened which in a normal new program wouldn't be accounted for, because they shouldn't happen. Anything that can go wrong has gone wrong. You know, companies have gone bankrupt, tooling that's not fixed for the purpose […]. So lots of things in the supply chain that can go wrong have gone wrong (PM of Headlamps, interview 10/2010).

To ensure attention was directed to Think's development priorities despite supply chain uncertainty, Think performed a number of environmental and engineering life cycle tests throughout the development of headlamps with pieces from different suppliers. First, Think would test, through a controlled process for the Think City car, that the integrated manufactured parts would achieve the headlight optical output to a predetermined value level, as also required by legislation for performance in a given market. As the manufactured parts that Think used changed on a frequent basis, these tests were repeatedly undertaken. Second, Think undertook heat tests to take into consideration the behavior of materials used in hot and cold climates; when used constantly and infrequently. Third, Think established an appearance quality check on behalf of its customers, which meant that a small grain scratch or dot on the headlight moldings would pass approval to sales, but that several impurity marks would not. Maybe these tests helped Think's headlamp development stay in the area of variance provided by the body panel, but they did not seem to enhance headlamp innovation.

5.5.1.5 HLMx partnership forming in relation to the design of headlamps for the new Think City platform, 2010

The next platform – a re-design and re-definition of the Think City – was still in development and was expected to launch in 2012. With this, Think had set out to form relations with other headlight suppliers, as Think PM of Headlamps, explained,

> So here is our opportunity to be very clear in the strategy of the headlight platform. We are very careful on the legislation and the markets we want to deliver the car to and with that I mean, we will better plan a new criteria performance test when we select supplier. So, you know, the supplier, that we've selected ten years ago, were not wrong, reflecting we might not have had the vision directed towards the world market, but more kind of domestic market in Norway. […] Business in general has improved looking at the sky a little bit broader and therefore when we are selecting a supplier it's gotta be a global supplier; it's gotta be one of the top five in the industry. And, you know, let's just say some of the shortcomings of our design back ten years ago is a lesson learned, which I suggest will help us do it right the first time by an approach in the future… I would like to think (PM of Headlamps, interview 10/2010).

Past experience had fostered the desire to start from scratch with the design of headlights. Furthermore, there was a clear aim to better envision the possible variants of headlight models and market legislation that may be decisive in terms of where the Think City could be introduced, as Think PM of Headlamps, described,

> We should introduce a sort of life cycle of the platform because, I have to be honest and that's where we as an organization have failed time and time again. We developed a component or a system to support a product without thinking well about how we will expand the life of the products. And that leads us into, as I also said, at the moment, you know, we have three projects with the headlamps; so far alone at the moment for the US version, for the 2+2 leveling version and then the right-hand drive project is coming soon (PM of Headlamps, interview 10/2010).

Think had learned that both a long-term and a short-term headlamp development vision may have an important impact on how headlamp partnerships form, break and reform.

5.5.2 Headlamp partnerships breaking

5.5.2.1 HLM1 partnership breaking as Think's financial problems drifted, 1999

The partnership with HLM1 broke the first time as Think's financial problems drifted, and as Ford took over Think, the company drew on its own network of suppliers. How the partnership between Think and Ford headlamp suppliers unfolded could not be traced.

5.5.2.2 HLM1 partnership breaking as HLM1 went bankrupt, 2006

The partnership with HLM1 broke a second time as HLM1's financial problems drifted and another company, HLM2, bought it. Being listed in the order book of HLM1 made it easier for Think to enter into a dialogue about technology development partnerships with HLM1's new owner. Think PM of Headlamps confirmed, "that led us to the company [HLM2] who bought the order book of the old company and later ensured us a new relationship with a new supplier" (PM of Headlamps, interview 10/2010). As such, the order book listing represented a solution to Think's problem of finding a new supplier.

5.5.3 Headlamp partnerships reforming

5.5.3.1 HLM1 partnership reforming around HLM1's redesign, 2006

When Think reignited development activities and resurrected lamp design on the Think City back in Norway in 2006, the lack of compliance of the H4-bulb came to light. Think tried to start redefining the headlamp together with the same partner it had had earlier (HLM1), which was a company that was also willing to supply. However, while Think was in the process of revitalization, HLM1 was going through receivership, which made the partnership unpredictable. There is no record of former HLM1 management or direct HLM1 contact persons helping Think form the new partnership with HLM2, but given its willingness to work with Think again, this research considers it a possibility.

5.6 Partnerships around the financial engineering of the electric car

This part explores how relations between Think management, as financial engineers, financial investment partners and the electric car itself have been forming, breaking and reforming. The case follows the same analysis principles as the previous three did, but it also tells the story about the development of finance as a technology innovation component. Think interconnected technology innovation financing to public events through which it gained wide-reaching stakeholder contacts, legitimacy and support; this is a turbulent story that reveals further understandings of technology innovation partnerships.

The financing of electric vehicle technology innovation can be based on public and private sector funds, or both. Technically, the funds can do the same thing: pay for the costs of internal and external services or goods. Practically, however, funds typically earmarked concrete installations or processes that intended to further knowledge about electric vehicles, market potential or innovation components embedded in the electric car. Often, pilot or demonstration projects, patents and policies serve as both deliverables and enablers of funding. To have a virtual overview of funds, spreadsheet instruments are designed to integrate different funds in relation to different technology innovation aspects. The financial component is directly involved in a lot of different ways – daily operations, development, research, tests, and production – which explains its importance in relation to other technology innovation components.

Financial investment partners explore effects of funding in relation to expected technology, economic and social outcomes in order to reduce innovation finance overheads, while securing benefits to the innovation good being created. Similarly, Think's financial engineers explored how funding could cover different expenditures and be mixed without binding claims for the technology innovation process or outcomes.

Over the years, Think has worked with a number of financial engineering partners: besides its founder Ringdal, the list has come to count Oslo En-

ergy, Hydro Aluminium, Statoil, Telenor, the Norwegian Post, Ford, Kamcorp, Inspire Invest, Kleiner Perkins Caufield, Byers and Rockport, Ener1, Valmet, Investinor, and Think employees. **Figure 15** and **Figure 16** show how financial engineering relations had evolved over time.

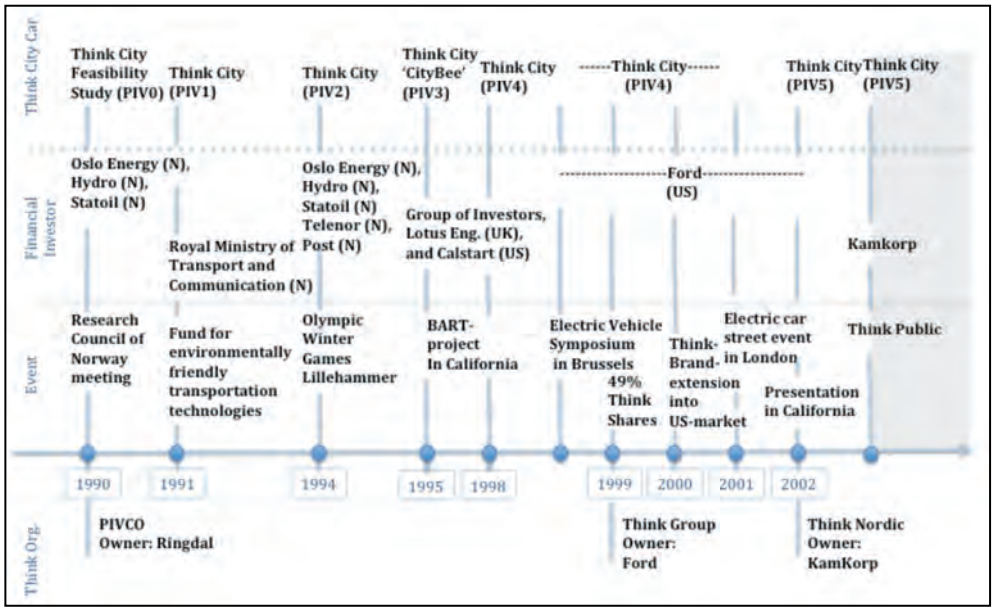

Figure 15 Think financial development partnership overview - the years 1990-2006

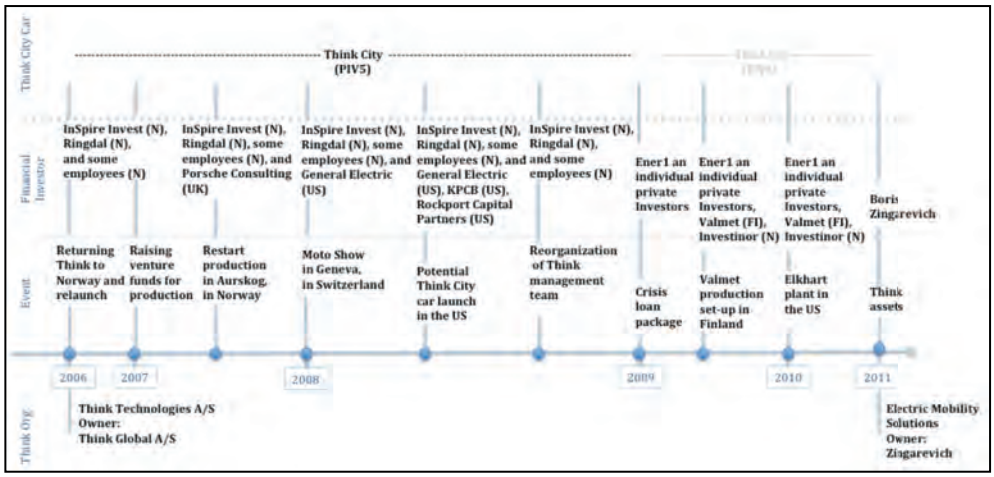

Figure 16 Think financial development partnership overview - the years 2006-2011

5.6.1 Financial partnerships forming

5.6.1.1 Oslo Energy, Hydro Aluminium and Statoil partnership forming upon the Research Council of Norway meeting, 1990-1993

In 1990 the Research Council of Norway hosted an open discussion on environmental issues at which several potential technology innovation investors such as Innovation Norway, SND Export Norway, the Norwegian Post and Oslo Energy attended. Invited by a friend, Ringdal participated by introducing his idea of an electric car. Historically, Norway has had little experience in car-making, which meant that Ringdal was approaching a green field. However, shortly after this Norwegian meeting, Ringdal founded the company Think and a collaboration with Oslo Energy began forming, through which about US$35M–40M had been invested in Think by Oslo Energy, between 1990 and 1998. Not only was Think's new associate interested as an energy producer, but Oslo Energy was also attracted by the prospect of becoming a potential user of electric vehicles. In addition, Ringdal had approached Statoil since he previsioned the possibility of using its petrol stations as recharging stations, had interest in Statoil's plastic competence, and sought affiliation with a company that, in general, was an important actor in the Norwegian industry. To Statoil, the Think partnership was of interest in part because it allowed Statoil to demonstrate environmental awareness, as Ringdal once explained to Dedijer Media AB, "I think Statoil sees it as an important way to contribute to efficient and non-polluting ways of using energy […]. Fossil fuels are too valuable to burn wastefully" (2000). Norsk Hydro, a chemical and aluminium company, was also approached by Ringdal, who perceived the potential of using light-weight aluminium technology to develop what became Think's internationally patented space frame. Hydro reciprocated involvement too, which was likely founded on interests similar to Statoil's. In his preparation for presentations to different potential partners, Ringdal profited from knowledge exchanges with Professor James Utterback from MIT in Boston and Professors Schmid

and Niederer from ETH in Zürich. Besides this, the Kewett[32] electric car production team in Denmark was consulted. Based on the financial support Ringdal received from Think's partners he conducted a feasibility study in 1990 and 1991. Through his presentations Ringdal learned that it was important to qualify the level of risk involved in the technology innovation project when talking to investors, because as he presented, investors would ask about which factors potentially could and should be defined in relation to or in opposition of existing automotive market value parameters, and with that, political, economic, and social interests. Furthermore, collaboration with these different commercial partners enabled Think to receive a grant from the Norwegian Royal Ministry of Transport and Communications[33], who had created a fund in 1991 to support Norwegian development of environmentally friendly transportation technologies. This grant mainly paid for the development of the first prototype of the electric car, the PIV1. Thus, the first prototype development was accomplished despite the fact that neither Ringdal nor his partners had previous or direct experience in the automotive industry. Was Think's partners deliberately building the foundation for a Norwegian automotive industry from scratch, or were they thinking of this project as an experiment with many possible outcomes?

5.6.1.2 Oslo Energy, Hydro, Statoil and Telenor and the Norwegian Post partnerships forming upon the Lillehammer Winter Olympics, 1993-1994 (Roeste, 2004)

Ringdal envisioned the 1994 Winter Olympics in Lillehammer as an opportune place to test and present the electric car to the public. This locality provided a large international audience as well as the challenging conditions suitable for

[32] Kewet was founded in Denmark in 1988. Today, Elbil Norge, who took over the concept in 1998 and renamed the electric car 'Buddy', produces it. See www.BuddyElectric.no

[33] This funding was given based on a collaboration between NTNF (Norges Tekniske-Naturvidenskaplig Forskningsråd), the Ministry of Transport and Communication, and the Ministry of Petroleum and Energy. Noticeable is that evidence that the decision to fund Think was a direct result of ordinary ministerial decision-making in research on innovation policy governance cannot be traced. Rather, the funding was prompted by "garbage can logic" — it was an interesting innovation idea as compared to the other opportunities (Roeste, 2004, p. 14).

a convincing demonstration of the prototype's technical feasibility: a hilly environment and extreme weather conditions. Ten new second-generation electric cars (PIV2) were built and put on show at the Winter Olympics. At the time, Think was still being sponsored by Oslo Energy, Hydro and Statoil, but in relation to this event, the Norwegian telecommunication operator Telenor and the Norwegian Post also became important sponsors. Telenor invited prominent guests to the VIP-lounges at the games, to and from which Think chauffeured guests. The additionality for Telenor was that it could provide its guests with a different technology experience, indicating its advanced position in relation to technology newness. Among the prominent guests were Ford representatives, whereby Ringdal could receive advice that could help ensure highway approval for the electric car. The Norwegian Post offered Think access to its car parking space in exchange for branding on the cars. In both the case of Telenor and the Norwegian Post it appears that there was no monetary exchange, though clearly, these partnerships were of financial importance and it would not have been difficult to put a price on the services exchanged – one prominent example is how the Winter Olympics enabled Ringdal to land a contract with the San Francisco Bay Area Rapid Transit station car project (BART-project), which became its next milestone.

5.6.1.3 A group of private individuals and professional investors, Lotus Engineering and Calstart partnerships forming around the San Francisco BART-project, 1995-1998

For the BART-project, Think developed the third-generation electric car, called the CityBee (PIV3), funded by a group that consisted of private individuals and professional investors. During 1995 and 1996, 120 CityBees were built and 40 were shipped to California where they were leased for three years to the San Francisco BART-project based on a US$1M contract. This was a field-test program intended to determine the viability of electric cars for short daily trips. Both Lotus Engineering and Calstart were partnering with Think in this development. Calstart, a Californian based organization supporting high-tech clean transportation, was interested in exploring how technology and different resources could possibly be combined for the necessary in-

frastructure, and for Think, this partnership meant it could obtain a locally integrated service and consulting partner. The collaboration with Lotus Engineering served two of Think's predominant interests, which were to draw on professional automotive skills while satisfying Think's financial partners' needs for investment security and quality assurance. The remaining CityBees built in this period were rented to Norwegian companies and hotels taking part in local environmental awareness programs. Think gained real-road experience with its electric car. This led to the decision to move production from the rented cellar space it occupied below a bike store in Oslo city to more spatial facilities. Beginning in 1996, new lean production facilities were built in Aurskog, Norway and a production line was installed in collaboration with Lotus Engineering. Based on experiences from building prototypes, Think developed and crash tested the first true production model, the Think City car that obtained EU market approval. At this time Ringdal began to envision that Think should operate satellite production sites when it would expand, and how each could have an impact on local interests and identity; but, Think's financial situation was drifting.

5.6.1.4 Ford partnership forming around the Think City launch at the 1998 Electric Vehicle Symposium in Brussels, 1998-2002

The first production model, the 'Think City' was launched in the autumn of 1998 at the Electric Vehicle Symposium in Brussels. Ringdal understood that he had to use this event as an opportunity to contact potential investors. He spoke to different automotive makers, and there was an agreement made that he should present to a Ford audience later that year. Upon his return to Oslo he was informed that Ford would send two men in November to hear his presentation, and he used this as an opportunity to initiate the constructs of a letter of intend (LOI)[34] that he could then use to convince the probate court in giving Think more time to solve its problematic financial situation. The two

[34] A letter of intent or an LOI is generally a non-binding agreement to a contract that will be signed at a later date. An LOI briefly describes the matter two parties intend to agree upon, thus it is not without value, though it is legally considered controversial (Investopedia, 2013).

Ford representatives left Think impressed and promised to push for an LOI, but made it clear to Ringdal that introducing new ideas to upper management in the month of December could be problematic. However, on 3 January 1999, Ford CEO Jack Nasser presented the Think City at the North American International Auto Show (NAIAS[35]) in Detroit to about 700 journalists. And, on 5 January 1999, Ford bought a 51% share in Think industries, which was renamed Think Nordic AS (Think). The Think President Lilleng commented,

> For us it is fantastic. We worked very hard to find a global partner that had not only capital but knowledge of marketing and distribution. This will help make the car a global product, not just a Nordic vehicle. […] We could believe in it and dream about it. […] But we needed a partner to turn the dream into real business (Pryweller, 1999).

As Think worked hard to find investors in 1998, the effects of the 1997 Asian Financial Crisis caused the Norwegian stock market to drift, which made it impossible for Think to find local investors. Besides this, Think realized that there were no local investors who had the necessary automotive production competencies and global presence it needed for expansion. Founder Ringdal explained,

> Ford's interest in our company is a strong recognition of the Norwegian electric vehicle project. […] This partnership will make possible a global expansion of a new, clean and purpose-built vehicle for personal mobility in urban areas (AutomotiveIntelligence, 1999).

However, Think also came under strategic consideration in terms of bringing recognition, skills and market access to Ford, as Ford CEO Jack Nasser confirmed in a press statement,

> This car will give us immediate access to a whole new market niche; it will provide a wealth of ideas for us to develop. We are particularly interested in new concepts in the use of plastic body components, as well as low-volume and flexible manufacturing (AutomotiveIntelligence, 1999).

[35] NAIAS is an annual auto show and among the largest in North America usually taking place in early January and typically in Detroit.

Indeed, this was a very rich statement of expectations regarding Think's supposedly smooth navigation from market to technology, to configuration system, to experimentation and back. Furthermore, the partnership was interesting to Norway's business, economic and political sectors not only because it ensured the continuity of the Think City electric car, but since it also boosted expectations about employment and legitimized Norway as as automotive producing nation. The Norwegian Prime Minister Kjell Magne Bondevik, endorsed this partnership, in a press release stating,

> The Norwegian Government welcomes the fact that Ford Motor Company now enters PIVCO Industries AS [Think]. In particular we find it interesting that Ford has chosen to support the development of Norway's electric car Th!nk. Through Ford's technical resources and global sales network, PIVCO [Think] has now been offered a possibility for its electric cars "Th!nk" to become a success (GSA, 1999).

As a partner, the Norwegian government had already supported the project by offering free parking spaces, making no claim to weight tax, recycle costs, or yearly taxes, and during 1999 it also enacted a decision to make it cheaper to use electric cars as company cars and delivery cars (TU.no, 1999).

Ford did not show any intention of shifting production to the US and market plans for the Think City car also focused on Europe, where gas prices were high in comparison to hydroelectric power. The Think City car would have to prove it could meet US federal standards prior to sales there, and this became a promising prospect for all partners and potential customers.

5.6.1.5 Ford partnership forming around the purchase of Think's remaining 49% shares, 1999

Later that same year, Ford bought the remaining 49% shares of Think. Ford paid approximately US$23M for the whole of Think and invested about US$100M into Think over subsequent years. Think not only enjoyed direct support from John Wallace, Director of Electric Vehicle Research at Ford, but from the CEO, Jack Nasser. In November 1999, production of the Think City restarted and over the next two and a half years, 1005 vehicles had been produced and sold or leased in several countries. Think operations remained in Norway, but Think became linked to the Ford EV-project, including the USABC,

and thereby prepared for launch in the US. This partnership was a milestone, Think CTO Mollestad recounted,

> The big breakthrough came as Ford bought themselves into Think and later took over all shares. It opened a new world to us, and we became part of the good company. And Ford has competences in all the areas where we are needy. They [Ford] have taken a strategic decision as to where to place their odds [on Think]. It is very inspiring that an automotive giant has such good faith in this project (Asphell, 2001)*.

In the same interview, CTO Mollestad also noted some challenges in the nature of the partnership,

> Ford is a very big organization with lots of control and bureaucracy with demands about reports and routines, which are designed for production in high volumes. That doesn't fit well with us [Think], which is an absolute niche production. Also as a part of corporate Ford, our challenge lies in maintaining enthusiasm and the entrepreneurial spirit from the pioneering time (Asphell, 2001)*.

The partnership with Ford solved many problems for Think, but it also brought about new problems: Think had to prove itself as a viable member of Ford's greater product portfolio. Though Think was aiming for high-volume production of the Think City car, it was still a smaller player in need of support.

5.6.1.6 Ford partnership forming in relation to the Think-brand extension into the US market, 2000

In January 2000, at the NAIAS in Detroit, Ford introduced a range of products under the Think brand: an electric bicycle, a golf cart and a fuel cell car. There seemed to be no limit to Ford's enthusiasm and expectations in terms of Think, as Ford CEO Nasser said, "Think is an organization that will provide us with ingenious mobility solutions for the new millennium. It is further proof of the company's commitment to connecting to the customer" (ElectrifyingTimes.com, 2000). Ford's engagement with the Think City car led Calstart – a company Think had worked with during the BART-project – to

honor Ford with the Blue Sky Award[36] in recognition of its support for the Think City car. Simultaneously, however, there were growing concerns in terms of pricing, as the Vice President of Marketing and Communication of Calstart Van Amburg explained, "If Ford can sell the [Think] City [car] for less than $20,000, it will be able to tap into a solid market base" (Miel, 2000). Indeed, Ford had received attention for its efforts in creating a product family around the Think City car, but it would still need to overcome the problem of pricing the car competitively in the US market. Low sales in Europe and a delay in the US launch was disappointing to Ford and raised skepticism. To solve the problem of disappointing sales in Europe the partnership worked on forming further sales agreements for distribution throughout Europe and creating political appeal. In an interview, Think Market Director Eggen explained,

> Now we are working on getting distribution agreements in the most important European markets, which means Germany, the UK, France, Italy, Switzerland and Denmark, above and beyond the sales in Norway. We also hope that politicians can stimulate this environmentally friendly vehicle further by freeing it from VAT sales tax next year. Then the price can be reduced from 199k Norwegian krone to 162k Norwegian krone in Norway. That may accelerate sales to regional and public organizations, which otherwise cannot deduct the sales tax. Such initiatives, combined, make us optimistic for the coming year (TU.no, 2000)*.

Pricing was an issue, but all the same, Think was setting up sales offices in California in order to prepare for servicing distribution needs, particularly since the expectation for auto dealers to sell at least 40,000 electric vehicles in 2003 was in place, according to the ZEV-mandate.

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[36] The CALSTART Blue Sky Award™ was first presented in 1996 to General Motors and had since been granted to Toyota (1997) and the U.S. Postal Service (1998) prior to Ford/Think being presented with the award in 1999. The award winner is selected based on outstanding contributions to clean air, improved energy efficiency and contributions to the growth and advancements in the transportation industry (Carlstart, 2013).

5.6.1.7 Ford partnership forming upon the electric car street event in London, UK, 2001

The Think Group was increasingly gaining experience and insight about Ford automotive technology and business activities critical to good car production and commercialization. In 2001, through collaboration with leading businesses, environmental groups and the government, this experience included a larger infrastructure pilot project with 15 Think City cars in London, UK. Among the partners were Friends of the Earth, The Energy Savings Trust, and London Electricity. This proved to be a successful and beneficial project, not least to the partners in London, where the cars remained for use as delivery cars. The Ford-Think partnership had come to understand that a crucial part of the sales problem related to the initial targeting of countries rather than cities for distribution. Think Vice President of Marketing and Sales Alkil explained,

> The marketing strategy is to target cities rather than countries because the Think City is designed specifically for use in urban traffic. Its polyethylene body offers scratch and dent resistance, it is small, under three meters, quiet and has no emissions. In short, it's the perfect city car (Ford, 2001).

However as the City Council of Oslo declared its objective to making "Oslo one of Europe's most environmentally friendly cities", its order of 180 electric cars went to the Renault Kangoo and not Think (McNamara, 2001). This exemplified the problem of local market penetration that Think was experiencing, and it hoped to financially overcome such hurdles in its upcoming launch in the US. But was this also a sign of unpredictable political support and as to whether Norway should keep building electric cars?

5.6.1.8 Ford partnership forming upon the launch of the new Think City car in the US, 2002

In January 2002, Ford presented the new Think City car in Los Angeles. The Think City car was now certified not only in Europe, but it was also ready for sale in the US market. In addition, the car had a new design, equipped with airbags, ABS brakes, servo drive and other functionality that enhanced safety and improved handling as well as driving comfort. Still, experimenting contin-

ued, and in March 2002 the Think City cars used in the London pilot project were equipped with a data collection unit. On the one hand this unit helped track vehicle driving history data to the benefit of Think's market and technology development, while at the same time the Think City deliberately served to showcase another technology innovation project. As such, Think was perceived as useful in terms of helping to solve problems associated with the launch of other technology innovations. It seemed that Ford was ready to launch the Think City car for sale in the US market, however, in the month of August of that same year, Ford suddenly decided to stop its Think program and announced it was looking for potential buyers.

5.6.1.9 Kamkorp partnership forming in relation to the Think Public, 2002-2006

Think received visits from several potential investors in the autumn of 2002[37] until the Swiss company Kamkorp signed an LOI with Ford in late-December 2002. While no details were revealed concerning the sale price, Ford revealed that the price was low and that the contract was conditioned on that electric car production should continue in Aurskog (Svalastog, 2002). To Kamkorp, a partnership with Think was interesting as the company also produced electric cars. Through its Frazer-Nash Research Company in Surrey in the UK, a Kamkorp company, Kamkorp had experience with fully electric golf carts, delivery vans and city cars. Kamkorp representative Winkler explained,

> We are delighted to have this opportunity. [...] There is a 10-year history of EV production in Norway, and the workforce [there] had unrivalled experience and expertise in this specialist area. Ford has kept this tradition alive, and now we are thrilled to be negotiating to take it over (ElectrifyingTimes.com, 2002).

Though Kamkorp had designed different electric car models, none of them were in mass production at the time, and Ford's investment in the alignment of the Think's production process, advanced crash testing, and

[37] Among potential investors were Zap, a Californian manufacturer of electric bikes and scooters, who offered about US$10M. Through other acquisitions, Zap also makes electric cars today.

market certifications approvals, were of special interest (TU.no, 2003). Meanwhile, in relation to the Think City car, Kamkorp gained the opportunity to use its own drivetrain technology instead of the existing technology used by Think. Think was relieved and looked forward to continuing work on the Think City car. From an outsider's perspective, the notion that this partnership had rescued Think seems plausible, but Kamcorp's lack of experience in mass production had become a setback to the project development. There was a visible possibility that Kamkorp, given its focus on electric cars, would support the development of a whole Think car-series. However Think announced few developments over the subsequent 18 months. Think's silence raised frustration within the Norwegian political arena. Aurskog-Høland regional speaker Gulbrandsen said, "We used to have good dialogues with Think, but since the new owner took over there has been no contact" (Bakken, 2004)*. Had Think's business played a vital role in the Aurskog-Høland political decision-making and financial budgeting? Then in the summer of 2004 Kamkorp issued its first layoff notices at Think and Kamkorp's Think-boss reported plans to move Think activities to Malaysia (Berglund, 2004). Over the next few months, approximately 50% of Think's employees lost their jobs. Kamkorp had chosen to turn the focus from the development of a new Think City model towards the development of a micro-sized electric bus, the Think Public. In the autumn of 2004, at the ELE-DRIVE show in Portugal, a Think Public was presented and throughout subsequent months testing was undertaken. The Think City car was not in production and as Think announced financial problems in December 2005, it was uncertain what would happen next[38].

[38] In the spring of 2005 Think engaged in the pan-European hydrogen project, HyNor, which meant that technology innovation development began on a hydrogen version of its Think City car. In relation to this, the Norwegian Research Council granted 11M Norwegian krone to Think. My research does not go into detail regarding the HyNor project, however this partnership, which also continued for several years, enabled Think's engineers to keep some connection to the Think City car while Kamkorp focused on the Think Public as the main electric vehicle model.

5.6.1.10 InSpire Invest, Ringdal and some employees' partnership forming around Think's company relaunch, 2006-2008

As Think's founder, Ringdal heard about the bankruptcy, he initiated negotiations with a number of prospective investors so as to aim towards Think returning to Norwegian ownership. He contacted Jan Olaf Willums, a friend and founder of Norwegian InSpire Invest[39]. Available documentation was assessed and interviews with Think employees were carried out. The employees made it known that they had ideas about how to relaunch the company based on work from the Ford era. By the end of March 2006, the Think Group was acquired for 14M Norwegian krone by a number of former employees and the Norwegian investment group InSpire Invest, which included Ringdal as a co-investor. Think Global AS was established as the main company that would seek ownership of Think Technologies AS.

Think was revitalized with a team on board and ideas from brainstorming sessions at Googleplex in Mountain View, where green business consultant and author, Joel Makower facilitated. In August 2006, the company announced that a new Think City model was under development and Think was hiring engineers, purchasers and staff with other skills. Was Think on the cusp of a new and successful financial structuration? A new production model[40] came to light in Aurskog in February 2007 and Think Global announced that same month at the Cleantech Forum in San Francisco that mass production would start in the summer months of that year. Manufacturing would include the production of the Think City car and cabriolet version of the Think City car. Technology innovation development came back into focus.

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[39] Founded in 2003, InSpire Invest initiated as a partner in a research project on corporate governance that was launched in collaboration with the Global Governance Forum of the World Bank. InSpire went on to focus on environmental, social and governance issues relevant to financial analysis and seed investment in sustainable development projects and clean technology ventures such as those led by Think, MoveAbout and OptiNose.

[40] This new production model of the Think City car should be understood as the product (or final version) of the Ford engineered model. Therefore, it has been defined as the Think City car (PIV5) in this thesis.

5.6.1.11 InSpire Invest, Ringdal and some employees' partnership forming around new venture funds, 2007

The partnership began attracting venture funds and defining new commercialization initiatives with different partners. In the spring of 2007, Think worked on raising US$100M, of which US$25M was secured by the end of February (Kanellos, 2007a)[41], and by July, another US$60M had been raised (Berglund, 2007a)[42]. Think had therefore linked itself to investors who believed in Think's technology and were interested in earning money on Think City car sales. Think CEO Willums said, "We think the time now is completely different. Everyone speaks about electric cars. [...] Investors think it is interesting to engage in a time-right project, and we have a different market and better technology now" (Ensby, 2007)*. Still, Think understood that to start earning money it would need to reach a yearly production of 10,000 Think City cars. This amount was not possible alone with the Aurskog plant that had a maximum capacity of 7,000 cars per year. Financial engineering was still a problem.

Commercialization initiatives included the sale of production and marked licenses, customer battery leasing agreements and car insurance policies to advance marketization. Indeed market conditions had improved in Norway. Think Technical Chief Asphjell explained, "The government in Norway has created the world's best market for EVs. This means no yearly taxation, no toll fees, no parking fees, and no sales tax" (Tunmo, 2006)*. But in other potential EV-markets politicians were only opening up to such political support. Was a network lacking where politicians could make exchanges regarding EV-market ideas, or were politicians reluctant to make EV-trials because of partnership experiences with the traditional automotive industry?

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[41] Investors mentioned in this relation were Ketchup producer Heinz Trust, Wintergreen Advisors, Norwegian hotel owner Petter Stordalen, shipping heir Peter Sundt, retailing tycoon Stein Erik Hagen, and a family member of the Centra grocery chain Christian Stabell Eriksen (Berglund, 2007b; Ensby, 2007).

[42] Investors mentioned in this relation were Norwegian real estate magnate Atle Brynestad, US venture company Rockport Capital Partners and the UK capital venture company Capricorn Investment Group (Berglund, 2007a; Kanellos, 2007b; Woody, 2007).

Think prospered and potential customers signed waiting lists. The public could simply not resist a 'futuristic' two-seated electric car that could be bought at a price well below €27,000, with a battery rental charge of 975 Norwegian krone per month which could also be recharged directly from standard electrical sockets at home. It was true that the car's top speed of 100 kms/h and range of 203 kms did not match the performance of fossil fuel cars. But then again, as a car for the urban environment, its performance would be sufficient for most users, and it could even outcompete other urban electric cars. Think PL Eimstad explained,

> The public understand to a greater extent that all the different technologies such as EVs, hybrids, hydrogen, bioethanol-cars, biodiesel-cars and conventional cars can live side by side. The electric cannot solve all transportation needs, but a part of them. Besides, even conservative energy political groups in the US have become more open in relation to EVs (Hattrem, 2007).

Think found that the readiness of potential customers was promising and focused on restarting Aurskog's production.

5.6.1.12 InSpire Invest, Ringdal, and some employees' partnership forming with Porsche Consulting around the restart of production in Aurskog, 2007

In September 2007 production in Aurskog had not yet restarted as there were problems with production allowances. With no earnings from car sales in 2007, Think was burdened with an augmenting deficit. The management team contacted Porsche Consulting who agreed to work with Think. The idea was that Porsche Consulting would integrate its lean automotive manufacturing experience in Think's production processes with the objective of improving Think's quality and efficiency. This resulted in the development of a system that enabled the parallel processing of different production tasks, including the advanced handling of purchase and supplier collaborations. Perhaps Think became ready to start production, while Porsche Consulting had gained a showcase for its most updated and lean automotive manufacturing experience. The partners were working on getting the first production cars off the line by November, which they achieved, and announced sales for the start of March 2008 in relation to the Think City car presentation at the Motor Show in Geneva.

5.6.1.13 InSpire Invest, Ringdal, and some employees' partnership forming with General Electric upon a commercial presentation at the Motor Show in Geneva, 2008

In March 2008, at the 78th Motor Show in Geneva, Think put on display its electric car potential in order to attract customers, investors, and technology innovation development partners. Visible redesign of exterior and interior components was emphasized, a five-seat concept car, the Think Ox, that had been developed in collaboration with Porsche Consulting was displayed and the Think City car could be presented and tested on Think's large out-door exhibition area. Maybe Think was simply exploring EV-making in a new way when developing the Think Ox, though it was intended that potential investors should consider Think's growth potential through its demonstrations. At this event Think also announced its new investment relationship with General Electric (GE) who, through its GE Energy financial services venture company, invested US$4M into Think. Think CEO Willums commented, "We see many important opportunities emerging from our new relationship with GE. This relationship will help Think – the manufacturer of the first highway-approved electric car in mass production – to stay at the forefront of electric vehicle technology" (GE, 2008, March 5). The partnership GE made with Think was also relevant to GE's larger investment made in the battery supplier A123; GE intended to benefit from Think's experience and expertise which could equally contribute to securing its investment in A123. But aside from the battery research focus of this partnership, Think perceived that the potential for collaboration could lead it to gain footing in the US.

5.6.1.14 Kleiner Perkins Caufield and Byers and Rockport partnership forming around the potential Think City car launch in the US, 2008-2010

As a venture capitalist with experience and connections in the US, Think CEO Willums helped Think link itself to US venture capital companies. In April 2008, Think announced that a US launch was planned for 2009 in collaboration with venture capital company Kleiner Perkins Caufield and Byers

(KPCB)[43] and Rockport Capital Partners[44]. These were two companies specialized in financial engineering in relation to the promise of clean technology innovation development. Rockport Managing Partner James said, "This is not a toy, this is a serious car that is able to be mass-produced and sold" (Reuters, 2008). This claim was supported by KPCB partner Lane who stated,

> The transportation industry is undergoing its largest transformation since Henry Ford built the Model T. today we are witnessing a seminal event – the first highway-capable electric vehicle intended for mass production, representing a big step toward a zero emission transportation industry (BusinessWeek.com, 05/2008).

The venture capitalist partners hoped to be selling 30,000-50,000 cars per year within a few years at a retail price lower than US$25k. However, while increasingly positive publicity about Think spread in the US, Think was struggling to deliver ordered cars in Europe to customers who had already signed contracts back in 2007, and it faced mixed publicity as Think launched in the UK, promising deliveries as of the summer 2009, while it received cancelled contracts from Norwegian customers. Possibly the financial engineering partners created many important US-market and sales relations, while they were less effective in overseeing Think city car production affairs. Think had problems developing its approach to assembly and distribution in Europe.

5.6.1.15 InSpire Invest, Ringdal, and some employees' partnership forming around the reorganization of the management team, 2008

Think became conscious of the fact that it needed to develop its skills and understanding of automotive strategy and operation. Though discussions between Ford and Think in 2008 about a potential reforming did not led to changes in these areas (see page 219), Think was able to forge strategic relations with Ford executive Richard Canny, which became more formalized in

[43] With KPCB as partner, a company also underpinning the launch of Amazon.com and Google.com, Think had direct contact to Al Gore, who was a senior partner in the company.

[44] The investment amount was not mentioned in any record. However, it is assumed that funding from the two US venture capitalist companies would be dedicated to activities in the US, rather than support for any European parts of the project.

August 2008. Canny had been part of the Ford-Think discussions and at this new point in time, joined Think as CEO. Willums, who had been Think's visionary CEO since 2006, remained member of the Board. In addition, two automotive senior executives from Sweden joined Think, and contributed with production and launch experience they had gained from Volvo and Saab. The three new members of the management team looked forward to bringing Think's production up to speed, despite the fact that Think was experiencing financial trouble and was yet to satisfy 600 buyers waiting for the delivery of their cars (E24.no, 2008). The new management team secured the support of 167M Norwegian krone in equity investment to get the production backlog cleared, since Think faced the dilemma of not being bankable prior to it being in production. Meanwhile, Think announced its European roll-out plan for 2009 which was worked-out and scheduled according to the cities it considered as being 'most EV-friendly' – this was calculated based on the EV-friendliness Index Think had developed – and as such, Think launched its marketing campaign in London. To add, Think had received the "Norsk Form" award for having "carried out the most ambitious and complex design and industrialization project in Norwegian history, inspiring entrepreneurs and Norwegian business life" – accolades it could use (Hauger-Dalsgard, 2008)*. However, beginning in December 2008, Think was again facing serious financial problems.

5.6.1.16 Ener1 and individual private investor partnerships forming around the crisis loan package, 2009-2010

In early-January of 2009, Think Global announced that it had received a crisis loan package from individual private investors, which enabled it to call back some employees and undertake necessary work in applying for long-term financing. Norwegian investor, Stein Hagen and founder of a solar cell company, Alf Bjørseth contributed, but the main source of capital, worth around US$5.7M, came from Ener1[45] (Gran, 2009), owner of EnerDel, the battery

[45] Ener1 Group was in turn 66% owned by Bzinfin, a British Virgin Island company owned by Boris Zingarevich, a Russian businessman who later bought Think (see page 212).

company that Think was collaborating on in its battery technology development. Ener1 was convinced that the Think was two years ahead of its competition in part due to the certifications it had passed and it also forecasted the sale of at least 10,000 Think City cars for the following year, in the US alone. Furthermore, Ener1 wanted to establish Think production in the US within 2009 (Gran, 2009).

Based on this crisis loan package and market research leading to the 'Think EV-friendliness Index', Think entered into agreements with the Austrian (Motavalli, 2009), Dutch (Think, 2008a) and Swedish governments whereby it contracted the delivery of 100, 500 and two electrical vehicle projects, respectively, in 2009. Later in 2009, an agreement with the Spanish Ministry of Industry was established, whereby 550 electric cars were introduced (Think, 2008b). Think was also expected at the United Nations Climate Change conference in Denmark (COP15)[46]. Its potential reaffirmed, Think seized all opportunities gained by its first-mover position in the European electrical vehicle market and the general public-spirited movement of establishing a new norm for cleaner cars, which placed electrical vehicles at the center of automotive attention. However, Think was still struggling with its financial engineering, production had not restarted, and therefore some employees had still not been called back.

5.6.1.17 Ener1, Valmet, Investinor and individual private investor partnerships forming around the Valmet production setup, 2009-2010

At the end of August 2009, Think announced it was out of court protection, that it had an approved debt settlement plan, and that it was ready to restart production with new investors and capital on board with Ener1 from the US, Valmet Automotive (Valmet) from Finland and Investinor, a Norwegian government-related investment fund. Think had been looking for an automotive partner and discussions with potential Swedish investors had taken place that

[46] During COP15 Think's car-sharing partner Moveabout was officially launched and Moveabout signed leasing contracts with the Austrian Municipality for pilot projects. Moveabout had a stand at COP15's main conference hall where it would also taxi journalists about for free.

would have led to collaboration with Saab, but an agreement was made with Valmet in Uusikaupunki, Finland, which limited such plans because of Saab's own financial problems at the time. At that time, Valmet was a venture belonging to the international technology company Metso, who was working on securing assembly projects for Valmet. Therefore, as part of the investment agreements with Think's new Board of Directors the production plant in Aurskog was transferred to Valmet. This transfer represented the loss of financial partnership not only to Aurskog, but to Norway, according to Aurskog-Høland Municipality speaker, Mærli who said,

> All statements from state and government about how good Think and its [EV-] technology was fades if the production disappears out of Norway. They have not lived up to what they said about the importance of keeping this technology in Norway (Fallet, 2009)*.

However, Investinor argued that this change projected future earnings for Norway through Think. According to Investinor's communication representative, Sævik:

> We evaluate this through an economic and engineering perspective, and ask ourselves if this is good business or not. The conclusion was that it is [good business]. Some will probably criticize us and say that we contributed to moving jobs out of Norway. We disagree with that (Hovland, 2009)*.

Within 80 days, in the autumn of 2009, Think's production line was integrated alongside Valmet's other assembly facilities where the Porsche AG Boxster and Cayman models were also being produced. Perhaps the transfer of production meant that Think could come out of court protection, despite the fact that the greater financial and technology development implications remained unpredictable. Think CEO Canny maintained his position, but a new Board of Directors took seat (Think, 2009a) and Think acquired new Heads of Finance and Sales. Another Think restructuring seemed satisfactory by the end of 2009.

5.6.1.18 Ener1, Valmet, Investinor and individual private investor partnerships forming around the US Elkhart plant, 2010

Think was spreading activities further internationally. Think investors were interested in a Think US plant. This was deemed as possible if invested partners gained access to the US Department of Energy's (DOE) Advanced Technology Vehicle Manufacturing program (ATVM[47]). On 5 January 2010, Think announced the plan to position its US production in Elkhart County in Indiana. To Ener1, this was a potential solution to advance the production and development of EnerDel's batteries. To Indiana Governor Daniels this was a possible solution to the high unemployment problem the state was facing, as he explained, "We're out to be the capital of the electric car vehicle industry and EnerDel is the center of our hopes" (PRNewswire, 2010). Besides the fact that Ener1's battery company EnerDel was located there, Indiana was already home to recreational vehicle production. As such, Think could potentially tap into an automotive workforce used to work with plastics and small-scale production. Think developed a EV-friendliness Index for the US, as it had done for the European markets in 2008, as part of early commercialization work (Think, 2010m), and targeted New York as one of its first cities for Think City car sales. However, the inclusion of a European focus in 2010 was still appealing, as Think CFO Neerland said,

> I think maybe the biggest achievement financially in 2009 was that we are actually here. We were able to raise US$47M. This established the end of the ground for a continued life. The main objective of 2010, I think is to secure the business plan. That's crucial for our continued success (HN, All Team Meeting, 01/2010).

In 2010, Norway and the European deals were supposed to be the main markets of interest to Think in order to ensure that the financial engineering of 2009 would continue to work satisfactorily. To make this happen Think was increasingly focusing its European city marketing on power companies. Think CEO Canny stated,

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[47] ATVM had received a grant worth US$2bn from the DOE, where Ener1 was applying for US$480M (Norton, 2009).

> It makes sense really that some of our best customers are the largest suppliers of the very resource that powers our vehicle, and it is very reassuring that they – clearly experts in the field of electrification – are universally giving the Think City [car] such a significant vote of confidence (Think, 2010c).

During the first half of 2010, while Think was in the process of consolidating leftover activities from the Aurskog plant with those of the Oslo headquarter, which would be gathered in a new Think product development central location, several new Think technology innovation project partnerships were initiated, primarily in Europe, which were emphasized in Think's press communication: charging technology development projects, pilot test projects, sales agreements, and EV racing were announced, among others[48]. These projects represented situations where increasingly, external partners would approach Think, inquiring and proposing collaborations. There is a possibility that EV-friendly cities took interest in partnering with Think, while Think's financial partners strengthened their interest by the impending US prospects.

In May 2010, Think announced that its investment partners had provided another US$40M in funding, and the "aggressive schedule" to launch production in the US was confirmed (Think, 2010a), especially projected for the second half of 2010. The Think Board of Directors made several changes in management, appointing a new Internationalization Manager, Head of Marketing, Head of Human Resources, Head of Finance and Head of Purchasing. Think CEO Canny was appointed as Vice Chairman of Think North America (Think N.A.) and another former Ford senior took on the new role of Think CEO, Barry Engle. Nearing the end November 2010, the plant in Elkhart had 25 em-

[48] In 2010, Think established a partnership with AeroVironment (AV) to develop fast-charging stands for EV-fleets (Think, 2010n); announced a four-seater Think car for 2011; had the Think City selected as car for BBC's Electric Road Trip Documentary Across Europe series (Think, 2010d); initiated an EV distribution partnership with the Swiss retailer Migros (Think, 2010l) whereby Migros' first store opened in October with the Think City car as the focal point of attraction (Think, 2010f); also took part in the START Eco Car trials in the UK (Think, 2010e) and the e-miglia 2010 race in Germany (Think, 2010j); entered the French market in partnership with a corporate giant, MOBIVIA (Think, 2010i) and the Finnish market in collaboration with Valmet.

ployees and the first 220 Think City electric cars where on their way through the production line. Think had set itself the target that before the end of the year, 300 should be completed in Elkhart (Bakke, 2010). Think CEO Engle commented, "This is another milestone for us. We are now manufacturing and selling in both Europe and the US and have produced more than 2,500 Think City vehicles" (Barclay, 2010). Think was ahead of their US schedule and the Think City car successfully passed CARB requirements as a zero emission vehicle.

As the first 15 cars rolled out of the Elkhart plant in the middle of December 2010, Elkhart county was experiencing renewed optimism. A representative from the Elkhart County Economic Development Corporation said, "This clearly gave us some hope in a very trying and difficult time, and we're seeing the momentum pick up for this particular company, Think" (Damp, 2010). To Think CEO Engel, the Elkhart production demonstrated innovation opportunity as he recounted,

> I think there is an opportunity for American manufacturers to reassert ourselves and be at the forefront of electric vehicle production. [...] Electric vehicles represent a paradigm shift. Historically the amount of infrastructure and investment that was required to start up [a] traditional car company and brand was prohibitive. Everything changes with EVs. [...] Fleet customers have a critical role in proving out the technology for retail customers. What we are talking about here is seeding the market, and getting mainstream customers comfortable with the technology and understanding that it's something they can have confidence in and it will work for them. [...] Being able to deliver a consistent range in real-world environment is the advantage [Think has] after having done this for so long. [...] If 20 or 30 years from now, if we're able to convert what is an existing industry that has all kinds of social, economic, and environmental impact, and if we're able to replace that with something that is far friendlier in all those aspects, whether it's our children or grandchildren, they'll look back and say that was pretty cool. They will say that was money well spent (Berman, 2010).

Engel was pointing to what the Think City car represented in the automotive historic perspective; how the cost of investment was unpredictable, how Think, through extended external partnerships had created and proven technology innovation development experience, and how the return on investment was uncertain, but defined through its impact on technological,

social, economic and environmental aspects. However, to potential customers in the US, the price for a Think City car was defining and it was perceived as being too high to many. Sales did not take off as expected and Think was lacking working capital. In April 2011 production stopped and employees had to leave, but it would get worse.

5.6.1.19 Boris Zingarevich partnership forming in relation to Think assets, 2011

After Think had declared itself bankrupt in June 2011, it was announced in July 2011 that Russian Boris G. Zingarevich, who had a background in the Russian pulp and paper industry and who since 2002 had served as Director of Ener1, had bought Think assets in agreement with Ener1 and Valmet (EVWorld.com, 2011). To Zingarevich the Think brand was of particular value, as he said,

> Having achieved the position of one of the world's most highly regarded electric vehicle products, the Think brand is a valuable asset that deserves to continue its key role in the global shift to electrification (EVWorld.com, 2011).

Anew, Think would be sold by the company Electric Mobility Solutions AS, registered in Norway, and it was announced that sales would commence in the first quarter of 2012.

5.6.2 Finance partnerships breaking

5.6.2.1 Oslo energy, Hydro and Statoil partnerships breaking around the first Think City car production model, 1998

Through partnerships with Oslo Energy, Hydro, Statoil and Science and Technical Research Council of Norway[49], Think had developed a feasibility study, a technical concept model and a first production model of the Think City car. The Norwegian government had invested close to US$12.5M through grants and US$5M in loans to the project since 1991, and shareholders had invested an estimated US$17.5M (PlasticsNews, 1998). But Think was a for-profit orga-

[49] Commonly known as NTNF or Norges Teknisk Naturvitenskablige Forsningsraad.

nization with a project and mission of sustainable urban mobility. However, while the project mission was firmly established through many years of development in the electric car industry, the economic feasibility and profit goals were still largely out of reach. The costs of entry into the automobile industry were higher than the financial resources of the small company. As most of the existing investors were unwilling to support the project further and the effects of the 1997 Asian Finance Crisis made it difficult to find new investors the company went bankrupt at the end of 1998. This occurred despite Ringdal's efforts to convince investors that the probate court could not be held back, and despite Think City cars' successful participation in the BART-project in California, where the news "was met with dismay and disappointment", as BART Manager Nerenberg revealed to the press,

> I was looking forward to Pivco's [Think's] next-generation vehicle. We were supposed to see them next spring. […] We need more Pivco [Think] vehicles. I am disheartened about what's happened. […] We're really rooting for a US manufacturer to get involved now. It would open a lot of doors to the company and for the [electric car] industry (Grace & Pryweller, 1998).

Ringdal was aware that he had public support and it was important for him to keep his team together, so he choose to involve the team in the details of the situation. Think received visits from several potentially interested automotive partners which led Ringdal to understand that potential investors valued Think's competence in serial production, lean manufacturing, beyond the fact that the Think City was certified in the EU. Nonetheless, no one decided to invest at that time. The eventual outcome was no longer irrevocable: on a Monday, in November 1998, the probate court demanded a full-stop.

5.6.2.2 Ford partnership breaking around Ford's financial trouble and as the California ZEV program lost its mandate, 2002

Several events (see battery case page 127) caused Ford to face a troubled year in 2002, and as the ZEV program lost its mandate, Ford announced its intention, in August 2002, to sell-off the Think Group and focus on other alternative energy research programs. John Wallace wrote to EV World "that the [Think] program was very unprofitable" (Moore, 2002). At that point Ford had invested an estimated US$123M into the Think-project, but the Think City car

had not yet been launched for sale in the US; it was only being offered for lease through various pilot tests. Ford's interest in Think had drifted and Think City's technology innovation development entered a vacuum. (TU.no, 2002)

However, Ford's announcement to sell Think got considerable attention. It turned out that breaking the partnership with Think was not a problem-free affair for Ford. First, Think employees activated their value stake, and supported by their unions[50] they called for government support to negotiate with Ford. A Think engineer said to Aftenposten, "If the authorities don't come with some clear incentives, there's great danger that [Ford's] efforts to find new investors will come to a halt" (Berglund, 2002b). That led to political support from the former Norwegian Minister of Energy who called for further support, pointing to the moral obligations of the Minister of Transportation, the Environmental Minister, and the Minister of Trade and Industry. Should the production be shut down it would not only impact Think, but it would also affect the little Aurskog-Høland Municipality. This led the Minister of Transportation and the Environmental Minister to decide that an introduction of the "Californian-demands" in Norway should be analyzed, as the former stated, "Regardless of what happens to Think, the government will go through with its many suggestions to stimulate the use of zero emission cars. This is an environmental matter more than a matter of trade" (NRK.no, 2002)*. Though Ford had made a business decision that was supposed to help solve its financial problems, it had created another business problem that Think employees needed to solve, and also a stronger policy support for zero emission demands in Norway. Secondly, customer fan-clubs, such as the Bergen and Trondheim Think fan club and the Yahoo-Think EV Group, that had all formed during the Ford era, and Californian customers engaged publicly in discussions about Ford's decision resulting in bad publicity for Ford and the discredit of carmakers' technology development intentions, as examples demonstrate,

> Maybe Ford wouldn't be experiencing such financial woes if it sold Thinks rather than SUVs and big trucks? If they lose more than $5.5 billion with their current way of doing business,

[50] Union support came from the local departments of the Norwegian Engineering Association (NITO) and Norwegian Civil Engineering Association (NIF) (TU.no, 2002).

> maybe they should change that. For one thing, moving towards a sustainable business model and selling Thinks would be a part of that. – Nick Carter, President, North Bay Chapter, Electric Auto Association (EVWorld.com, 2002).

> It is ridiculous for carmakers to claim lack of demand when they have not tried to properly market or sell these cars. Consider the hours of television advertising devoted to SUV's and luxury trucks in the U.S.A. […] The real issue and reason US carmakers are suppressing electric vehicles are that they are less profitable, not completely unprofitable. […] For automakers and oil companies the EV possibility is a nightmare. Ron Fischer (Berglund, 2002a).

Thirdly, in August 2004, Ford faced renewed attention around its Think City car-decisions. A campaign arranged by Greenpeace and several other partners[51] took place in Norway and in the US in order to pressure Ford into returning around 350 produced, but unsold Think cars, which Ford had planned to destroy. The campaign-makers wrote a public letter to Ford, arranged demonstrations and raised questions regarding Ford's partnership-intentions at the time it had purchased Think: to only satisfy the Californian ZEV-mandate (Greenpeace, 2004), or to take the Think City out of the market (Orskaug & Ellingsen, 2004)*. It was argued that should the cars be returned to Norway, 25 employees could look forward to keeping their jobs at Think. The campaign also got political support in Norway, where Ford's partnership motive was of similar concern to the Norwegian Minister of Transportation Skogsholm who stated, "This is completely incomprehensible. We need the cars in Norway. There is a waiting list in the Norwegian market for buying an EV. It is very strange that the Norwegian-produced EVs should be destroyed in California. I do not understand Ford's decision" (Orskaug & Ellingsen, 2004)*. After meeting with the campaign partners in Oslo, Ford did not take long to agree internally not to destroy the Think City cars and while the Norwegian shipping company Willenius Wilhelmsen offered to ship the cars back for

[51] Among the partners mentioned in different articles were EV Norway, the Environmental Alliance Norway, Rainforest Action Network and Global Exchange.

free[52], Ford would undertake mechanical checks upon arrival to ensure they could be sold through Ford's Norwegian dealerships.(Sharke, 2004)

5.6.2.3 Kamkorp partnership breaking around Kamkorp's financial trouble, 2006

Kamkorp's partnership with Think broke as Kamkorp lacked the governmental support and the financial solidity to continue and the company went into receivership. The Think City car was put on hold while a new Think Public model came into focus during this partnership. However, the Think Public did not go into production. In December 2005 Think requested financial support from its investors. Administrative Director Neal explained, "The situation is very serious. We have big liquidity problems, making it impossible to pay November salaries to employees. It is clear that we have to find a solution fast" (Hauger-Dalsgard, 2005)*. After a Think Board meeting, the media reported (Røiseland, 2005; VGNett, 2005) that the owners of Kamkorp had committed a portion of the 50-100M Norwegian krone that Think had requested to balance accounts.

However, in February 2006, Think declared bankruptcy. This time it was Think employees who initiated the proceedings after not having been paid their salaries since December 2005. But Kamkorp was also behind on rental payments for the Aurskog plant, by several months. Spokesman Eimstad commented, "Kamkorp had the will but not the way, I guess. [...] The money just hasn't arrived as it should" (Berglund, 2006). Another way had been to stick with the Think City. Former Think Administrative Director Lilleng[53] said, "It surprised me that the new owners dropped the focus on the electric car, which was almost production-ready as Ford pulled out. That electric car would certainly have had a place in the Norwegian and international market today" (Hauger-Dalsgard, Fremmerlid & Bergerud, 2006). Though

[52] The 350 cars had been used in different EV-programs such as the New York Power Authority's Clean Commute, where they were leased for roughly US$199 per month. As sponsored programs ended, the US Department of Transportation's waiver ended too, and Ford was not allowed to sell or lease the cars (Sharke, 2004). However, there is no information that points to Ford having made an effort to prolong the waiver.

[53] Per Lilleng was Administrative Director of Think Nordic between 1997 and 2001.

Kamkorp had high expectations for the Think Public it was unable to make the financial engineering work that Think depended on from its owners and instead Think had drifted away from its electric car product idea.

5.6.2.4 Individual private investor partnerships breaking in relation to Think's financial trouble, 2008

In 2008 Think and its investors' partnerships had taken steps to creating distribution abroad. Trial-and-demonstration projects were planned for 2009 and Think had opened office in the US, and the UK management changes had taken place, with a new CEO and COO taking office. Over the course of the summer, 100 cars were delivered to Norwegian customers, but some 700 customers were estimated as still being on the waiting list. Think was struggling with the increasing demands and the new requirements on production and delivery. In December 2008, Think was out of cash. Several re-launch postponements of the new Think City had drained its financial resources. As the global economic crisis escalated, Think suppliers required upfront payment, whereby Think's financial distress further increased. Current investor partners were approached for a boost in equity, however, some investors could not be persuaded, such as hotel owner Petter Stordalen, so Think had to seek out new investors.

Think contacted and met with representatives of the Norwegian government for a crisis meeting in December 2008. Think CEO Canny, who was uncertain how Think should get through its crisis, explained,

> There is a crisis for green-car projects in the world, and it is very difficult to get 'green money'. [...] We knew we would need more money. The financial crisis has made it more difficult to get this money. And, it is more difficult with new investors. We will now ask the government for a rescue package for the Norwegian car industry, like the Swedish rescue package. It is not only Think that is affected, but also many Norwegian suppliers (VGNett, 2008)*.

> I came here to make the car ready for production. Now I work day and night to save the company. The situation is critical, that I can say. If we have to wait until the government crisis-package arrives in January-February, it may be too late (DN.no, 2008)*.

Think's CEO found support from the leader of the Norwegian Confederation of Trade Unions, Flåthen, who considered that the government had to take action since the financial markets, where Think typically could have created opportunities for capital, were not working (TU.no, 2008). But other voices, such as those from car industry analysts were critical of further support for Think's project (Svendsen & Fremmerlid, 2008). Think had hoped for government financial support still in 2008, but the government did not take ownership of Think or provide an immediate rescue loan package, which had been Think's preferred solution. Deputy Minister of Trade and Industry Lind said, "There are many companies that are in demanding financial situations. […] The government cannot go in on the ownership side or provide loans to specific companies in today's situation" (Berman, 2008). However, Think's specific technology innovation development focus was a matter of interest to the government. Minister of Transport and Communication Navarsete said, "In Norway we don't have a big car industry, but we have one which is at the forefront of EV-development. Getting risk-capital for this industry will be a part of the initiative package which the government will present in January" (Dagbladet.no, 2008a)*. Still, the government crisis-package would only arrive in January 2009, and only so through applications to the public innovation funds Investinor and Innovasjon Norge.

On 15 December 2008, Think announced a stop to production and that layoffs were to be expected. Think CEO Canny said, "We are in a very difficult and unstable situation" (Dagbladet.no, 2008b)*. Think was in need of roughly US$29M, and had to send home close to 250 employees. This was a situation that provoked an uncertain future for Think, and it also demonstrated that political interest in Think and the Norwegian EV-industry was unpredictable. Think CEO Canny said,

> We were so close to break-even and being cash-flow positive. […] It doesn't seem right that the traditional auto companies are getting massive public money to stave off their decline, while newcomers in the electric-car space are being starved of capital (Abboud, 2009).

5.6.2.5 Ener1 partnerships breaking around Ener1's diluting share price, 2011

In March 2011 Think demonstrated satisfyingly its four-seater at the Geneva Motor Show which seemed have generated positive leads, though Think was also recalling a number of its newly sold Think City cars in the US due to potential problems with the gearshift (AutomotiveFleet, 2011). But Think had financial problems. Think was running out of working capital. Former Think CEO Canny recounted,

> One of the big mistakes was not immediately getting out there and while the car was still selling well, while the company still had cash doing fundraising to bring in another $50, 60 million US. [...] Christmas of last year nothing had been done to start any kind of fundraising activity. And at that point it was imminent that the company was going to run out of money sometime in the next couple of months (RC, interview 07/2011).

In 2010 Think's financial partners had not been engaging in fundraising activities for Think, but relied on sales of the Think City car and receiving a loan from the US Department of Energy. However, the US sale price of the Think City ran at about US$40k, and that was a problem to many potential customers, despite government incentives that would reduce the end-price. Consequently, sales did not take off as Think financial partners had projected. In addition, EV-competition was increasing. Former Think CEO Canny recounted,

> There was a significant disagreement between management, the board and Ener1 regarding how to respond to the pricing of the Nissan Leaf and the Mitsubishi cars in Europe. What happened around May in 2010 was that Nissan announced the price for the Nissan Leaf and basically it was a much a lower price than everyone had expected. It therefore put much more stress on the business equations of the Think City car to get through the point of profitability (RC, interview 07/2011).

It had been difficult for the partners to agree on a pricing of the Think City car as it was uncertain how future EV-cars would be priced. In terms of the US Department of Energy loan, things became problematic for Think and Ener1 – Ener1 had a controlling partnership position in terms of Think's work decisions and Think was Ener1's main customer. Former Think CEO Canny explained,

> One of the reasons why Think didn't get a US Department of Energy loan was because the combined entity of Think and Ener1 was not credit-worthy. Ener1 themselves never got a loan either. So it was a symbiotic relationship that was more negatives than positives in marketing. It would have made a huge difference to Think, but the credit risk of Think and Ener1 was too much (RC, interview 07/2011).

To Ener1, as an investor in Think, the situation meant double trouble: neither Think nor its battery company EnerDel met sales expectations, and as Ener1 experienced considerable first-quarter financial losses in 2011 and a decline of 18% in its share price, it decided to write off its entire Think investment in May 2011 (SeekingAlpha.com, 2011). As a result, Think lost its main investor and on June 22, Think declared bankruptcy.

5.6.3 Finance partnerships reforming

5.6.3.1 Ringdal and employees' financial partnership reforming around the potential Ford deal, 1998

As Ringdal invited his team for home dinners they discussed the formal and sensitive things about the bankruptcy situation of Think. If Ringdal could not succeed in creating a new salary agreement that would be ready right after Christmas 1998, 40 people stood to loose their jobs. Ringdal had initially met representatives of the Ford Motor Company at the 1994 Winter Olympics in Lillehammer and during the Brussels Symposium in October 1998 they had agreed that he should present to a Ford audience later that year. This presentation was scheduled two days after the probate court requested a full stop of activities in Think. Together with some of Think's former managers and employees and Bakelittfabrikken AS, Ringdal managed to temporarily bring back the bankrupt company, and collectively, they put all their hopes into a complete revival of Think through the Ford presentation. Their attitude to embracing uncertainty was expressed by Think Development Engineer Aanonsen, "In projects like this, it is always risk – you know that from day-one. […] [The Project] will not go down the drain. It has gone so far, it is more or less impossible to stop" (Grace & Pryweller, 1998). Ford could be a groundbreaking connection for the company and though Ford showed great interest in Think in Brus-

sels, Ringdal was made aware that set-up and negotiations of ownership could take several months, at best.

5.6.3.2 Ford investor partnership reforming around Think's US launch plans, 2008

As Think resurrected in 2006 after the period of ownership by Kamkorp, dialogue with Ford was reforming. Think needed so-called Ford component parts' approval letters to revive relations with some of the technology suppliers that Think had worked with during the Ford-era. Then in 2008, discussions about reforming a partnership took place. Former Think CEO Canny recounted,

> I was managing that discussion on the Ford side. And clearly Think has not been successful in its ability to form partnerships with traditional automotive companies. With the benefit of hindsight, Think had opportunities to do a partnership with Ford that could have been quite interesting but unfortunately they pushed Ford so hard to become an equity investor. On the Ford side that was very complicated because in typical fashion Ford had paid a bit of money for Think and then sold it for next to nothing. […] There could have been some form of strategic alliance based on contractual cooperation and sharing of development and ZEV[54] credits and things like that. But unfortunately Think was a little bit overconfident (RC, interview 07/2011). (CARB, 2012)

To Ford it could have been interesting to partner with Think due to its experience and expertise in EV-engineering, which meant they could be alliance partners, but Ford was not interested in reforming the partnership as an owner working to build Think as an EV-car company. However, Think was not interested in focusing on EV-engineering as a piece in an automotive value chain, rather, it believed it could solve the complexity involved in building a car company from the ground up – including the development of EV-car models, production, assembly and distribution. As a result, these diverging perspectives led to a halt in potential partnership discussions with Ford. Think

[54] To provide interested stakeholders transparency in relation to the fufilment of the ZEV Regulation the CARB requested production data beginning in year 2009 and credit balances in 2010 to be made publicly available. Specific demands were defined for large and medium volume productions and one credit unit calculated in grams per mile Non-Methane Organic Gasses (CARB, 2012).

needed to develop its skills and understanding of automotive strategy and operations in another way.

5.7 Synthesizing cases on the Think City car's technology innovation development

The four analysis narratives have aimed at including a wide range of the socio-technical contingencies that account for the successes and failures in technology innovation development. Focusing on technology innovation partnerships in socio-technical ensembles was revealing. Across the four cases presented above, a number of main themes relevant to Think can be brought forward.

First, Think's development process was slow and demanded change in the environment. In the battery case, Ford had changed its perspective on how to build the electric car and acceded to Think's approach. In the drivetrain case, Siemens shared Think's development attitude and became committed to its success. It was only when partners were willing to deconstruct their frame of expectations for the technology innovation development project, in terms of what it was supposed to be doing or delivering of benefit, that they became open to radical new ways of developing and combining technologies. Only then could partners become detached from the effects of the socio-technical environment in which they were connected at any given point. But not all partners made changes to their direction in support of Think. And, whenever partner expectations centered on 'time-to-market' the focus seemed to shift to routines and habits and this became unsuitable for Think's radical innovation. To Think, speed was the enemy of constructive change.

Second, drift in the environment had a changing impact on Think's project activities in all cases, as it did on the overall Think City car project. Sometimes drift led to progress for Think, sometimes setbacks, but Think was not immune to the impact of environment drift. In the battery case, a regulatory drift on NiCad batteries had an impact on Think and Ford's joint development direction, and an organizational drift on behalf of Tesla resulted in setbacks for Think's production and sales promises. In the drivetrain case, a drift in corporate interests on behalf of Ford prompted Think to develop it own drivetrain. In the headlamp case, the experience of frequent drifting situations of tier-two suppliers mobilized Think to work with multiple suppliers. And in the financial engineering case, the Norwegian stock market drift in

1998 hindered Think's chances of finding local investors for its project. The drift in the California ZEV mandate in 2002, coupled with Ford's faltering financial situation, had propelled Ford's decision to divest Think, leaving Think in a technology innovation development vacuum. Think had to try to exist, not through stability, but through continuous transformations in partner-networks as well as by redefining itself and the product idea. As such, Think experienced many possible futures influenced by a variety of collaborative socio-technical ensembles. In fact, its progress with technology innovation has provided knowledge about possible futures for electric cars. Outcomes deviated from planned and predicted actions or otherwise proved that the unexpected could be possible. Drift was part of the process.

Third, partner interests and expectations were important for how and with what purpose they could 'use' one another. To Think, it was often a struggle to keep the Think City car development interests up-front as its partners would 'use' Think to advance their own, divergent interests. This was particularly the case whenever Think had been used for showcasing purposes or as a test-site for other technology being experimented with. In the battery case, SAFT profited from Think as a partner who could showcase its products both at the Winter Olympics in Oslo and during the BART-project in California. Similar, the battery producer A123 considered Think an exhibitor for its lithium-ion batteries, and although the contract was hindered, A123 picked up emergent learning from the collaboration that directly contributed to its own battery improvements. In the drivetrain case, Siemens used Think as a showcase to reveal development potentials for its own technology. Nevertheless, Think also learned how to use partnerships as showcases for itself, as it did in relation to the REEvolution consortium. Indeed, as an experimental platform, Think could provide good conditions as it basically had locally integrated all technical EV-infrastructure in and around Oslo. Moreover, the Think City car concept had a flexible design which made adaptations to fit smaller or bigger components relatively easy, and different engineering competencies were hosting a broad and long history of testing-experience in-house. In that sense, different experiments seemed to enable Think's sustainability. Think would begin to understand that it could play a decisive role as a showcase platform

for other EV technology development innovation projects, and in the process, Think had become an OEM, carving yet another role for itself out within the EV space. But, Think also kept pursuing the idea of becoming a 'real' car manufacturer, which was perhaps what partners were least interested in supporting, or even least expecting from Think.

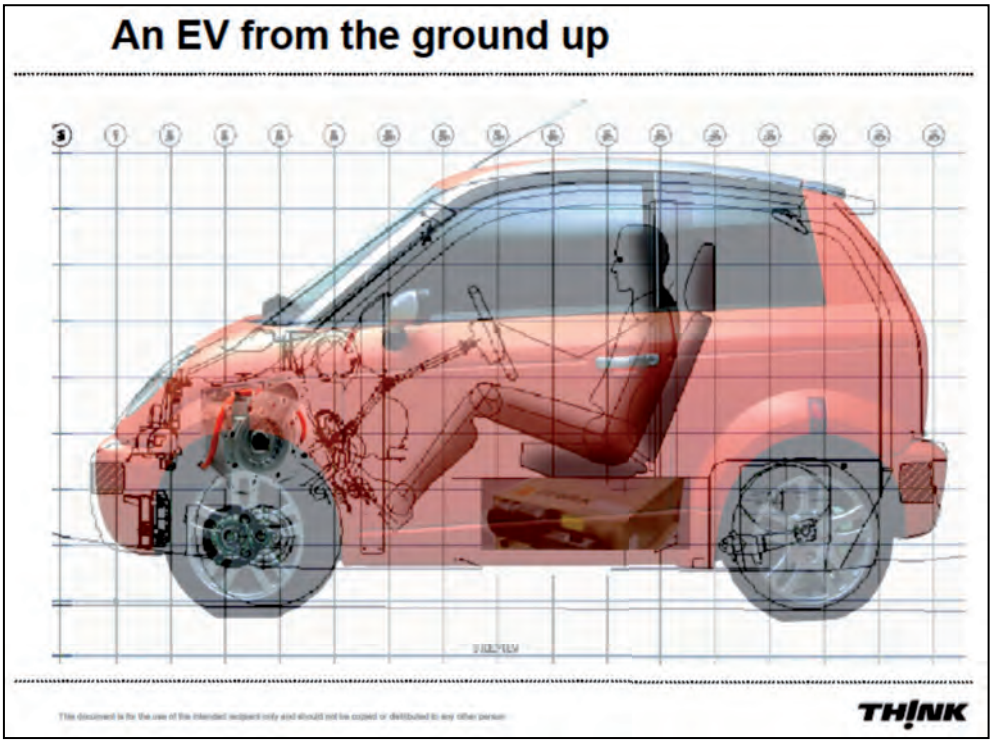
Forth, Think's flexible approach to innovation played an important role in its ability to exist through time. This flexibility was reflected in its overall project; for example, in the design of the Think City, in the manufacturing lane, and in the technology innovation partnerships. One of Think's advantages was that any technology company that seemed able to help it advance in one of its areas of development became of interest to it, and partners could also draw on dispersed knowledge and emergent learning. Another benefit was that Think could spread its risk by working with several cutting-edge battery technology suppliers in parallel. To many technology companies Think's flexible innovation approach equally meant lower risk and offered them a network of complementary resources they would not have been able to maintain themselves. In contrast, when partners were aiming for supply exclusivity and tight collaboration with their other technology investments, Think was often left with operational rigidity and a lack in technology innovation learning opportunities.

Fifth, emergent learning, rather than time-to-market, was a qualifying factor for Think in its innovation journey and the ability of emergent learning developed through different partnerships. Emergent learning prompted progress, direction and opportunities. In the drivetrain case, it was through emergent learning that Think noticed Brusa would only be able to supply a few models at any given time, which was far from Think's envisioned productions scale – and this prompted Think to look for other partners. Emergent learning was also a means to discovering how to organize the collaboration between Think and Itouchu, while the partnership evolved, largely unplanned.

Overall, these five points help us grasp and understand – free of theory – what technology innovation development at Think was, from different perspectives and in relation to collaborating partners, on a firm-to-firm partner-

ship-basis. The next chapter will connect back to the broader theoretical perspectives.

[iii] An important feature of the Think City was that in the middle of the car, removable from underneath, a rectangular battery box was located as shown in the figure below. This box carried measures that basically allowed any battery part to fit inside. Parts needed to meet Think's defined interface specifications of the vehicle itself and the battery's rectangular box, specifications for the electrical connections, as well as specifications regarding the electronic communication on the other relay. The battery philosophy was built into the car.



The Think City car from the ground up, around the battery box (source: Think presentation, 2010)

[iv] Think's battery criteria led to partnerships around energy efficiency, energy density and lifetime: to date, electric vehicles are expensive to produce as compared to conventional cars. Since the battery system is the main cost-driver in the electric vehicle, it is a fundamental part of the electric car that will continue developing. In relation to battery development, Think worked with three main priorities: energy efficiency, energy density and lifetime, in relation to which cost was considered an implicit component: e.g. better efficiency = better battery cost structure. Energy efficiency refers to the aim of getting as much energy into the battery as possible in order to get as long a range as possible; for example, 150 kilometers. Energy density refers to the aim of using hot air energy that

allows for a smaller battery, which also makes the vehicle lighter and in that respect more efficient to drive. And, lifetime refers to the aim of having a battery that lasts, ultimately, as long as the car. These three criteria apply to one and the same battery system, as Mollestad, CTO at Think, explained:

> Today, our design criteria for the battery system are that it should be able to take 1000 full charging cycles. One full charging cycle is able to give the car a 160-kilometer range. That means that the design would take it up to 160000 kilometers. We have done now quite the number of laboratory testing and it seems like we are significantly better than that target. Some of the tests actually detect that we might even get about 2000 cycles out of the battery before we approach end-of-life; and we define end-of-life as 80% of the initial energy. That means that you, as customer, have to accept that you will loose 20% of your waste before your battery doesn't work anymore (EM, interview 11/2010).

The number of charging cycles that Think achieved by 2011 allowed Think to consider multiple chemistry solutions that enabled high energy density. As a result, Think also had different price offers to consider. Some of the solutions had a short lifetime and if the battery system already reached its end-of-life by four or five years, the Think City incurred huge costs in maintenance. As such, integration challenges also remained in relation to the modular battery design and Think would experience unpredictable setbacks at a later point in time.

6 Dynamics of partnership reconfiguration during long periods of ferment

The purpose of the empirical studies of this thesis was to examine the phenomenon of what happens with partnerships, complementary assets, and competencies in an innovation process, and to concentrate specifically on what happens when a special focus – namely that of partnership drift - is applied to the dynamics of partnership relations during the innovation process as they unfold. Methodologically my focus was on problem-solving by different technology innovation partnerships in different socio-technical ensembles across time. This approach is considered as a complement to existing research that prioritizes emergence, heterogeneity and narratives.

This chapter turns attention back to **Table 5** on page 78 whereby the three analytical perspectives on partnerships were presented, along with their different views on partnerships in general, on partnership initiation, changeability, project uncertainty, and understandings of project outcome. The objective is to provide a joint discussion of the Think cases in the light of the three approaches. The level of attention is therefore slightly above the structure and insights of each case that explored the forming, breaking, and reforming of partnerships in detail. Here the empirical findings are instead reorganized as to how the four cases considered as a single, overarching Think case, supports dominant design, open innovation or partnership drift and what happens through the innovation process.

The battery case focused mainly on how partnerships were initiated. The drivetrain demonstrated specifically how emergent learning changed the innovation process. The headlamp case exemplified how partnerships try to hold on to a standardized and planned approach yet similarly exhibited traits of emergent learning. The financial engineering case distinguished itself by challenging the traditional perception of what is a component in innovation technology development, the creation of valuation, and thereby highlighted the differences in understanding innovation outcomes. Based on this rough

division, empirical observations have been traced according to the five different analytical dimensions: what is the general understanding of partnerships?; How are partnerships initiated?; What is the understanding of change during the process?; What is the understanding of uncertainty?; What is the understanding of outcome? **Table 7** on the next page presents these, which have also been categorized in relation to the three theoretical perspectives. As a result, the following discussion is grounded in empirical insights from the four individual cases and the subsequent synthesis of outcomes. The study of the empirical context, as presented in Chapter 2 is brought into the discussion to help support and contrast findings.

Table 7: Contrasting the empirical findings based on theoretical perspectives model examples

Innovation perspectives	Dominant design	Open innovation	Drift approach
General understanding of partnerships?	B – --- D – standard rules for intellectual rights H – -- F – pushing own technology in the place of Think's; reluctant to partner outside own domain	B – --- D – good and safe quality large company H – standard product supplier F– global partner with knowledge, marketing and distribution; niche access	B – focus on sharing and defining assumptions, forming around a burned out car; non-exclusive conditions; to increase general industry interest D – collaboration forming around EV-symposium or component problem-solutions; around modularized design; H – activating existing relations; ongoing puzzle and play with material, mass, machine, and minds F– an exchange of services; help to launch other technologies
How are partnerships initiated?	B – -- D – -- H – meeting legal requirements F –partnering only within own domain; roll -out plans	B – through interface specifications; based on Think's small production volume size D – with off-the-shelf drivetrain system and global position H – with frequent environment and engineering life cycle tests F – seeing potential use of partner technology; obtain locally integrated partner and infrastructure	B – through existing partners; public testing; through system redesign; D – through academic relations; with several partnership interests at stake; by reconnecting; through product demonstration; organic doing H – through cost and quality compromises F– through demonstrate environmental awareness; exploring technology combinations; through venture capital relations
Understanding of change during an innovation process?	B – -- D – -- H – specified by requirements F – consolidating internal activities	B – based on Think's accumulated EV experience D – based on larger partners verified experience; passing through formal lines of approval ; replace to best available technology H – -- F –	B – confronting system flaws; embarking on specialization and co-development ventures; learning about costs and revenue interests; facing unmet expectations; D – learning about production capacity and growth ambitions; understanding complexity of sub-supplier relations; recombining technology; abandon outdated management decisions; seizing emerging opportunities; bidding processes; H – a tough learning curve; unstable development and production F – learning about local market penetration; a zero emission industry forming
Understanding of project uncertainty?	B – -- D – -- H – monitoring costs F– monitoring competition and sales; crisis loan package	B – D – -- H – -- F –	B – working with only one supplier; challenge to understand future market standards; lacking ability to overcome constraints; willing to trust and take risks; customers driving experience; changing market demand D – willing to work on others ideas and willing to provide freedom; willing to be a showcase platform; different communication cultures; new investors; innovation inexperience; H – different marketplace conditions F – define relation of innovation in opposition to existing automotive market; transfer production site
Understanding of project outcome?	B – D – -- H – legislation conformity F – bringing production up to speed; realizing aggressive marketing plans	B – successful through component assembling – no in-house development, satisfied investors through partnering D – successful sustainability project result in new stake owners; discontinued projects if mis-alignment with new strategic direction H – -- F – value measured in revenue related to yearly production	B – burned down car was a valuable learning experience; relative robust systems; influenced by regulatory drift; convincingly working prototypes D – through confronting inexperience; drift as partnership focus change H – unpredictable supply conditions F – bankruptcy as way out of a bad relationship in retrospect; unpredictable cost of investment

Legend: B - Battery case; D - Drivetrain case; H - Headlamp case; F - Financial case

Building on the contrasting of empirical findings, it is possible to extend the technology life cycle model as presented by Van de Ven and his colleagues (2008, pp. 10-11), as previously introduced in **Figure 4** page 63, with the notion of partnership drift, with the notion of partnership drift, by explicitly adding forming-breaking-reforming — now exemplified in **Figure 17**. This extension supports the analytical strength of the model as it specifies what is meant by "relations with others" (Van de Ven et al., 2008, pp. 10-11).

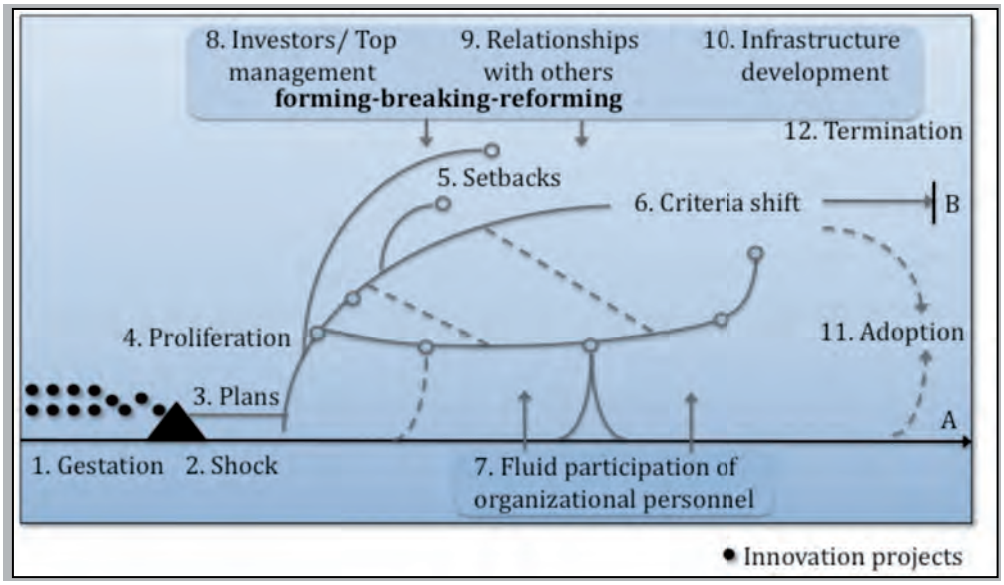


Figure 17: Extended model of emerging innovation process example

Overall, the structure of the model is similar, as this research supports the action-flow described in the original model. However, this model illustrates how the technology life cycle process can be analytically understood, with the additional inclusion of partnership drift. In other words, it is only via a view on partnerships as a component of the innovation design process that an understanding of the innovation journey as a whole can come to light. During collaborative processes it becomes clear that different opinions and assumptions are defended, which in themselves represent problems and barriers to the work being carried out. Whether they remain implicit or are made explicit, they have an influence on effectiveness.

The next part of this chapter elaborates, by revisiting the three theoretical perspectives, what each of the four cases in this research provides as examples to support the individual perspectives of dominant design, open

innovation and drift approach. The discussion is structured along the questions highlighted in **Table 7** page 229.

6.1.1 How is the general understanding of partnerships

The cases bring forward the general notion that partnerships are a mix of problem-solving interests, which are distributed, emerging and temporary, expressed through sensemaking roles that correspond to different organized groups. This is reflected in all four cases as well as in Think's empirical context. A partnership is thus not exclusively an expression of the connection between two collaborating companies, but of a dynamic form of situated collaborative orientation that is constructed as innovative activities take form involving actors, interests, technology, and their wider environment.

The cases bring forward the notion, especially in relation to Ford's intentions of partnering with Think, that in the eclectic, heterogeneous, forming stage of a market, partnership alignment is not a concern (as in the battery case, drivetrain case and financial case). However, the cases also demonstrate that without innovation development partnerships, technology experiments and demonstrations can be hard to realize. This is expressed, for example, in the instances where Think became advantageous as exhibition partner or showcase platform, where no deeper company alignment had been pursued. The Ford and SAFT partnership examples revealed that for product, organization structure and financial reasons partnerships were as desirable as approaches (battery case).

The cases also demonstrate that although a component may not initially appear to be as strategically important in an overall technology innovation project sense, and is rather perceived as a standardized industrial product (headlamp case), partnership collaboration is not necessarily more stable or problem-free. Another example highlights that the initial appreciation of a larger company as a good and safe quality product supplier (battery case and drivetrain case) may turn out to block technology innovation collaboration, as partnership collaboration struggles to free itself from perceived 'best-practice'

approaches towards development. Both examples resonate well with Doz's (1996) plea to regard learning ability as related to initial conditions.

The last example highlights the transformational shift of partnerships themselves. The cases demonstrate that whenever partnerships focused on sharing and defining assumptions, when they accepted non-exclusive partnership conditions and held a general industry interest (battery case), when they worked on modularized design (drivetrain case), and through such approaches generally accepted that technology innovation development is an ongoing puzzle that should incite play with materials, masses, machines, and minds (headlamp case), partnerships move and move technology innovation development. With time and experience, the understanding of partnerships in a collaborative ensemble will change, as experiences and emergent learning settle into partnership sensemaking. The answer to the question 'How is the general understanding of partnerships?' therefore suggests that more specific insights are gained from knowing how partnerships are initiated.

6.1.2 How are partnerships initiated?

If partnerships are seen as emergent within wider socio-technical ensembles this has obvious consequences for identifying and defining how they are initiated. This perception raises awareness to whether partnership possibilities and opportunities can be considered and assessed independently of technology innovation development experiments and tests, or whether they are created as part of the ongoing innovation process (battery case, drivetrain and financial case).

The cases demonstrate that partnerships are initiated through existing relations (battery case, drivetrain case and financial case), around demonstration, testing, redesign, and organic doing (battery case and drivetrain case), with several partnership interests at stake that were more or less explicit and often didn't align partners (all four cases). For example, it seems that drivetrain partners had different interests in experimenting in technology, as opposed to those in the battery case. In the drivetrain case partners wanted to see a working car, which stood in contrast to the battery case where lots of

technical drift was apparent. Hence, Think's collaborative flexibility was valuable to helping it pursue its own technology innovation interests, and initiating new partnerships.

Exchange of ideas, dialogue, and discussions, written explanations, technical specifications and sometimes technology prototypes assisted the ways in which partnerships formed and learned about seemingly realistic possibilities and opportunities for the partnership as a whole (all four cases). However, the cases also emphasize that Think did not follow company-standardized market screening, selection and negotiations processes before beginning to collaborate with external partners – this was not because it aimed at an excessively emergent organizational structure or strategies, but Think remained flexible to the various partners it worked with as it did towards the process of collaboration itself and its development, as noted in the example above (drivetrain case).

As much as the Think cases emphasize partnerships between two companies at a time, the Think financial engineering case is found particularly interesting with its multiple-partner focus. Here several partners seemed often to join up together, simultaneously. The case demonstrates that it takes a lot of collaboration between founders of technology innovation projects, governments and private industrial investment to initiate and make innovation happen. While experiencing forming, breaking and reforming partnerships, Think's founder, subsequent CEOs and employees had to dare to believe in their seemingly impossible and irrational ideas. Secondly, before the Think City car was sufficiently advanced for leasing, sale or other ways of commercial distribution, financial contributions from government and large industry partnerships acknowledging the information and contingency growth, as a return of investment, were pivotal. Thirdly, non-local, industry-experienced external investments were key to advancing and commercializing the Think City car, which means that considerable return on investment benefits went abroad, but employment, skills, technology innovation, and production stayed within Think in Norway, with the exception of when production moved from Aurskog to Valmet in 2009, where employees were hired locally. However, to assume that the move of the physical production was a fatal decision would be

to ignore that it was not the actual shift that became a central problem to Think's production. But the overall financial concept was uncertain. Fourthly, no government policy could effectively enrich environmental innovation without the transformation of activities by artisan people with skills and guts to embark on new projects.

Partnerships were formed because partners had expectations about what the Think City should be to them, not how it should be used by end-users in a wider urban mobility heterogeneity. In other words, partnerships were opportunistic (all cases). Partnerships persistently perceived the Think City car as a sustainable alternative to conventional cars (battery case, drivetrain case and financial case). This is a debatable interpretation, since sustainability also in-part depends on the degree to which the Think City car is recycling, and on how electricity is being produced, which are factors that are beyond Think's organizational limits and often beyond the reach of their partners too. Nevertheless, the Think City car was deemed important for environmental reasons, partly because its emissions neared zero, and partly because it represented a different 'idea' and 'ideal' of a car that could challenge dominant, existing technology. When partnerships failed to consider the wider innovation process, they would place constraints on Think. Partnerships broke when partners shifted automotive interests, when malfunctions became unacceptable, when professionalism or entrepreneurial attitude was lacking, when financial situations changed and when the readiness to accept unpredictability and uncertainty was no longer present (financial case).

Using the analytic perspective of partnerships as forming, breaking and reforming raises the question of whether it matters who takes the initiative in the different situations, and perhaps most importantly when partnerships break. In the case of Ford, the break-up almost became as important as the collaboration itself or the technology innovation that was created during the partnership (battery case, drivetrain case and financial case). The break-up has the characteristic of a cumulative process, in the sense that it was not a single event but rather a transition around a turning point that included the cessation of production of Think City cars by Ford. Ford decided it would be better off without Think, and so Think was pushed away from the 'good com-

pany' it had once been invited into. The break-up was not a collaborative decision, but a deliberate choice made by Ford. At the time, Think incurred the greater loss since it lacked in technical supervision and leadership.

No break-up was deliberately planned at the inception of partnership formation. That partnership reforming would occur was even more unimaginable at the outset of any collaboration, or at the time that partnerships became severed (battery case, drivetrain case and headlamp case). But, as frames of reference changed, these had ramifications for Think. Partnership developments were uncertain and unpredictable (all four cases). Consequently, as partnerships act, they are both assembling as well as being exposed to change.

6.1.3 What is the understanding of change during the innovation process?

As indicated above, perceptions of change become very relevant when understood as part of ongoing innovation processes where possibilities and opportunities may be assembled, and uncertainty is equally present. In relation to understanding change, the empirical cases bring forward examples of tension between expectations and engagement, company interests and collaborative flexibility, and trade-offs in development ideas' time horizon and time-to-market focus.

Change during the innovation process generally came about when partnerships confronted system flaws, embarked on specialization and co-development ventures, approached recombining and redesigning technology, and faced unmet expectations (battery case, drivetrain case and headlamp case). Again, the burned out battery and the ongoing adaptations of the headlamp components serve as examples. Change also transpired through: learning about unstable development, production capacity and growth ambitions; the complexity of sub-supplier relations; and, bidding processes or as part of the learning about costs and revenue matters (battery case, drivetrain case and headlamp case). The drivetrain analysis delivers an important learning example about how something that hadn't originally been considered a possibility emerged as a reality — through emergent learning Think changed both its company interests and collaborative flexibility. Initially, Think did not

intend on developing its own drivetrain, but through technology exploration, experimentation and testing, Think gained a sense of how to build, combine, refine, operate and demonstrate the drivetrain component performance it had learned in relation to existing ways of conceptualizing and using drivetrains. But Think also picked up the emergent learning about how to envision the drivetrain differently and discovered the potential of making a different model.

The cases demonstrated that partnerships understood change — in the sense of innovation capacity — as directly related to past experiences accumulated (battery case and drivetrain case) and such an understanding placed expectations onto the collaboration process. While documentation would give an indication of partners' collaborative flexibility (headlamp case), it was only through experimentation that Think would find out how its partners' interests became vested in the project (battery case, drivetrain case and financial case) through which they could also determine how much experience and change-orientation they would benefit from. Think's collaboration challenges with Enova demonstrated such tension, as Think got stuck in Enova's formal lines of approval and found that its organizational structure didn't match its technology development efforts. Therefore, it is likely that it was not only the questions surrounding drivetrain technology that prompted Think to change its management decision about in-house development, but that learning about its own organizational strengths and capacity to change played an important role.

The breaking of partnerships enabled another kind of change — the evaluation of and reflection on the overall innovation development direction, also in relation to the trials and errors of forming collaborative partnerships. However, Think's attention seemed to have been on the first alternative solutions to technical problems while the effects of change and the repository of partnership-making were less intentional. A relative stability surrounding the battery system was imbalanced. It created a vacuum that prompted bold decisions in finding resources for survival. Interests had drifted as partners were consumed by critical financial situations; sometimes they had to do with market strategy priorities, and at other times, the focus had to be on internal con-

flicts related to technology or organizational issues. Expectations in relation to technology or market opportunities were left as light impressions in the process of development; without ownership, their meaning was up for interpretation, as was the meaning of Think as a technology innovation partner.

All four cases demonstrated that technology innovation experimentation and demonstration activities could result in project drift because this is when the full mix of a socio-technical ensemble is present. All aspects are formed and joined together: economic, technical, social and environmental – strategic, as well as less strategic relations and elements proved their role and how they potentially contribute to or impede technology innovation development. It is through this interwoven ensemble that different dimensions of what seems to be one single relation become apparent. Furthermore, it is at this point that these four dimensions will be consciously thought of as a part of a partnership, and they will thereby expand the notion of partnerships to more than their technological dimensions. Thus, it is in the relational socio-technical ensemble that all dimensions of a relation are embedded and may change together. Of this, the burning battery was a striking example.

6.1.4 How is the understanding of project uncertainty

In the face of uncertainty great efforts are often put into short-term results, securing tactics and controlled execution (headlamp case and financial case). But in the case of Think, partnerships with such focus placed greater uncertainty unto the Think City car development project as a whole. Think was in these cases left with little room to experiment on alternative ways of building momentum, in the sense of building a Think City car model that was robust enough to help Think as an organization endure uncertainty.

Project uncertainty was demonstrated when partnerships underestimated their technology inexperience, relied too much on their previous car-project experience, enforced standards, and placed overly optimistic expectations to outcomes, and focused on financial value over technical progress (all cases), Uncertainty also came about whenever Think would be searching for a new partner, forming, braking, and reforming with a partners. And project

uncertainty was related to lacking customer, local market, and global market understanding.

The cases demonstrated that Think partners would seek to control uncertainty by invoking monitoring systems based on past experiences and company individual organization structure (battery case, headlamp and financial case). Monitoring would focus on competition, predicted sales, and financial revenue, while cost-spending in detail seemed in most partnerships to run out of hand more often than not. However, The difference between their perceived and real ability to control uncertainty was reflected in the technology innovation process. For example, Ford applied a lot of automotive experience, organizational resources and structures to develop an electric car based on an existing car model they had. They were so determined to make it work, that conceptually they reduced uncertainty to a matter of finding the right mix between existing components and ignored for a long time the outcome uncertainty the innovation work process brought forward. While Think endured uncertainty of whether and when it would make sense to Ford to try Think's suggested approach (battery case).

The cases also demonstrated that partnership interests and expectations at times were overly optimistic placing uncertainty on how satisfying a project outcome would be perceived (financial case). While at other times partners interests and expectations seemed very different to those of Thinks. For example, it is questionable whether any of the financial partners, besides Think, were wholeheartedly interested in designing the personal, independent vehicle that the Think City car was conceptualized as from its inception. In the case of Ford and Ener1, it is obvious that Think was rather serving other purposes; to Ford, Think represented an opportunity to comply with policy and to Ener1, the partnership centered on shareholder interests in relation to its other and more prioritized investment interests, namely in terms of EnerDel. The partnership with Ford is also a useful example that can illustrate how big firms find it difficult to hedge, as much as small firms do. It turned out that expenses and market expectations has a lot to do with size (battery case).

To Think its own organizational uncertainty was perceived to increase when it worked with only one supplier in relation to a development compo-

nent (battery case, headlamp case and financial case). This sense of uncertainty was in turn related to changing market demands and the challenge to understand future market standards that confronted Think at any time. In contrast, Think perceived less organizational uncertainty when they partnered with companies willing to work on Think's ideas and who were willing to provide Think freedom both in terms of technical and organizational matters (battery case and drivetrain case). In these partnerships Think could concentrate on technology innovation development and the uncertainty related to the process by confronting socio-technical constraints, taking risks, exploring product, customer and market experiences. This highlights partnership formation as a central mechanism, also in coping with enduring ferment (uncertainty, open pathways), because they are a mechanism for reorienting. For example, Think experienced such collaborative openness in the partnership with Inspire invest, which enabled a Think business model sophistication and a more general battery evolution in the sense that the battery system was explicitly given customer attention (battery case). A development that at the same time changed, the balance of battery development uncertainty, between Think, its suppliers and its customers. Think came to understand that project uncertainty held resource potential, could with advantage be tolerated as it raised an appropriate awareness towards the novel.

The understanding of project uncertainty was also demonstrated in relation to partnerships approach to

6.1.5 How is the understanding of project outcomes?

The aim to understand outcomes of activities may be especially pressing in innovation project studies where the process is so clearly open-ended as Think's 20-year journey has been. Through various ways of observation and levels of analysis Think's technology innovation development is also found to produce outcomes that stretch widely into the greater environment. I address the understanding of project outcomes in relation to emergent learning, technology development and assembling of an EV-market.

The cases demonstrated that project outcomes were perceived in different ways in different partnerships. At times it was a question about meeting

legislation conformity, ensuring that what was perceived as general operational functions were in place and running at high speed, and realization of aggressive marketing plans — definitions rather resembling those pertaining to traditional daily business (headlamp case and financial case). An example is the headlamps case. As compared with the two other technology component cases in this thesis, headlamps may seem less demanding in terms of technology development, however, they were no less important from an outsider's perspective. Continuous development efforts had to be undertaken to adjust headlamp design to new adapted local headlamp regulations and this resulted in ongoing, parallel-projects. Thus, Think experienced a shift in the view on outcomes through emergent learning that placed all aspects of car development in a dynamic frame.

In other partnerships it was successful assembling between own and external developed technology components, convincingly working prototypes, a burned car that offered valuable technical learning experience, or a bankruptcy as way out of a bad relationship (battery case, drivetrain case and financial case). An understanding reflecting how partnership ambitions merge into a learning focus and activities were sought to be contextual meaningful. For example, partners molded their expectations into the battery system design along the lines of what role it should play, what it should do, and how it should interact with the car; but, partner expectations were also modified by the heterogeneity of the development process. As such, when partnerships, the battery system, and the car became connected, they formed a socio-technical ensemble that enabled technology innovation development.

Other partnerships led to an understanding of outcomes as revenue measured in relation to yearly production, return on investment, and structured supply conditions (battery case, drivetrain case and financial case). This was also partnership where efforts were high to match resources and markets needs through business models. But partners had difficulty in articulating upfront a product value proposition and specific offerings, identifying suitable supply value chains, and market position entry (financial case). Think collaborated with a number of serious players, who had honorable intentions of realizing the Think City, with some who also had hopeful branding intentions for

their own products, considering Think as a showcase-extension. Whatever the partnership, partners could never really project what was to happen until they got off the ground and began tinkering with actual problems and solutions through trials and experiments. For example, the financial case demonstrates that funding opportunities were created through experimentation, market analysis overviews, the development of prototypes and the proving of concepts — not on business modeling exercises alone. In turn, this translated into professional improvements for the engineers themselves, who developed into more qualified electric car professionals.

Along these different descriptions of collaborative outcomes, the striking thing is that Think remained flexible and this helped Think maintain its existence, not through stability, but through continuous transformations in partner-networks as well as by redefining itself and the product idea.

7 Conclusion

I opened up this thesis with a brief review and discussion of how the technology innovation development of electric cars in general has unfolded between different partners across time. I continued by presenting and discussing how different perceptions of technology innovation seem to escape or engage with an understanding of technology innovation partnerships and with that our understanding socio-technical innovation development in general. Then, I explored relatively contemporary technology processes of partnerships in relation to four Think City car technology cases, more precisely, the engineering of battery, drivetrain, headlight and financial development – with the aim to understand *how does the formation of partnerships interact with innovation processes under endured periods of uncertainty*.

Along the way I have been summing up the main findings in different sections and it is based on these insights that I explain in this chapter what I consider to be the theoretical and practical contributions of this research, research limitations and potential future research avenues.

7.1 Theoretical contribution

Research on technology innovation development is approached through different levels of analysis and focuses on different aspects such as planning, patterns and processes, which makes it a heterogeneous field. As a result there is debate about basic technology innovation development issues. This research has tried to demonstrate that it may potentially be fruitful to think about technology innovation by paying attention to the collaborative relationships within different socio-technical ensembles and innovation change, in order to develop novel interpretations and insights.

The insights that this research revealed were brought together in the overview of partnership drift examples, as presented in **Table 7**, page 229, in the discussion chapter. That overview provides a structured basis for further conceptualization of how partnerships interact in and with innovation proc-

esses. Put more succinctly, I have contributed with a drift perspective to the life cycle literature and open innovation concept, which makes it possible to understand dynamic partnerships, in a new way. This has been achieved through the presentation and demonstration of three dimensions: forming, breaking and reforming partnership processes. This is of course a simplification, yet a clarification of aspects relevant to partnership drift, which cannot be assigned unambiguously to either economic, social, technical or environment changes that influence collaboration and thus the innovation process. The whole has pointed out that partnership formation is a central mechanism for technology innovation development, serving as a mechanism for reorientation — and perhaps especially, in relation to coping with endured periods of uncertainty.

Engaging with the complexity of innovation processes and partnerships through a drift perspective revealed important insights about the role of relative stability and changeability of partnerships and this has a direct impact on how we continue the debate about interests, expectations, uncertainty and processes of innovation. Recounting my point from Chapter 3, it is important that managers of innovation projects learn to consider and continually take in what happens in the innovation process as learning occasions rather than threats. As the drift perspective emphasizes, 'something' during the innovation process cannot be controlled or planned out of scope by good preparation and solid steering — obsessively trying to do so reflects the fear of uncertainty (Mintzberg, 1994, pp. 201-203). Uncertainty cannot be avoided in the innovation process, nor can it be clearly predicted, but it hosts learning potential. Still, this principal idea should not be understood as discarding all efforts of visualizing, conceptualizing, or planning an innovation project, however, it calls for careful preparations through "projected conditions planned" (Kreiner, 1995) and a road map (Van de Ven et al., 2008).

Presenting different perspectives on how technology innovation partnerships have been studied highlights what may be expected, or exactly what may not be expected, by research pursuing a certain level of analysis that aims for a more-or-less deliberate narrative about innovation processes. Although the framework of open innovation addresses partner relations, it assumes

they are purposeful and stable and fails to explain the dynamics throughout the innovation journey to any depth or detail. Also, where the dominant design theory appears to characterize the entirety of the innovation journey as uncertain and unpredictable, open innovation seems to ignore the uncertainty and unpredictability. Given that partnerships have complex interests and conflicting expectations, it is not surprising that innovation processes may be perceived as both failing and succeeding in a given situation, through time. Again, partnerships remain dynamic in their form.

This thesis aimed at examining how these differences affect partnerships, complementary assets, and competencies by use of the drift perspective and found that the approach could fill another gap as it allowed for an exploration of and analysis on an intermediary-level, or sociotechnical-level — the level between the industry and company-specific — which was oriented towards interests and sensemaking. The analysis demonstrated that any experience can be considered a failure if partners and the socio-technical ensemble are good enough at making it seem that way. And, any experience may equally come to be regarded as contributing to technology innovation development if partners and the socio-technical ensemble collaborate in making it exactly that. Thus, partnerships, complementary assets and competencies are exposed to uncertainty and change at any point in time, as contested futures and many meanings flow at every given moment.

This thesis supports innovation studies that consider uncertainty and unpredictability as key to a conceptual framework of innovation and innovation processes (Pinch & Bijker, 1984; Van de Ven et al., 2008). Innovation projects do not try to simply follow patterns or pursue plans, but explore, experiment and test in order to understand what is uncertain, how it's uncertain, why it eventually remains uncertain, and how this uncertainty may be of use.

7.2 Contributions to open innovation debates

7.2.1 Collaborative success and failure

Think's history timeline illustrates that the technology innovation processes happened in the open as a collaborative process of success and failures, where

the support and dependency of partners, policy makers, energy and raw material manufacturers, financial investors, and automotive incumbents were as crucial for forming Think's existence as they were for its innovation deconstruction and revival. In that way, partnerships were assignments as part of the technology development innovation, which led each partner to take part in demonstrations and problem-solving and thereby enlarge and deepen their technology innovation understanding. Partnerships forming, breaking and reforming forged new contexts, which provided Think with possibilities for change also in periods of endured uncertainty. The question of 'if Think will be a success', shifted towards 'when, in which form of partnership would they (Think and its partner) be able to adapt to new contexts? Noteworthy is that the problem-solving activities that took place within Think-partnerships seemed more unplanned and emergent upon the learning that was experienced by the people who happened to be involved, rather than something that was planned and discussed by carefully selected and coordinated partners. However, the study of Think also demonstrates that views of success and failures, whether politically, economic, technologically, or environmentally related, change during innovation processes.

This may indicate, in general, that learning to embrace the act of failing when trying out new things as different solutions are required for a variety of problems — recognizing potentiality in relation to other approaches for successful innovation, is part of innovation processes and success.

While the dominant design model takes a macro-level perspective, it suggests that the successful firm is the one that is able to, at the right time, put a winning design together and scale production (see for example Klepper, 1996, p. 580). Looking at the dominant design model, success therefore seems as though it has become a one-dimensional matter in terms of how quickly a product gets to market, for instance. Then, once in the market, dominant design seems to validate success as something that is then purely related to how well an innovation stands against its competition, which is again related to market sales over time. As a result, returning to the case of Think, and evaluating things from this perspective, not only do other automotive companies sell more than Think, this very fact delineates how Think's technology, organiza-

tional construct, social importance and environment role are unsuccessful – but this is totally incongruent to what this research has proven. Throughout Think's technology innovation journey it has demonstrated its merits and success, as did its partners, on several occasions, and on several levels, including technological, social, economic and environmental. A dynamic view on partnerships in innovation processes, as the one a drift perspective contributes with, provides therefore a more nuanced analysis.

7.2.2 Expectations and opinions

Partnership expectations didn't promote learning in the case of Think; it stunted learning and also restricted technology innovation development and limited experimental experiences. Whenever expectations were used to pressure Think, this gave semblance that everything had been figured out and consequently, emergent learning opportunities were not given attention which would have pointed to the socio-technical gaps that the partners really needed to attend to. The problem wasn't that opportunities for success didn't surface for partners, but that expectations undermined opportunities. The challenges of the technology 'not being there yet' was not more damaging than partners working with the technology innovation development who were unable to change their minds about its importance, or the fact that partners were too focused on their expectations. Partners had different opinions about the Think idea and its chances for becoming a profitable product. Sometimes their motivation was not to consider how they could contribute to Think's idea and innovation, but how they could simply profit from what Think had already developed. Environmental concern was not central. Partners found interest in Think's way of working with different materials, how it combined different components and explored interfaces (A123). Partners also found interest in how Think could be the showcase of what their technology could be used for (Oslo Energy, Ener1). Interests were grounded in economic aid, but not in projections that would influence the consumer's perceptions or preference. Moreover, Think demonstrated its strong value as a partner through its ability to lower its partners' cost of process drafting for possible development oppor-

tunities and challenges, by letting partners view their technology innovation project through Think's real-electric vehicle conditions.

These observations stand in contrast to alliance literature (Das & Teng, 1998; Doz & Hamel, 1998; Kanter, 1994), that argues it is critical to have clear and common expectations in relation to, for example, resource flows, technology innovation outcomes, and financial returns. This stability and consensus about expectation, of course, is not possible in an era of ferment, where most actions are likely to influence or create new expectations resulting in partnership turbulences. Expectations can therefore not be explicitly defined and act as a kind of control of joint and individual interests.

7.2.3 Slow-doing, forging endogenous transformation

If a long-term partnership means depending on one another through ups-and-downs over the course of time then Think has rarely been going steady. Think has been absolutely, socio-technically broken several times throughout its existence. It was also relationally broken. But Think has known that in order to move forward it had to let go of the old: the old ways of thinking about Think, and the old ways of working things out in relation to Think. Regardless of whether, in that broken-moment, it or its relevant social groups perceived Think as success or failure, because of past achievements or expectations related to Think, one had to let go. For example, at a certain point it didn't really matter anymore how Think got into financial trouble, only that it could take ownership of that situation and begin to take action to change it. In a way, bankruptcies were a good thing, because they helped demonstrate that partners were laboring under conditions of expectations that were too extreme. Think realized that in the periods of slow-doing, it became more open to listening to other partners alongside whom it was previously moving to fast to collaborate with. Who fails and who suffers from the failure? Think seemed to recover relatively soon after bankruptcies, but investors, policy makers, the environment and interested buyers seemed to suffer the failure a lot longer. Had Think gotten stuck with the notion of being 'right' in its actions and character before any given break-up, it would have missed the whole point of de-

velopment. Think had to embrace its new fragile constellation every time, change its frame of mind, open up to new partnerships, and only through this endogenous transformation was it able to begin to dream about a new future for itself.

7.2.4 Uncertainty and unpredictability is where innovation possibilities begin

The study of Think demonstrates first of all that the innovation process cannot be predicted but is, as described by by Van de Ven and colleagues an uncertain and dynamic exploration into the unknown "where the 'best' ways to proceed is seldom apparent and the individuals involved have to be satisfied with finding a potentially promising technological path" (2008, p. 170). Thus, this case is similar to what has been found in other settings through studies on, for example the Sony Walkman case (Sanderson & Uzumeri, 1995) or the Nokia case (Giachetti & Marchi, 2010) where experimentation, flexibility and re-identification were similarly important factors, as earlier noted. But it is different to the bulk of empirical innovation studies as it addresses a small high technology company and focuses on the uncertainty of partnerships. All four Think cases presented in this thesis exemplify that innovation happens while political, technological and economic markets change, which supports the understanding of the innovation process as unstable and unpredictable. It is therefore not a question in relation to innovation development that is defined by time-to-market to meet a window of opportunity, but rather ongoing transformation into changing windows of opportunities. Importantly, technology innovation development actors seem to be risk-adverse and therefore position themselves in partnerships that will assist them in navigating different paths if needed. This may be observed widely within different manufacturing industries such as textiles and pharmaceuticals[55]. While they may not all anticipate

[55] For example in the textiles industry, H&M, its denim-producing suppliers and the World Wildlife Fund partnership to create a sustainable water strategy for H&M (Stevens, 2013). In parmaceuticals an example is Lundbeck and Otsuka Parmaceuticals's partnership that

having to adapt to changing opportunities, it is what they do — even the big players.

Understanding that something happens in the innovation development process raises awareness to the fact that nothing ever had to have happened the way it actually did happen. It is therefore not, as path dependency literature would suggest, past events that make their entry and play out their parts, but rather, as path creation explains, actors who "meaningfully navigate a flow of events even as they constitute them"(Garud & Karnøe, 2001, p. 2). Think's partnerships could have formed in a number of different ways at any point in time during the process. The partners never knew in advance what problems, possible solutions, dead-ends and progressing actions or new relations they would encounter.

In that way, research also demonstrates that different players, such as policy makers, small and larger industry players, and financial investors, working in partnerships or as stakeholders in a wider socio-technical ensemble cannot and should not always rush technology innovation development. Sometimes bittersweet consequences ensue when pressing on for the delivery of what appears to be, for example among potential competitors, a market opportunity, positive return on financial investment result or sophisticated technology functionality. Sometimes the partners at work are not nearly as ready, or 'present' to play their complementary roles. So the rush that we impose on technology development becomes the source of failure; not the idea per se, nor the technology, or the partners but the imposed socio-technical pressure becomes the demise. Emphasizing the problématiques about technology innovation in relation to economic, social and environment factors may prove as far more promising for existence, resistance and persistence.

The unpredictability and uncertainty of the innovation processes also made it difficult for Think to develop not only an overall strategy, but also individual strategies for different component development areas. Uncertainty and unpredictability left Think with two options each time they became ap-

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enables the delivery of innovative medicines targeting psychiatric disorders worldwide (Lundbeck, 2011).

parent: to be stopped by upon approach or creatively used to reform partnerships through imagination and contingencies. As such, uncertainty and unpredictability appear to be where stability ends, but also where a new future and innovation possibilities begin. Think has dared to go about uncertainty and unpredictability as resources of opportunity for forming complementary partnerships: being in uncertainty and feeling unpredictability. Thereby Think has pushed off from the brink of failure, which has helped it move further than it ever knew it could with other constituting partners and through socio-technical resource complementarities. Understanding that Think itself was a resource complementarity to a given partner, in some form or another, was also another form of the manifestation of uncertainty and unpredictability. This reveals the dynamics of technology innovation as much more complex and dynamic than macro-level or specific micro-level analysis can contain, and therefore raises awareness for intermediary-level dynamic approaches. Consequently, this thesis makes no attempt to formulate an overall strategy, but rather suggests foci for guiding and organizing emergent learning and collaboration in socio-technical ensembles. Tending to the partnership forming, breaking and reforming efforts around technology components and pilot-test projects may allow organizations to reveal environment drift, learning need, and locked-in projections that limit the innovation development process.

7.2.5 Emergent learning as a partnership outcome

The idea of an electric car was not a new one when Think set off to develop the Think City. As the empirical chapter revealed, there was a past of electric cars which Think has had to confront at several points in time with various partnerships. But Think has been part of a new era of electric cars intended for public mobility and this has been full of well-intended, but often lofty expectations for partnerships, which didn't just relate to the development of the Think City car, but which also pertained to Think as an organization and its environment. Think hasn't turned out to be the answer to every question about sustainable mobility, yet it has still managed to decipher interesting search directions for itself, its partners and other electric car manufacturers because

it represents a different 'idea' of a car. Think proved that staying focused on automotive experimentation and building an experience repertoire were helpful under conditions of endured uncertainty — in drifting situations — since these activities supported ongoing development activities and organizational adaptation. Think has provided people with experimental learning courage and the possibility to envision ways of making the environment greener, and continues to do so by being a beacon of clean technology innovation development. As such, Think and its journey have also provided us with the possibility to recognize and question the social-technical infrastructure we have around us.

This may indicate, in general, that it is not up to partners to determine what they learned from technology experimentation, rather, it is in their power to have chosen to pay attention to emergent learning or not. But if partners are focused on the patterns of innovation and not the processes they don't even bother to consider what the emergent learning may be. If partners concentrate on the present, contributing to the innovation project – showing up for it as fully as they can – then any moment during the process of innovation may hold a radical turn.

7.3 Practical relevance

This thesis offers critical ideas for how to think about processes of innovation and how to embrace uncertainty and unpredictability in innovation. I use the terms forming, breaking, and reforming to emphasize technology innovation partnership unstableness and performance flexibility. While at the same time, I present different component innovation processes to emphasize the different mix of technology complexity and utilization skills present in an innovation project at any time. This tense socio-technical ensemble stimulates and enables the heterogeneous engineers to make experiments and learn about possible novel solutions and development directions.

When organizational innovation technology life cycle models and their attachments pursue order and predictability they tend to neglect and block out by design the managerial awareness and attention to endured uncertainty and unpredictability that are embedded factors in innovation processes. As a

result, technology innovation development activities are likely to take standardized forms similar to daily business routines. Innovation partnerships become based on thorough selections and long-term contracts, held together by joint patents, and partnering teams that increasingly hold similar development experience background. And, innovations that do not fit into existing frames of product and competition understandings are likely to stand out as useless, unproductive, and unprofitable alternatives. This orderly approach to innovation development is based on the assumption that the very order and predictability of activities can and will ensure successful innovation outcomes. Such managerial focus on innovation planning, process efficiency and overall organizational business model integration may duly pose opportunities in situations where partnerships need to evaluate a shared understanding of the development context for an innovation project — how and why the technology development innovation is useful — and the problems being addressed, also in relation to changes in the 'real' environment. More so, obstacles that can contribute to the building of experience and learning in drifting environments as well as possible future forms and functions of products and competitions must equally be evaluated.

Sometimes innovation projects approach the need for picking-up learning as a matter of getting onboard and attracting people who have recently up-skilled their technical knowledge. Sometimes they also incorporate best-practice standards from the field, and reflect on current industry and business topics that seem to be generally relevant in order to find out how to consider aspects of these topics as well. This leads to a focus on pre-project training activities that mold partnering teams to take similar approaches to solving the challenges they confront. While this approach upholds the assumptions about order and predictability as explained above, it also assumes that learning throughout the course of the project itself is a non-priority, which may even be considered as a waste of time.

The time-to-market pressure on innovation development reduces partnering possibilities for turning the focus around: proving the disutility of existing frames of product and competition and demonstrating a new innovation's usefulness and efficacy in terms of the assembling heterogeneity sur-

rounding it. Technology innovation partners are overwhelmed and discouraged by facing the broader socio-technical complexity that the innovation-making entails in such a short period of time without opportunities to reflect on innovation learning and implications. Having little time to exchange and discuss bits and pieces of information recognized as innovation-related, customers and users are left with blurring frames of reference to political, economic, social and environmental factors that in the now are important for their existential interests and that complicate their sense of direction towards becoming users with different interests in a different context. Time-to-market pressure may, however, be useful when innovation partnerships' collaborative motivations seem to be falling apart, such as when interests begin to drift while experiments or tests are ongoing. If such tests stop, they could have a wide and detrimental impact on an overall project's ability to advance. Similarly, time-to-market can be useful when time is related to how flexible a partnership is in relation to product development and iterative changes, that may or may not be problem-solving.

Arguably, bold partnership expectations and opinions may form momentum in the innovation process mobilizing the wider context, but this tends to result in unrealistic requirements to the innovation that is being developed. Innovation expectations and opinions based on matters of problem-solving that are not emerging from the work done by the technology innovation partnerships themselves tend to be undermining the capacity of the partnerships to solve the innovation development problems they find surfacing in various activities. In contrast, partnership expectations and opinions based on specific problem-solving experiments, testing and demonstrations may be considered collaborative devices within the developing socio-technical ensembles giving direction to the innovation process. Gells and Raven point to expectations of directional influences, both in terms of their importance to attract potential partnerships and also in relation to learning processes and technical development activities that are focused on innovation development (2006, p. 377). They argued that, "expectations about future technological performance cannot be checked independently, but only through actions that make them come true" (Geels & Raven, 2006, p. 375). So as partnerships work through expecta-

tions — those that are explicit as well as tacit — they continuously re-visited and adapted those expectations in an effort to realizing them. To avoid falling prey to conflated expectations, I suggest time should be spent on identifying concerns that a partnership has in common in relation to the technology innovation. Identifying where partners' interests overlap and letting that be the 'rule for work' is key.

Consequently this thesis states that the organizational innovation design is not restricted to work in long-term partnerships involved in making a new technological design, or maybe a related infrastructure, and demonstrating intriguing business cases that present potential for the success of all of these elements. Rather, the organizational innovation design involves confronting existing frames of reference that are close to the innovation-making and in the more distant environment which may result in technology innovation partnerships forming, breaking and reforming to keep the problem-solving work ongoing. That is the misunderstanding. Innovation is not about avoiding problems; it's about developing the skills to dwell within problems in a curious and responsible way. This involves looking close and far away in order to identify aspects that needs to be confronted, which then takes the innovation through an investigation of social, economic, environment and technological factors. Living in a question, and to be okay with not knowing the answer before it genuinely seems to emerge from experiments, demonstrations and contextual practices may exactly testify as to the strength of an innovation project. Implicit in this statement is the offering of the idea that uncertainty and unpredictability are potent resources that when embraced may be used to build flexibility into technology innovation projects and eventually into the meaning of innovations across time. It is when partnerships face uncertainty and unpredictability squarely in the eyes – in relation to the innovation project ambitions and in relation to the socio-technical ensemble – that innovation directions begin to transpire.

7.4 Research limitations

The end-user is an interesting agent in understanding the elements of unpredictability and uncertainty in technology innovation development. In a number of ways I have addressed user perspectives of the Think City car in relation to technology innovation development. Financial investors, politicians, technology suppliers and environmental groups have been some of the users of the Think City car, but the Think City electric car end-user, understood as a car driver with the interest of satisfying a more or less regular mobility need through the Think City car, has not been part of the focus of my research. As I introduced the notion of interactive learning I commented on how it may not be useful to consider the end-user early in the technology development project, but that is not to say that the Think City car driver-user perspective is irrelevant relative to Think technology innovation development entirely, and that uncertainty and unpredictability don't exist in this relation. Focused research on Think's participation in different pilot project studies could give relevant data in this regard and would perhaps place greater focus on the uncertainty and unpredictably embedded in the current urban infrastructure. However, I choose to keep the car driver indirectly present in the research through Think's employees, some of whom have been with Think for several years and became Think City car drivers in private too. So, it is fair to say that some of the most experienced and relevant car drivers were included.

The external technology innovation partners are in focus, though I did not contact relevant external partners in relation to any of the four analytical cases. Nevertheless, it would have contributed to the validity of this research if I had interviewed some of the external partners directly involved in the battery, drivetrain, headlight and financial engineering. On the one hand, the retrospective analysis approach to Think's partnerships restricted my access to technology innovation partners whose experience perspectives on collaboration with Think could have enriched the understanding of how and why partnerships formed, broke and in some cases reformed. Some partners had simply gone out of business. On the other hand, my approach to craft empirical data was based on personal face-to-face interviews, and I only conducted telephone interviews once I had already met the interviewee prior to the call.

Also, the geographic spread of Think partners made it too costly to include such interviews. Even if I had opted for another data collection approach, I judged it would have been further time-consuming and it would have added too much complexity to my research setting. Overall, this research does not exhaust or examine all relationships, though I have aimed to produce construct validity through other means, as discussed in the method chapter.

7.5 Future research strategy and options

This study kindled my interest in further research, which I point to in this section. I find one possible option for supporting the present work to be through comparative studies. The historical work I have made on Think is not contrasted to the process of socio-technical ensembles in relation to other technology innovation projects. For example, it leaves open whether Think has been portraying a 'new normal' with its serial bankruptcies. Perhaps we would find that bankruptcies have long been a part of the process in technology development projects, because the projects develop for a future, which needs sufficient proof to make sense of the technology as part of what is the 'now-normal'. Think demonstrates that we cannot preserve the past as we are aware of both changes in technology and political interests, but we cannot keep up with the vision of the future just yet as our social and economic paradigms struggle to find appropriate ways to change. There seems to be a lack of understanding in how to value the social impact of information created across the socio-technical ensemble that benefits the technology innovation, but Think indicates bankruptcies are a trial of robustness of the 'new normal' and perhaps the processes of bankruptcy help develop innovations that are more democratic and based on learning for the valued good because bankruptcy ignites meaningful conversations about the realization of the basic technology innovation idea, social needs and the heterogeneous complexities involved that result in a more consciously engaged socio-technical ensemble. Recent financial studies about motivating innovation (Ederer & Manso, 2011; Manso, 2011) could provide relevant insights for this topic. For example, Ederer and Manso refer to incentives for innovation as "debtor-friendly bankruptcy laws,

and golden parachutes [as] examples of schemes that protect the agent when failure occurs and thereby encourage exploration" (2011, p. 4). In light of the analysis I have undertaken with respect to Think, I believe these could be useful enquiry-elements that could lead us deeper into the processes and understandings of bankruptcies related to innovation projects.

Another question that remains intriguing concerns the role that dedicated technology innovation policies play in technology innovation partnerships related to alternative mobility. Throughout this research I focused on the alternative car, the Think City car, and the partnerships surrounding it. But across the different parts of my empirical material, related to the empirical context or the Think cases, situations revealed that public policy played a particular role in relation to technology innovation development and at times, policy also influenced partnerships. How may this role be understood? Is dedicated policy failure to blame for sidestepping the electric car in mobility competition, and in relation to Think, its technology innovation partnership responsibilities? Has its promises been hollow and has policy left technology development projects with too much of a dilemma between directions and possibilities? Has policy been designed for stable relations? If so, how could policy be designed to provide real space for technology innovation development, and in this case, for alternative mobility development? Perhaps we would find that dedicated policies do more harm than good in terms of stimulating innovation. A comparative study focusing on technology innovations that were intended to benefit from dedicated policies and how partnerships were forming and breaking around such policy agendas could reveal important insights. Studies in policy analysis and governance may here be relevant. Having the same empirical focus as the present research this could for example include work by Nilsson, Hillman, Rickne and Magnusson (2012; 2012), as they focus on the relationship between policy change and the development of technological innovations in low-carbon vehicles, including electric vehicles, with the interest of understanding how the governance of innovation can foster sustainability.

The third issue I find value in focusing on is collaborative technology innovation partnerships. The partnership focus seems to have been a potent

vehicle towards understanding technology innovation development in its larger eco-system context, but also raised questions as to what role proximity and global networks play in innovation. Understanding how localness and globalness affected the openness of partnerships, partnership responsibilities and resource complementarities could provide further insights to the assembling of innovations. I would suggest such research to take an even more fine-grained approach focusing the analysis on, for example, collaboration with financial investors; this could include a focus on angel investors who are often considered to be both a kind a of local and global partner for innovation projects, also considered in early stage development (Harrison, Mason & Robson, 2010). While current studies may be relevant, I could only locate a very small quantity and quality of literature on angel investors and angel investments[56]. A recent study conducted by the OECD (2011), focusing on insights from different economies, may be of inspiration to a research agenda on this topic.

[56] Searching the Business Source Complete database for scholarly reviewed journal articles 146 results for 'angel investor' and only 64 results for 'angel investment' were found.

Appendices

Appendix 1: Interviews/Speeches/Observation Notes

The overview of Interviews, Speeches and Observation Notes documents all formal direct interaction that I have had with various Think and Think-related individuals in relation to this research project. From the initial meeting where I requested permission to interview and visit Think to the latest follow-up calls. Some email correspondence has also taken place, but this has mostly been for planning purpose and these have not been listed.

Interviews/Speeches/Observation Notes						
Date-Time	Dura-tion	Role	Type	Topic	Collected	Tran-scribed
080930_1300	3:00:00	Founder Ringdal	Conversation Interview	Think history	FieldTrip1	KSI
081001_1100		Think CEO Willums	My notes from conver-sation	Reflectionary account	FieldTrip1	KSI
090821_1200		Think CEO Canny	Meeting	My research at Think	Field-Visit_Oslo	KSI
090917_1600	1:30:00	MoveAbout DK	Conversation Interview	Your story with Think	Field-Visit_CPH	KSI
091213_0147_	0:04:15	Vorarlberg PM	Speech	Press Conference MoveAbout	Field-Work_COP15	O2I
091213_0152_	0:03:22	MoveAbout CEO	Speech	Press Conference MoveAbout	Field-Work_COP15	O2I
091214_0502_	0:07:04	Think various	Meeting conversation	EV20 Round-table Meeting	Field-Work_COP15	O2I
100118_1218	0:22:17	Think CEO Canny	Conversation Interview	Think through 2008 to Jan 2010	FieldTrip1	O2I
100118_1702	0:45:36	MoveAbout CEO	Conversation Interview	Relation to Think and MoveAbout	FieldTrip1	MBJ
100119_1006	0:36:32	Think CTO Mollestad	Conversation Interview	Your story with Think	FieldTrip1	MBJ
100119_1045	0:31:41	Think Head of Design von der Lippe	Conversation Interview	Your story with Think	FieldTrip1	KSI

Interviews/Speeches/Observation Notes (Cont.)						
Date-Time	Dura-tion	Role	Type	Topic	Collected	Tran-scribed
100119_1211	0:46:17	Think PL Feltheim	Conversation Interview	Your story with Think	FieldTrip1	PH
100119_1307	0:06:43	Think PL Feltheim	Conversation Interview	Your story with Think	FieldTrip1	PH
100119_1523	1:37:31	Founder Ringdal	Conversation Interview	Think History	FieldTrip1	PH
100120_1022	0:23:04	Think SM Brown	Conversation Interview	Your story with Think	FieldTrip1	KSI
100120_1322	0:27:51	Think Marketing Mgr Brentes-braaten	Conversation Interview	Your story with Think	FieldTrip1	PH
100120_1445	0:35:14	Think CEO Canny	Speech	Think_All Team Meeting_Jan	FieldTrip1	O2I
100120_1521	0:11:42	Think Head of Purchasing	Speech	Think_All Team Meeting_Jan	FieldTrip1	O2I
100120_1550	0:21:35	Think Marketing Mgr Brentes-braaten	Speech	Think_All Team Meeting_Jan	FieldTrip1	O2I
100120_1611	0:18:11	Think CFO Nerland	Speech	Think_All Team Meeting_Jan	FieldTrip1	O2I
100120_1630	0:14:12	Think Head of HR Jansen	Speech	Think_All Team Meeting_Jan	FieldTrip1	O2I
100120_1645	0:34:04	Think various	Q&A session	Think_All Team Meeting_Jan	FieldTrip1	O2I
100121_0955	0:06:00	Think CFO Nerland	My notes from conver-sation	View on Think	FieldTrip1	KSI
100121_1101	0:03:40	Think Exter-nal Project Mgr 2	My notes from conver-sation	View on Think	FieldTrip1	KSI
100121_1551	0:04:21	Think Head of HR Jansen	My notes from conver-sation	Reflectionary account	FieldTrip1	KSI
100303_0906	0:14:50	Think Head of Sales Waitz	Conversation Interview	Your story with Think	FieldTrip2	PH
100303_1004	0:51:56	Think Head of PDD Neal	Conversation Interview	Work with external part-ners	FieldTrip2	KSI
100304_0846	0:38:24	Think SM Brown	Conversation Interview	Work with external part-ners	FieldTrip2	KSI
100304_1010	1:01:24	Think Exter-nal Project Mgr 1	Conversation Interview	View on Think	FieldTrip2	O2I

Interviews/Speeches/Observation Notes (Cont.)						
Date-Time	Dura-tion	Role	Type	Topic	Collected	Tran-scribed
100304_1403	0:33:52	Think various	Speech and Q&A	Think_All Team Meeting_Mar	FieldTrip2	O2I
100727_1614	0:37:07	Migros PM Schröder	Conversation Interview	Migros project with Think	Field-Visit_Zürich	SS
101126_0300	0:49:28	Think CTO Mollestad	Conversation Interview	Battery and Drivetrain	Telephone Interview	O2I
101126_0300	0:06:07	Think CTO Mollestad	Conversation Interview	Battery and Drivetrain	Telephone Interview	O2I
101201_1100	0:33:45	Think PM Headlamps	Conversation Interview	Headlamps	Telephone Interview	O2I
100531_2021	0:44:17	Ex-Think Head of PDD Neal	Conversation Interview	Think in touble	Telephone Interview	O2I
110706_1605	0:55:39	Ex-Think CEO Canny	Conversation Interview	Think through 2010 to 2011	Telephone Interview	O2I

Appendix 2: Think Material Bank

This is an aggregated overview of the material that I refer to in this thesis, which I have collected from desk research in the public domain (predominantly through the Internet) or which I have received during field research visits.

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Appendix 3: Research presentation given to Think

This presentation was prepared for the first field trip visit to Think in 2010. A similar presentation was prepared for the second field trip as well.

1

Wish list *(after all its Christmas!)*

- Workstation at a place that allows me observe and sense what goes on when people move around,
- A space where I may ask people to join me for a conversational interview
- Conversational interview with key managers
- Attend meetings/talks between key managers: planning, discussion or decision meetings.
- Access to Think Intranet:
  - company official presentations in relation to various events
  - conceptual papers
  - business cases
  - roadmaps
  - service contracts with partners
- …

Limitations of 1st field research trip

- As this is my first full visit at Think there will be some people I speak to for the first time, which may impact the efficiency of the conversations
- …

Approach to field research (1/3)

- This project is set up to conduct qualitative field research. That means formal as well as informal interaction with the people at Think is of decisive importance.
- The aim is to gather the data under the most natural, every-day familiar and more or less relaxed conditions as this mirror the reality of those at Think being interviewed or observed.
- 'Data' is many 'things'. It may be what is seen, heard, read or otherwise observed. As my familiarity with Think increases so is my focus on data likely to become more specific.

Approach to field research (2/3)

- Analysis of what may be the appropriate complementary resources to investigate and which not
- Analysis of Think archive data related, relevant and accessible regarding the selected complementary resources
- Interview with key mgmt to identify principles/drivers behind the selected complementary resources in relation to past events
- Observation in meetings concerning the selected complementary resources and upcoming events

Approach to field research (3/3)

- Archival data will be listed and in my possession kept secure through doc. lock system
- Interviews will be tape recorded or video taped depending on interviewees permission
- Meetings will be tape recorded or video taped depending on meeting organizers permissions
- Observational notes will be hand written.
  Photo documentation or video recording according to CEO permission

Schedule Week 3: January 18-22

	18.01 Monday	19.01 Tuesday	20.01 Wednesday	21.01 Thursday	22.01 Friday
8:00					** Erik Skaarnaes
9:00	Workstation set-up			9-10:00 Helge Nerland	
10:00	Talk with Jan Jansen	Meeting room with projector 10-10:45 Egil (CTO) 10:45-12:00 Katinka 12-13:00 Ole	Meeting Room 10-10:45 D. Brown 10:45-12 Arne Degemose	10-11:00 Talk with Magnus Blomstrand 11-11:30 Pictures	** Chris Neal
11:00					
12:00	Talk with R.Canny				
13:00					Talk with R.Canny
14:00		TRANSFER	14:30-17:00 All Team Meeting		Talk with Jan Jansen
15:00		Talk with J O Ringdal			
16:00	TRANSFER				Workstation clean-up
17:00	Talk with M. Eimstad		Private Appointment		
18:00					
Evening					

Open points to 1st field trip

Ensure commitment by key managers at Think	ok	11.01.10 JJ
Book meeting room at Think and 4-6 interviews	ok	11.01.10 JJ
Organise entry card and workstation	ok	08.01.10 JJ
Prepare detailed interview guide	in work	13.01.10 KSI
Convert Think-wall overview into Visio	ok	10.01.10 KSI
Book hotel /and flight	ok	06.01.10 KSI
Book recording equipment	ok	04.01.10 KSI
Book meetings with MoveAbout, JO Ringdal	ok	12.01.10 KSI
Book meetings with Innovasjon Norge, Research council Norge -> take up point with Think	n.a.	13.01.10 KSI
Update briefing presentation by 14.01.2010	ok.	13.01.10 KSI

Conditions for making THINK happen

- ***Connecting*** is about aligning the actors around the sustainable innovation journey and knowing why one actor's involvement in 'the making' in one particular situation is better than that of another.
- ***Uncertainty*** and ***contingencies*** are aspects of organization, holding both chance and risk, and which are likely to change during the course of a project and affect the way we think, decide and connect.
- ***Convergence/Divergence*** are terms popularly associated with the bundling and un-bundling of technologies as one relatively dominant technology trajectory is observed

TH!NK,

- the Norwegian electrical car manufacturer
- the case company in this research

In a society in constant motion, the history of TH!NK points to that they have managed to connect into very complicated networks and this way created **climate strategies for business *through* partnerships**.

The research basics…

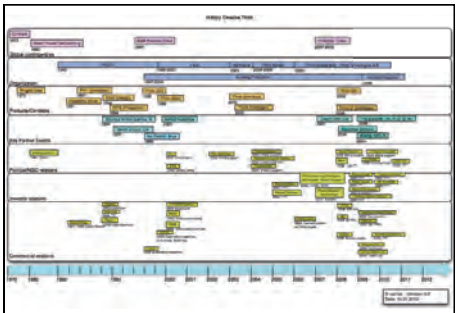
Period: Sept. 2009 – Aug. 2011

Literature: Innovation and organization literature applying a process perspective

Method: Qualitative research (Archives, Interviews, Observations, Photos and Video)

Contact: Karin Strzeletz Ivertsen / ksi.ioa@cbs.dk

Before joining CBS, KSI worked several years within the telecommunication and the hearing instrument industry. Her academic background is in strategy, organization and management studies based on an MBA, BA (Hons) and as Academy Economist.



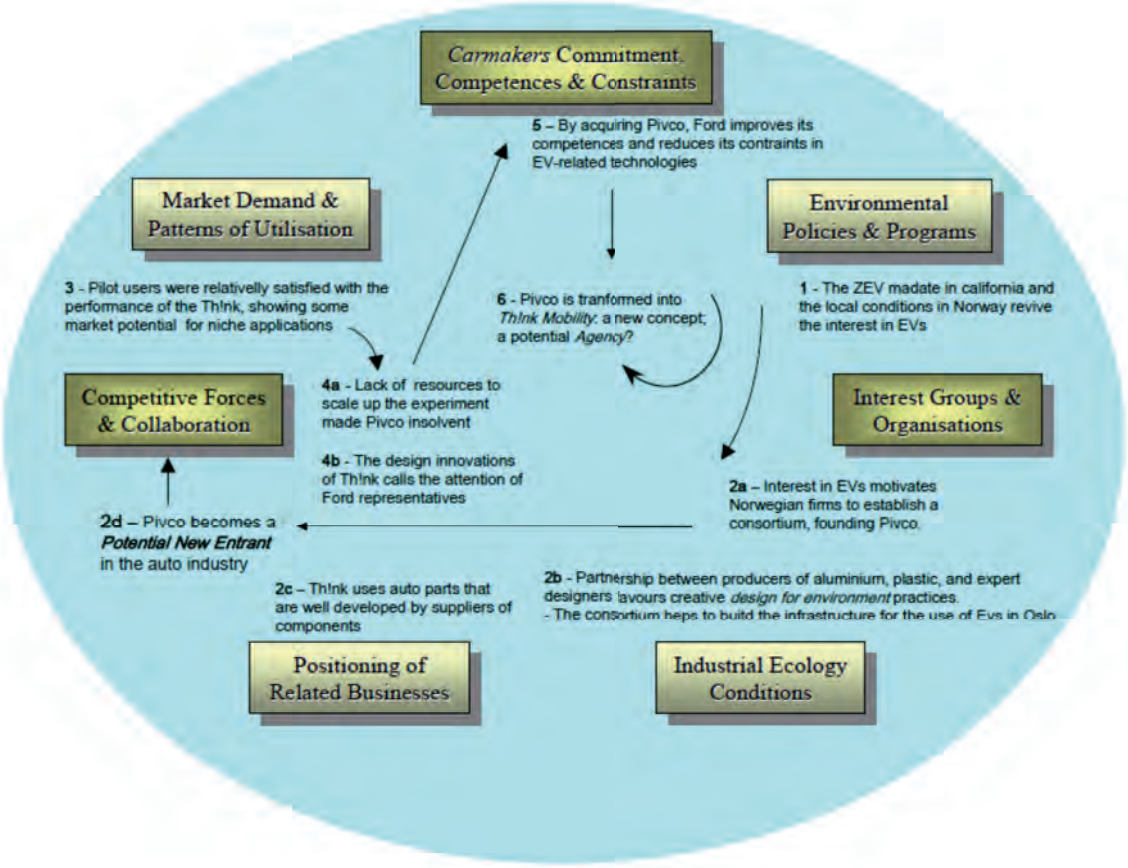
Conditions for making THINK connect

4

Appendix 4: Orsato figure of the evolution of the PIVCO-Th!nk Venture

This figure originates from the Orsato (2001). The Ecological Modernization of Industry: Developing Multi-disciplinary Research on Organization & Environment, a PhD thesis from University of Technology, Sydney, page 259, and is used to illustrate how I approach an understanding of socio-technical ensembles in more detail.

Figure 10.2: The Evolution of the *Pivco-Th!nk* Venture



Appendix 5: Overview macro trends battery choices for EVs.

This table presents a rough overview of macro-trends on battery choices by electric vehicle manufacturers. It illustrates that several battery types are considered for the development and production of electric cars, reflecting little standardization in the market. Optimistic and bold expectations characterize identified forecasts, in part based on an expanding electric vehicle battery market, which is said to grow from a value of $3.6 billion in 2008 to $10.3 billion in 2012 (Yahoo-Finance, 2013).

Type of Battery	Battery characteristic		Efficiency in charging	Energy density	Sales volume	Market share Evs	Automotive manufacturer	Battery manufacturer
	Advantages	*Limitations*						
Lead acid	Inexpensive and simple to manufacture, Low self-discharge, High specific power, Good low and high temperature performance	Low specific energy, Slow charge, Must be stored in charged condition to prevent sulfation, Limited cycle life, Flooded version requires watering, Transportation restrictions on the flooded type, Not environmentally friendly	70-75%	30-40 WH/kg	$38 billion (estimate total global market 2013)	While an $18 billion market share is estimated for 2010, of which 58% is within the transportation sector, conventional lead-acid batteries is not considered dynamic enough for emerging applications and complementary technologies used in EVs (ref.greencarcongress.com)	GM, Kewet City-Jet and Buddy models, Think	Oriental and Motolite Marketing Corp, Shenzhen Center Power Tech. CO., LTD, Guangdong Aokly Power Co., Ltd, U. S. Battery Manufacturing Co., Trogen India, Shenzhen Guixiang Battery Technology Co.,Ltd., Concode Battery, Bharat Accumulators P. Ltd., East Penn Manufacturing Company, Inc., Fuan City Gexin Storage Battery Co., Ltd, Discover Energy Corp.
Nickel metal hybride	Fast and simple charging, High number of charging cycles, Good load performance, Long shelf life, Simple storage and transportation, Good low-temperature performance Economically priced, Available in a wide range of sizes and performance options	Relatively low specific energy Environmentally unfriendly, Needs recharging after storage	60-70%	30-80 Wh/kg	$725 milliom (total global market 2009)	No global data found. Most specific example found is Toyotas Prius which has sold a total of 3 million cars by June 2013, and holds 68.8% of the hybrid market share (ref. Wikipedia and edmunds.com)	GM, Honda, Ford, Suzuki Swift, Toyota, Think	Sanyo, Union Suppo Battery (Liaoning) Co., Ltd.
Zebra (Sodium-sulfur)	Fast-charging, Non-toxic, Low cost, Operating in extreme temperatures, Conditions of continuous use	Must be heated,	n.a.	120 Wh/kg	n.a.	n.a.	Think, Smart	MES DEA S.A./FZ Sonick
Lithium-ion (differentiate between Li-cobalt, Li-manganese, Li-phosphate, and Nickel-Manganese-Cobalt)	High energy density, Relatively low self-discharge, Low maintenance	Requires protection circuit to limit voltage and current, Subject to aging, even if not in use, Transportation regulations when shipping in larger quantities	80-90%	200 WH/kg	$9.6 billion (estimated total global automotive lithium battery market by 2015 - ref. prweb.com); $4 billion (estimated total EV share 2015)	0,4 Million EV in 2015; 1.4 Million EV in 2020 (ref avicenne.com)	Tesla, Killacycle, General Motors, Fisker Automotive, Daimler Buses North America, Smith Electric Vehicles electric trucks, Navistar electric trucks, ALTe Powertrain Technologies extended-range EV powertrains, VIA Motors, Shanghai Automotive Industry Corp.'s Roewe brand, BMW, Mercedes-Benz High Performance Engines, Buckeye Bullet land-speed racer, Phoenix Motorcars, Lightning Car Company, Proterra, Rolls-Royce Motor Cars, Modec, Allied Vehicles, RUF Automobile, Jaguar Cars, Land Rover, Electric Car Corporation,Beijing Automotive Group, Saab Automobile, BMW Mini-E, Tata, Chrysler, Daimler AG, Ford, XL Hybrid, Think	3M Automotive, Electric City Motors, Panasonic, Boston Power, E-One Moli Energy, Electrovavy, EnerDel, Johnson controls, Li-Tec Battery Gmbh, LG Chem, SB LiMotive, GS Yuasa, SAFT, AAP Global Limited, Ev Fern Ltd., ElectronVault, Inc., WISDOM Industrial, Enterprise Ltd., Tianjin Lishen Battery Joint-Stock Co., Ltd., EEMB Battery Co, Ltd., Envia Systems, Inc., b. p. electronic ApS, A123, Axeon, Valence Technology, Altairnano

Abstract (English)

This thesis is about a Norwegian car-development company's experience — Think's experience – of long-lasting periods of product ferment and how it endured these periods of ferment without failing. The thesis is also about the surprising dynamics of technology innovation partnerships in relation to complementary assets, competencies and electric car developments at Think. My empirical observations show a dynamic process that is characterized by changing and redefined partnerships throughout an innovation journey; indeed Think has been able to maintain its existence, not through stability, but through continuous transformations in partner-networks.

Based on a close empirical study of selected car development projects at Think, the thesis presents four complementary stories about battery, drivetrain, headlamp and financial engineering. Each offers insights into the way partnerships are involved in and impact the innovation process. Built upon an analysis of these cases, the thesis argues that if partnership processes become understood as being premised on uncertainty and drifting relations, then partnership drift can be a productive learning element in technology innovation processes. The case in this thesis is unusual in the sense that it highlights an anomaly. My empirical data and analysis show how changing and redefining partnerships, complementary assets and competencies are assets in keeping innovation projects moving towards possible success.

I draw upon and discuss three approaches in order to illuminate and contribute to the theoretical understanding of partnerships and their drift in technology development. First, I present the technological life cycle approach — a macro-organizational-level perspective. The underlying assertion of this theoretical tradition is that a company must seek to 'master' the cyclical product and process development that characterize the ripeness and mass of a product management organization, which in turn prompts the company in choosing its winning technology development trajectory. The technological life cycle approach has begun to suggest that a partnership selection process is taking place at the micro-organizational-level of an innovation process. How-

ever, the literature does not further expound on the micro-organizational-level processes. Second, I present the open innovation approach that, in contrast, focuses explicitly on the micro-level analysis of an innovation process. The important contribution of the perspective's studies is that they point out the centrality of partnerships and access to external competencies in innovation processes. However, open innovation studies say little of how partnerships unfold in a context of endured uncertainty. The premise of this theoretical strand is that to survive in a time where the workforce is mobile and globally available, where skills, ideas and early stage technologies are commercially for sale, companies must seek to buy or license processes or innovations from other companies. Third, I include the drift perspective on innovation processes. This approach considers innovation and uncertainty as inseparable and emphasizes the importance of embracing uncertainty in the innovation process and how this can be considered useful to the innovation process itself. Thereby, the drift perspective allows for an exploration and analyses on an intermediary-level, or sociotechnical-level — the level between industry and the company-specific — oriented towards interests and sensemaking.

In the thesis I take a process research approach, linking the notions of environmental drift, emergent learning and sensemaking through the ethnographic approach of Social Construction of Technology (SCOT) to form an understanding of the logics of open innovation: that endured uncertainty and unpredictability host future development possibilities and opportunities. Starting from a constructivist view, I move towards an increased analytical focus on partnerships forming, breaking and reforming, and collaborative socio-technical ensembles in emergent processes. The process research approach enabled me to make three important observations. First, I could highlight and identify the critical events and turning points in the innovation project studied through which the notions of overall direction, relevant actors and frame of reference for process connections could be conveyed. Second, the research process directed the lens of interpretation towards concrete cues, social factors, actions and talks, as well as other forms of communication across existing relations. Thirdly, I could ascertain a potential extension of current understandings of open innovation that emphasizes socio-technical

ensembles as mediating contextual factors, which also accentuates an awareness of and sensitivity to uncertainty and unpredictability. Integrating the three theoretical approaches with my research approach has given way to a uniquely developed a framework that enabled me to undertake the following research question: "How does the formation of partnerships interact with innovation processes under endured uncertainty?

The thesis provides a structured basis for the further conceptualization of how partnerships interact in and with innovation processes. Put more succinctly, I have contributed with a drift perspective to the life cycle literature and open innovation concept, which makes it possible to understand dynamic partnerships, in a new way. I have achieved this through the presentation, deconstruction and examination of three dimensions: forming, breaking and reforming partnership processes. This is of course a simplification, yet a clarification of aspects relevant to partnership drift, which cannot be assigned unambiguously to either economic, social, technical or environment changes that influence collaboration and thus the innovation process. The whole has pointed out that partnership formation is a central mechanism for technology innovation development, serving as a mechanism for reorientation — and perhaps especially in relation to coping with endured periods of uncertainty.

Engaging with the complexity of innovation processes and partnerships through a drift perspective revealed important insights about the role of relative stability and changeability of partnerships and this has a direct impact on how we continue the debate about interests, expectations, uncertainty and processes of innovation. It is important that managers of innovation projects learn to consider and continually take in what happens in the innovation process as learning occasions rather than threats. As the drift perspective emphasizes, 'something' during the innovation process cannot be controlled or planned out of scope by good preparation and solid steering — obsessively trying to do so reflects the fear of uncertainty. Uncertainty cannot be avoided in the innovation process, nor can it be clearly predicted, but it hosts learning potential. Still, this principal idea should not be understood as discarding all efforts of visualizing, conceptualizing, or planning an innovation project, how-

ever, it calls for careful preparations through projected conditions planned, and a road map.

This thesis aimed at examining how different perspectives affect partnerships, complementary assets, and competencies by use of the drift perspective. Overall, my research activity has distended current theoretical understandings and has filled some important research gaps as the partnership drift perspective enabled the exploration of and analyses on an intermediary-level, or sociotechnical-level, which oriented attention towards partnership interests and sensemaking. The analysis demonstrated that any experience can be considered a failure if partners and the socio-technical ensemble are good enough at making it seem that way. And, any experience may equally come to be regarded as contributing to technology innovation development if partners and the socio-technical ensemble collaborate in making it exactly that.

Resume (Danish)

Denne afhandling drejer sig om organisationer, hvis produkter har langvarige og turbulente tilblivelsesperioder. Den drejer sig også om, hvordan organisationer udholder disse tilblivelsesperioder uden at det fører til fiasko. Og endelig drejer den sig om de overraskende dynamikker, der er i partnerskaber inden for teknologisk innovation, og om partnerskabernes rolle i forhold til teknologisk innovations komplementære aktiver og kompetencer. Afhandlingens fokus er på udviklingen af elektriske biler. Det empiriske materiale er udviklet på baggrund af studier i det norske biludviklingsfirma Think, der blev grundlagt i Norge i 1991, og som i dag er kendt for deres elektriske bil med navnet Think City. Mine observationer fremhæver en dynamisk proces, der er karakteriseret ved partnerskaber, som forandres og omdefineres, og som afspejler, at Think har været i stand til at opretholde sin eksistens ved gentagne gange at omdanne sig inden for partnernetværker og ikke gennem stabilitet.

Med baggrund i empiriske mikro-studier af udvalgte biludviklingsprojekter i Think bygger afhandlingen sin argumentation på udviklingen af fire komplementære komponenter, der udgør en del af ressourcerne i den elektriske bil: batteri, fremdriftskomponent, forlygte og finansieringsteknik. Hver ressource fremhæver aspekter af, hvordan partnerskaber er involveret i og bidrager til innovationsprocessen. Afledt af disse analyser argumenterer jeg for, at skift i partnerskaber kan være et produktivt læringselement i en teknologisk innovationsproces. Specielt når præmisserne for at etablere partnerskaber er usikkerhed og skiftende relationer. Casen i denne afhandling er usædvanlig, fordi den belyser en anomali. De empiriske data og analyser viser nemlig, hvordan skiftende og omdefinerende partnerskaber, komplementære aktiver og kompetencer er værdifulde, for bestræbelsen på at bevæge innovationsprojektet mod en mulig succes. Således har Think været i stand til at bevare sin eksistens gennem såvel vedvarende forandringer i partnernetværker som ved at redefinere sig selv og selve produktidéen.

Jeg trækker på og diskuterer tre teoretiske tilgange til partnerskaber for dermed at fremme og bidrage til en teoretisk forståelse af partnerskaber

og deres skift undervejs i teknologiske udvikling. Først inddrager jeg forståelsen af "den teknologiske livscyklus"(dominant design) – et analytisk perspektiv på makro-niveau. De grundlæggende antagelser ud fra dette perspektiv er, at virksomheder skal tilstræbe at styre produkt- og procesudvikling, to aspekter, som kendetegner en nuanceret produktorganisation, idet et sådant fokus vil hjælpe virksomheden til at vælge en succesfuld vej for teknologisk udvikling. Den teknologiske livscyklus' litteratur er begyndt at antyde, at der i den innovative proces finder en udvælgelse af partnerskaber sted på et mikro-organisatorisk niveau. Men partnerskaberne studeres ikke i detaljen, og innovationsprocessen relateres ikke til en specifik teknologi. Dernæst præsenterer jeg forståelsen af "den åbne innovation" (open innovation), som eksplicit fokuserer sin analyse på et mikro-organisatorisk niveau, i modsætning til den teknologiske livscyklus. Det vigtige bidrag fra disse studier er, at her ses partnerskaber og adgangen til eksterne kompetencer i innovationsprocessen som central. Men studier i den åbne innovation siger kun lidt om, hvordan partnerskaberne udfolder sig i en sammenhæng, hvor organisationen må udholde usikkerhed over en længere periode. Den grundlæggende præmis i dette perspektiv er, at en virksomhed må tilstræbe at få licens til eller købe processer og innovationer fra andre virksomheder for at overleve i en tid, hvor arbejdsstyrken er mobil og globalt tilgængelig, og hvor færdigheder, idéer og teknologiske koncepter er til slag. For det tredje inddrager jeg forståelsen af "drivperspektivet i innovative processer"(environment drift). Denne tilgang påpeger, at det uforudsigelige nødvendigvis forekommer i en innovationsproces, og den viser, at det uforudsigelige netop er brugbart i selve innovationsprocessen. Denne tilgang åbner dermed for at udforske og analysere innovationsprocessen på et socio-teknisk niveau – dvs. niveauet mellem industrien og virksomheden – der handler om interesser og meningsskabelse.

Min tilgang er "procesforskning". Jeg præsenterer et holistisk, socioteknisk synspunkt på teknologi-innovation, særligt på Thinks partnerskaber. Jeg sammenkæder begreberne om miljøskift' (environmental drift) og 'bevidst læring' (emergent learning) og meningsskabelse (sensemaking) gennem Social Construction of Technologys (SCOT) etnografiske tilgang. Min tilgang giver en forståelse for begrebet 'åben innovation': det forhold at en organisation,

der udholder usikkerhed og uforudsigelighed, har mulighed for at forstå og erkende, at fremtidige udviklingsmuligheder og -chancer netop forefindes under disse betingelser. I min undersøgelse af processen tager jeg afsæt i et konstruktivistisk synspunkt, og bevæger mig derfra hen mod et overvejende analytisk fokus på, hvordan partnerskaber bliver dannet, opløst og genskabt. Det gælder også, når jeg undersøger de samarbejdende socio-tekniske helheder i de processer, der opstår. Tilgangen "procesforskning" giver mig anledning til at foretage tre væsentlige observationer: 1) at identifikationen af kritiske begivenheder og vendepunkter i det innovative projekt bliver belyst, 2) at fortolkningen af processerne afhænger af tidskoder (cues), sociale faktorer, handling og samtale samt kommunikationen mellem partnerne, 3) at vores forståelse af 'åben innovation' udvides ved at opfatte de socio-tekniske helheder som det, der formidler sammenhængende faktorer, og ved at fremhæve følsomheden over for usikkerhed og uforudsigelighed. På baggrund af denne tilgang kan jeg besvare spørgsmålet: Hvordan interagerer dannelsen af partnerskaber med innovationsprocesser, der finder sted under udholdt usikkerhed?

Mit perspektiv er, at de forbindelser, som skabes, brydes eller genskabes mellem partnerne, er sammensat af heterogene dimensioner. Det har på samme tid med materialer, økonomi, interesser og meningsskabelse at gøre. Jeg undersøger, hvordan uforudsigelige forandringer i disse dimensioner kan føre til nedbrud eller kan genskabe partnerrelationer. Jeg nedbryder således dynamikken i den socio-materielle helhed, som udgør Thinks eksistens på et givet tidspunkt.

Kapitel 2 giver en empirisk ramme for min forskning. Her præsenterer jeg observationer fra automobilindustrien, især med fokus på udviklingen af elektriske biler.

Kapitel 3 sammenligner de tre teoretiske perspektiver på udviklingen inden for teknologisk innovation med særligt henblik på forståelsen af partnerskaber inden for teknologiske innovation. Jeg argumenterer for, at den relationelle usikkerhed og uforudsigelighed, som Think har oplevet, enten bliver parentetisk eller overset.

Kapitel 4 fremlægger den metodiske tilgang. Case study-aktiviteterne og dataindsamlingen præsenteres, og valget af SCOT forklares. Desuden redegør jeg for, hvordan jeg bevæger mig fra et konstruktivistisk synspunkt til et analytisk fokus på dannelsen af partnerskaber i bevidstgørende (emergent) processer.

Kapitel 5 præsenterer fire analyser i relation til Thinks innovationsrejse. Det drejer sig om fire komponenter: batteri, fremdriftskomponent, forlygte og finansieringsteknik.

Kapitel 6 præsenterer den viden, vi har fået omkring innovationsprocesser gennem analysen af dominerende design, åben innovation og perspektivet på skift i partnerskaber anvendt på hver af de fire samarbejdende partnerskabshelheder i relation til den elektriske bil.

Kapitel 7 konkluderer specifikt på indsigterne fra studiet af Think og udlægger det teoretiske bidrag, som fører til at diskutere, hvad vi kan lære af praktisk relevans. Desuden diskuterer kapitlet undersøgelsens begrænsninger og fremlægger et perspektiv på videre forskning.

Afhandlingen bidrager med et struktureret fundament for yderligere konceptualisering af, hvordan partnerskaber interagerer i og med innovationsprocesser. Sagt mere kortfattet har jeg bidraget med et driv-perspektiv på partnerskaber, som gør det muligt at forstå dynamiske partnerskaber på en ny måde. Det har jeg gjort gennem præsentation og demonstration af tre dimensioner: danne, bryde og genskabe partnerskabsprocesser. Dette er naturligvis en forenkling, men stadig en afklaring af de aspekter, som er relevante for skift i partnerskaber, og som ikke utvetydigt kan tilskrives økonomiske, sociale, tekniske eller miljømæssig forandringer, som også har indflydelse på samarbejdet og dermed den innovative proces. Dannelsen af partnerskaber er en central mekanisme i udviklingen af teknologi-innovation, en mekanisme som reorienterer – måske især i relation til at håndtere det at udholde perioder med usikkerhed.

Ved hjælp af drift-perspektivet afslørede studier i kompleksiteten i innovationsprocessen og partnerskaberne nogle vigtige indsigter omkring den rolle, som partnerskabets relative stabilitet og foranderlighed spiller. Det har direkte indvirkning på, hvordan vi fortsætter debatten om interesser, forvent-

ninger, usikkerhed og innovationsprocesser. Ledere af innovationsprojekter skal i højere grad lære at betragte og kontinuerligt opfatte det, der sker i innovationsprocessen, som en mulighed for læring end som en trussel. Drift-perspektivet belyser, at 'noget' under innovationsprocessen ikke kan kontrolleres, forudsiges eller undgås gennem grundig forberedelse og solide styringsværktøjer. Opfattelsen af, at alt kan kontrolleres og forudsige, afspejler frygten for usikkerhed. Men usikkerhed kan ikke undgås i innovationsprocessen. Og usikkerheden har et iboende læringspotentiale. Denne hovedidé skal ikke forstås sådan, at alle bestræbelser på at visualisere, konceptualisere eller planlægge et innovationsprojekt skal opgives, men den opfordrer til at planlægge omhyggeligt omkring de skønnede betingelser og et processuelt vejkort.

Denne afhandling sigtede mod at undersøge, hvordan usikkerhed og forandringer påvirker partnerskaber, komplementære aktiver og kompetencer ved hjælp af drift-perspektivet. Resultatet er, at drift-perspektivet også udfylder et andet hul i forskningen. Drift-perspektivet åbner for udforskning og analyse af et mellemniveau – det socio-tekniske niveau, niveauet mellem industri og virksomhed – som er orienteret mod interesser og meningsskabelse (sensemaking). Analysen demonstrerede på den ene side, at enhver erfaring kan blive betragtet som en fiasko, hvis partnerne og den socio-tekniske helhed er gode til at få det til at se sådan ud. På den anden side demonstrerede analysen også, at enhver erfaring bidrager konstruktivt til udviklingen af teknologisk innovation, hvis partnerne og den socio-tekniske helhed samarbejder om at få erfaringen til at være et værdifuldt led i udviklingen

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