# The New Innovation Process of Undergoing Digital Transformation in Industries

20211118

**Author:**
**Chaisung Lim**
Professor, Konkuk University
Chair, Korea Industry 4.0 Association
*edisonfoot@gmail.com*

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# 1 INTRODUCTION

The firms undergoing digital transformation (henceforth "DX") in industries need to change their processes as one of the business factors driving the DX.[1] A survey on DX reveals that one of the major factors making digital business different from non-digital business is culture and mind set.[2]

At the back of culture lies process. The process changes, which reveal concrete changes of culture, can be a subset of cultural change.[3] The purpose of this paper is to clarify the characteristic of the new innovation process of firms undergoing DX in industries, to raise management issues related to reducing conflicts of the process with other elements of the management system and to offer recommendation on the Industry IoT Consortium's (IIC's) strengthened role in supporting firms' new innovation process.

Here, innovation processes means innovation processes of the end user firms. The end user (henceforth "EU" or "user") is a DX firm that deploys and operates IIoT solutions found mostly in asset-intensive industries such as manufacturing, smart city, health care, agriculture, energy, transportation and retail. The firm is a customer of an IIoT solution provider (henceforth "SP" or "provider").

EUs, who operate mostly with industrial goods and services, need to adopt a new innovation process to integrate IT and OT. Let's take an example of manufacturing process innovation of a manufacturer, as an end user. EUs' dominant innovation process is likely to be OT-focused, implemented by OT workers with hardware-focused engineering knowledge. Because of the rising share of IIoT technology, the operators need to integrate OT with IT. The existing process focused on OT would be a slow and closed process, not effectively utilizing innovation opportunities from fast integration of IT and OT.

Benchmarking best innovation practices, EUs could emulate currently popular innovation frameworks, of the IT firms, including lean startup, design thinking and other agile method. These frameworks, would be useful to a limited extent. The main reason is that the environment of the firms in industries are different from software world where existing popular frameworks originally had been created.

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[1] Morrish, J., Zarkout, B. (ed.) (2020) *Digital Transformation in Industry White Paper*, with A. Ferraro, C. Lim, S. Lin, J. Morrish and B. Zarkout as authors, Industry IoT Consortium: Boston.

[2] Kane, G. C.; Philips, A.; Copulsky, J.; Andrus, G. (2019) *The Technology Fallacy*. The MIT Press: Cambridge, Massachusetts.

[3] Levy, A. (1986) *Second-order planned change: Definition and conceptualization.* Organizational dynamics **15**(1): 5-23.

EUs have to face problems in dealing with complexity of the innovation process of integrating IT and OT and the constraints of the physical world in which they operate. Software in the IT world can be created and tested quickly, at low cost, but integrating IT and OT takes more time to test. EUs are likely to have organizational structures emphasizing hierarchy. The structure aims at perfect quality. They tend to be slow innovators, and slow to experiment with prototypes of imperfect quality. They may produce a wrong offering due to the lack of feedback of customers on prototypes of intended solutions because they prefer to show an offering when the design is perfectly created and tested.

If the EU's innovation process could be clearly defined and understood correctly, SPs would avoid possible mistakes in interacting with customers (a.k.a. EUs). An SP interact with an EU over SP's innovation process of understanding customer needs/problems and creating and deploying a solution. The EU interacts with an SP over the EU's innovation process of identifying problems of a process (e.g. manufacturing process) and searching for external or in-house solution and implementing the solution.

An SP in the IT domain can make mistakes on testing in interacting with the EU. For example, after an initial test of a solution offered to an EU, the SP may expect further opportunities to test the solution in the EU facility while the EUs in asset industries may be disappointed from the initial test, expecting a perfect quality product from the beginning.

In asset-intensive industries, the perfect quality of a product at an initial stage test is regarded as much more important than in IT industries where most of SPs belong to. Because of the different expectation on testing, collaboration between SP and EU could be easily disrupted. By understanding the EU's process, an SP can come up with a new approach in interacting with the customer. Also, the EU needs to change its process, not allowing frequent tests, because the EU would not reap benefits from "more frequent than before" tests in interacting with the SPs.

This paper defines a new approach of innovation of firms undergoing DX in industries, as "BizOps for DX in industries." "BizOps for DX in industries" (henceforth "BDXI") can be defined as a new approach of innovation of firms undergoing DX in industries, integrating not only business, development and operation but also IT and OT, for fast and customer centric innovation through application of best innovation approaches/practices including design thinking, lean startup, agile methods and BizDevOps.

BDXI can be applied for product innovation, business model innovation, process innovation. The "Industries" in "BizOps for DX in industries" are asset-intensive industries: smart city, manufacturing, agriculture, retail and logistics, transportation, health care and energy industries. So, we can say that BDXI process is a new innovation process, adopting a new approach to innovation, of firms undergoing DX in industries.

Target audiences are those working for organizations that apply or support the BDXI process: IT departments working together with the manufacturing smart factory project team,

manufacturing division, customer experience data collection department, product and service sales department, department of planning for digital strategy and business model, or smart products and services development department. Target audience also includes CIO and CTO/CEOs who are driving change of innovation process under their DX strategy. This article can be used as a reference paper suggesting the rationale for the promotion of initiation and settlement of new innovation processes of firms facing the DX challenge.

This paper defines commonly appearing features of BDXI processes of the firms, of creation of solutions achieved by integrating OT and IT, and BDXI framework as a starting point of the innovation process change and identifies conflicts of BDXI processes with other elements of management systems and suggests several IIC initiatives to help guide BDXI processes.

This paper has a relevance with IIC's other documents. The Business Strategy and Innovation Framework (BSIF)[4] is an IIC framework for IIoT business model innovation. Even though BSIF discusses integration of OT and IT, the complex process of innovation has not been discussed in detail. The BSIF has a process called ideation, preparation, evaluation and the initiation for IIoT business model innovation.

BDXI offers a framework for dealing with detailed complex processes of "IT/OT integrating" business model innovation, product innovation or process innovation. In the case of IIoT strategy planning, strategic planning process can include using elements of BDXI from the beginning, such as reviewing empathy level and formulating everything in user stories or planning with backlogs (taken from the agile aspects of the BDXI). From this approach, an experience oriented or outcome-based business model innovation strategy can be set up.

The BDXI process has a relevance with IIC's work on DX in industries.[5] Firms undergoing DX in industries need to change their processes as one of the business factors driving the DX. BDXI is a new innovation process which can be a part of the process of the firms undergoing DX in industries. The testbed results report of IIC[6] suggests that respecting physical world constraints of a solution operator is to be preferred in innovation process. Following the early stages of a design thinking or lean startup process and emphasizing empathy with customers may not lead to beneficial outcomes. If you look at test bed results, you can see that even if an SP in the IT domain tries to interact closely with its customer in asset intensive industries the SP may find it difficult to identify target problems of the customer due to a lack of the IT domain knowledge of its customer.

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[4] *https://www.iiconsortium.org/BSIF.htm*

[5] Morrish, J., Zarkout, B. (ed.) (2020) *Digital Transformation in Industry White Paper*, with A. Ferraro, C. Lim, S. Lin, J. Morrish and B. Zarkout as authors, Industry IoT Consortium: Boston.

[6] Durand, J. and Lim, C. (2020) *A Compilation of Testbed Results: Toward Best Practices for Developing and Deploying IIoT Solutions*, Industry IoT Consortium (IIC): Boston.

## 2 COMMON FEATURES OF BDXI PROCESS

BDXI process is a new innovation process, adopting a new approach to innovation, of firms undergoing DX in industries.

Figure 1[7] shows where BDXI process can be positioned in a case of a smart connected product producer, as an EU. DevOps integrates IT, research and development and operations. For the firm, the product development process should go beyond DevOps for IT development and integrate IT and OT. DevOps needs to be more tightly integrated with business than before because smart products tend to be linked with a new business model. So far, BizDevOps has been an approach to software development that encourages developers, operations staff and business teams to work together so that the organization can develop software more quickly, be more responsive to user demand and ultimately maximize revenue.

**Table: Approaches and Application Area: DevOps, BizDevOps, BDXI**

| | DevOps | BizDevOps | BDXI |
|---|---|---|---|
| Approaches | An approach to development that encourages developers, operations staff teams to work together. | An approach to development that encourages developers, operations staff and business teams to work together. | A new approach of innovation of firms undergoing DX in industries, integrating not only business, development and operation but also IT and OT, for fast and customer centric innovation through application of best innovation approaches/practices including design thinking, lean startup, agile methods and BizDevOps. |
| Application Area | Software | Software | Software and hardware |

This approach can be applied to the IIoT operator firm undergoing DX. Development work should be carried out by close cooperation between a collocated team of developers, operations staff and business teams. However, EUs find that insights from existing BizDevOps are insufficient to integrate IT and OT. BizDevOps should include participation of hardware engineers, hardware developers, hardware operation staff and hardware business teams too. We think it's necessary to make BDXI as a kind of BizDevOps extended to apply to innovation activities of integrating IT and OT.

[7] Porter, M. E. and Heppelmann, J.E. (2015) *How smart, connected products are transforming companies*. Harvard Business Review, 93(10): 96-114.

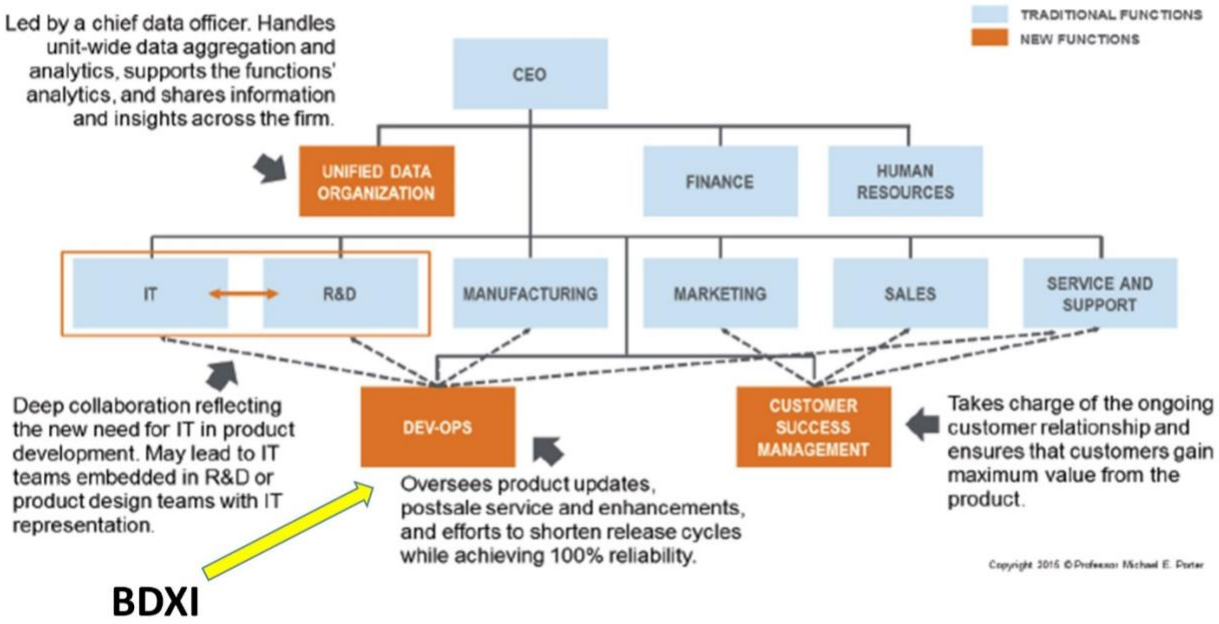


Figure 1: BDXI position in a smart connected product producer firm.
*Source: Porter and Heppelman (2015) modified.*

The common features of the BDXI processes are the following.

First, it is the innovation processes, reflecting selective adoption of best innovation practices from design thinking, lean start-up and agile methods and BizDevOps. The resulting process reflecting the best practices can be simplified, as shown in Figure 2. The process includes understanding the customer, with empathy on the customer's needs, solution ideation and creating a minimum viable product, testing and learning from validation of a solution from the customer and initiation of the solution into action. This can be summarized as discovering customer needs, developing solutions and learning whether the solutions are feasible and putting them into action.

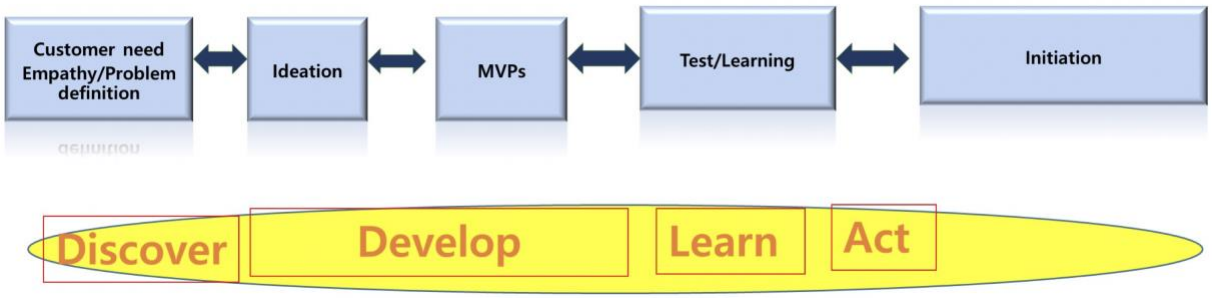


Figure 2: Simplified BDXI process

Second, it is the customer centric process. As more customers are connected to networks such as the Internet, they can be more directly connected to EUs, and customers want more customer-

friendly products and services that can be provided in a connected environment, so this customer-centric process is in demand more than ever. This customer-centric innovation process is achieved by application of design thinking, lean startup and agile process, respecting customers' needs or outcome through empathy and frequent feedback of customers.

This process is the one reflecting the complexity of integrating IT and OT, checking the validity of applying new IT and new OT in creating a solution to the target problem of IIoT solution operators. Even though the SP try to understand customer needs deeply, the SP would fail in creating customer friendly offering. With an EU who "does not know what they want" because of a lack of the IT domain knowledge, the SP in the IT domain cannot start the empathy stage of understanding what the EU wants.[8] The SP might have to wait until the EU realizes what the firm wants or help them to do so by offering workshops on available IT technology and on a way of defining a target problem for an application of IT technology.

Third, it is an open process, encouraging collaboration among different divisions and among different firms, ranging from developers to operations staff and business teams. The BDXI process is the process of resolving problems in cross functional communication and collaboration among various departments (or organizations) including IT and OT departments (or organizations). This is a challenge to EUs with the "closed mind set" of asset-intensive industries.

The open process is stimulated by extensive use of IT, leveraging connected things and people, facilitating open access to data or information of partners, customers and suppliers in both IT and OT. To solve low interoperability and high integration complexity of integrating EU's IT and OT systems, open dialogue between people or organizations you have never interacted with before is important. Openness is more important than ever with the advent of an ecosystem in which firms collaborate across vertical and horizon value chains to create value. The BDXI process addresses the problems of the "closed mind set" typical of hardware-driven organizations.

The fourth feature of the framework is the facilitation of fast innovation processes while accepting constraints of the physical world. This is enabled by fast experimentation with MVPs and other agile methods, such as parallel sprints. When creating an IT solution, the operator needs to embrace quick and imperfect deliveries of MVP solutions. The operator needs to find a cost efficient and fast way of testing MVP solutions. There can be conflict on fast experimentation between IT jobs and OT jobs people. The experimental approach in the world of IT professions may have limited applicability due to physical world constraints and the lack of cooperation of people in the OT profession.

People in the OT profession, who prefer the perfectly planned scheme, need to allow more frequent experiments, which are necessary for MVPs. OT jobs people need to find cost efficient

[8] Durand, J. and Lim, C. (2020) *A Compilation of Testbed Results: Toward Best Practices for Developing and Deploying IIoT Solutions*, Industry IoT Consortium (IIC): Boston.

and less risky ways of testing, possibly through collaboration with IT jobs people. Over the process, there would be OT alignment towards IT and IT alignment towards OT (see Figure 3).

The experimental approach in the world of IT professions may have limited applicability due to the constraints of the physical world and the lack of cooperation of people in the OT profession.

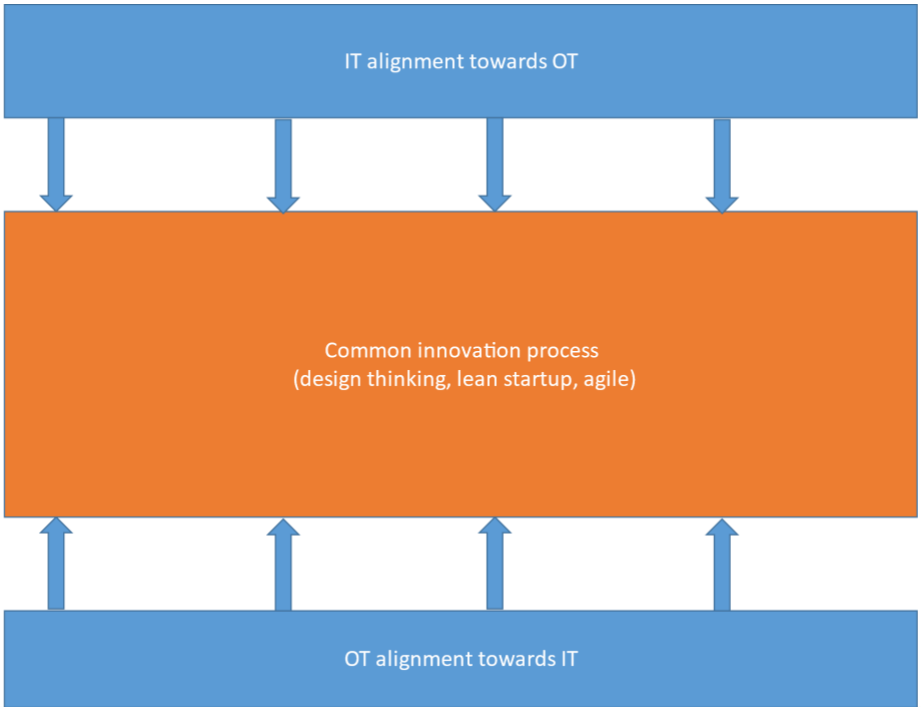


Figure 3: Differentiated feature of BDXI

# 3 BDXI Framework as a Starting Point of the Innovation Process Change

For EUs undergoing DX, successful implementation of innovation processes integrating IT and OT domains is crucial. A good way to empower this change and manage the quality of innovation is through well-established innovation processes, integrating IT and OT, which can be driven by an innovation framework.

Managing quality of production is crucially important for competitiveness. To build competitive production processes, organizations have deployed frameworks for managing quality of production, Six Sigma being the most popular example,[9] with most Fortune 500 firms having

[9] Zhang W.H., Arthur V., Gilbreath G.H. (2009) *Six Sigma: A Retrospective and Prospective Study*. Production and Operation Management Society 20th Annual Conference [serial on the Internet] [accessed 13 December 2020].

adopted Six Sigma.[10] When initiating changes to an existing innovation process, an organization should have a framework in place to manage the quality of innovation. In contrast with Six Sigma, there seems to be no framework like Six Sigma in innovation process because innovation process of firms are more diverse and there is less room for standardization than the production process.

In order to changes the innovation process, a firm needs to have a clear and shared understanding on what that new innovation process should involve and how it should operate. In order to define the process, it needs to develop a framework reflecting the mental model of "what that new innovation process should involve and how it should operate" in the context of the EU's situation. The framework is an explicitly described "should be" process, that offers a guide to implement BDXI process concretely.

Next, we take a look at a few examples. You can see an example of a framework for implementing a BDXI process. The most publicly known case of a BDXI framework is GE's FastWorks, which was known to have been created through the application of the lean start up principle and design thinking. The FastWorks has been applied to creating solution which can be achieved by integrating IT and OT. FastWorks is a product of GE's tradition of creating its own frameworks by integrating world best practices and knowledge on management and engineering.

Six Sigma, adopted by GE, is one of the examples of the frameworks inheriting the tradition. FastWorks' process starts from understanding customer needs with empathy, creating a potential solution, checking leaps of faith (assumptions of potential solution design), creating MVPs for verifying high priority assumptions identified in "leaps of faith process and making "learning metrics" from recorded feedback of customers.

After a review of learning metrics created from the fast feedback of customers, "pivot" or "persevere" is decided. Persevere means continued iteration based on existing product or production process ideas. You pivot when you realize that your initial idea is wrong, so you change and iterate from there (see Figure 4).[11]

The application of the framework resulted in fruitful results. When GE developed the Series X Diesel Engine in 2012, a large multi-platform engine with 20-30% percent more energy efficiency that can work in various situations, GE reduced the development period from five years to two years. This was made possible through the application of the FastWorks framework, which allowed for fast creation of an MVP (a modified version of existing engine) over a year and

[10] Goh, T. N. (2002). *A Strategic Assessment of Six Sigma, Quality and Reliability Engineering International*, 18(5): 403-410.

[11] Goldstein, V. (2016) *How to Grow New - Lean Startup Week 2016*, 11 November 2016, accessed on 17 July 2019.

reaching a finalized product design by reflecting fast feedback results of a few customers who bought and installed the MVP.[12]

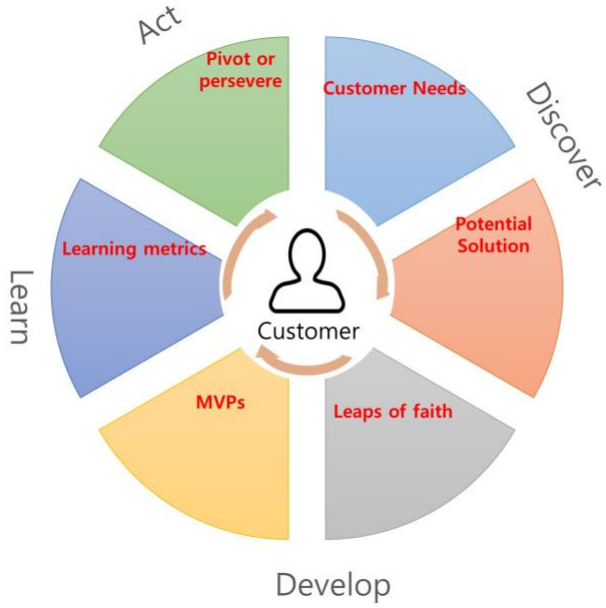


Figure 4: Fastworks of GE as an example. *Source: Goldstein (2016).*

Figure 5 provides an example of a framework of BDXI process.[13] In this example of Bosch, the shipping company's automated cargo management (ACM) solution for managing cargo contamination and wet damage of bulk carriers could be developed by following the Bosch's MVP as a service framework. MVP serves as a foundation for discovering sustainable, scalable IoT solution.

Bosch could fast introduce solutions for the bulk carriers. When asked at the IIC member meeting, "what would have happened if Bosch had not used the MVP as a service framework?" the answer was that Bosch and the shipping company would have started looking for a package solution that would solve the whole problem and would have gotten lost in the process of implementing the project. It was insisted that by applying MVP as a service framework, you can develop and validate an MVP to solve each problem one by one.

[12] Ries, E. (2017) *The Startup Way*, Penguin Random House: New York.

[13] Lim, C., Hackbarth, K., Kordel, K., Seo, G. and McCann, J. (2021). *BizOps for Digital Transformation in Industries*. Boston, Industry IoT Consortium.

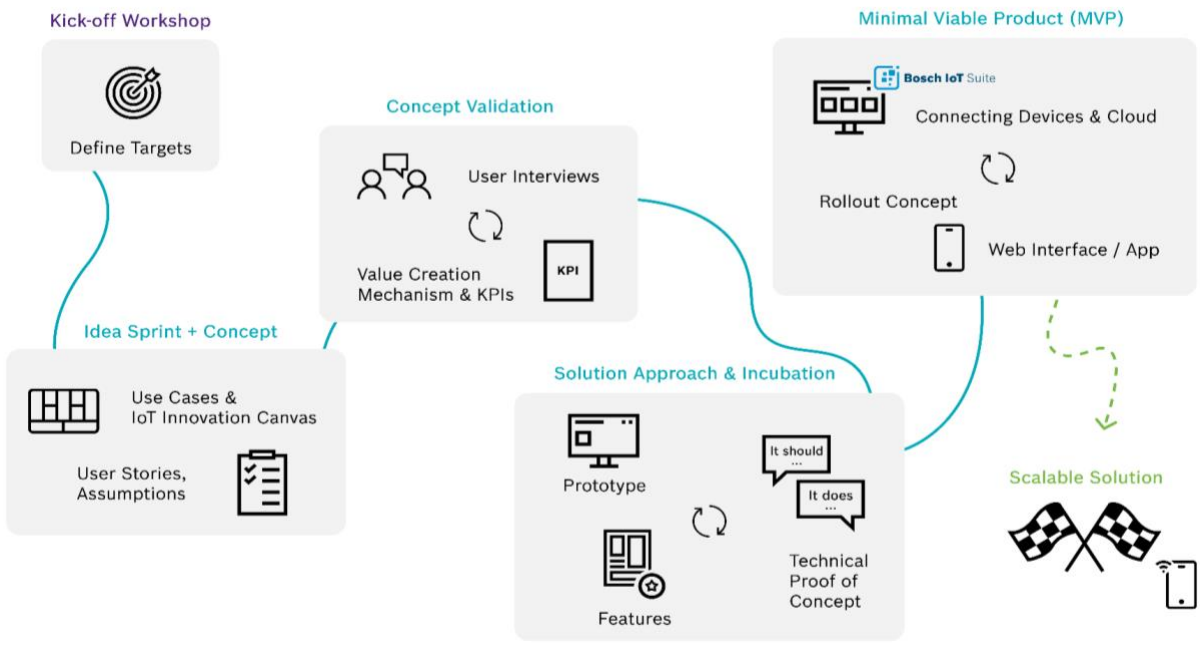


Figure 5: Process of building MVPs. *Source: Bosch.IO in Lim et al. (2021).*

# 4 Conflicts of BDXI Processes with Other Features of Management Systems

Because the BDXI process is new, it is likely to conflict with elements of the management system (such as other existing processes, organizational structures and incentives). Conflicts must be identified and reported to top management so that top management can respond to eliminate the conflict by redesigning the elements of the system.

In the case of GE, for example, the incentives and structures of the organization collided with BDXI's rapid experimentation process. After training engineers on FastWorks, when asked about their intentions, engineers answered that they did not want to implement FastWorks processes. Implementing FastWorks means generating more prototypes and improvement upon them for engineers. According to GE's management system, creating many prototypes and carrying out many "reworks," get negative evaluations for engineers.[14] This means that FastWorks conflicts with their human resource evaluation system.

Fast iteration of FastWork cycles allows for pivots, meaning an increased number of projects stopped or changed due to the change of goals or projects. This conflicts with GE's funding system

[14] Ries, E. (2017) *The Startup Way*, Penguin Random House: New York.

that has fixed targets, fixed amounts and annual budget system[15] BDXI performance can be positively influenced by resolving conflicts, as shown in Figure 6.

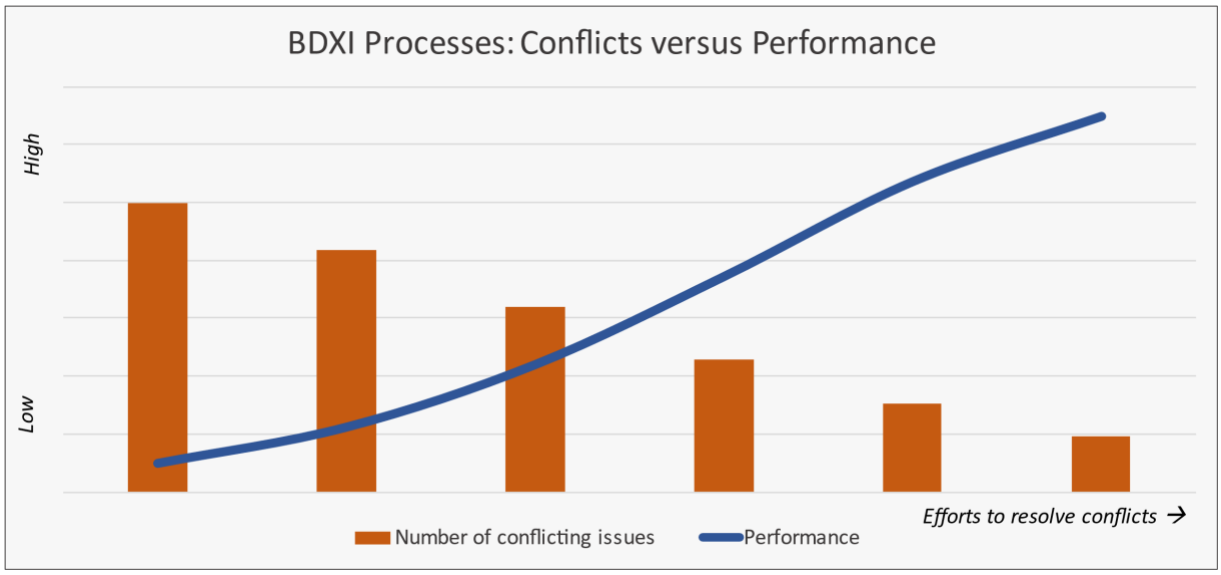


Figure 6: BDXI processes: conflicts versus performance. *Source: Lim et al (2021).*

So, GE realized the conflicts and GE's management system was gradually changed to resolve the conflicts. The FastWorks evolved from FastWorks 1.0 to FastWorks 2.0 and FastWorks 3.0. Fast works 2.0 and 3.0 were made possible with changes of the management system.[16]

These changes in management systems are made possible by the top management's drive towards initiation and settlement of new innovation processes without avoiding the redesign of the management system for reducing conflicts of the processes with the management system. Therefore, whenever a conflict of the BDXI process with other elements of the management system is discovered, it needs to be reported to the top management. Eliminating the conflict requires modifying the design of the management system, which needs to be modified with the highest level of agility of the top management.

Bosch's example shows that creating "agile teams" (that will be considered teams for the BDXI process) is not sufficient to implement a new innovation process. Top executives work as an agile leadership team of 5-6 top executives, along with a product owner and an agile master, in an interactive format for ''board meetings where participants stand, use plan walls, and constantly

[15] Ries, E. (2017) *The Startup Way*, Penguin Random House: New York.

[16] Goldstein, V. (2016) *How to Grow New - Lean Startup Week 2016*, 11 Nov 2016. Accessed on 17 July 2019.

ask what are the next steps in their journey." The executives could see common barriers across the firm with visible progress on key initiatives, on agile values.[17]

This agile leadership team consisting of top executives can also be found in Johnson and Johnson. The team embraces agile principles, having the CEO as an "initiative owner" of building an agile firm. The challenge for Executives on the team was playing multiple roles including building and running the agile enterprise operating system, overseeing business units and functions, serving serve as mentors and decision makers and handling the crises of the moment.[18]

All of this means that conflicts between the BDXI process and elements of other management systems need to be continuously reported, and the BDXI process needs to be settled as the conflicts are eliminated through sensitive responses from top management with agility. Therefore, the promotion of the BDXI process as a new innovation process should be done together with the establishment of a reporting mechanism by the top management for the conflict and the establishment of an agile response mechanism by the top management.

# 5 IIC INITIATIVES TO HELP GUIDE BDXI PROCESSES

Due to increasingly fast technical changes enabling DX, the EUs undergoing DX face the challenge of fast innovation in which "test fast, learn fast, scale fast" matters.[19] IIC has been maintaining activities and programs that help the DX firm's innovation process: "Identify opportunities, create concepts, validate concepts, develop solutions, deploy solutions." (These are part of innovation processes in ISO 56000 [ISO standard for innovation management]).

For examples, IIC's activities clarifying DX enabling technology and hot new technologies ("identify opportunities"), use case program for collecting and sharing cases ("create concepts"), test bed program ("validate concepts, develop solutions"), test drive program ("deploy solutions"), IIoT challenges ("create concepts, validate concepts, develop solutions and deploy solutions").These activities and programs are ones supporting innovation processes of firms which are implemented through collaborative efforts among firms and other organizations.

In order to support effective innovation process of firms, it is recommended that:

[17] Howard, Annie (2018) *Agile Transformation at Bosch*, Presentation at Scrum@Scale, 28 February 2018, *https://www.youtube.com/watch?v=jYpAVKgqFig&t=28s* accessed on 22 June 2021.

[18] Rigby, D., et al. (2020). *The Agile C-Suite: A new approach to leadership for the team at the top*. Harvard Business Review 98(3): 64-73.

[19] Kane, G. C.; Philips, A.; Copulsky, J.; Andrus, G. (2019) *The Technology Fallacy*. The MIT Press: Cambridge, Massachusetts.

i. IIC offer a generic BDXI framework or maturity model which can reduce time and cost of firms in creating a firm's own BDXI framework suitable for the firm's specific environments such as industrial sector, firm size or resource constraints,
ii. IIC offer meetings, events or publications for sharing insights and practices on BDXI process or an individual firm's BDXI framework.

This paper tried to clarify the characteristics of the new innovation process of firms undergoing DX in industries and introduced examples of the BDXI framework, which helps to manage the innovation process from idea to launch, as a starting point for innovation process change. It identified conflicts between the BDXI process and other elements of management system and it was argued that the BDXI implementation process should have a feedback mechanism of reporting its conflicts with other elements of management systems.

It also suggested several IIC possible initiatives to help guide BDXI processes. IIC's BDXI related activities or programs are expected to strengthen the role as an organization that helps the innovation process of DX firms and thereby reinforcing its position as a global leading organization that supports the innovation process of firms undergoing DX in industries.

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