Strategic Actions in Ericssons Management of 'Bluetooth'

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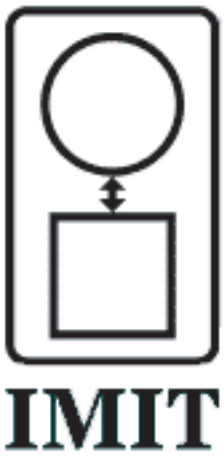
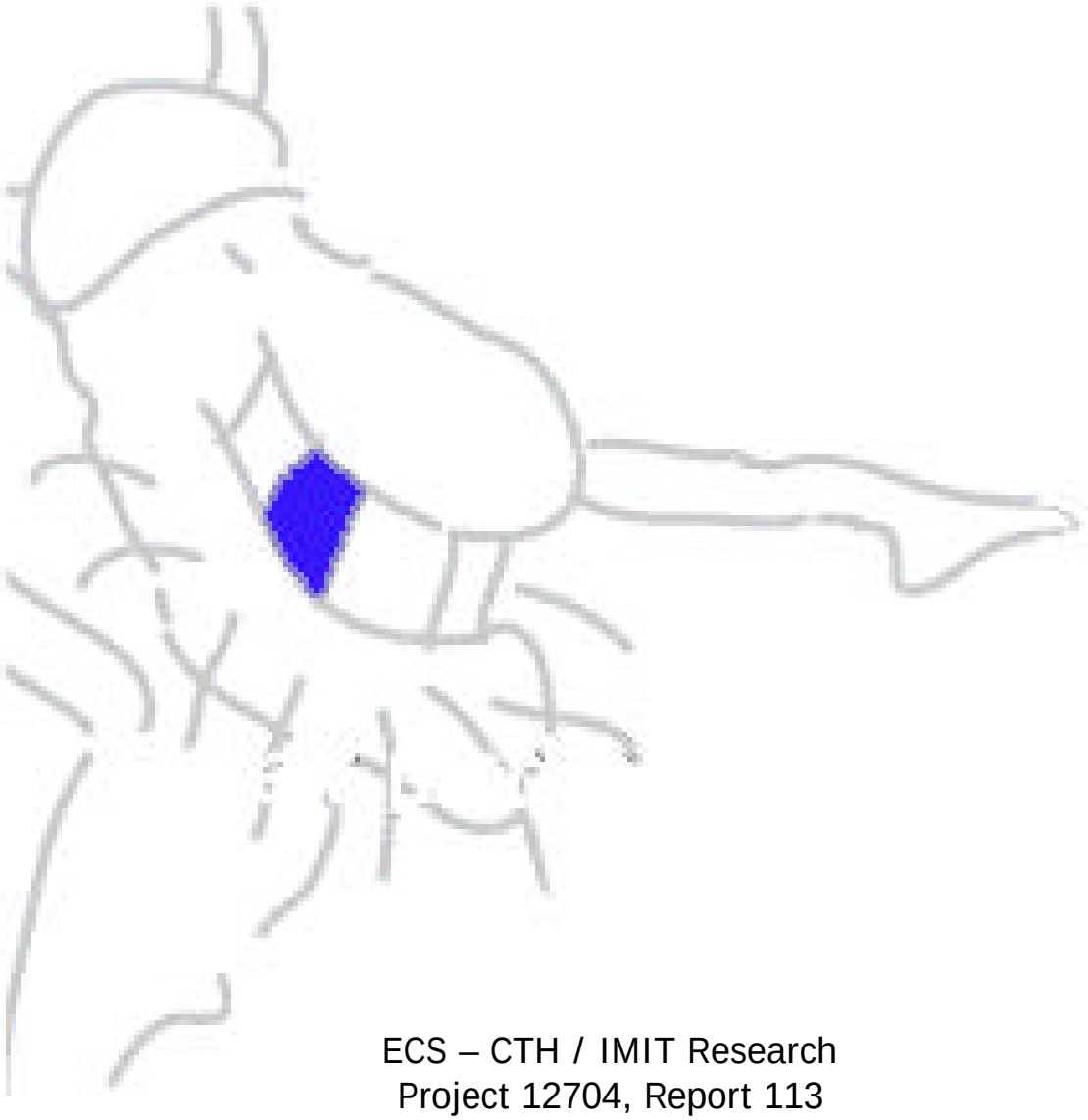


Institute for Management of Innovation and Technology

An Ambidextrous Organization in Practice

- Strategic Actions in Ericsson's Management of 'Bluetooth'



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ERICSSON

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This is a Chalmers / IMIT research report written in cooperation with Ericsson Mobile Communications. The report is part of an on-going research project titled 'Technology and Business Integration'. Here follows some reading guidelines:

Bluetooth Case Study Interest

Section 4.4 *'Bluetooth Evolution – From Idea to Global Presence'* and
Section 5 *'Strategic Actions'*

(8 pages in total)

Bluetooth Case Study Interest + Some Analysis

Add to above Section 6 *'Case Reflections'* and Section 7 '*Bluetooth Summary'*

(+4 pages)

Bluetooth Case Study Interest + Some Analysis + Future Outlook

Add Section 8 *'Discussion and Outlook'*

(+2 pages)

The Whole Story!

Add the theoretical parts and the methodology

(Total 21 pages)

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The successful and rapid evolution of the revolutionary 'Bluetooth' technology has not gone unnoticed. As of March 2000, over 1600 companies have joined what is now, one of the fastest growing industrial organizations ever to promote a new technology. The core of this special interest organization unites nine of the leading firms in the computer and communications industry, with Ericsson Mobile Communications serving as the initial catalyst. The developed Bluetooth specification has been accepted as the (de facto) standard for wireless personal area networks.

In order to deal with this technology, Ericsson created a dedicated, Skunkwork-like unit separated from its mainstream organization, which represents a first step for them towards what has been termed 'ambidextrous organization'. The benefits of creating a separate dedicated unit is debated among many researchers, mainly because of the trade-off between development speed gained at the unit and potential integration problems with the mainstream organization. The beneficial speed has been validated in many cases, but the integration – or better termed – the re-integration has seldom been in focus.

This paper analyzes the strategic managerial actions during the evolution of a dual structure as well as subsequent re-integration efforts between the separate unit and the mainstream organization. The findings present practical insights into the management of ambidextrous organizations, presents a new type of integration 'Mindset' mechanism as well as reveals a more nuanced and dynamic view of differentiation and integration than that presented by traditional research

1. Ambidextrous Organization Concept

This paper explores the evolution of a dual organizational structure and analyzes further the integration challenges between these two structures; all in the light of strategic actions affecting technology development or knowledge transfer. The case studied is Ericsson's management of a new internal venture set up to deal with a revolutionary wireless technology called 'Bluetooth'.

The importance of managing according to today's requirements while at the same time acting upon tomorrow's possibilities in order to stay competitive in the long term is widely acknowledged. There are, however, numerous examples of efficient companies that have not managed to bridge revolutionary technologies (e.g. IBM Corporation and Xerox in the late 80s) [8] [40]. Others have similarly concluded that established firms are dismal at transforming new ideas into viable businesses. Moreover, in many of these cases researchers have pinpointed the organization's inability to handle tasks with different time horizons and characteristics as a major underlying explanation for not succeeding (e.g. [21] [36] [41]).

In response to these difficulties, the concept of dual organizational architectures has emerged. Allen & Katz (1985) strongly recommend managers to build parallel structures to enable long-term R&D tasks to be carried out as well as product development aimed at today's products or next generation products [21]. They further state that these two tasks represent two major forces that compete with one another for recognition and resources, making a co-existence within the same structure unnecessarily difficult. Burgelman (1985) agree, urging established firms to provide an adequate structural context for dealing with these two forces [4]. Tushman & O'Reilly (1997) build further on this tradition and introduce the concept of ambidextrous organizations, i.e. *"…organizations that celebrate stability and incremental change as well as experimentation and discontinuous change simultaneously"* [40, pp. 14]. Hence, the organizational approach based on the creation of dual structures is advocated when handling tasks with different time horizons and goals.

1.1. Dual Structure Characteristics

Tushman & O'Reilly (1997) describe the ambidextrous concept by characterizing the two major organizational structures, each focused on two different time horizons. The characteristics of the structure focusing more on short-term results are that it usually is more cost driven, evolutionary focused and has more formal processes in place. The characteristics of the structure focusing on long-term revolutionary technologies are that it has more loose processes, seeks out new opportunities, and is more experimental in nature. It is also seldom profitable.

The short-term focused organization (cf. Simon, Houghton, & Gurney, 1999) will in this paper be termed the 'Parent organization', highlighting the origin of the smaller opportunity-seeking organization. As for this second organizational structure, several different terms have been widely used, i.e. Entrepreneurial unit [40], Skunkworks unit [34], New venture [37], Tiger team [42], etc. In this paper, the term 'Skunkworks' will be used for dedicated units with budget responsibilities that are separated, at least geographically, from the Parent organization. In the early definitions of this term, it usually represented undercover work being done by isolated engineers without management awareness, however, as the concept has been refined, it is now much more of a management tool towards organizing for breakthroughs [16].

Tushman & O'Reilly (1997) further give the following advice towards managing this intra-business heterogeneity: "Management needs to protect, legitimize, and to keep the entrepreneurial unit physically, culturally, and structurally separate from the rest of the organization" [40, pp 171]. Gwynne (1997) goes even further, suggesting that the Skunkworks unit must operate in near-total secrecy but must, on the other hand, also attain maximum publicity and corporate acceptance in the shortest time possible. What also seems to be a widely accepted stylized fact is that the Skunkworks unit is basically counter-cultural with regards to the Parent organization, in order to cope with the often revolutionary tasks ahead [16] [41]. The challenge seems to be to create co-existing highly differentiated, yet highly integrated, organizations.

Moreover, the dual structure is further aimed at facilitating the search for new business value outside the traditional mainstream markets. Edlund & Magnusson (2000) build on Prahalad & Bettis' (1986) framework and elaborate around the concept of dominant management logic [11] [29]. They state that the Parent organization's dominant logic of how to conduct and manage your business should be questioned and reflected on when starting new internal Skunkworks units. Moreover, the synergies of using the Parent organization's resources ought to be carefully considered to avoid unnecessarily constraining or framing the new unit.

To summarize, the ambidextrous organization is one that consists of dual structures (Parent organization and the Skunkworks unit) that focus the work towards two different time horizons and that are built around two different logics.

Dual Structure Benefits

There have been few studies analyzing the symbiotic relationship or the mutual benefits associated with having two organizational structures. The Parent organization has seldom been mentioned in these relationships. One rare example is Burgelman (1985), who puts forward the benefits associated with career opportunities and attraction for the Parent organization and the financial backup strengths for the Skunkworks unit [4]. However, there have been substantial amounts of evidence put forward the high performance related to the Skunkworks structure (e.g. [14] [16] [20]).

The most notable Skunkworks approach originated in the USA with the Manhattan project, i.e. the gathering of the best minds in the world with the purpose of building the atomic bomb [14]. The concept was recognized and labeled during the 40s by the legendary Lockheed Martin's unit, formally titled Advanced Development Projects (more familiar as the 'Skunkworks' in Palmdale, USA) [24]. They viewed their unit as "A concentration of a few good people solving problems far in advance – and at a fraction of the cost – of other groups… by applying the simplest, most straightforward methods possible to develop and produce new projects" [20, pp 171]. This is all in line with the characteristics of Tushman & O'Reilly's ambidextrous organization concept. Moreover, this unit reported tremendous success with regards to the development of advanced military aircraft, often in record time, below budgets, and with revolutionary results. Examples of projects undertaken by the Skunkworks are the world's first operational jet fighter (P-80 Shooting Star), which was developed in 43 days by a team of 23 engineers and tens of support personnel [16]. Other examples include the world's highest flying single-engine jet aircraft (U2), the fastest and highest-flying air-breathing aircraft in the world (SR-71 Blackbird), and the world-renowned stealth fighter (F-117A).

There are few comparisons between having a Skunkworks or not. However, the Lockheed Martin's own Skunkworks chief, Kelly Johnson, once got the mission to set up a Skunkwork-like organization to rescue 'The Agena-D launch vehicle' project at Rand Corporation, which was related to a satellite project. The start position was 13% reliability, and 1206 people in quality control alone. The results achieved by the Skunkworks unit set up were impressive with 96% reliability, 69 persons in quality control, and 350 drawings (instead of projected 3500), 150000 USD (instead of projected 2 MUSD), all within nine months instead of the double as projected [20, pp 167]. This, of course, represents one industry under certain circumstances (e.g. large investments, high degree of secrecy, strong position towards suppliers).

Furthermore, the Skunkworks concept has been applied by several other industries as well. For example, in the automotive industry, Ford Motor Company initiated two Skunkworks units in 1991 and 1992, where one of them focused on vehicle interiors and had the purpose of accelerating the implementation of automotive features [38]. Examples can also be found in the computer industry, e.g. IBM Corporation Research Headquarters in New York and Steve Job's Macintosh project at Apple, which both successfully used the Skunkworks concept [34]. In more recent years, Gwynne (1997) reports that large high-tech companies are increasingly turning to the Skunkworks concept [16]. One example is Sony, who is well known for embracing the Skunkworks approach, and the development of the artificial intelligence robot called AIBO.

AIBO originated from a Skunkworks team and led, among other things, to Sony for the first time testing the Internet as a new sales channel, in this case with astonishing results1 [39]. Another example is the Intel Corporation, who in 1998 went for a dedicated Skunkworks-like approach when bridging over to the Internet side with Intel Online. They migrated within 18 months from zero to over 40% of web-based order management [44]. Schrage (1999) notes further that this behavior is a trend seen among other established companies as well, i.e. to set up a Skunkworks organization to e-enable themselves [34].

Hence, it can be concluded that several different industries and companies have been organized like Skunkworks with success and that the trend does not seem yet to have reached its peak. Those reported cases solely focused on the Skunkworks unit's successes and seldom analyzed the relations with and potential effects on the Parent organization.

1.2. Dual Structure Challenges

Despite the tremendous successes reported with dual structures, several drawbacks and managerial difficulties have been reported as well. Burgelman (1984a) refers, for example, to destabilizing forces generated by the creation of dual structures, and Campbell, Goold, & Alexander2 (1995) question the value of

1 10000 robot dogs were offered for 2500 USD, 135000 orders were received, November 1999

2 This study was targeted at a higher aggregated level, the multidivisional firm, though the arguments are likely to hold in the dual structure setting.

the Parent organization [2] [6]. Frand (1991) claims further that Skunkworks are great if you have a specific problem and more money than time, indicating that the use of Skunkworks units is not an appropriate approach under all circumstances [14].
On the industrial side, Xerox is one example of a company who has experienced dual structure related problems [16]. Xerox abandoned the Skunkworks approach they encouraged during the 80s, mostly due to the difficulties of getting organizational acceptance of the new unit from the Parent organization.
The issue of how much autonomy to allow the separate Skunkworks unit is hard to resolve. Simon, Houghton, & Gurney (1999) discuss, in a theoretical paper, the trade-off between the Parent organization providing adequate support and synergies while at the same time avoiding to choke the new unit [37]. Christensen & Overdorf (2000) argue that the primary requirement is to avoid competition between the new unit and the Parent organization for resources [8]. Moreover, by separating the Skunkworks unit both geographically, budget wise and culturally, differentiation problems might occur. Cordero (1991) takes this furthest in his recommendations when claiming that the Skunkworks approach is not an option because of its related cooperation and integration problems with the Parent organization [9]. Gwynne (1997) underlines the difficulties by noting that companies in the nineties were quite good at starting Skunkworks but had difficulties in the cases where they needed to hand over the knowledge when commercializing the results [16]. Schrage (1999) argues for the Skunkworks approach to represent a 'managerial shortcut' and warns against units becoming "…exclusive suburbs in contrast with the grubby slums of the mainstream business" [34]. He bases his statement on the argument that separating and differentiating the unit creates a sense of elitism. He also raises the question of how much integration is desirable and actually sought.
The integration problem seems to be the toughest challenge for Skunkworks units. Burgelman (1985) and Schrage (1999) are in agreement with Tushman & O'Reilly (1997), pinpointing the issue as: "Differentiating units is easy; achieving integration is not" [41]. Tushman & O'Reilly further conclude that the potential of ambidextrous organization is lost if the company fails to integrate the capabilities from the two structures.
Hence, it can be concluded that there are some severe difficulties related to the dual structure approach. The level of, and mechanisms used for, integration with the Parent organization has emerged as one of the tougher challenges.

Integration Hardship

Once dual structures are created and a new Skunkworks unit is set up, there are several potential scenarios that might face the organization. This has though not been well described in the literature; hence, the author's conceptualization of potential scenarios is presented in Figure 1. Figure 1 presents four scenarios, each categorized using two dimensions: Knowledge integration and Organizational separation. The horizontal axis refers to the degree of separation between the Skunkworks unit and the Parent organization. The vertical axis indicates the need for re-integrating the knowledge (mainly from the Skunkworks unit to the Parent organization), i.e. representing the degree of symbiosis.

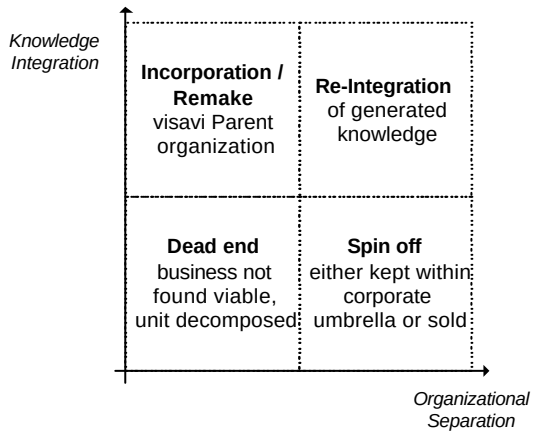

Figure 1 Potential Skunkworks unit scenarios.

Consequently, the lower left area is the scenario when the Skunkworks unit has reached a dead end3, or when the business is not deemed to be viable and is then consequently dissolved. The scenario in the upper left area demands a higher degree of knowledge integration where the unit is also dissolved, but this time by incorporating the unit under the management of the Parent organization, or the new unit might end up by substantially remaking the Parent organization. In the latter case the new unit might turn into the new core business (c.f. Intel's case described by Burgelman & Grove, 1996). The lower right area represents another scenario, where the unit is spun off and either still kept within the Parent organization as an individual company or sold to an outsider. The spin off indicates more independence or, in the sell out option – no dependence at all, between the two organizational structures. In both cases the separation is high and the integration need low. Finally, the upper right area represents a scenario where the Skunkworks unit is still kept organizationally separate from the Parent organization, but where the Parent organization and the unit are interdependent with regards to technology supply or knowledge exchanges. Hence, a continuous flow of communication is sought. This area has not been much investigated, though representing an interesting integration versus separation challenge. The Skunkworks unit is held separate from the Parent organization while at the same time there is a mutual need for exchanging knowledge. This dilemma is further elaborated in this paper under the term re-integration4.

Furthermore, building on the twin principles of differentiation and integration, elaborated by Lawrence & Lorsch (1967), the differentiation into dual, symbiotic yet separated structures, as viewed in Figure 1, clearly presents a potential integration barrier [22]. Roberts (1979) pioneered this field and presented three different groups of integration mechanisms termed as bridges; the Procedural approaches, the People approaches, and the Organizational approaches [33]. His work was though centered on transferring results from R&D labs to the mainstream business. The Procedural approaches aim at tying the two businesses closer by joint efforts, such as joint planning between the sending and receiving units. The People approaches consist of moving people both ways as a means of transferring knowledge. Finally, the Organizational bridges deal with, for example, the creation of specific transfer teams. This last suggestion has been further refined by Iansiti (1995), who (in the mainframe computer industry) suggests the use of dedicated technology integration teams [18]. Roberts (1979) concludes further by stating that the selection and mixture of bridging approaches are contingent on the heritage, organizational setting, and capabilities in place [33].

In the specific case of the ambidextrous organization context, Tushman & O'Reilly (1999) put forward three main integration mechanisms to bridge that potential gap [41]. These are:

* Strong company-wide vision
* Consistent senior support
* Healthy team processes

The first integration mechanism refers to building a 're-invention based' vision that guides both of the two structures and enables a mutual understanding of both existences. The authors give examples of visions like the HP way and GE's mission to be number one or two in the segments or not to be there at all. The second mechanism deals with the issue of top management support. In this case, they not only seek sustained support but also the understanding of what it takes from the management to manage two different structures (e.g. Motorola's strive for being world leaders in portable devices). Finally, the third mechanism deals with the fuzzy term 'healthy team processes'. In this case, the researchers refer to having a team that supports both implementation and creativity issues. It is though unclear if they refer to the Skunkworks team, the Parent organization, or the top management team. They do, however, suggest a few ways for homogeneous teams to foster creativity, namely by using rotation programs or by mixing individual backgrounds. The issue of staffing is also put forward by Sharma (1999) as one challenging task in internal new units [36].

Other researchers have made general proposals for how to integrate the activities of the Skunkworks units with the Parent organization as well. Burgelman (1984b) suggested, for example, a procedural-based approach of tying the activities of the Skunkworks unit closer to the Parent organization by using a steering committee [3]. This steering committee should involve managers from both structures.

Summarizing, it can be concluded that Roberts (1979) proposes different bridging categories, stating that the selection of mechanisms is context-contingent, O´Reilly and Tushman (1997) further suggest rather general integration mechanisms. This does not, however, guide the actions of managers in ambidextrous organizations on any detailed level. Few have actually researched the evolution of dual structures, the purposes behind, or the actions towards integrating the knowledge created in such a setting. This is alarming since many have

3 …which represents a result in itself and should not necessarily be seen as a misdirected effort.

4 Re-integration represents the continuous attempts at transferring foremost the technology back to the Parent organization to be incorporated in products, either pro-actively or as a response to direct technology implementation needs.

identified the integration dilemma as the toughest challenge facing ambidextrous organizations.

2. Research Focus

Despite the promising potential of organizing in dual structures and a seemingly clear trend in several industries towards introducing dedicated Skunkworks-like units, research on how such ambidextrous organizations work in practice is scarce. There are many reports of both extremely successful and of unsuccessful efforts in the area, though few analyses have been made of the relations and potential integration efforts with the Parent organizations. Thereby, omitting the dynamics of creating and managing ambidextrous organizations.
Hence, the aim of this paper is to explore the evolution and first integration efforts made within the creation of a dual structure (representing the first step towards an ambidextrous organization). This is studied by focusing on strategic actions taken affecting technology development or knowledge transfer.
With this aim, the opportunity to examine managerial difficulties and challenges related to the evolution of a dual structure, as well as the differentiation and integration dynamics within an ambidextrous organization, is given. This also requires a thorough description and analysis of the created Skunkworks unit, its relations with the Parent organization, and not least the larger context where the organization is operating.

3. Methodology

The case-based research design enables an understanding of the dynamics present within one single setting. The approach is practice and problem centered, analyzing and contrasting current research status in the field. This is in line with Eisenhardt's (1989) argument for "…intimate connection with empirical reality…" [12]. The individual case design enables the study of the complex interactions and interplay between the two structures studied within one setting. It is also a result of the trade-off between depth and width, where the kind of research questions set out to explore, benefits from in-depth analyzes [45, pp. 25].
The specific Bluetooth[5] case selection was preceded by a pre-study (built around 22 interviews), thereby strengthening the construct validity and ensuring a proper contextual understanding [45, pp. 1]. The purpose of the pre-study was to analyze R&D management and to identify potential research opportunities, i.e. where both large industrial needs and substantial academic interests were matched. Hence, the case selection was both theoretically sampled and industrially valid.
The case chosen was the 'Bluetooth'-case, which originated at Ericsson Mobile Communications (ECS). It is widely recognized as a successful project and technology, both internally at Ericsson as well as by external stakeholders [1] [30] [43]. Internally, the time from first vision to acknowledged and proven technology was fast (3-4 years) for being a revolutionary technology. Ericsson had decided to create a new Skunkworks-like unit to rapidly develop the new technology. Externally, Bluetooth resulted, among other things, in one of the largest industrial organizations ever to promote a new technology
The study of the development of the Bluetooth technology and related strategic actions is mainly based on semi-structured interviews, though multiple data collection methods have been used (e.g. internal documents such as first project specification [23], slide presentations, web documents, organizational announcements, etc have been collected). The data collection was concluded when saturation was reached [15]. One important demarcation is though the choice to cover the events until 1999/2000, i.e. up until one important milestone in the Bluetooth project – the announcement of the next step in the standardization work for the Bluetooth technology.
As for the interviews, they were, similarly to the pre-study, taped and analyzed using the Nud*ist software. From the nearly 100 pages of transcripts of the 28 hours of interviews, text blocks were identified and iteratively coded. Reports were generated that described the intersections between codes. This indexing and subsequent analysis was targeted to develop common themes (e.g. strategic actions) and to identify quotations representative of these themes.
This time-consuming effort was done to ensure and strengthen the reliability. A total of 19 persons playing key roles have been interviewed; from the top manager down to individual engineers. The selection has been made by the researcher to ensure an appropriate variety as well as continually through advising both the Ericsson

5 'Bluetooth' is originally, and most simply put, a name for a radio-based cable replacement.

steering group and the interviewees along the way. Both the first targeted project to integrate Bluetooth with the Parent organization and persons directly within the Skunkworks unit have been approached. People's timely involvement (early stages, mid, and implementation stage) has also been taken into account when choosing appropriate interviewees. To ensure a wider understanding and to reach a higher external validity, the operational Bluetooth manager at Intel Corporation, the communications marketing manager, and a software engineer, who worked as a resident engineer from Intel at Ericsson for two years were also interviewed. Intel represents one of the instrumental core firms in the special interest group of Bluetooth. The findings were in line with the results from the Ericsson interviews on the major issues, strengthening the reliability. All of the Ericsson interviews were carried out during a period of three months. The interviews conducted at Intel were carried out a couple of months later. Late versions of the paper have also been reviewed by the interviewees to further strengthen the validity.

As regards the strategic actions, these are mainly seen and analyzed from inside ECS and out, representing a framing in itself. The concept of strategic actions is derived from Burgelman & Grove's (1996) discussions of the Intel case and the realization of corporate strategy by performing a series of strategic actions [5]. This implies that the strategic intent is mainly attributed to the company-wide effort of betting on the Bluetooth technology, while strategic actions are attributed to the decisions and actions in realizing this intent. Especially, the actions that have been instrumental in the successful development and/or re-integration of the Bluetooth technology have been in focus[6]. The relation between the Skunkworks unit, the Parent organization (=ECS) and, to some extent, the SIG group has been under the microscope. However, the relation between ECS and Ericsson as a whole has not been analyzed. Moreover, it is a relevant question to ask under what specific conditions the Bluetooth case has been operating. The timing of releasing wireless products seems to be appropriate; the media interest, the consumers, alliance partners, and complementary technologies all seem to have reached a certain maturity level. The environment has been very understanding, patient and at the same time interested in the results. As for the technology itself, it does not possess any constraining assets that would hinder other technologies from pursuing a similar route towards commercialization. All this put together indicates a favorable, but not exclusively or unrepeatable unique, research setting.

Moreover, being an individual case study, it is in itself limited to how far the findings can be generalized, though it should be noted that this is not the aim – instead the complex interactions and an understanding is sought. By visualizing and analyzing the complex context of developing a new technology and transferring related knowledge, the study offers both practitioners and academia valuable insights.

4. Bluetooth Case Context

In this section, a brief presentation of the industrial and company specific context is given together with the Bluetooth technology basics. Moreover, the progress and evolution of Bluetooth are presented longitudinally to facilitate the forthcoming analysis, reflections, and discussion.

4.1. Computer & Communications Industry

Bluetooth is operating in the wireless world within two major arenas, the computer industry and the communications industry. The world market for mobile phones consisted of 475 million users by the end of 1999; this is to compare with approximately 20 million laptops [13]. The characteristics of the computer industry are that the companies are used to working with de facto standards[7] (e.g. PCI, the USB interface, and 'Plug and Play' initiative), a few large players dominate the market, and they face a performance as well as a recently initiated cost race [25]. Moore, Grove & Barret (2000) at Intel describe the opportunities ahead as moving towards a fairly clear direction: "…to help drive the growth of the connected world" [25]. As for the mobile phone industry, these companies, similar to the computer industry, experience continuous growth in terms of demand and also have a few large companies dominate the market. The characteristics of the mobile phone industry are, further, that large institutions are in place producing and approving vital technical standards (e.g. ETSI[8]) and that intellectual property (IP) rights have a major importance. Having a constant flow of new

6 This demarcation leads, among other things, to the technology marketing side, by many regarded as extremely successful, not being dealt with in any depth.

7 A de facto standard refers to a 'standard' that is not officially acknowledged by any formal standardization body, but by its market presence (or by other factors) is recognized as the dominant standard. One example is the PC Windows operating system.

8 European Telecommunications Standards Institute, 730 members from 51 countries aiming at influencing standardization and regulation.

innovative but cost efficient products is a key factor in this business.
The overshadowing trend at this moment is the long predicted convergence between computing and communication solutions [13] [26]. This trend also supports the convergence of industries and services as well as technologies and is further crystallized in the emerging wireless solutions; the demand for mobility and connectivity is increasing rapidly [17].

4.2. Ericsson Organization

Ericsson Mobile Communications (ECS) is a part of the business segment 'Consumer Products' within Ericsson and develops / manufactures millions of mobile phones and accessories yearly. The main R&D activities are located in Lund, Sweden, though ECS has several other international R&D centers and manufacturing plants. During the study period, ECS in Lund employed more than 1200 persons. The company is R&D intensive (15-20% of sales annually9) and has a rapidly shrinking product life cycle and a development cycle of approximately 18 months. ECS originated from an internal spin-off from Ericsson in Stockholm, Sweden. This is notable since the decision to re-locate the entrepreneurial mobile phone unit to Lund, approximately 700 kilometer from Stockholm, was done to give the business a chance to survive. This is the company context where the Skunkworks-like Product Unit (PU) Bluetooth was created and has been operating as a separate entity (see Figure 2).

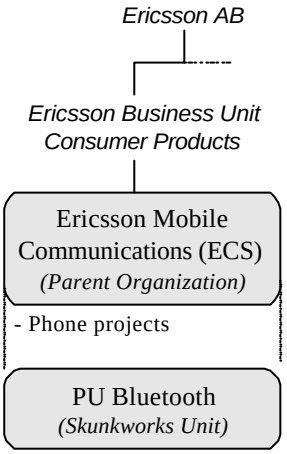

Figure 2 Schematic presentation of the context at Ericsson.

4.3. Bluetooth Basics

The Bluetooth technology's initial mission was to replace the, often proprietary, cables between the mobile phones and the accessories. The radio-based solution for this is to be considered as revolutionary [17]. Moreover, one of the first examples was to use a Bluetooth earpiece when talking, using a mobile phone that can be kept in a pocket or bag (there is no line of sight restrictions). Today, the Bluetooth objective is to provide a wireless link between all mobile devices and to incorporate applications within data and voice access points, cable replacements, and ad hoc networking. The applications are plentiful and almost constrained by imagination only.
The Bluetooth radio operates in the open unlicensed 2.45 GHz ISM (Industrial Scientific Medicine band) spectrum. The current solution is small (1.0 by 0.5 inches), consumes little energy (0.1W active power), and is targeted at a low cost [26]. The initial range represents a personal bubble of 10m. As announced for March 2000, the first Ericsson Bluetooth module will rely on a three-chip solution consisting of baseband, radio, and link manager, distributed by Ericsson Components (Figure 3).

9 That is, Ericsson Business Segment Consumer Products as a whole.

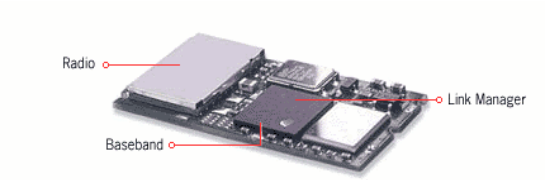

Figure 3 Ericsson Bluetooth module as of March 2000.

The massive global interest in and support for the technology have led to predictions of over 100 million mobile phones, computers and other electronic equipment being Bluetooth enabled by 2002 [13].

4.4. Bluetooth Evolution – From Idea to Global Presence

For the major milestones and related timeline in the Bluetooth evolution, see Figure 7 and Figure 8. The Bluetooth project was initiated from a subsystem of a larger 'concept' project called Multi-Communicator (MC) at Ericsson during 1994, which among else things focused on the "Ease of Use"-concept. The MC was a universal, user-friendly communicating device, which could be used to access services on the World Wide Web. The portable MC device would be connected to the web via a cellular terminal. The MC Link represented the wireless link between the MC device and the terminal. The MC project was dispersed as a whole, but the MC Link was continued.
Dr. Nils Rydbeck, senior Vice President, Research & Technology, and Chief Technical officer at Ericsson Mobile Communications, formulated at this time a vision covering half a page regarding this link. The discussion partner at this point was Per Svensson, a skilled strategist and former head of purchasing and accessories at Ericsson since 1987. This vision statement was then presented to Dr. Jaap Haartsen10, a systems architecture researcher, together with the question if it was possible to extend the MC Link to, apart from voice, the transfer of data. Dr Haartsen gave this some thought during the summer of 1994, played around with the concept and, when attending the WCM conference, he became convinced that it was the unlicensed ISM band that was the one to choose. The technology concept was now being formed by Haartsen on the system specification side, and by the appointed project manager for the MC Link project, Sven Mattisson11, a recruited Professor specializing in radio chip integration. The chief scientist Paul Dent, a well-recognized inventor with a huge patent portfolio at the Ericsson unit in the USA, functioned as the devil's advocate at this point and as an important advisor.
During 1995 and 1996 the work was still carried out in a rather small research group, mostly consisting of borrowed personnel from the Parent organization (ECS GSM12 unit). Their work was now receiving more attention but was still seen internally as "…nice, but not really serious". The basic requirements were in place [23], but no project demands were established, such as commercialization or other formal dates. Per Svensson initiated the first contacts with one computer equipment manufacturer and one computer manufacturer. Their responses were tepid, and no actual collaboration followed.
The beginning of 1997 marked an important step when Dr Nils Rydbeck recruited Örjan Johansson to head a dedicated Skunkworks-like unit termed Product Unit (PU) Bluetooth. Johansson had ten years' substantial experiences from working with creating de facto standards as a development manager at ABB Automation, but also prior to ECS as Vice President of a smaller company. Johansson belonged to the same university class as the current manager of the Parent organization's technology development unit and as the current manager director of ECS, so there were already some informal relations in place. Johansson started out by recruiting one administrative assistant and one technology marketing manager. Together with the key person mentioned above, he also met with Intel. Stephen Nachtsheim, currently Vice President and Director of Operations at Intel Capital (internal corporate venturing), quickly realized the high potential and fully supported the concept. Jim Kardach, principal engineer, who had among other things twelve years' experience in chipset and processor development at Intel, for some time had the strategic mission to investigate what the combination of the wireless and laptop concept meant. Together with Simon Ellis at the strategic marketing organization, they had appointed this area as a total market growth enabler. Hence, almost a perfect match

10 Announced 'Inventor of the year 1997' at Ericsson, based on his work with indoor communication systems.
11 Later appointed 'Inventor of the year 1999' at Ericsson, primarily based on his product oriented work with Bluetooth.
12 Global System for Mobile communications; GSM is a digital mobile telephone system that is widely used in Europe and other parts of the world.

was found, and Kardach got the mission and a budget from Nachtsheim to proceed with the collaboration.
Now an intense period of work started with adaptations to laptop requirements and discussions with other leading computer and communications companies. This work resulted in the formation and announcement on the 20th of May 1998 of the establishment of the Bluetooth Special Interest Group (SIG). The founding members, i.e. the promoters, were Ericsson, Intel Corporation, Nokia Mobile Phones, IBM Corporation, and Toshiba Corporation – five corporations together representing a dominant market share of the computer and mobile phones market. Many of these promoters had been doing some work within the wireless domain earlier (e.g. Nokia's low-power RF), but now all agreed upon developing an open Bluetooth standard and promoting the technology. With these five promoters, there was a rapid increase in adopters, i.e. companies signing the SIG requirements.
The royalty-free Bluetooth standard 1.0 was released on the 26th of July 1999, a document of approximately 1500 pages divided into two parts – one core (component focused) and one part describing different usage functions (protocols and procedures). The standard was initially announced nearly three months before it was actually released. This 1.0 standard thereby specified the requirements for diverse Bluetooth devices to be able to communicate with each other. The growth of adopters continued and, after the standard 1.0 was completed; the contractual agreements for the SIG group were ended. Consequently, a new SIG 2 was to be formed to keep the work going. At this moment, four additional promoters were added to the core team – Microsoft, 3Com, Motorola, and Lucent. A simplified, official, organization scheme is presented in Figure 4.

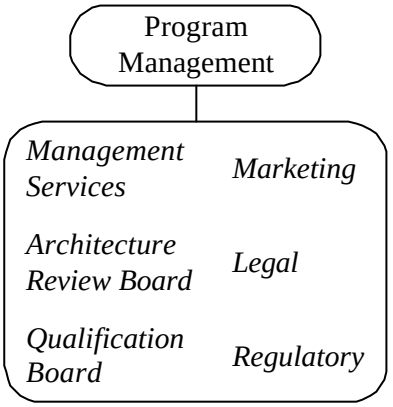

Figure 4 Schematic organization of SIG 2.

During this period, Ericsson announced the first Bluetooth product (a wireless headset) during the fall Comdex conference in Las Vegas, USA (Figure 5).

Figure 5 Ericsson's first announced Bluetooth product.

Now the race was on; Danish Digianswer promised Bluetooth-enabled PC cards and USB adapters to be delivered on the 1st of March 2000 [10]. During the Bluetooth developers' conference in December 1999, Intel demonstrated two laptops synchronizing data over Bluetooth and utilizing Intel's radio module and software suite [19], and many more firms have announced products to be launched during year 2000 (e.g. Nokia, TDK, Xircom, Palm Computing) [7].

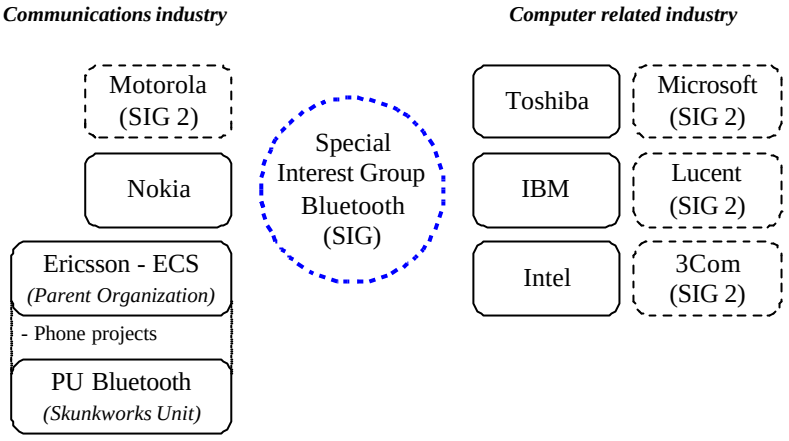

Figure 6 Bluetooth major stakeholders, an overview.

Summarizing, the major stakeholders discussed in this paper are presented in Figure 6. The figure describes the five original SIG founders, the four additional SIG 2 promoters, the Ericsson Parent organization and the separate PU Bluetooth Skunkworks unit. Worth noticing is the two main customers for the Bluetooth technology, the computer industry and the communications industry. The many adopter companies are not included in the figure.

5. Strategic Actions

In this section, strategic decisions and actions related to the evolution and expansion of the Bluetooth technology are presented and analyzed. Those strategic actions were identified as the formation of a dedicated unit, the immediate global intentions, and the actions towards knowledge re-integration.

5.1. Forming a Dedicated Unit

Forming a dedicated unit was specifically argued by over 80% of the interviewees to be one of the most important actions taken internally to enable the Bluetooth development and to get enough focus.

The Bluetooth technology to be had been pursued for three years in a small group of approximately five to six, mostly borrowed, research-interested engineers from the Parent organization under Mattisson and Haartsen's directions. This group was not isolated, though enjoying top management protection. There were also some problems in finding people to do the software part. These persons were a scarce resource already in the Parent organization and were working hard to meet sharp deadlines. However, they now had a convincing specification and a trustworthy chipset prototype in place, though it is worth noting that the project still was considered as high risk. This was the time when the decision, supported by Dr. Rydbeck, was made to form a dedicated, Skunkwork-like unit – Product Unit Bluetooth. Figure 7 shows a rough timeline of milestones and events preceding the appointment of a unit manager. The Skunkworks unit was organizationally located within ECS under Dr. Rydbeck's Research & Technology unit and entitled 'strategic technology'. The reasons for creating this new unit were several:

* Rapid growth
* Own control over resources
* Potential larger than just mobile phones
* Focus

Focus was the main driver behind the decision. The Bluetooth technology also needed to grow so fast that the pace demanded an own organization for planning and commercialization. The group also needed to get control over their own resources, both financial to be able to show revenue in the future and with regards to people "…to have control over the resources and to avoid too much mixing of people".

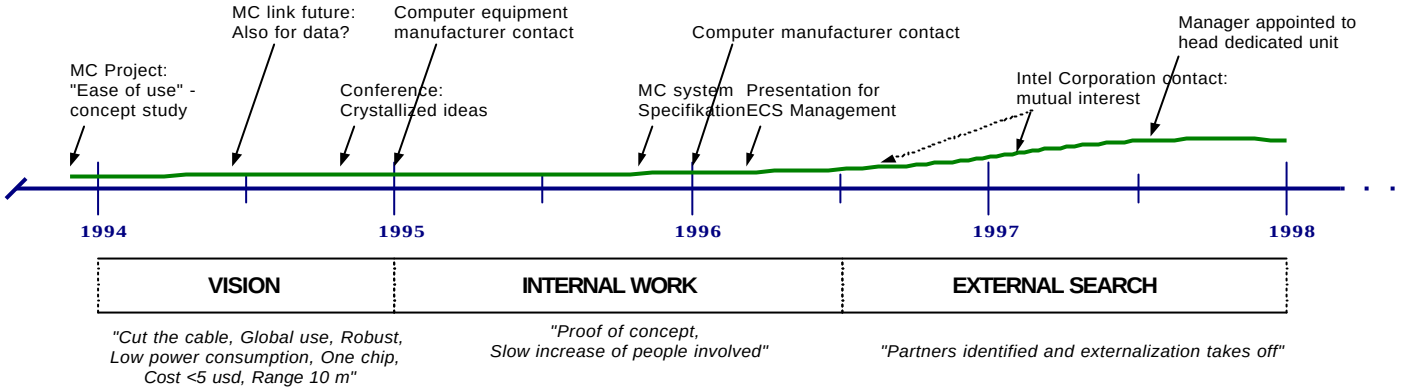

Figure 7 Timeline covering events until the appointment of unit manager.

Örjan Johansson was recruited to set up and head the Skunkworks unit. The shift from Vision, Internal work focus, to a more External search for partners is indicated in Figure 713. Further, the Skunkworks unit was geographically separated from the Parent organization, i.e. it was located at Ideon – a research park 15 minutes walking distance from the headquarters. This was also the place where ECS was originally set up. The doable staffing strategy and the intentions was to recruit mainly from outside the Parent organization. Approximately 75% of the staff at Ideon was, by the end of 1999, recruited from the outside. This strategy was adopted due to the people in the Parent organization being very busy working to get new product lines to the market, making internal recruitment very hard. As one manager put it: "…when you are starting up a new business, you will have to find people who are not in the core business in order not to cannibalize the resources there". The intentions behind the choice of going after unbundled staffing were also related to the attempt to create a separate culture for the new unit and to get immediate focus. It was seen as worthwhile to add people that had 'a clean desk' – "the relay-race baton is always sticky", thereby being able to focus on the new tasks. The recruited persons were, though, not totally unbundled; they had their own network and this network was used to recruit additional people. Moreover, it was also important for people working with Bluetooth to have a personal interest in and to have that work as the highest priority, even if Bluetooth did not have the same priority set within Ericsson. One constraining factor at this stage was that Ericsson as a whole imposed a general prohibition on advertising for new employees, a factor affecting the rapidly growing Skunkworks unit as well as their ambition to find skilled people.

Another staffing dimension concerns the choice of recruiting people from the mobile phone accessories unit, a unit that is very product focused and used to frequently getting products to the market. This is remarkable in the sense that the Bluetooth project still was close to being a research project. Magnus Hansson was recruited as the manager for Bluetooth technology development. Hansson had ten years of work experience in phone accessories behind him. Moreover, a product unit in Emmen Netherlands, which formerly worked with mobile pagers, was set to work on commercializing Bluetooth accessories14 (e.g. the Bluetooth headset). This was an action that matched Ericsson's current needs well and at the same time was perceived as a good way to get focus on the Bluetooth accessories (due to geographical location and competence base).

An internal approach to communicating the mission of the Bluetooth unit, foremost among the internal staff, was to work with the concept of "technology products". Hansson formulated this concept to spell out that what was delivered from the technology development department was to be seen more as technology products than as solely new technologies. The implications of this concept were that a new technology does

13 The vertical axis represents the increased differentiation / external efforts taken by Ericsson.

14 They are now also working with developing new mobile phone accessories as well (e.g. Ericsson's chatboard).

not make up a new technology product on its own; it has to be a part of a delivered system desired by customers – consisting of the technology as a base but also of proper packages, well structured documentation, etc. The total system is thereby in focus.

As regards the specific culture of the Skunkworks unit, it has proved not to be equally distinct as the culture within ECS. The interviewees mostly refer to differences in the age of the organization, not in the specific tasks that are related to the Bluetooth unit. Examples of characteristics are that the unit is perceived as being less bureaucratic, a bit immature, and as having a strong focus on tasks ahead. There is, though, some formalization naturally in place due to the creation of the Bluetooth specification within the SIG. Moreover, the perception differs between the two extremes "…rapid wild west culture, where vital decisions are made on the spot" and "…about the same culture as within the GSM [=Parent] organization". Hence, the predicted consistent differences between the two structures due to differences in time horizons etc are not evident.

Summarizing, forming a new, dedicated unit enabled the Bluetooth to have a focus. A representative statement from one of the interviewees is "Focus is extremely important to get a technology like this to fly…".

5.2. Immediate Global Intention

The vision was from the very beginning intentionally formulated for global adoption. The core of that vision statement was to develop a globally applicable, robust wireless link between the mobile phone, the headset and the Personal Digital Assistant (PDA) working at a range of 10m at low cost (<$5) and low power consumption, using a one-chip solution. If it were to be global, it had to use the open ISM band, meaning that it had to be robust to operate side by side with, for example, microwave ovens. If it were to be widely implemented, it had to have a low power consumption to avoid large batteries. Finally, if its cost were to be below $5, a one-chip solution would be chosen. Hence, the global intent was there even before the technology was in place.

Moreover, this original vision is also to be seen as widely spread and accepted, both internally within ECS15 and externally. As one interviewee put it: "The vision has permeated the project from its very beginning". Kardach at the mobile computing group at Intel, for instance, attributed a lot of the technology marketing success of Bluetooth to the clarity of the vision and its ease of communicating – "…you do not have to be a rocket scientist to understand the value of replacing the cables". Kardach further stated that, "…when we started with the target of $5, everyone was laughing at us". However, research at Intel had shown that the cost to reach a ubiquitous implementation of the Bluetooth technology demanded the cost to be at least below $10, maybe initially around $30 if the price was promised to be lowered after the volume increases. The cost of $5 also equals the cost of the cables targeted to be replaced. Recent price estimations are around the figures above, e.g. $14 estimated by the president of Micrologic Research [43]. The cost target was also seen as a good way of constraining and giving focus for the development.

As for the realization of this vision, Johansson had already seen the rapid voluminous expansion of the mobile phones and, with his experience of standard work; he saw it as natural to use the mobile phone as a platform for creating industrial de facto standards. In fact, he was recruited with the mission, and own interest, from day one of his employment to create a new de facto standard based on the Bluetooth technology. With this in mind, market share for potential promoters was what counted. The target was to reach companies that together represented more than 50% of the total market. This interest was mutual and also strongly initiated by Intel, who, among things, called for at least another communication company to ensure second sourcing of the radio system. Hence, discussions began in December of 1997 with the traditional competitors Nokia, IBM, Toshiba, and a few others with the aim of promoting the Bluetooth technology through a more organized effort. As for the Bluetooth name, the Viking story has been repeated frequently in the media. It was initially an internal code name, coined by Kardach, and used within the SIG group, which later went public, mainly because the proposed name Personal Area Network (PAN) was not possible to use on a global basis due to trademark barriers.

15 90% of the interviewees described the vision as strong and giving directions for their work.

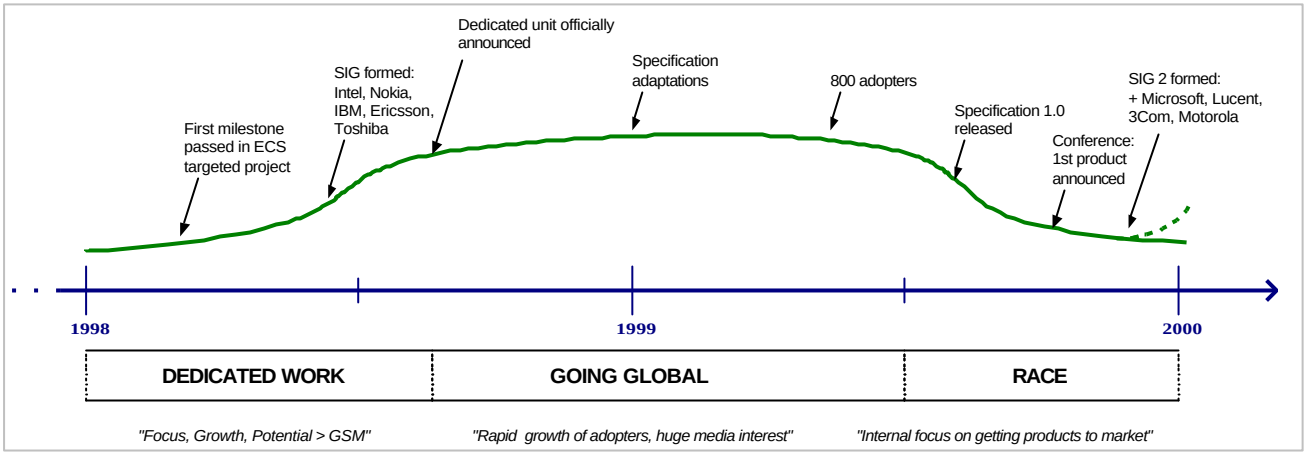

Figure 8 Timeline until the announcement of SIG 2.

Figure 8 represents a schematic timeline of the events until the formation of SIG 2. The timeline covers the shift from Dedicated internally focused work, through the Global mission to the Race to market.

Another requirement, urged by Intel, was to work on an open Intellectual Property (IP) basis to reach a global presence. Ellis stated "…open IP is a way of reducing the politics from the collaboration equation". This was a common way of working in the computer industry, but more revolutionary in the mobile phones industry. Dr. Rydbeck was inspired by the working methods of the Java technology and consequently agreed upon the open IP, a decision supported by Johansson. This caused a large debate internally at Ericsson, some stating that Ericsson is giving important patents away. Others argued for the value of opening up the IP, such as:

* Increased value of other related patents
* Increased value of the mobile phones
* Increased value of the Bluetooth network to come

In fact, ECS appreciated working with an open IP because they saw the value of aiming for the best technology solution instead of, as might be the case earlier, targeting the solutions that rely on Ericsson's patent portfolio. The contractual agreement for the SIG group took the form of a zero-cost agreement, where member companies qualified for a royalty-free license to build products based on the Bluetooth technology as well to access the forthcoming Bluetooth specification. It should be noted that this did not include the potential implementation patents nor that the agreement was reciprocal (i.e. the adopting companies also agreed on adding their own patents in the area to the collective 'Bluetooth basket').

Consequently, the SIG 1 group was formed in the pursuit of a global de facto standard. The core founders were Ericsson, Intel, Toshiba, IBM, and Nokia. These five firms now created a virtual SIG organization consisting of one program management team and several different sub teams, each responsible for a certain section or topic in the planned specification. In this highly competitive context of IBM – Toshiba, and Ericsson – Nokia, Intel was left with some kind of moderator role, representing 'objectivity'. They met regularly face to face and used telephone conferences every week. There were no monetary transactions internally. The voting rules were based on consensus. The strive for global enabling went on and as evidence that Bluetooth was on the right track, the pace with which the adopter companies joined the SIG was increasing (Figure 9).

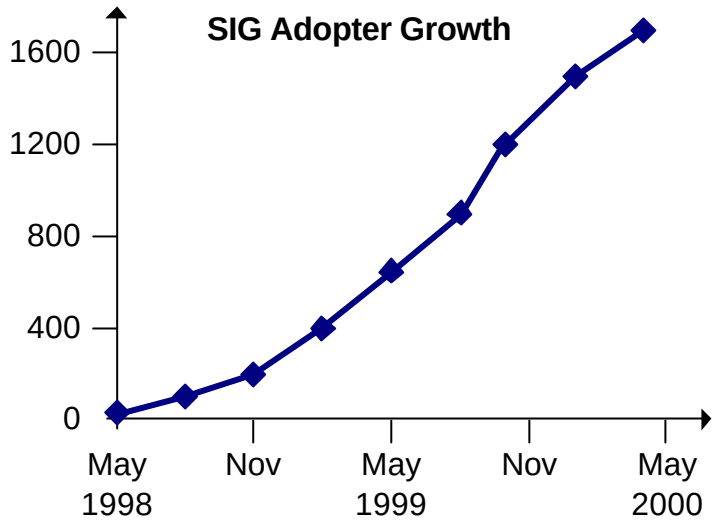

Figure 9 Bluetooth SIG adopter growth.

Within 18 months, more than 800 companies had joined the SIG. They belonged to many different industries and settings (e.g. automotive, consumer electronics, medical, media industry), targeting a wide variety of applications and devices. Ellis highlighted the approach of "…having dedicated marketing personnel at each company to work with the promotion, launch etc instead of having a bunch of engineers working with a technology and then subcontracting the marketing efforts", as being essential with regards to external communications.

The interoperability between different Bluetooth-enabled devices was early on recognized as a key issue for spreading the technology among different devices. The basic intention was to Bluetooth-enable as many different devices as possible, all to maximize the network effect and in the end increase the value of the computers and the mobile phones. Consequently, they followed a practice used in the mobile phones industry – structured qualification programs (e.g. GSM qualification). This was manifested in, for example, interoperability tests, aimed at solving underlying interface problems. During the latter part of 1999, this was one of the major issues dealt with. For example, Hansson stated during that period "…interoperability is a keyword". The large numbers of adopters were intentionally left out of the discussions of how to change the specification to increase the interoperability; there would simply be too many players to coordinate.

One lesson from the adaptations and tests were that, from the very beginning, there were only lower protocols in place, but Intel, IBM and Toshiba soon implemented also the higher layers to enable proper communication with the computers. It was not enough just to standardize the Bluetooth link – the standardization had to take place at the upper levels as well, e.g. how a file was to be transferred, how a call was to be set up, etc. The infrared standard organization IrDA16 also gave advice regarding taking care of the higher layers as well, i.e. to avoid potential interoperability problems. Ericsson contacted both irDA and Home RF, two standards that early on were appointed as competitors or substitutes, in order to make the positioning and offer of Bluetooth clear.

In order to be truly global, the used frequencies and the security issues had to be solved and type-approved in each and every country. The countries that caused initial legislative barriers (they did not allow free use of the ISM band) were, for example, France, Spain, Israel, and Japan. However, the legislation in Japan has been changed, after influence from a SIG sub group, and Bluetooth devices can now function in Japan [1]. This would most likely not have been possible to achieve by a single company, but with over thousands of companies already signed up it proved possible. Moreover, as one manager put it "…this was one benefit of having fresh people on the job, they did not know that it was not possible to change legislation in Japan".

After the first Bluetooth standard 1.0 was released; Microsoft, Lucent Technologies, 3Com Corporation, and Motorola also in December 1999 officially joined the SIG promoters to develop standard 2.0. This situation was, however, a difficult one for the new promoters. The initial five promoters had now been working together for three years and had a tight personal relationship in place. Kardach describes the relationship as "…you know how they work, function and interact, and you know when something is bothering them".

16 The Infrared Data Association, founded in 1993 as a non-profit organization, and as of March 2000 with 120 members.

Moreover, by March 2000, over 1600 companies had joined this SIG as adopters of the Bluetooth technology. The media interest at this time has by many, both internally and externally, been described as very close to a 'hype'.

5.3. Knowledge Re-Integration Efforts

The actions towards re-integration have taken many forms. At a certain point in time at ECS, the decision was taken to integrate Bluetooth solutions into appointed mobile phone projects, i.e. to commercialize the Bluetooth technology via the mobile phones developed in the Parent organization. This represented certain challenges at the time, e.g. the staffing was roughly 75% new, the Bluetooth unit had, for a time, been running by itself, and the Bluetooth specification was not yet set. At the same time, Ericsson was also a key player in communicating the Bluetooth technology to the adopters and in assisting them in their integration efforts.

Re-visiting the staffing dimension of the Skunkworks unit, there were mainly newly recruited personnel, but there were also key persons who had been transferred from the Parent organization (still in the Skunkworks unit) as well as a core of researchers still involved. The experienced key persons from the Parent organization had all impressive personal networks in place, which they frequently used. As for the core researchers, they were both engaged in the development of the first Bluetooth chipset – and then went on to new tasks. They were though certainly available and have ever since been working at least part-time with Bluetooth, though they were not co-located with the Skunkworks unit. This sounds okay, but actually resulted in a couple of delicate dilemmas. For example, interviewees in the Skunkworks unit expressed a lack of technology champions, i.e. persons with an understanding and responsibility for the overall system. These characteristics were initially possessed by the core researchers. However, since they did not all transfer to the Skunkworks unit, they were not kept totally up to date with the ongoing development. Hence, when difficult problems arose – their responses rested upon the prior setting, as they knew it.

As for the unbundled staffing, this could, as discussed earlier, be a positive factor for focus, speed lack of knowledge of potential barriers (e.g. legislation in Japan). However, when the re-integration efforts began, certain challenges arose. One example of this is the choice of location of the Bluetooth antenna. The antenna location and connection affects the whole mechanical architecture, and the mobile phones are tightly packed products. The first project chose a certain location, but this is likely to be moved in the next project due to possible interferences. One knowledgeable radio engineer expressed his concerns and also thought that more experienced radio engineers probably would have avoided this location. Another similar example is the radio chip, whose location was not considered as an optimal one with hindsight. It was described as more opportunistically placed, and usually this represents no problem for ordinary chipsets; but this was a radio chip, a fact that has certain location implications.

At the time when the phone project targeted for the Bluetooth solution started at the Parent organization, there was little or no knowledge about the Bluetooth technology as such or of possible mobile phone implications. Concurrently, the Bluetooth specification was still developed. In the beginning, the targeted projects were trying to keep up with the specification changes and new directives. However, they soon realized that this was not a viable approach. They took their own decision where they thought the specification would end up, and then they pursued the project for a long time without glancing at the evolving volatile Bluetooth specification. As one engineer expressed the situation, "…we worked in a vacuum for almost one year, not knowing the specification requirements". The most important issue from the project's standpoint was to integrate the Bluetooth functionality into the targeted mobile phone, whether it followed the forthcoming standard or not.

The initial prediction was close to the final specification, but integration problems related to the audio channels arose for example. Now there existed two radio interfaces in the mobile phone, and this led to the need for a basic understanding of how the audio actually flows. In order to respond to this and similar integration problems, a System integration group was formed in March 1998 within the phone project, which worked for approximately five months. They focused mainly on this specific audio problem, but the work also resulted in a prioritized list consisting of both Bluetooth functionality and mobile phone functionality. As one participant described the work "…it was a discussion on the technology level; what can we do with Bluetooth, what does it mean, and what do the interfaces look like?". The group mainly included engineers, though one product leader also assisted foremost in the market related discussions, such as what functionalities would be accessible at the same time, and how they would appear to the users. This group did not interact to any extent with the Skunkworks unit, though some of the engineers within the group had earlier been involved with prototype building within the Skunkworks unit.

Another structure was also initiated within the phone project, the Functionality Team Bluetooth. This functionality group was initiated by the project leader and was one of eight groups focusing on different critical

issues. It was further active in the start up of the project and did not last very long. This was seen as a project response to increase the knowledge about Bluetooth, foremost from a software perspective. There were opinions expressed in hindsight that the internal marketing in the beginning could have been improved, "…there were not many people knowing much about Bluetooth". The initial focus was to find out what Bluetooth meant for the project in question, but the focus changed once the specification was in place – turning more toward auditing the specification. This team was seen as a good effort in the right direction, though the outcome and goal were a bit unclear. However, the team was abandoned once the actual implementation efforts began.

From the Skunkworks unit perspective, two different structures were formed: the Technology Council and the Technology Review. The Technology Council Bluetooth operates on a higher management level. This council functions as a steering committee for the Skunkworks unit, where decisions, advice, and directions are given. This council has meetings every sixth week, is administrated by the Skunkworks unit, and consists of the main project leaders for the mobile phones and accessories, the management of the Skunkworks unit, and representatives for home communication issues. The Technology Review meetings have, on the other hand, the basic purpose of reporting the progress of the technology development initiatives at the Skunkworks unit. This is intended for almost everyone that is interested, mainly project leaders. It should also be noted that both the Technology Council and the Technology Review structure mirror the Parent organization, which has similar structures in place.

Within the Skunkworks unit, different actions were taken to try to integrate the system knowledge and to have the engineers consider cross-functional issues. Internally, they created the concept of 'engineers-without-borders', after the non-profit organization 'doctors without borders'. The intention was to encourage engineers not to consider themselves solely as being a 'baseband engineer' but also to consider and not to hesitate working with related areas as well. These efforts are, however, still at a very early stage. Moreover, when speaking with Kardach, his response to this concept was to refer to a similar policy at Intel, known for long as the 'open door policy', facilitating contacts between functions.

Externally, the integration efforts with other promoters as well as adopters have taken different views. Similar to the concept of resident/guest engineer used in the automotive industry between suppliers and OEM's, Intel placed one engineer at the Skunkworks unit for a period of two years, to increase and improve the coordination and mutual understanding of working methods between the two companies. One example of the different perspectives in the two industries is the use of the term 'launch'. In the computer industry one does not launch anything until the products are on the shelves. However, in the communications industry it is much more a question of trying to establish leadership.

As for the adopters, there were initially some capacity constraints to handle the inquiries and requests from the numerous adopter companies. There were a lot of companies in the learning mode, trying to catch up as fast as possible. There were also companies around who used the Bluetooth solution as a backup for their own wireless efforts. A typical statement is "…the adopters have not quickened the process, but we have on the other hand reached a more comprehensive, higher quality specification". Intel did, however, not perceive the curious companies as equally problematic; they already had a support organization used to dealing with engineers as customers. Hence, they merely trained their support staff in the Bluetooth technology and they also referred frequently to the developer conferences to provide the answers.

What the Skunkworks unit did for the external stakeholders was to create a support organization to function as the first filter. Examples of other actions taken are using one e-mail address for all inquiries, setting up one-day informative seminars, arranging Bluetooth conferences, and finally developing a supportive web site. Moreover, they did also, during 1999, package technology and prepare to sell technology in new variants. These new variants are, for example, selling licenses for the baseband chipset, offering reference designs[17], providing 'approved by Ericsson' tests, and selling developers' kits (e.g. $15000 for one year's support, two professional development tools, and a 'cookbook'). Almost all of these actions represented new working methods and challenges for ECS. Questions arose of how to properly package IP, an issue referred to by one of the interviewees as "…being one dissertation in itself". Other interesting implications are that Ericsson's trademark is now being promoted through other channels than traditionally (e.g. 'Approved by Ericsson').

Finally, it can be concluded that PU Bluetooth faced a tough challenge trying to manage the external network at the same time as working concurrently with creating the standard, developing the technology, forming new services, and managing for re-integration with ECS.

17 ~knitting instructions in eight folders, and including 100 hours of implementation consultations.

6. Case Reflections

The purpose of this article is to explore the evolution and the first re-integration efforts taken within the creation of a dual structure. This study has been based on the Bluetooth case, mainly with a focus on Ericsson's strategic actions in getting the technology up to speed and on the efforts at re-integration. Further, there are a number of principles that crystallize when viewing the working methods of the Skunkworks unit and its relationship with the Parent organization and with the external networks foremost via the SIG group.

6.1. Forming a Dedicated Unit – Dual Structure Evolution

The reasons for creating dual structures in the Bluetooth case was to enable rapid growth, provide control over resources, gain focus, and enable a potential that might be larger than the Parent organization's potential constraints. The latter reason is in line with Magnusson & Edlund's recommendations regarding dealing with the dominant management logic [11]. However, the dual structure also created certain internal tensions between the new unit and the Parent organization. One example of this is that the Skunkworks unit has two main customers, the Parent organization (mobile phone projects) and the computer industry. These two customers represent two different subset demands, requirements and priorities, making internal resource prioritizations a matter of debate. This tension might not necessarily be bad, though putting more emphasis on top management directions and internal communication.

Other key areas identified in the evolution of the dual structure are the initial key staffing and the top management view of the forthcoming potential. Burgelman (1984a) puts forward the assessment by top management of the strategic importance as a key issue, though not discussing in more detail what the implications might be [2]. However, the first persons to be recruited to the growing unit rapidly ended up with key management roles. This represents one challenge in itself, making the initial recruitment critical and perhaps changing the recruiting aim from positioning the best engineers in the management role to recruiting managers able to head a potentially large business. It was also expressed by many in the Skunkworks unit that recruitment of new employees not only takes a lot of time but would also benefit from getting access to human resource persons to assist in the recruitment process. This issue is tightly linked to the top management recognition and insight into the possible potential. If the business eventually turns into a large billion-dollar market, would they react differently in the start up of new units? This puts, in line with Burgelman (1984a), additional emphasis on the evaluation of new unit potentials [2].

The Skunkworks unit was, in line with theory recommendations, separated budget-wise, geographically, and structurally. There has, though, not evolved any distinct separate culture within the unit. The question can be raised if those counter-cultures can be related to the immaturity of the organization as such, not representing any goal in itself. Without having any distinct culture, it might, for example, be easier for the Skunkworks unit to meet and discuss with the Parent organization on an equal basis, avoiding the risks put forward by Schrage (1999) of forming a basis for elitism [34].

Regarding the relationship with the Parent organization, Burgelman (1985) highlighted the career opportunities and the financial backup as two mutual benefits [4]. In the Bluetooth case, the career attraction (i.e. recruiting persons that would not otherwise have been interested in Ericsson) has not been evident. The financial backup is though a strength for the Skunkworks unit, providing over 100 persons work on a technology that so far has not yet created any revenue streams of any magnitude. Moreover, what is also evident in the Bluetooth case, from the Skunkworks unit's perspective, is the benefits of using the prominent Ericsson name – giving valuable credibility and enabling the SIG companies to join such an initially hazardous business. The Skunkworks unit has also had the opportunity to borrow experienced engineers and to get advice from the large Ericsson body, though initially being hindered from recruiting new employees due to a general temporary prohibition. From the Parent organization's perspective, the ability to form new structures to deal with new technologies provides a potentially sustainable working method to rapidly get up to speed, and not to forget to search for new business values outside the traditional areas of expertise.

6.2. Immediate Global Intention – Technology Development Speed

ECS' and the PU Bluetooth unit's actions towards technology development speed have been critical, both in getting up to speed and rapidly reaching a global breakthrough. They also represent new experimental ways of working.

The strong vision has been vital for providing a common goal and continuous direction, both internally within the Skunkworks unit and within Ericsson as well as among the SIG promoters and adopters. Previous

literature states that having a strong vision is important. This is though not very enlightening. To be more precise, based on the Bluetooth case – it seems, as having not only a strong, but also a framed, constrained vision is a key to success. The vision of working towards a one-chip solution was acknowledged by the management as worthwhile work, whether it led to a specific successful project or not. However, from the very beginning, the researchers at ECS faced both challenging cost constraints and constraints in the form of cutting two specific cables, but not all cables – just the ones between the mobile phone, the headset and the PDA. By highlighting the cost issue, the researchers are immediately forced to consider the production tasks as well. Finally, the globally adopted Bluetooth vision definitely played an important role in directing the technology development efforts.

The creation of a new, dedicated unit to deal with the Bluetooth technology clearly represents an important milestone. This action enabled the group to rapidly get up to speed and to gain focus. At this time, they no longer had to rely on borrowed resources; they could now start to recruit the people they needed. The formation of a new unit was also a way for the management to protect and legitimize the business. It was though also a way to open up for new business opportunities, realizing that the potential might be larger than just the mobile phone side. If the technology development would have been kept within the Parent organization, the fear was that the group would not have the power to seek out new opportunities and thereby risk being snatched to solve today's problems as well as to lower the technology development speed.

The staffing of the new unit signifies a different approach compared to the literature recommendations. Previous literature has highlighted the benefits of having people stay with the technology from 'cradle to grave'. In the Bluetooth case however, some of the involved researchers went on to new challenges (though staying on as advisors). Though, the most interesting approach is the way the Skunkworks unit recruited persons to technology development. They were recruited from product development of phone accessories, a very product focused part of ECS, bringing the market clockspeed to the research efforts. They brought in product people into the research efforts to speed up the technology development. The argument was, among others that they knew what it takes to get out to the market. They also chose a relatively large percentage of fresh employees, both intentionally and for practical reasons. This was also seen as an important factor to get the technology going, since these persons did not have any former assignments requiring their attention. However, the need for a technology champion in a project leader-like position was called for. This could be related to the strive for conceptual integrity, i.e. having one person responsible for the system as a whole, frequently interacting with the subgroups and functioning as a second project leader focused on the technology interface.

The next step affecting the technology development speed was the formation of the SIG group. Ericsson could have developed this technology faster internally but, with a global aim, this was not considered an option. To base a global (de facto) standard on market shares of involved companies clearly presented a very fast route (apart from going through any formal standardization body). The bandwagon effect, or as Kardach termed it, the Rabbit theory, resulted in a rapid increase of companies supporting the forthcoming standard. The incentive for joining the group was strong, especially with the open IP concept. Working with Bluetooth technology and not being a part of the SIG group could be unnecessarily expensive. According to Shapiro & Varian (1999), standard wars are especially bitter and at the same time crucial to the business in markets with strong network effects [35]. This is certainly the case in this setting, but war seems to be avoided due to the pursuit of the open IP standard and the cross-industry commitment.

Additionally, the SIG group provides a forum for vendor interaction and co-development opportunities. Moreover, the open IP concept was also important for how the internal work was carried out within the SIG promoters. ECS and Intel noted that the sharing of ideas and striving for the best solution, no matter whose idea it originally was, was strongly promoted in this setting – easing rapid technology development. Hence, open IP could be seen as a way of overcoming Not-Invented-Here syndromes in collaborative settings and of reducing the uncertainties reported by Norén et al. (1992), when studying a similar standard creation setting involving several firms [28].

The creation of the SIG also enabled some inter-industry transfer of good practices, facilitating technology development speed. While the computer industry had been used to work in special interest groups and brought that knowledge into the formation, the communication industry brought knowledge about setting up qualification procedures for the adopters. One example of this is the interoperability tests aimed at solving underlying problems. This practice actually spread also outside Bluetooth, when the USB-IF 218 was using a similar compliance procedure.

18 USB (Universal Serial Bus) Implementers Forum, Inc. is a non-profit corporation founded by the group of companies that developed the USB specification. The promoters are Compaq, Hewlett-Packard, Intel, Lucent, Microsoft, NEC and Philips.

6.3. Knowledge Re-Integration Efforts – Use of Bridging Mechanisms

The term integration has proved too loose and static when analyzing the Bluetooth case; a more precise term indicating the dynamics, suggested by the author, would be re-integration. Re-integration represents the attempts at transferring foremost the technology back to the Parent organization to be incorporated in the products, either pro-actively or in response to direct technology implementation needs. The re-integration approaches used in the Bluetooth case have, according to Roberts' (1979) general taxonomy, mainly been focused on the Procedural and the Organizational bridges and less on the People approach in the traditional meaning [33].

The People approach (such as moving experienced engineers from the Parent organization to this new unit) was especially difficult due to the already existing high pressure on the Parent organization in combination with the constant lack of enough experienced engineers, indicating this approach to be less practical in this setting. However, a refinement of the People approach was used in a new innovative, and as reported by the interviewees also successful, manner. This was done when product people were brought to the unit prior to commercialization of the new technology, sharing their mindset and experience of frequently launching new products. Another way of integrating and coordinating the work between ECS and the external partner Intel was tried by placing one Intel employee at the ECS site for a period of two years.

As for the Procedural approaches, two different forms of integration committees were set up, the Bluetooth Technology Council and the Bluetooth Technology Review (Figure 10). This approach is a refinement of Burgelman's (1984b) suggestion of using steering committees [3]. The Technology council is the one most similar to Burgelman's concept of steering committee, where representatives from both the Parent organization and the Bluetooth unit are present. However, that committee is more targeted at the management level and deals with management of the Bluetooth unit, hence an information forum for mainly engineers and project leaders was also initiated – the Technology Review. In this case, the logic and the way of organizing in the Parent organization were reflected and mirrored in the Bluetooth unit. Viewing the re-integration and coordination challenges more externally, the whole de facto standard creation process could be seen as a Procedural mechanism. This process aims at tying the efforts of the involved companies together to achieve the goal of global adoption. This could also be said about the seminars, adopter conferences, and use of the web site.

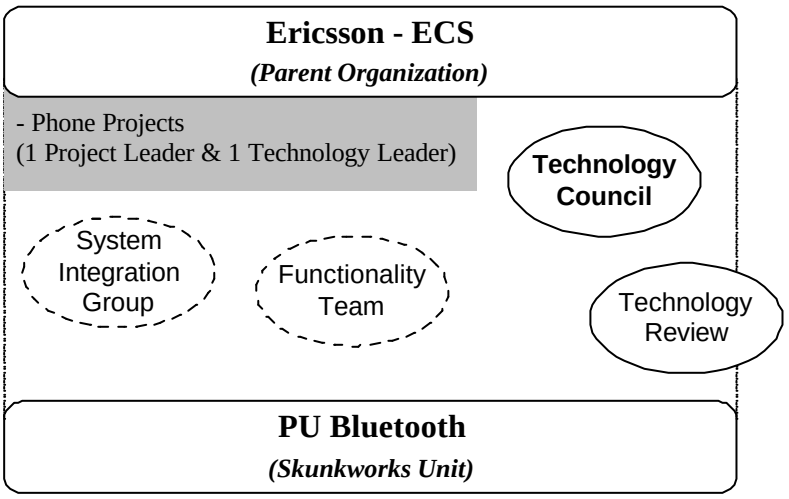

Figure 10 Examples of internal integration mechanisms between the Parent organization and the Skunkworks unit.

The Organizational approaches chosen have mainly come from the targeted projects within the Parent organization (Figure 10). This is apart from the creation of the SIG group, which in some sense could be seen as an Organizational approach toward inter-firm integration and harmonization. The internal projects proactively set up one System integration group focusing on potential integration problems and one Functionality Team, ending up with merely auditing the Bluetooth specification and giving valuable insights from the phone project's point of view. One lesson learned from those temporary re-integration groups is that

the output needs to be clearly formulated, avoiding task creeping and providing a clear direction. Moreover, despite having these structures in place, many Skunkworks unit engineers are still not continuously updated on the phone project's progress and changes; it is too often assumed that they already know everything.

When studying the Bluetooth case, a fourth integration category appears that adds to Robert's earlier bridges [33]. This fourth category could be termed a 'Mindset' mechanism and refers to the aim to integrate the work between different functions, whether they operate within the Bluetooth unit or externally, by using compelling statements. For example, in the Bluetooth case, the concept of 'engineers without borders' was formed to facilitate cross-functional discussions and involvement, clearly indicating that those kinds of efforts are actually expected from each individual engineer. Another example is the concept of developing 'Technology products', highlighting the commercialization aspect.

Further, analyzing the specific, though aggregated, suggestions of Tushman & O'Reilly (1999) in the case of Bluetooth, a more detailed view crystallizes [41]. Ericsson has not yet fostered a company-wide re-invention based vision. They have, however, developed a strong persistent vision for the new unit that has been accepted and adopted company-wide and beyond. Perhaps, this strong vision is powerful enough to provide at least this new unit with enough protection and legitimization to thrive. As for the second proposed mechanism – consistent top management support – it could be noted in the Bluetooth case that Dr Rydbeck and his personal reputation and commitment have had a great influence. The understanding of working in dual structures and the protection can be attributed to Dr Rydbeck alone. However, considering the time line, this is likely most important in the start-up of the new unit, when it is most sensitive. As for now, the Bluetooth unit has proved such a success that the need for protection and legitimization has decreased. Finally, the third and most fuzzy mechanism proposed – the healthy team processes – has been approached in an interesting manner. Two different layers can be identified, the creative, visionary management layer and the implementation focused, more down to earth, layer.

Summarizing, it can be concluded that the knowledge re-integration efforts have taken several different forms and that the Bluetooth unit's working methods in a sense could be described as novel and experimental. Further, the term re-integration was introduced, representing efforts aimed at transferring knowledge, gained from development of new technologies in a Skunkworks-like unit, back to the Parent organization, either explicitly in an implementation effort or implicitly as a way to leverage the lessons learned.

6.4. Dynamic Differentiation & Integration – A New Perspective

The traditional view of differentiation and integration is usually discussed within a certain static context. However, the Bluetooth case suggests a much more dynamic view of differentiation and integration, introducing the time factor and related different needs of the evolving Skunkworks unit as influential forces.

In the beginning of the Bluetooth technology, the work was still visionary and consisted mainly of internal, dedicated integration efforts and proof of concept work (Figure 7). As the technology concept crystallized more and more, the differentiation and global aim actions began. Several other companies were contacted in the pursuit of appropriate partners for developing this technology, thereby extending the use from just the mobile phones. These differentiation efforts were accentuated with the creation of the SIG 1 group and the tremendous number of subsequent adopters. However, after the specification 1.0 was released, the race towards the market really took off. The rules were all set, and the prize of being the first to reach the market with a Bluetooth product was prestigious. This resulted naturally in a more inward attitude, focusing on technology development speed. This cycle (see Figure 7 & Figure 8) might change due to the formation of the SIG 2, again enabling a more outreach approach. This represents a tough challenge. No Bluetooth product has yet been released, but substantial commitment is required for the development of specification 2.0 while at the same time introducing the new promoters to the working methods and concepts of the promoters. The future of the SIG group is also interesting. The SIG 2 could currently just as well be representing a company in itself. There have also been some internal complaints about the efficiency in developing standards; text contributions were made from persons rather inexperienced in writing standards. One possible future direction that has been discussed is to hand the standardization process over to a professional standardization body. One could ask if the initial intention has already been fulfilled via the current global acceptance, and if the maintenance of the standard could benefit in the future from being handed over.

Summarizing, the traditional view of a static balance between differentiation and integration is of no value when viewing the Bluetooth case. Instead, a more dynamic view, taking the time factor into account and considering the contingent needs of the individual unit, emerged.

7. Bluetooth Summary

The presented and analyzed Bluetooth case offers both insights into the complexities of evolving into an ambidextrous organization and lessons learned regarding technology development and promotion.

The case contributes to the academic scholarship in several ways, foremost in the above-mentioned detailed study and analyses of the evolution of dual structures. One example of a strategic action taken by the Skunkworks unit was to staff the new unit foremost with people from the outside or from the product side. This enabled not only the time-to-market drive from the product people, but also adding people with clean desks ready to solely work with the new technology, thereby avoiding the dilemma of being snatched to solve today's problems. However, as has been predicted in the literature, some integration problems appeared. The Bluetooth re-integration strengths lay in the different kinds of refined procedural approaches. The term re-integration and examples of mechanisms used were introduced, representing the efforts to re-integrate knowledge into the Parent organization. For instance, a new type of bridging mechanism was conceptualized, i.e. the 'Mindset' mechanism, referring to intentionally introduced concepts aiming toward functional integration (e.g. 'engineers without borders').

Moreover, the highly theoretical recommendation for the new unit to go for a counter-cultural approach was not evident in the Bluetooth case. Potential implications might be easing the re-integration efforts and avoiding Schrage's (1999) fear of fostering elitism [34]. Other questions also arose. The concept of competitors' time to imitation is traditionally seen as something bad, but in this context it was actually not only aimed for but also actively facilitated.

As for the more managerial lessons of the Bluetooth case, it seems to be beneficial to create not only strong, but also framed, visions by, for example, adding the cost complexities. Other 'Bluetooth Principles' have involved the planning for immediate global diffusion, rapid technology development by using a new dedicated unit, and mutual efforts from the Parent organization and the new unit toward re-integration. One example is the beneficial effects on the working environment when operating under the open IP paradigm, i.e. moving from a defender position to a joint strive for the best solution – no matter whose idea it originally was. Working with a cross-industry effort, this way not only enables transfers of best practices and functions as integration mechanisms between companies with similar interests but also raises questions of value to the Parent company. It seems also to be a delicate issue to decide when to open up and share technology with others. The appropriate support organization needs to be in place once started, and at the same time the companies approached ought to have a fair chance of catching up and influencing the evolution.

The challenge ahead lies in managing the dynamics within a Skunkworks project, but also avoiding making the Bluetooth case a single happening, i.e. to put systems in place to continually evaluate the need for a dual approach. Potential futures might be to re-integrate not only the technology, but also perhaps the whole unit, representing a more dynamic and broader view of differentiation and integration as presented around the four scenarios in Figure 1.

8. Discussion and Outlook

By creating the new dedicated unit, ECS truly fostered experimental working methods. New business logics have been tried out, for example, the emphasis on early technology marketing, the trademark exposure through 3rd level parties, working with an open IP policy, providing reference designs, selling licenses, and trying out new channels. For example, one interesting implication from the Bluetooth case that somewhat contradicts earlier research is Ericsson is striving for rapid imitation of other companies in order to increase the value of its Bluetooth enabled phones (network externalities). Zander & Kogut (1995) discuss the competitors' ability to imitate products or manufacturing capabilities as something unwanted and not desired [46]. They also claim that the time to imitation should be kept as long as possible, while at the same time trying to speed up the internal transfer between different company sites as much as possible. Kogut & Zander further measure the time to imitation with two dimensions; degree of codification and teachability. However, in the Bluetooth case, imitation is actively encouraged in both dimensions (e.g. through codifying the specification, and through offering seminars). Though, trusting the internal capabilities to be sufficient when trying to be the first to hit the market with a Bluetooth product.

There are further some strategic considerations that appear when viewing the Bluetooth case using the four proposed scenarios in Figure 1. The dead end scenario where the business is not found viable and where the unit is consequently dissolved is not seen as likely in the Bluetooth case due to the high industrial commitment

and momentum. If a major setback would occur that would lead to dissolving the unit, several critical tasks would naturally follow. For example, new positions within Ericsson would need to be found for the over 100 persons currently engaged (and in this situation probably feeling less motivated), a major information campaign explaining the move would need to be made, etc. The more positive scenario might be when the Skunkworks unit succeeds to an extent where the business model and the working methods of the unit end up remaking and replacing the mainstream business. There is also another minor version of this scenario where the one would imagine that the Bluetooth chipset would be a commodity in all mobile phones in the future, which might lead to the incorporation of the Skunkworks unit with the Parent organization. The Skunkworks unit would then function as any other department. Considering the large potential outside Ericsson's current core business, this is though not a likely approach in this case. The third scenario deals with what would happen if the Skunkworks unit at this stage went for an IPO (Initial Public Offering). This scenario would truly provide the unit with resources to invest more heavily in the new technology and at the same time provide Ericsson with a potential exit strategy, or at least with some financial injections. The question is not easy to handle: When has the Parent organization played its role? And who are actually discussing those potential pros and cons?

Finally, the last scenario, the current Skunkworks unit's re-integration mode, enables rapid technology development but places on the other hand tougher demands on the re-integration mechanisms used. The Skunkworks unit has faced several related challenges and decisions with this approach. One important choice was the recruitment of relatively fresh employees who almost immediately had the chance and responsibility to represent Ericsson on a global basis. Regarding the active responsibility for the system as such, the Skunkworks unit might benefit from having a dual project leader structure, where one focuses on the implications between different function groups if a certain parameter is changed – or more simply put, a technology champion in an operative role. As for the internal integration, it would have benefited from earlier and more internal marketing of the technology. ECS though responded and set up two temporary groups to deal with the new technology. One related alarming issue is that the key area that the System integration group worked on has since then been left unnoticed. This highlights the need for a more sustainable group than a single project focusing on new technologies and their integration. Especially, since there is evidence in place that the integration of new technologies in the telecom industry is increasing rapidly.

Another example of challenges common for the scenarios based on using separated units is the need for appropriate procedures in order to utilize the internal side-applications and potential technology spin-offs. These side-applications might occur within the Skunkworks unit, but might not fit in with the current race or strategic direction of that unit. There is a risk that those side applications could prove very valuable in the long run, but the Skunkworks unit is currently under high pressure and might not have the time necessary to investigate. One way of solving this could be to clearly appoint one group, for example, the concept development group at ECS, to handle these kinds of efforts – and to communicate this thoroughly internally.

Following the line of ambidextrous organizations, what would it take for a company like Ericsson to form new structures, such as the Skunkworks unit, in a continuous effort? The next new technology might not have such a strong indisputable vision as Bluetooth. A more appropriate approach in the long run might be to aim for the company-wide re-invention concept. Further, most likely, the approach needs to have a broad top management acceptance and, moreover, the issue of organizational structures needs to be a common discussion on the board meetings to actually form a continuous basis. Issues that need to be dealt with on a high level are the degree of exceptions accepted within the organization as a whole. For example, should new units in critical phases be prohibited from recruiting new employees by a general decree? Or, would that create too many internal disturbances and foster elitism? The first attempt has already been taken; one similar structure has been set up within ECS based on open IP and working towards a de facto standard regarding secure mobile electronic transactions (e.g. Ericsson, Motorola, and Nokia's Mobile E-Business cooperation, announced April 11, 2000).

Moreover, the concept of ambidextrous organization based on the dual structures can, and recently has been, questioned. Nadler & Tushman (1999) refine the original ambidextrous organization by claiming the need for polydextrous organizations, i.e. organizations that can create and handle multiple divergent internal structures [27]. They do not, however, state any different structures than the ones mentioned earlier. This seems to make sense; at some point though the concept loses its strength and its explanatory power.

As for the more dynamic view of integration and differentiation, managers with a good process knowledge could benefit and proactively move accordingly, managing and being prepared for both differentiation and integration tasks. This is especially important, as those tasks might require different sets of skills and approaches, and as the dominant internal view seems to exchange the external strive in a fast cyclical manner.

This paper represents one case study, and while conclusions drawn require healthy caution, valuable insights into the evolution and the related strategic actions have been provided. Summarizing, the Bluetooth case represents a cross-industry fertilized strategy for managing new technology in a demanding, growing

industry. It further illustrates the setup and evolution of a dual structure, as well as the re-integration efforts taken. Finally, the case highlights managerial technology dilemmas, where speed of development and transfer is essential.

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