Implementation of Synchronization Process to Coordinate R&D and Product Planning Using Technology Roadmapping Tool

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Abstract--**This paper discusses product planning processes in manufacturing companies that coordinate workflows between fundamental research and product planning activities that are conducted on different timescales and have different roles and motivations. The author's research group developed a reference model called "Synchronization Process (SP)" in 2014. The paper presented at PICMET '15 demonstrated how the SP model worked and also presented a specific case in step-by-step sequences using a technology roadmapping tool to enable discussion in a visual form.**

The objective of this paper is to discuss how the SP model can be implemented in organizations that accommodate a wide range of technologies and potential applications. This paper introduces shared knowledge pools called a "Gap Table" and an "Awareness Map" in order to systematize the SP model and enable a combination of technologies and expected applications to be identified. These pools indicate the potential solutions and classify them by difficulty or uncertainty based on the current business position of the company. The design of these pools is based on the actual product development history of mobile phones for elderly customers. The contribution of this paper is to introduce a scheme to match technologies and applications in large-scale companies.

I. INTRODUCTION

In the information and communication technology (ICT) industry, the product-planning process is becoming much more complicated, especially for manufacturing companies. This change is due to the rapid acceleration in the performance of various technologies [1][2], as well as their increasing complexity, which also increases their importance.

In this situation, well-known classical innovation process models such as the Linear Model [3] and Klein Model [4] no longer seem effective for capturing and managing the actual workflows conducted in manufacturing companies. The major reason for this is that the product value has become more diverse and more complex. Consequently, this is a challenge faced by the manufacturing industry.

The author's motivation is to establish a process to coordinate the fundamental research phase and the product planning process in a manufacturing company in the ICT industry. In earlier work, the research team the author belongs to proposed a reference model called the "Synchronization Process (SP) [5]." In this paper, the coordination among departments is referred to as "synchronization."

The research on the SP model has been reported in two phases. The first paper, presented in 2014, reported the SP model through an investigation of the product development history of a competitive product to reach new markets. The SP model was supposed to be an intermediate function between the fundamental research and the product planning. The model was composed of blocks consisting of knowledge pools and decision processes, which were extracted from case investigations of Fujitsu's mobile phone product intended for elderly citizens [6]. The second paper, presented at PICMET'15, demonstrated how the development was conducted along with the SP model. As the analysis methodology, the paper introduced a technology roadmapping (TRM) tool called Innovation Architecture (IA) [7], which was used to visualize and analyze the cases. The author began the research analysis for the strategy using a TRM tool in 2008 and presented papers at PICMET '09 [8], PICMET '13 [9], and PICMET '15[7] and published the research in an international journal [10].

The goal of this research is to compose an SP model that is operable in actual development projects in manufacturing companies. However, there were several limitations in the earlier work. The SP model was composed based on the "success cases" in organizations that have highly talented researchers and engineers who bring exceptional and innovative ideas to achieve the products' new features. In general cases, we have to conduct projects without expecting as many "visionaries."

This paper is organized as follows. Section II describes the limitations and challenges of the original SP model. Section III introduces the methodologies for revising the original SP model using IA and the future insight program called Scan. Section IV discusses the steps to build the SP so it is operable in large-scale organizations. Section V presents some discussion points, and section VI is the conclusion.

II. THEORIES

A. Reference Models of Synchronization

Fig. 1 illustrates the Synchronization Process (SP) model presented in 2014 [5]. This model was composed of function blocks defined by observing the actual development history of mobile phone product development.

The details of the components described in Fig. 1 are as follows.

- Generalized Technologies (GT): Features of technologies described at a "scientific level"
- Product Requirements (PR): Concrete requirements or specifications for a product
- Matching (M): The decision-making process
- Human Capabilities (H): The practical driving force of the synchronization process, which includes the capabilities of researchers and engineers, as well as knowhow and implicit knowledge

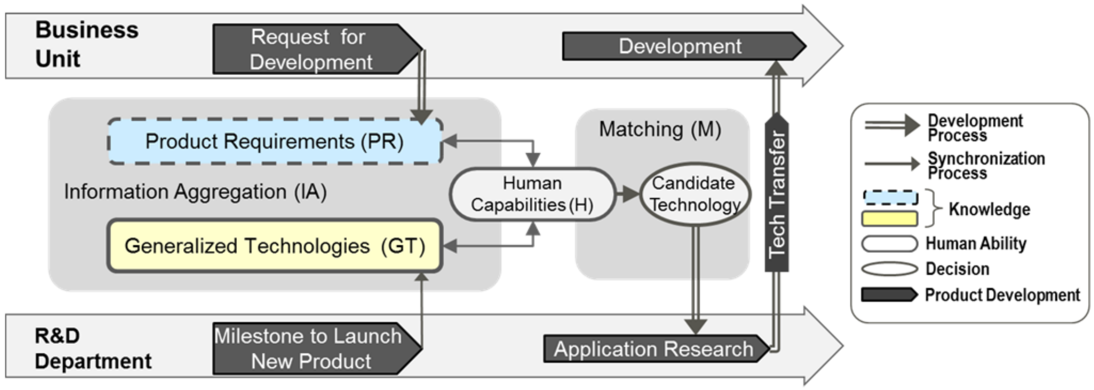

Fig. 1 Synchronization Process (SP) Model [5]

The R&D department and the Business Unit operate on different time scales (product cycles or development periods) in their workflows, even within the same company. With such different processes, these departments try to identify common ground on both a time scale and in the value of technologies in each workflow in order to create and release a competitive product on the market at the ideal time. Deep insights are sought and decisions reached that span both departments in order to identify the "synchronization" points in timing and/or technologies and/or applications. The Product Requirements (PR) and the Generalized Technologies (GT) indicate this knowledge.

The subsequent paper presented at PICMET'15 demonstrated how the SP model was applied in the actual development history of a mobile phone. The paper traced how the fundamental research and product planning were coordinated in step-by-step sequences.

B. Limitations in the Reference Model

In general cases, R&D activities and product planning proceed along with the well-organized and documented product development plans. However, the achievements in the successful case studies of mobile phones included opportunities that happened by accident. Under the business environments that companies change at a real-time speed, it is not easy to identify the optimal synchronization timing or to determine the advantages and disadvantages in technical requirements and market trends. This is reflected in the SP model, which had the following limitations.

Issue 1: Dependence on individuals

The GT and PR knowledge pools are defined by extracting the behavior of key contributors who led the project to a breakthrough. Unfortunately, not all organizations accommodate such employees demonstrating an exceptional standard of behavior. This tendency might be especially true for traditional companies.

The previous paper concluded with a proposal to establish an educational program such as on-the-job training (OJT) in the strategy-planning departments or to implement job rotation among departments to obtain various viewpoints. However, education for selected individuals would take a long time. We should therefore establish more systematic ways of finding new business opportunities and avoid an over-reliance on individuals.

Issue 2: Explosion in size of needs-seeds matrix

A basic approach to examine pairs of technologies and applications is a simple "needs-seeds matrix [11]," which is a table containing the possible combinations of technologies (seeds) and applications (needs). In the accelerating technologies and markets described earlier, the size of the needs-seeds matrix increases at an explosive rate. For example, the recent development of artificial intelligence (AI) has rapidly expanded the application areas for computers; sometimes AI is even expected to compete with humans [2]. These changes have a significant impact on the current workflows of product planning departments in how new products are identified from a needs-seeds matrix. We should therefore seek strategies to improve the efficiency of finding new targets in order to keep up with the expanding needs-seeds matrix.

Issue 3: Organizing "Obeya" meeting

Large-scale companies are involved with a wide range of technologies and products to meet the requirements of customers and society. This seems to be an advantage for the first two issues described above. However, there can be limitations. Sometimes new products are planned through a long-term relationship between particular departments in a company. Some departments organize *Obeya* style meetings among organizations. *Obeya* is a Japanese word meaning "large room" and was first applied in this way by Toyota Production Systems [12][13]. The benefit of an *Obeya* meeting is to share the context of discussions among a wide range of stakeholders in one room at one time. Even in the traditional atmosphere, though, the successful cases (of mobile phones) included several exceptions that happened that were not documented or planned. To build a process to identify solutions in the expanding needs-seeds matrix in a systematic way (avoiding individuals), we should develop a new meeting style.

C. Strategies of Flexible Obeya Style Meetings

The goal of this paper is to build a common knowledge pool to promote the establishment of an *Obeya* style meeting among various types of departments in a large-scale company without requiring complicated procedures or formal negotiations, which impede organizational management. The strategy to build knowledge pools equivalent to GT and PR is expected to help prevent an overreliance on individuals.

III. METHODOLOGIES

A. Analysis Using Technology Roadmapping Tool

A technology roadmapping (TRM) tool is introduced here in order to discuss the application of SP from the perspective of management. TRM tools were originally developed in the electronics industry in the 1980s [14]-[16]. TRM tools make it possible to analyze and discuss the product planning process by visualizing the knowledge and capabilities of a company.

As the TRM tool this paper utilizes Innovation Architecture (IA) [17][18], which was proposed by Prof. Hugo Tschirky at ETH Zürich. IA serves as a communication tool for discussing strategies shared among departments that have different roles in order to create competitive products and services. Businesses cannot achieve innovation or huge successes with competitive technologies alone; they also need a business environment that factors in product plans, business systems, and market trends. A company also has to ensure harmonization among departments such as R&D, finance/accounting, marketing, and procurement. IA and other TRM tools can be a common and visual language to achieve such consistency.

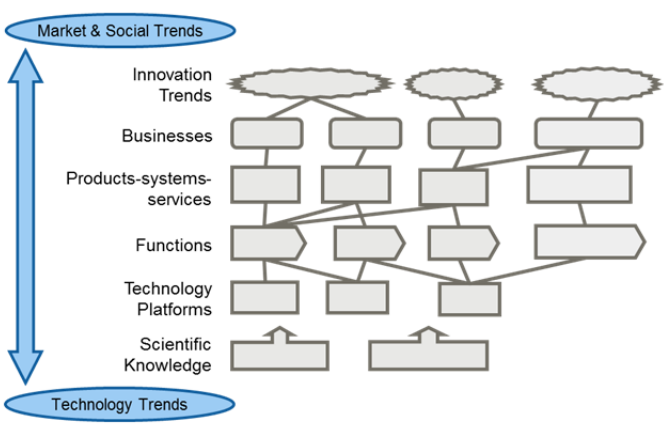

Fig. 2 Basic structure of Innovation Architecture

The typical structure of IA is shown in Fig. 2. A segment of IA provides snapshots of a project's status by combining core technologies and scientific knowledge, business systems, and promising market trends. IA consists of technologies and business resources that are classified into six levels, from bottom to top: Scientific Knowledge, Technology Platforms, Functions, Products-systems-services, Business Systems (Businesses), and Innovation Trends. The lower layers address the technology aspect, and the upper layers address market or social trends.

IA enables participants to discuss the questions "Where did we come from?," "Where are we now?," and "Where do we go from here?"

B. Implement Knowledge Pools

This paper introduces "shared knowledge pools" as a way of implementing the knowledge pools Generalized Technologies (GT) and Product Requirements (PR). The formerly defined GT and PR in the SP model are presumed to contain explicit and objective knowledge, comprising, for example, calculable data and/or fully described requirements and specifications. However, a database containing "calculable" knowledge to measure competitiveness is not feasible in terms of cost to build, operate, and maintain company-wide. In the author's experience, a new product idea that might lead to innovations in the company would not be calculated using a database, but rather, would simply flash into an employee's mind. The content of the knowledge pool is discussed in the next section through the case themes.

The case analysis discussed in the next section reveals that business plans are arranged based not only on the official information shared inside the company, but also sometimes on unofficial information that leads to a breakthrough. According to the author's observations, there are three kinds of arrangements.

1. **Documented**: formal information such as a finalized business plan
2. **Hidden or undocumented**: intentionally or unintentionally concealed activities in each organization
3. **Unaware or uncertain**: uncertain arrangements or lack of knowledge of significant trends.

A small number of visionaries in a company would generally create or handle the Undocumented or Unaware information to develop a novel product plan.

This paper also introduces the Scan™ service, which is an interactive future insight program provided by *Strategic Business Insights Inc.* [19]. Scan provides customers with several types of reports and discussions organized by experts. At Fujitsu, there are two benefits from using Scan. One is that Scan provides customers with report sets called "abstracts," which might include information on the common background knowledge in a company as well as information on worldwide events that indicate signals of change as well as specific insights. The other benefit is that the company receives a standardized worksheet of the outcomes of Scan discussions to share across the organization. Employees who join Scan discussions are able to find "common patterns of change in the market." These patterns are expressed in "clusters," which is a table-style worksheet that indicates descriptions of potential new fields, even those the majority of the people in the company may not yet be aware of. The accumulated clusters visually express areas of potential opportunity, which may have a huge impact on the company's next strategy.

C. Outlines of Case Themes

To discuss the requirements for revising the SP model, this paper uses a case study consisting of the product development history of one of Fujitsu's mobile phones. The story was originally presented in the former paper [5], but this paper also refers to it in order to discuss it from the viewpoint of "aware" or "unaware."

Fujitsu started the product planning of mobile phones specialized for senior citizens in around 1998. At that time, however, the mobile phone market was expanding in the younger generation segment. The majority of employees in the company insisted that resources should not be invested on creating a specialized phone for senior users. Instead, they thought the product should be considered as a "subset," with essential components taken from the mainstream line for younger customers, in order to avoid risks. Through in-depth investigations and discussions, the planning team selected three core concepts: ease of listening, ease of looking at (e.g., numbers and letters are easy to see), and security (for personal health and safety, or other factors). These core concepts were selected for use over the long term in the new category of cell phones for senior users [20].

The following sections trace the product development history of motion-sensing technology involving the *Raku-Raku* Phone (product name) designed for senior customers [6]. The analysis is described based on published information; however, several details include the author's estimations.

IV. RESULTS OF ANALYSIS

A. Case Study: Development of Motion Sensing Technology

Motion sensing technology is a key feature of mobile phone and smartphone handsets today. Fujitsu's mobile phone and smart phone handsets are equipped with Fujitsu's proprietary three-dimensional (3D) motion sensors, which are key elements of the "Human Centric Engine (HCE)" [20] that captures and digitizes a user's activities, for example, exercise or sporting activities such as playing golf or running. HCE may also record information beneficial to personal healthcare applications.

The original plan for this technology did not include using it in mobile phones. The technology was originally developed as the core feature of HOAP-1, Fujitsu's humanoid robot released in 2001 [21]. The unique algorithm that supervises the motion of the humanoid robot was derived from self-learning algorithms that were inspired from biological nervous systems that could be described using mathematical models.

Stage 1: Identifying Gaps between Departments

The first generation of the Raku-Raku phone was equipped with a pedometer, which was a function based on a third-party company's technology. The situation at this stage is represented in Fig. 3. The capabilities and knowledge of the R&D team were represented as the elements "Control Theory (A1)," "Algorithm (A2)," and "Posture Control (A3)." These three elements represent the accumulated knowledge of motion sensing and control technologies. At this stage, the R&D team was working to commercialize the humanoid robot HOAP-1 (A4) in the Product-Systems-Services layer, and thus, commercialization was the "Robotics Industry (A6)" goal in the Innovation Trends layer in Fig. 3.

At this stage, the R&D team was concentrating on commercializing the humanoid robot, and there had not been any particular relationship regarding the use of technologies between the R&D team and the mobile phone BU. There were "gaps" in the potential requirements and solutions between the departments.

At the same time, the R&D team was (presumably, unofficially and internally) exploring potential and alternative applications for these technologies other than in conventional robotics. The R&D team might not have been confident about their idea of expanding the use of the technology and so might have been thinking about applying the technology to other applicable areas. In the actual situation, both departments were unaware of the complementary value toward each other. The mobile phone BU was not aware of the technology in their product plan.

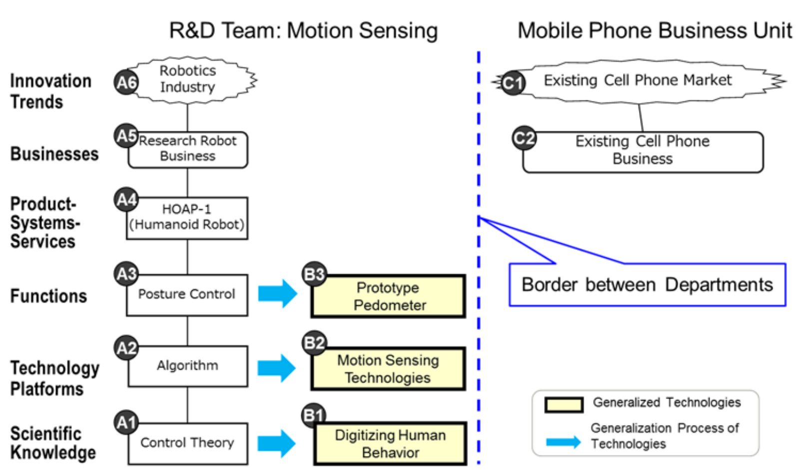

Fig. 3 Stage 1: Unmet needs and seeds (based on [7])

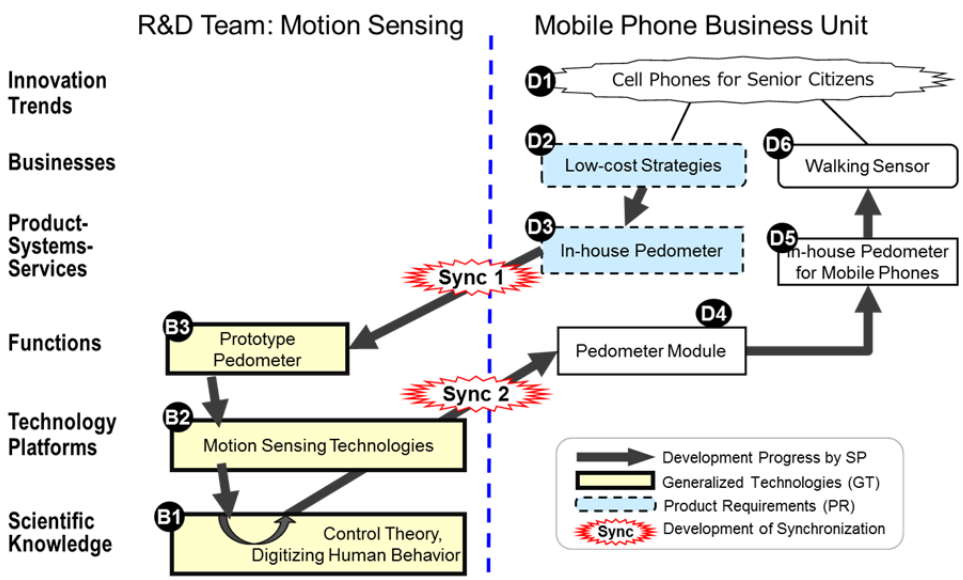

Fig. 4 Stage 2: Development of the in-house pedometer (based on [7])

In Fig. 3, the elements "Digitizing Human Behavior (B1)," "Motion Sensing Technologies (B2)," and "Prototype Pedometer (B3)" represent the modified technologies that are assumed as new application areas. These technologies (B1, B2, and B3) were linked with the mobile phone business in the Fujitsu elements "Existing Cell Phone Market (C1)" and "Existing Cell Phone Business (C2)."

Stage 2: Filling Gaps to Create New Product

At this point, a potential need for an "In-house pedometer (D3)" emerged from the mobile phone BU (Fig. 4). The BU started a new strategy to expand the market of "Cell-Phones for Senior Citizens (D1)" at the Innovation Trends layer in Fig. 4. The BU started investigating the candidate technologies inside Fujitsu across various departments; those are applicable to the "In-house Pedometer (D3)" based on the "Low-cost strategies (D2)" policy at the Businesses layer. The BU was not aware of the other functional value of the technology at the time.

The First Synchronization:

The breakthrough leading to commercialization was initiated by the BU when it was seeking candidate technologies inside the company and encountered elements D3 (In-house Pedometer) and B3 (Prototype Pedometer). Through the investigation, one of the key persons in the BU came across the in-house technology of the R&D team and immediately evaluated the prototype and approved it for commercialization in 2006 as a "Walking Sensor (D6)" at the Businesses layer in Fig. 4.

The most significant step that resulted in the commercialization was an idea the R&D team created for the "Prototype Pedometer (B3)" at the Functions layer. They redefined the original role of the algorithms, which was to sense the motion of robots, elements A1-A3, to "sensors that identify and digitize human behavior."

This result is marked as "Sync 1 (the First Synchronization)" in Fig. 4.

Stage 2 in Fig. 4 contains two "Syncs" in the IA, in which the gaps between the activities of the two departments were filled. This synchronization of departments was conducted because of unplanned decisions and accidental situations. As a success case, the gap was filled by visionaries in both departments. In this stage, both the R&D team and the mobile phone BU were concentrating on their respective activities. As mentioned, however, there were gaps between the activities of the two departments.

The intentions in each organization are summarized in Table 1. In this stage, both the R&D team and the mobile phone business unit were concentrating on their own activities, and there were gaps between the activities of the two departments.

TABLE 1 GAPS IN INTENTIONS IN THE FIRST SYNCHRONIZATION

	R&D team	Gap	Mobile phone Business Unit
Documented	1. Commercialization for robotics industry		1. Cost-reduction to replace existing pedometer
Hidden / Undocumented	2. Potential new fields	Sync1	
Unaware/ Uncertain	3. Application for mobile phones		

TABLE 2 GAPS IN INTENTIONS IN THE SECOND SYNCHRONIZATION

	R&D team	Gap	Mobile phone Business Unit
Documented	1. Seeds of motion sensor 2. Release schedule	Gap	1. Needs for in-house motion sensor 2. Release schedule
Hidden/ Undocumented	3. Potential needs for motion sensor 4. Knowledge for posture detection and control	Sync2	3. Future business with this technology
Unaware/ Uncertain	5. Other potential application value		4. Additional value for the in-house motion sensor

In Table 1, the visionaries (distinguished researchers or engineers) connected the “Documented” intention in the mobile phone BU (right side) with the “Unaware” intention in the R&D team (left side) to realize the first generation in-house pedometer in Fujitsu’s mobile phones.

The Second Synchronization:

In the product development process in the BU, the R&D team and the BU worked on their process to tune the algorithm for the pedometer in “Digitizing Human Behavior (B1)” to apply it to cell phones, which is represented in the “Pedometer Module (D4)” at the Functions Layer. As a major step in this stage, the R&D team completed development of the pedometer, indicated as “Pedometer Module (D4)” in Fig. 4, customized it for mobile phones, and achieved the “In-house Pedometer for Mobile Phones (D5)”.

This consequence is marked as “Sync 2 (the Second Synchronization)” in Fig. 4. The intentions of each organization are summarized in Table 2.

In Table 2, the “R&D team” conducted tuning of the motion sensing technology, which is described in the “Documented” intention on the R&D team side (left side of table). The outcome (tuned pedometer for mobile phones) was connected to the “Additional value for the in-house motion sensor” in the “Unaware” intention in the mobile phone BU side (right side of table). The connection of these different intentions was also identified by the researchers who have technical expertise.

The commercial success of today’s Raku-Raku phone [22][23] was achieved because the different workflows (of the R&D and BU teams) were integrated to obtain the appropriate time-to-market (TTM), or release date.

B. Identify the Gap

Fig. 5 divides the form of the process described on the left and right sides of the IA by the gaps indicated as “Sync 1” and “Sync 2” in Fig. 4. The left side of the IA accommodates the R&D department, which was focusing on research for robotics technologies. In this situation, there are no items in the “Businesses” layer for the future plan of the technology. In contrast, the right side of the IA is where the mobile phone BU had a new requirement for a cost-reduction strategy for the next-generation model plan. The two gap tables (Tables 1, 2) and their relation to the IA are illustrated in Fig. 5.

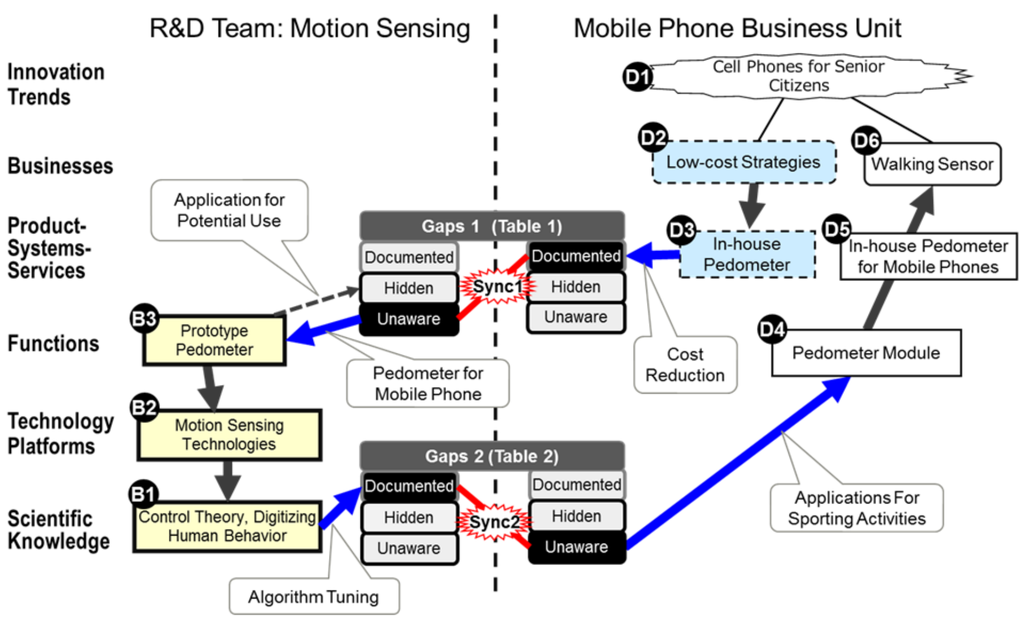

Fig. 5 Gaps in Intentions in Innovation Architecture

The visionaries in this case study found that there was a "hidden" or "unaware" intention and tried to connect the different objectives in the two departments. This brings a new question: should we wait for a visionary to find "hidden" or "unaware" intentions?

C. Awareness Map Assisting in Filling the Gaps

The gap tables (Tables 1, 2) revealed that there were differences between the intentions of the two departments. Even though the tables are shared among team members, most employees, except for the visionaries, cannot find a solution to fill the gaps. Managers should assume that there are no people with such vision in the actual organization who would be able to identify and connect the hidden or unaware intentions among the seeds and needs. There would be "uncertain" intentions that could not be controlled.

To address this issue, this paper introduces an additional table called an "Awareness Map" to use in managing such situations. The word "awareness" means in this paper is interests of the organization about uncertain future trends described in the clusters mentioned earlier (II. C).

In the Scan discussions, participants can share information about potential movement in the market; those discussions cover the Innovation Trends Layer in the IA. Each discussion group (in R&D or the mobile phone BU) creates a number of "clusters" that reflect insights based on the Scan reports and shares them throughout the organization. An example of an Awareness Map is indicated in Table 3.

TABLE 3 EXAMPLE OF AWARENESS MAP

	Near future	Mid-term	Long-term
Documented (Strong connection)	(D1)	(D2)	(D3)
Hidden (No connection)	(H1)	(H2)	(H3)
Unaware (Knows, but relation is uncertain)	(U1)	(U2)	(U3)

In the actual case, the author's affiliation started creating an Awareness Map containing clusters organized along two axes. One is the timespan to be achieved. The other is the distance to the company's current business areas.

In Table 3, the topics mapped in area (D1) are the most feasible trends to achieve or those that have already been realized. In contrast, (U1), (U2), and (U3) would contain the most uncertain trends. The trends that are the same as current business objectives would be mapped in (D1), (D2), and (D3). The items that have been realized move toward area (D1) at the top-left as time proceeds.

Fig. 6 illustrates how the Awareness Map works in the Innovation Architecture. The Scan discussion materials (abstracts) cover the "Innovation Trends" Layer. The Awareness Map covers the lower five layers.

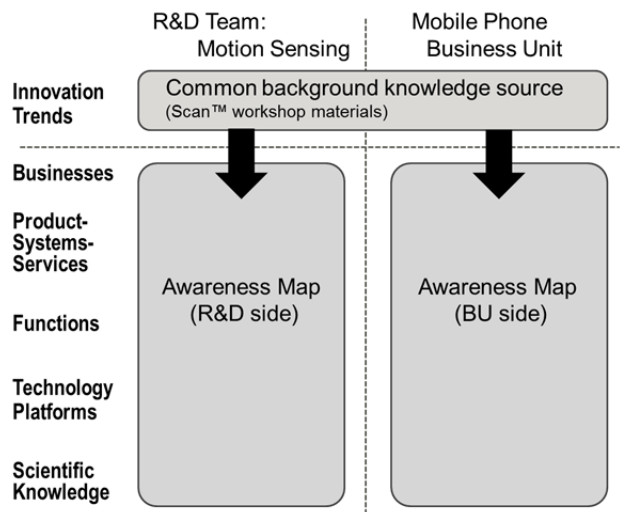

Fig. 6 Awareness Maps to implement GT and PR

Both departments represented in Fig. 6 accumulate the potential changes in the Awareness Maps for their future plans; those plans are independent of the existing or ongoing projects that directly concern the daily business. The next step is shown in Fig. 7, which combines Fig. 5 and Fig. 6.

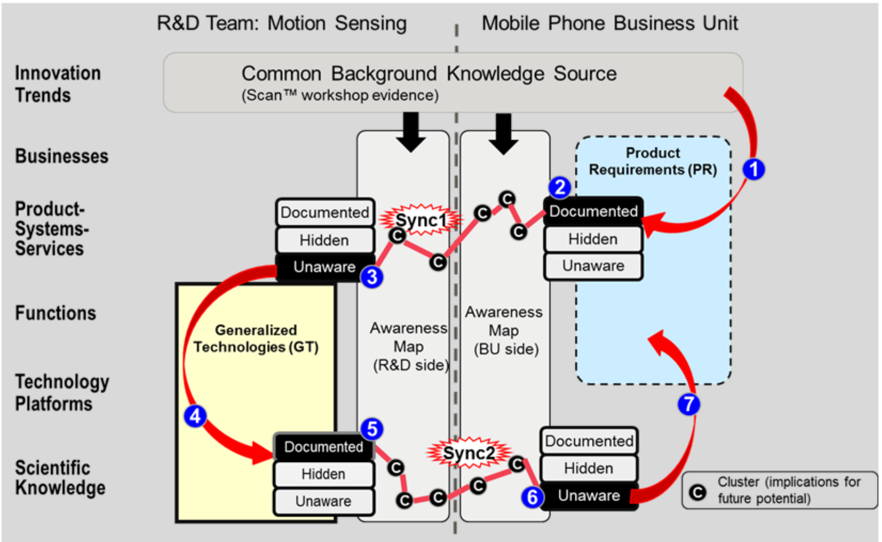

Fig. 7 Awareness Map initiating synchronization

The two Awareness Maps in Fig. 7, which are composed and regularly updated in each department, can help the "hidden (undocumented)" and "unaware" intentions to connect the unplanned relations between technologies and applications. These processes can be organized not only by the limited number of distinguished visionaries but also by most of the employees in the organization.

The following describes an example of an expected scenario that corresponds to the sequence numbers in Fig. 7.

1. The mobile phone BU describes "Product Requirements (PR)" of the "cost reduction of existing pedometer." That is a typical requirement in the manufacturing companies.
2. The PR is stored (recorded or shared in document or other media) in the gap table on the BU side as "Documented" status
3. Engineers and/or researchers in both organizations begin to investigate or discuss how to identify the applicable technologies using the two shared Awareness Maps. As a consequence, some selected candidate combinations of seeds and needs might be selected as the motion sensing technology (as the key technology) on the R&D side.
4. The R&D team tries to implement (creating prototype) the technology to meet the "Unaware" application to fit the PR described in 1 and 2.
5. The tuning of the motion sensing algorithm is completed as described in "Documented."
6. The BU obtains the in-house pedometer technology; however, they might not have realized the future value of this technology. As reported in the previous paper [5], this technology became the core of a Human Centric Engine [20].
7. The business unit applies the technology to enhance the motion sensing applications of mobile-phones.

Table 4 summarizes the issues and the outcome described through the case study.

D. Progress of Practice

The steps described above are currently on-going. The author began building the Awareness Maps using the Scan discussion methodology with the specialty division, *FUJITSU UNIVERSITY* (an in-house education department), and the business units in Fujitsu in 2015. An outline of the progress is given below.

Over 400 employees joined the Scan meetings; each session accommodated 20 to 25 employees. The meetings included discussions on the "Scan abstract sets" (reports used as background information) containing approximately 100 articles in various categories.

E. Revised SP model

Based on the above-mentioned steps, the author updated the original SP model, as shown in Fig. 8.

The difference between this revised model and the original SP model is in the addition of the two Awareness Maps and the Scan meeting between the departments. The two Awareness Maps play an equivalent role to GT and PR. To prove the generalizability of the revised SP model, the author plans operation examples in the actual projects.

TABLE 4 SUMMARY OF DISCUSSIONS

Issues described in Section 2	Summary of the solution in this paper
Issue 1: Dependence on individuals	Sharing process of future insights (knowledge pools) through Scan meetings involves all employees who wish to contribute to creating a competitive future plan as a team.
Issue 2: Explosion in size of needs-seeds matrix	The discussed approach expects to involve every person in the organization to maximize the possibility of finding new fields for the company and to avoid relying on a limited number of visionaries. All employees (in a large-scale company) can maximize the possibilities of finding new solutions.
Issue 3: Organizing "Obeya" meeting	Regular discussions of Scan meetings and outcomes, accumulated "Awareness Maps," help connecting "hidden" or "uncertain" intentions in each department (where they were the R&D team and mobile phone business unit). These items would promote the organization of "Obeya" style meetings in a company and accelerate discussions.

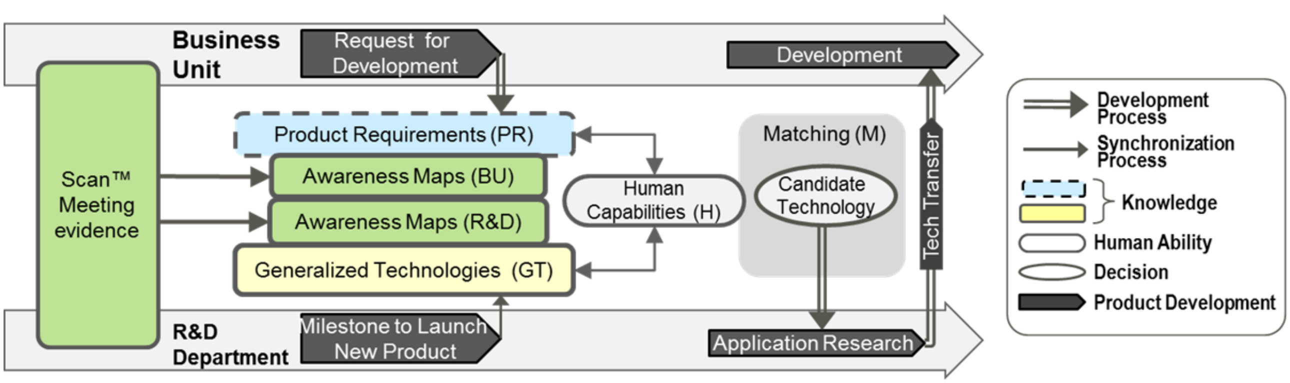

Fig. 8 Revised Synchronization Process model (2016)

V. DISCUSSION

A. Enabling Flexible "Obeya" Meetings

In the past, competitive ideas for new business were sometimes suggested by a small number of visionaries, who might have had great insight and/or possessed strongly controlled confidential information, and those stories were some of the success stories. The case of the cell-phone business at Fujitsu is just one such example since the important breakthrough was achieved by the inspiration of key persons both on the R&D team and in the mobile phone BU. However, the needs-seeds matrix typically expands at an explosive rate; the author surmises that depending on a small number of visionaries has been an old-fashioned way to proceed and could even be risky. From here on, projects that have "uncertain targets" will increase both in number and in importance. As discussed earlier, the methodology in this paper promotes the *Obeya* meetings among the various types of organizations. In the past, the procedure to set up an *Obeya* meeting was complicated and required building relationships between the departments. Research has been done on conducting *Obeya* meetings in a virtual environment [11][12]. However, this paper still focuses on face-to-face meetings.

B. Managing Unaware or Hidden Intentions

The author utilized Scan to compose the Awareness Maps in order to manage potential new trends that have not been recognized in the organization. Companies should manage such uncertain trends by updating their Awareness Map. Topics that are popular within an industry will receive a certain amount of attention from someone in the organization for a certain period. Managing the "Hidden" or "Uncertain" category would increase its importance in the future. The proposed and revised SP model is expected to contribute to exploring uncertain future topics company-wide.

C. Barriers in Mindset

Mindset is one of the notable barriers to organizing the activities discussed in this paper; there are three kinds of mindset barriers.

(1) Barrier of existing businesses

We conduct our daily tasks within the existing businesses and their environments. These tasks might involve utilizing common expertise and/or common business languages (e.g., programming, marketing, or accounting languages) inside the company. Employees might have difficulties discussing promising concepts for the future that are happening day-by-day outside the organization. However, in situations in which the needs-seeds matrix explodes in size, it is possible that a future competitor may emerge 10 years in the future from very different business areas or industries. Therefore, we should observe outside organizations to find small signals indicating game-changing behavior.

(2) Barrier of time scale

Another key to strengthening competitiveness is to identify future trends as early as possible. However, this could be the second mindset barrier. Such early awareness of uncertain and not officially recognized trends might use a lot of a company's time resources to "prepare for competition." This could be one of the largest barriers to competitiveness in R&D in their daily business operations.

(3) Barrier of uncertain problems

The major value of ICT service providers comes in recognizing the customer's requirements and possible solutions. However, social issues are changing rapidly today, so we should consider new approaches since even the customer and the requirements are uncertain. Snowden [24] proposed a framework called the "Cynefin Framework," which categorizes the complexity of problems into different domains.

The elementary domain is "Obvious." Before starting a career, students spend many hours in class, and most of the problems solved in the classroom are assumed to have identical answers no matter who solves them. The next domain is "Complicated." The causal relationship is clear in problems (e.g., building a tailored software system), but there are most likely several uncertain issues such as the need for new programming languages or a trade-off in cost-effectiveness. The third domain is "Complex." Current trends indicate that social issues are increasing in complexity. In this "Complex" stage, we do not always know what the problem is in advance or what solution is required. The framework defines the fourth domain as "Chaotic"; however, this might not be relevant to the private company sector at present.

D. Future Work

(1) Status of the Project

The project is on-going at the time of this writing. This means the benefit and effect of these methodologies, especially from a statistical viewpoint, would require continuous and iterative trials for a few years. For the additional plan, the author is planning to implement a procedure to track the finding of successful connections of particular seeds and needs using this approach.

(2) Applicability or Generalizability to Other Industries

The methodologies discussed in this paper were originally focused on the ICT industry, specifically assuming the combination of technologies such as software and/or hardware. These technologies could be combined with electronic-circuit interfaces or communication-data protocols and are based on various types of standardized specifications. The author expects that the methodologies are also applicable to multiple companies in the ICT industry.

For other fields or industries such as the materials or pharmaceutical industry, more precise investigations are required in order to discuss the application of the methodologies described in this paper, since the author does not have expertise in these fields.

VI. CONCLUSION

This paper discussed practical methodologies to synchronize the fundamental research and product planning processes in a company. In particular, this paper updated the previously proposed Synchronization Process model so as to be operable in a practical environment and started building the process in an actual organization in the Fujitsu group.

The approach discussed in this paper included the use of Gap Tables that indicate the differences in intentions between departments, and an Awareness Map that indicates uncertain future trends and the level of awareness about them within an organization. However, there is no royal road to learning or specific described procedure, but a company-wide focus on uncertainty would accelerate the finding of hidden gaps between needs and seeds that might not be discovered in the existing meeting and development style.

This paper reported in the later part that the author's research group recently started operating under a model in which information is treated as a shared knowledge pool described in the original Synchronization Process model. The strategies were implemented in the authors' group in 2015 and will take several years to obtain a certain amount of pooled knowledge.

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