3-2022

Development and Assessment of a Model-Based Framework on User Toolkits

Brandon J. Koury

DEVELOPMENT AND ASSESSMENT OF A MODEL BASED FRAMEWORK ON USER TOOLKITS

THESIS

Brandon J. Koury, First Lieutenant, USAF

AFIT-ENV-MS-22-M-219

DEPARTMENT OF THE AIR FORCE
AIR UNIVERSITY

AIR FORCE INSTITUTE OF TECHNOLOGY

Wright-Patterson Air Force Base, Ohio

AFIT-ENV-MS-22-M-219

DEVELOPMENT AND ASSESSMENT OF A MODEL BASED FRAMEWORK ON USER TOOLKITS

THESIS

Presented to the Faculty

Department of Systems Engineering

Graduate School of Engineering and Management

Air Force Institute of Technology

Air University

Air Education and Training Command

In Partial Fulfillment of the Requirements for the

Degree of Master of Science in Acquisition and Program Management

Brandon J. Koury

First Lieutenant, USAF

March 2022

AFIT-ENV-MS-22-M-219

DEVELOPMENT AND ASSESSMENT OF A MODEL BASED FRAMEWORK ON USER TOOLKITS

Brandon J. Koury

First Lieutenant, USAF

Committee Membership:

Lt Col Amy Cox
Chair

Dr. Michael Miller
Member

Lt Col Jeremy Geiger
Member

Dr. David Long
Member

AFIT-ENV-MS-22-M-219

Abstract

The Department of Defense (DoD) has a limited number of resources to accomplish a variety of missions which involve deploying personnel to support and maintain aircraft operating throughout the world. The DoD's maintenance structure codes maintainers to perform maintenance on specific airframes. This structure limits the flexibility of maintainers and leads to deploying resources in a reactionary manner to address capability gaps in deployed environments. The Just-In-Time Multi-Mission Airman (JIT MMA) concept aims to resolve these issues. Currently, the necessary technologies are unknown, but user toolkits are a concept to consider. A user toolkit is a concept that allows users to create, test, and share potential product designs within an experimental environment that is based on an existing production system. The DoD could explore using user toolkits to better utilize innovative maintainers within the maintenance community. However, current literature does not define the roles, tasks, and information flows that exist within a user toolkit environment. This research addresses the gap in literature by performing a model-based literature review to develop a model-framework on user toolkits. Additionally, this research applies the model-framework to The Griffin show how organizations can use the model-framework as an assessment tool for implementing user toolkits.

Acknowledgments

I greatly appreciated the guidance from my research committee throughout the course of this thesis. Additionally, I am extremely grateful for the support I received from my mentors and family throughout my time WPAFB. Their support contributed heavily to both my academic and professional success.

Brandon J. Koury

Table of Contents

List of Figures

List of Tables

DEVELOPMENT AND ASSESSMENT OF A MODEL BASED-FRAMEWORK ON USER TOOLKITS

I. Introduction

This chapter introduces the development and assessment of a model-based framework on user toolkits. The chapter begins with the background and motivation behind the problem. Then, the chapter addresses the problem through several research questions. After, the chapter details the focus of the research, outlines the methodology, and explains any assumptions or limitations. This chapter ends with an overview of the entire thesis document.

Motivation and Background

The Need to Innovate in the Department of Defense

Literature describes innovation as the ability to develop and field new or improved capabilities [1]. Users must innovate and respond to the changing environment by delivering adaptable systems than can readily add capability over time [2]; the need to innovate motivates this research. New systems must respond to user needs in an accurate manner to succeed, which drives the increasing need to innovate [3]. The action of driving innovation within the Department of Defense (DoD) is not new. Since the end of World War II, civilian and military policy members have sought to understand and improve upon the processes involved in the development of warfighting capabilities [4]. Recently, the DoD has been pushing to innovate faster to respond to near-peer and peer adversaries [1], [5], [6]. These publications emphasized the importance of modernizing

the DoD at an expedited rate to maintain an advantage over these adversaries. Additionally, these publications highlight the risk of losing the next major conflict if the DoD is unable to innovate and respond to changes in a quick enough manner.

DoD Resources and Introducing the Just-In-Time Multi-Mission Airman Concept

One constraint the DoD experiences relates to allocating a finite number of resources to accomplish the mission. Between 1988 and 2020 the defense budget of the United States grew from $634 billion to over $724 billion annually (2020 dollars). However, the defense budget, as measured against the gross domestic product of the United States, has fluctuated from 5.7% to 3.5%, which highlights how the United States Government cannot guarantee the same allocation of resources to the DoD each year [7]. This budget constraint affects how the DoD allocates resources for the deployment of troops to carry out missions. For example, previous estimates indicate the Air Force spends around 50% of their operations and sustainment budget on maintenance activities and a portion of the costs to perform these maintenance activities involves allocating sufficient manpower. Compounding the problem, allocating sufficient manpower becomes more challenging when dealing with a forward operational base (FOB). This complicates the problem further because the DoD must deploy a variety of aircraft to the FOB, which only specific maintainers can service based on their specialty coding. The specialty coding relates to the specific training the maintainers receive for a certain airframe. A serious issue arises when there are no maintainers trained to support a specific airframe. To address this issue, the DoD deploys maintainers who can support the specific airframe. Unfortunately, this decision is reactionary and requires additional resources. Recent estimates highlight the cost of deploying troops across a variety of

locations around the world. The Center for Strategic and Budgetary Assessments estimated the cost to deploy each service member in Afghanistan was around $2.1 million [8]. Another issue arises with the predictability of the DoD by only allowing maintainers to work on certain aircraft based on their specialty coding. The DoD becomes limited on where they can deploy resources based on the finite number of maintainers. This limitation means the location of the maintainers who support a specific airframe impact the availability of that specific airframe.

The Just-In-Time Multi-Mission Airman (JIT MMA) concept is a potential solution to reduce the DoD's reactionary spending and predictability among potential adversaries. This concept aims to use advancements in technology to better train and support maintainers in a way that enables them to perform maintenance tasks on multiple airframes in addition to their coded platform in a deployed environment. For example, the JIT MMA concepts could enable a F-15 maintainer to perform maintenance tasks on a MQ-9 by receiving additional training or information from other sources to perform the task without sending an MQ-9 maintainer to the deployed location.

This research analyzes a potential solution to support the JIT MMA concept by exploring user toolkits for user innovation. A user toolkit contains various features and feedback mechanisms that guide users throughout the design process. These feedback mechanisms and features enable the production of finished products that satisfy a set of requirements or unmet needs. Therefore, we can define a user toolkit as a concept that allows users to create, test, and share potential product designs within an experimental environment that is based on an existing production system. This concept benefits both the firm and the user through the solution space the firm provides. The solution space

allows users to articulate their exact requirements while providing firms access to precise information on customer needs [3]. For example, LSI Logic and Nestle each created their own version of a user toolkit, but both implementations of the concept is different from one another. LSI Logic created a digital toolkit by extending a portion of their proprietary software to their customers. This software allowed those customers to create and test integrated circuit designs within a digital solution space before having LSI Logic produce the final design [9]. Additionally, Nestle created a physical toolkit by providing a set of standard ingredients from their industrial kitchen to the executive chefs that worked in restaurant kitchens. This standard set of ingredients acted as a physical solution space that restaurant chefs could use to create and test recipes within their restaurant kitchens before sending the final recipe to Nestle to mass produce [3]. The *User Toolkits* section of this thesis provides a more in-depth explanation on user toolkits.

Members within the DoD have shown they can create innovative solutions to solve their problems. For example, a service member created a helmet mount spacer to fix a night vision problem the service was experiencing. This solution only costs about $0.04 and provided a savings of $19,000 per helmet [10]. The researchers believe the DoD could explore user toolkits as a viable solution to support the JIT MMA concept by tapping into innovative members within the maintenance community.

Introducing The Griffin and Relating the Organization to the JIT MMA Concept

There are ongoing efforts across the DoD to develop innovative maintenance concepts to improve the way maintainers obtain and demonstrate maintenance knowledge. One organization contributing to that effort is The Griffin. According to the Griffin's mission, the organization develops and delivers innovative maintenance content

to the maintenance community. Members of the Griffin analyze performance deficiencies and capability gaps to create a framework for products. The Griffin takes those performance deficiencies and capability gaps to develop need-based solutions. Some of the need-based solutions they provide include online interactive training modules. Through these online interactive training modules, maintainers interact with computer generated aircraft and perform the actual steps required to accomplish tasks that they need to know how to perform on the aircraft [11]. These need-based solutions assist maintainers with becoming proficient with maintenance tasks when the physical aircraft is not available.

These need-based solutions interested the researchers since they align with a portion of the JIT MMA concept that focusses on educating maintainers on maintenance tasks for multiple airframes. The researchers believe The Griffin could benefit from implementing a user toolkit to support their current mission. Additionally, the researchers believe a user toolkit could assist with developing solutions to support the JIT MMA concept by improving the sharing and capture of knowledge around these maintenance organizations.

Problem Statement

The DoD has limited budgetary and manpower resources to deploy troops to meet mission requirements. The location of maintainers also limits the DoD's ability to locate different airframes around the world. These limitations impact the DoD's aircraft availability and predictability among potential adversaries. The JIT MMA concept plans to leverage a variety of technological solutions to assist with solving these issues by

efficiently training and supporting maintainers. However, no solutions are available with the JIT MMA concept to solve these issues. Developing solutions to support the JIT MMA concept involves understanding how to capture and share knowledge. User toolkits are an existing concept the DoD could use to improve capturing and sharing knowledge within the maintenance community. Even though some organizations within the DoD provide innovative need-based maintenance content, like The Griffin, there are no solutions available that allow the whole community to create effective need-based solutions together.

The objective of this work is to develop a model-framework on user toolkits. The researchers perform a model-based literature review on user toolkits for user innovation to understand the roles, tasks, and information flows that exist in an environment that uses a user toolkit. The contribution of this research includes clearly identifying the roles, tasks, and information flows that exist in an environment that uses user toolkits while developing and implementing a model-based approach to perform a literature review using SysML. The model-framework could assist organizations with identifying potential opportunities when developing a roadmap for implementing user toolkits.

Research Questions

This thesis addresses the following research questions on the development and assessment of a model-based framework on user toolkits:

RQ 1: How can researchers use Systems Modeling Language (SysML) to perform a literature review on topics, such as user toolkits for user innovation?

RQ 2: What roles, tasks, and information flows exist in an environment that uses user toolkits for user innovation?

RQ 3: What industries do user toolkits exist in?

RQ4: What can researchers learn from applying their model-framework to a DoD organization?

Research Focus

This research focuses on capturing and sharing knowledge to support the JIT MMA concept by analyzing journal articles on user toolkits for user innovation. This research provides a model-framework that organizations can use as an assessment tool to develop a roadmap for implementing user toolkits.

Methodology

The researchers performed a model-based literature review with four phases to develop and apply a model-framework on user toolkits for user innovation. This research leverages SysML, which is a graphical modeling language for systems engineering that offers a variety of features for creating models and visualizing data. The researchers use SysML to model articles and capture information on the industries, roles, tasks, and information flows that exist in environments that use user toolkits throughout the first three phases of research. Two databases populated a dataset with 32 journal articles on user toolkits for user innovation.

- The first phase of research modeled 10 articles from the first database to capture and aggregate data on the roles, tasks of each role, and information flows that exist in an environment that uses user toolkits.

- The second phase of research applied the aggregated roles, tasks, and information flows from the first phase to model the remaining 12 articles from the first database.
- The third phase of research refined the master model from phase two by modeling an additional 10 articles from another database to validate any claims of data adequacy.
- The final phase of research applied the model-framework on user toolkits to an existing DoD organization, The Griffin.

Chapter III details the research methodology.

Assumptions/Limitations

This research has several assumptions and limitations. The number of journal articles found through the Air Force Institute of Technology (AFIT) library and through Google Scholar only allows the researcher to identify the existence of behavior within the dataset. Expanding the number or journal articles or data bases could influence the findings of this research.

The qualitative nature of this research also acts as a limitation. The analysis of the journal articles was based on how the researchers interpreted the information. Other researchers might have different interpretations.

The researchers also face limitations based on the model-framework they applied to the DoD organization. Refactoring the model-framework could further findings or change the interpretation of the organization the researchers applied their model-framework to.

Additionally, the researchers only applied their model-framework to one DoD organization. The amount of information that was available through the website of the DoD organization also placed a limitation on the research. Additional information on The Griffin or expanding the model-framework to other organizations could further the findings or change the interpretations of this research.

Thesis Outline

This thesis is composed of five chapters, which includes Chapter I as the introduction. Chapter II is a literature review on user innovation and user toolkits. Chapter III describes the methodology the researchers used for their research. Chapter IV elaborates on the analysis and results of the research. Chapter V concludes the research by discussing the significance of the research and by providing recommendations for action and future research.

II. Literature Review

This chapter provides more context on user innovation and user toolkits for user innovation. User innovation and the subfield of user toolkits for user innovation are both growing areas of interest among scholars [12], [13]. The DoD has innovative users, but the concept of user innovation is not new. User innovation is a mature area of research with many demonstrated benefits in product design and development. Users innovate for a variety of reasons and the communities of those users' value innovation.

Additionally, several concepts assist with harnessing user innovation. This chapter introduces a few of these concepts while primarily focusing on user toolkits for user innovation. This chapter also elaborates on the spectrum of user toolkits that exist while discussing the known characteristics that help with transferring information efficiently between firms and users. Additionally, this chapter summarizes previous research that discussed the benefits and disadvantages of user toolkits. This chapter also discusses how several industries implemented user toolkits. The researchers relate these implementations to the defense industry to highlight how other industries can adopt similar practices.

User Innovation

User innovation refers to innovation that users drive or create for their benefit [14]. For decades, research recognized users as a source of innovation [15], [16]. The user innovation phenomenon differs heavily from manufacturer-centric models, which emphasize firms as the major source of innovation. A key difference between user and manufacturer-centric innovation is how each actor, the user and the firm, benefits from

innovation. With user innovation, users benefit from innovation by consuming or using the innovation while firms profit from innovation by selling or licensing the innovation. For example, StataCorp created a proprietary statistical software that others can access if they pay for it. Meanwhile, other innovative users developed and provided similar products for other users to use online with no charge [17]. This example highlights how users benefit from innovation by accessing and using new features or products that were not available before, such as the statistical software, by either paying for a firm's product or finding innovative solutions form other users.

Additionally, research highlights how companies are recognizing the benefits of user innovation and are shifting from manufacturer-centric models of innovation to open, user-centric processes. [17], [18]. Shifting to user-centric processes affords a variety of benefits to manufacturers. Some benefits include reducing overall development costs and timelines. By reducing these factors, manufacturers can reduce the overall cost of their product when compared to other competing manufacturers who use traditional manufacturing methods. This reduction creates a mutual benefit by allowing users to obtain products at a much lower cost while producing profits for manufacturers. The kitesurfing industry experienced this exact scenario. A website allowed users to upload their designs for others to use. These users did not seek any form of payment for their work. A kite manufacturer recognized the popularity of this site and started producing and selling the designs. The user-centric process allowed the kite manufacturer to price their products much lower than their competitors since they did not have to spend the resources to develop the design. User-centric processes also allow manufacturers to differentiate themselves from other competitors. They could provide custom production

services to users by offering to produce user designs in a faster, better, and/or cheaper manner when compared to other competitors [17].

Observed Progression of User Innovation

As previously mentioned, a wide variety of research on user innovation exists spanning several decades. However, literature suggests the phenomenon extends back even further highlighting how people produced innovations to save their own labor [19]. Some early research emphasized how firms received inputs from users that directly influenced the development and marketing of products [20]–[22]. These early pieces of literature showcase how users can create innovative ideas that influence a firm's ability to create commercially viable products.

Earlier literature showcased the user's ability to generate innovative ideas, but Eric von Hippel (1976) was the first to systematically describe the idea of user innovation. In his literature, von Hippel explains how 80% of the innovation activity for scientific instruments occurred with the product user [16]. Additionally, other research on user innovation emerged across a variety of sectors, such as industrial machinery [23], software [24], semiconductors[25], pipe hanger hardware [26], residential construction [27], library information systems [28], sporting equipment [29], and commercial banking [30]. These sources of research on user innovation highlight the importance of users in the design and development process. These sources suggest that users are a source of innovation and do not only help firms produce innovative products [31]. Users tend to develop innovations that enable products to do new types of functions for the first time [32]. The variety of sectors where user innovation was emerging signals that user innovation is a broad field in which many people participate.

Additionally, user innovation is happening frequently. One study sampled 1173 UK household residents aged 18 and over and found 6.2% of them created or modified consumer products over a three-year period. Applying this scale to the UK population implies that, at the time of the study, about 2.9 million people participated in user innovation to meet a previously unmet need [33]. Researchers performed a comparable study in Japan and the USA, which produced similar results [34]. These studies highlight the amount of user innovation that is occurring in addition to where user innovation is occurring.

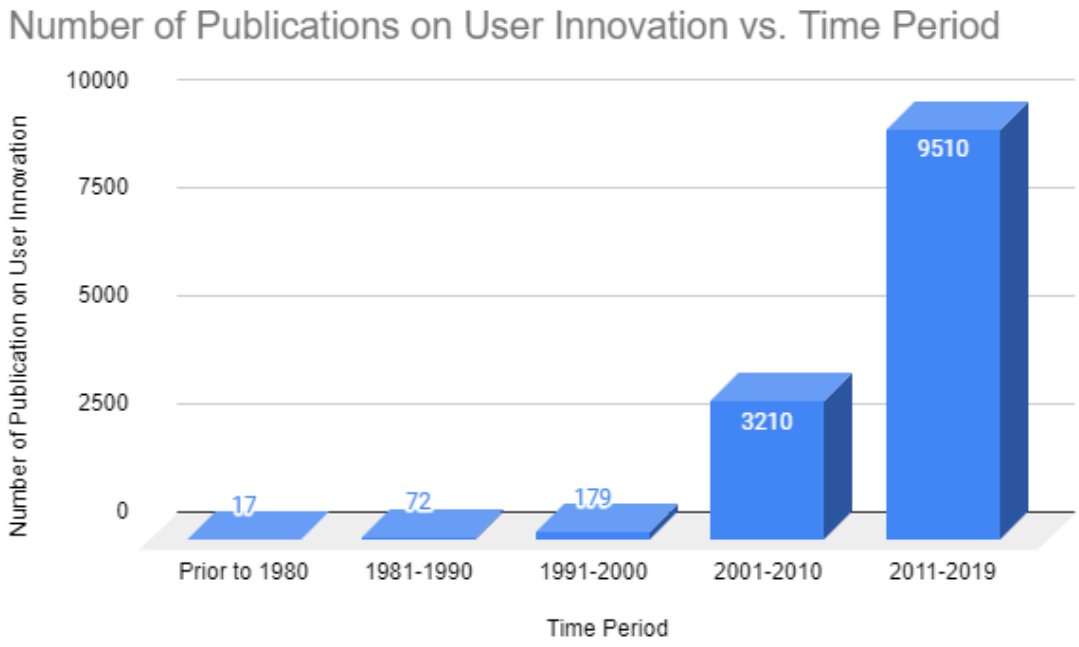

Figure 1: Development of the Academic Field "User Innovation" [12]

In addition to the large number of people who participate in user innovation, Figure 1 showcases the growth in research around the user innovation field. The first three bars highlight the relatively low growth in the field from before 1980 to 2000, where 17 publications existed from before 1981, 72 publications between 1981-1990, and 179

publications between 1991-2000. However, the last two bars emphasize the growth the user innovation field experienced since 2001, where 3,210 publications existed from 2001-2010 and 9,510 publications from 2011-2019. This signifies a growing interest in user innovation by scholars.

Motivation Behind Users Who Innovate

Through the clear growth of the user innovation research field, researchers have observed various findings on why users innovate. One reason why users innovate is the need to satisfy unmet needs [28], [35], [36]. Research has shown users who are a market of one with their heterogeneous needs have unmet needs because firms do not expect to profit from satisfying such a unique need [17]. The stickiness of information, i.e., the number of resources it takes to transfer information from its originating location to another, also impacts the perceived profitability of satisfying a heterogenous need since it is difficult to transfer information on the specific need from users to firms [12], [37]. The attributes of the information also impact the stickiness of information [38]. Thus, users have two choices: buying something that does not fully satisfy their needs or innovating new products. However, the needs of users can be deeply rooted in their personal experiences and arise from intuition. As such, they are often not consciously aware of or able to explicitly communicate their rationale [39]. If users have needs that diverge significantly from the needs that commercially available solutions satisfy, they will not pursue commercially available solutions, which leaves them with the only option of innovating to satisfy their needs [40].

Another reason users innovate is to obtain higher value solutions [17]. Users can request solutions from firms to satisfy their needs, but developing innovative solutions

can incur costs, including costs to ensure the firm follows the interests of the user, costs to commit the firm to not act against the user's interests, and costs associated with not fully meeting the user's needs [41]. Other research validates these costs by stating how firms have a difficult time identifying valuable information from various user statements or misunderstanding what users are requesting [17], [42], [43]. By innovating themselves, users reduce the likelihood of incurring these agency costs while meeting their interests. For example, sport equipment users who innovate found it challenging to communicate what would make a sport more amusing. However, when those same users developed their own new gear, they had more fun playing the sport [29]. Even in the medical field, surgeons developed innovative solutions to perform better operations [44].

In addition to acting in their own best interests, some users innovate to satisfy their intellectual curiosity [45], [46]. To innovate, the users must have the skills and knowledge to understand the reasons behind a specific need and to develop a solution [47]. Certain users might value the process of learning from innovating, which encourages them to innovate over buying solutions that fulfill most needs. Von Hippel refers to this process as "learning while doing" and emphasizes how this process allows users to gradually understand and refine what they truly need to meet their needs [17]. For example, studies that focused on why coders openly contributed code to software projects showed how the knowledge they gained from others motivated them as they completed their work [48], [49]. Another prominent example of people innovating because they enjoyed the "learning while doing" process include the scientists at the European Council for Nuclear Research (CERN). These scientists came together to

create the World Wide Web because they were motivated by the desire of improving how they shared information with one another [50].

Financial aspects also motivate users to innovate. While firms can mass produce products more economically than individual users, users with unique needs might find it more economical to innovate themselves rather than requesting assistance from a firm [17]. Firms are known to incorporate their existing solutions into future products and release products that suit the average needs of a particular consumer segment because these actions assist with keeping costs down while satisfying the needs of a large group of individuals [12]. However, some users might not want to pay for a product that incorporates these existing solutions because they want something that fits their exact needs [51], [52]. This thought process highlights how some users might not value features they might not use. Purchasing feature-rich products that users may never use motivates users to create solutions that fit their exact needs [17]. Additionally, some innovative users recognize the potential profitability of their innovations. When users innovate and create solutions that meet their exact needs, selling those solutions for a profit might motivate them to continue innovating. For example, some user innovations are at the leading edge of a market and are capable of satisfying a need that many users in a specific market will experience later [53]. These users are known to license their solutions to commercial producers or start their own business to produce and sell their novel solution to other users [47], [54]–[57]. Innovative users are also known to use their innovations to secure economic benefits from firms, such as employment opportunities [45], [58].

Securing a certain social status is another aspect that motivates users to innovate. Some users reported that their motivation to innovate comes from gaining a level of appreciation or loyalty from others as they release their innovations into a community of users with similar interests [59], [60]. The users who achieve a higher social status can use their status to achieve rewards or build relationships to improve their innovation process.

Importance of Innovation Communities

As mentioned in the previous section, users are a valuable source of innovation and there are a variety of factors that motivate them to innovate. In addition to understanding these factors, it is important to understand how their innovations become noticed and widely adopted. Innovation communities are an important entity that assists with diffusing the innovations of other users. In fact, user communities efficiently employ resources as users with very similar needs can share and reuse existing innovations [17]. When users freely reveal their innovations, they create a public good because anyone who has an interest can access the information [61]. If an innovation becomes popular, user communities assist with promoting the innovation and rewarding the innovators [17], [62]. In general, society encourages and rewards innovation, which further supports the action of sharing and diffusing innovations freely [63].

Innovation communities also facilitate valuable interactions for those within, and external to, the community. For example, innovation communities help increase the speed and effectiveness of user and firm innovations [17]. When innovators reveal their ideas to a community, other users can improve or provide feedback on the innovation, which creates a mutual benefit to community members and the innovators [64]. In

addition to pushing innovation further, the interactions within and outside of the community allow users to support one another [65], [66].

Concepts to Harness User Innovation

User innovation has positively impacted a variety of industries and concepts have emerged to access user innovations. Some of these concepts include the lead user method, crowdsourcing, and user toolkits. The lead user method involves firms searching for attractive user innovations and new business opportunities at the leading edge of an important market [53]. Crowdsourcing involves outsourcing innovation tasks to a broad group of external users. These external users use their problem-solving skills and abilities to generate a wide range of solutions for a given problem. A firm can then select a solution to implement or adjust from the crowdsourced ideas [67]. A user toolkit contains various features and feedback mechanisms that guide users throughout the design process. These feedback mechanisms and features enable the production of finished products that satisfy a set of requirements or unmet needs. Therefore, a user toolkit is a concept that allows users to create, test, and share potential product designs within an experimental environment that is based on an existing production system. These solution spaces can differ depending on the industry and the firm that implements the user toolkit concept. Additionally, well designed user toolkits allow firm's to translate almost any user designs into tangible products with little error since the toolkits are based off the existing production capabilities of the firm[3]. Due to the nature of this research, the next section will explore user toolkits further.

User Toolkits

A user toolkit is a concept that allows users to create, test, and share potential product designs within an experimental environment that is based on an existing production system. These solution spaces can differ depending on the industry and the firm that implements the user toolkit concept. This concept benefits both the firm and the user since it allows users to articulate their exact requirements while the firm gains access to precise information on customer needs. These needs are expressed within the solution space of the firm [3]. There is a growing interest in research on the use of user toolkits for innovation purposes. For example, Figure 2 depicts the growing trend from a 2011 literature review.

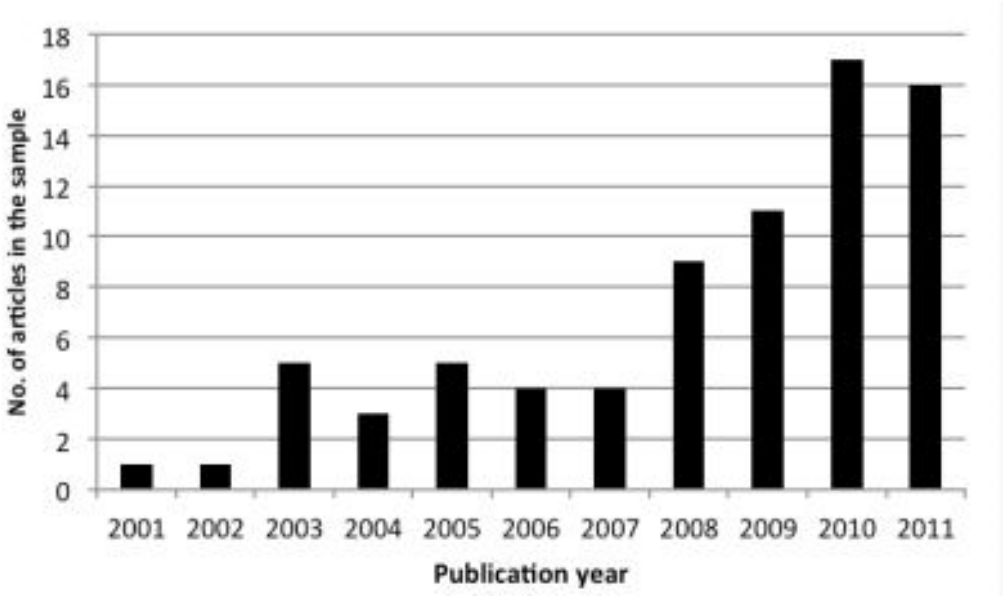

Figure 2: Publication Year of Articles in 2011 Research Sample [13]

Characteristics of User Toolkits

Previous research identified various characteristics of successful user toolkits. For example von Hippel stated in his research that there are five characteristics that are a part of a user toolkit [3]:

1. The ability for users to learn while designing a solution - The ability for users to "learn while doing" means that users can receive feedback while they develop their design. They can continuously incorporate this feedback to improve various portions of their design to work towards a product that meets their exact needs. In addition to receiving feedback on what does and does not work in their design, users learn about other capabilities within the toolkit that they can include, which allows the user to expand their existing knowledge.
2. A solution space built into an existing production system for users to work in - The solution space must allow users to create designs that existing production systems can produce. This characteristic sets a boundary around what products users can feasibly create with their freedom to innovate. If users start to request expansions on the solution space to innovate further, then firms may need to make investments to adjust their production system as well.
3. A user-friendly design that allows users to leverage and build upon existing skills – A toolkit that is user friendly means the toolkit is intuitive for users to use; they can embrace their own skills and do not have to receive much training on the toolkit itself.
4. Libraries of existing modules to provide users with a starting point for their design – Users can incorporate existing modules into their design. Additionally,

users can adapt and alter these modules to provide a starting point to design from while creating unique products that suit their needs.

5. The ability to translate designs into actual products without any error – Once a user creates a design that meets their needs, the user toolkit must translate the user's design into a tangible product without any error. This ability means the user toolkit can translate the user's design into a language that the firm's production system can decipher and vice versa.

These characteristics come together to create an environment to facilitates idea generation that leads to creating tangible and producible innovations. Additionally, these characteristics ensure the ideas are unique, contain the necessary details, and provide enough information to create a discussion point among users [68].

Spectrum of User Toolkits

There is not just one user toolkit; a spectrum of user toolkits exist that are based on the design autonomy that firms extend to users. Research describes design autonomy as the amount of freedom users have to schedule work, make decisions, and choose methods for designing and innovating within an environment [68]. In essence, design autonomy relates to how regulated users are as they proceed through the design process to meet a requirement.

On one end of the spectrum, user toolkits take on a simple form where firms allow users to choose from a variety of existing options to create a product. An example of this toolkit is Dell's system which allows users to create a custom computer by selecting from a variety of pre-existing options. The result is a product that best meets the user's requirements based on the available options that Dell offers. At the other end of the

spectrum, there are toolkits that provide users with a much more active role in the design process. The users create modules instead of selecting from a variety of existing options. This type of toolkit usually allows users to create more radical innovations since there is a much larger system boundary. An example of this toolkit would be open-source software where users can almost create whatever program that comes to their mind [69].

Reasons for Using User Toolkits

A variety of advantages exist that support the use of user toolkits for user innovation. One major reason for using user toolkits includes handling "sticky information" in an efficient way. Sticky information is known as information that is costly to acquire, transfer, or use [37]. User toolkits assist firms with acquiring insight on what users need since the user toolkit allows users to perform trial and error learning when creating a solution to meet a requirement or unmet need. Once the user reaches a point where they feel the design will satisfy their requirements, they can transfer their need-related information to a firm to produce the solution. This process assists with avoiding unnecessary back—and-forth communication between users and firms [3], [70]. The user clearly communicates their requirements by using the toolkit to form and submit their need-related information in a manner the firm can understand. The firm can take the user's need-related information and use their solution-related knowledge on manufacturing to translate the design into a tangible product [62]. In essence, a user toolkit assists with handling sticky information by separating and delegating need-related tasks to the user and solution-related tasks to those within the firm.

User toolkits also provide users with a starting point in their design process when they do not know exactly what they want or what they need to satisfy a requirement.

This starting point allows users to develop their ideas or style by adding to or subtracting from existing modules [70]. The starting point could also include standardized instructions, templates, and additional tools, all of which improve the user's ability to convey information to the firm [68].

User toolkits also act as a communication medium for identifying sources of innovation within a targeted community; sources like ideas, designs, and even innovative users [68]. Some users might have complex ideas that are difficult to explain, but a user toolkit allows these users to express their complex ideas as manageable modifications. The toolkit helps the user share their modifications with other users who are a part of their community. A community of users can identify innovative ideas from other users, the community can discuss those ideas, and everyone can build upon an idea together with the user toolkit [71]. Additionally, since a community can use these toolkits to ensure ideas are unique, community members can avoid duplicating similar ideas. This affords community members and firms more time to examine the viability of adopting proposed innovations versus just generating ideas. User toolkits also assist with identifying key players who act as a source of innovation [68]. Research has shown that firms seek out and employ the most innovative users through the use of user toolkits due to the user's frequent contributions within the community [72].

User toolkits also assist with creating more value with products. One of the earliest examples of user toolkits included custom integrated circuits. Several benefits emerged from incorporating a user toolkit: the overall market of custom integrated circuits grew to more than $15 billion, the toolkit cut development time by two thirds, and the toolkit decreased costs [9]. Additionally, other experiments with user toolkits

have shown how users are willing to pay over 100% more for self-designed products versus standard products [73], [74].

User toolkit also allow users to push innovation further since they help increase the quality and fluidity of interactions within a community, which increases the knowledge and innovativeness of that community [75]. Users are known to use a variety of user toolkits when developing designs to push innovation beyond the limitations of a single toolkit. Sometimes user toolkits allow users to develop and share tools that other users can use to create new and innovative designs outside of the boundaries set by the manufacturer. This process is known as learning from the leading edge, which highlights how users will use other sources to create innovative products [62].

Arguments Against User Toolkits

Despite the known benefits of user toolkits, counter arguments exist. User toolkits can be costly to develop, implement, operate, and change. Documented costs range from $100,000 to at least 10 times that cost [69]. These costs could prove to be too great for some firms to implement on top of their existing production system. The need to restructure an organization or existing products to successfully implement user toolkits is another aspect that impacts the cost [76]. The act of restructuring would require firms to expend additional resources outside of their traditional resources to develop a user toolkit.

In addition to cost, the complexity involved with a user toolkit could prove to be too great to produce meaningful results. Research highlights this complexity by questioning the benefits of user toolkits [77], [78]. One concern of implementing a user toolkit is overwhelming users with too many choices, referred to as mass confusion, since

the user toolkit provides a variety of tools and methods to create innovative solutions [79]. Users in these scenarios usually know they cannot decide on an option when they need to explore so many choices. With user toolkits, if the user finds the experience to be too complex, their interaction with the toolkit could be so unpleasant that they abandon the design process. Users might understand how to navigate the user toolkit, but the toolkit might complicate the process of knowing how to create innovative solutions, which can be a complex process. This complexity leaves the user without a viable solution to satisfy their unmet needs and the firm does not gain any insight into the information that the user could provide on future products to meet those unmet needs. The complexity involved with user toolkits means a user is unlikely to develop something innovative that could meet their needs [69].

Another argument against user toolkits is the inability to satisfy every user's needs [62]. This argument means the firm's investment in user toolkits could fail to gather information on what users need as users are unable to create solutions that meet their exact needs. Users might have to leverage other user toolkits to fill these potential gaps to satisfy their unmet needs or abandon the design process all together. This solution starts to turn into a similar problem mentioned previously where users must select from a variety of choices; the choices between available user toolkits could overwhelm the user as they try to develop a solution for their problems. If too many choices exist, users could face mass confusion. Additionally, a somewhat mature industry or product needs to exist to create a user toolkit because a user toolkit is built upon an existing production system [73]. If someone is trying to create something truly revolutionary, then a user toolkit might not be a viable option. This issue exists because

production systems provide scope to define the boundary of a user toolkit [62]. Without an existing production system, it becomes more challenging to understand the parameters required to successfully implement a user toolkit.

Implementations of User Toolkits

Despite the limitations previous research mentioned, a variety of industries implemented user toolkits.

Table 1 lists several industries that implemented user toolkits. The table lists the industry, a brief example of the user toolkit, and the source of information.

Industry	Example	Source
Software	Users were able to manipulate the standard security software to meet their security needs	[35]
Semiconductor	LSI Logic implemented user toolkits to develop custom application specific integrated circuits	[9]
Culinary	Nestle implemented a toolkit of standard ingredients for executive chefs to use to create custom recipes that could be mass produced easily	[3]
Fashion	Customers can develop their own design for t-shirts, watches, or other apparel	[80]
Sporting Goods	Sport enthusiasts used existing toolkits to make their own prototypes for the sport they were interested in	[29]
Video Games	Users could develop their own items to use in a video game and could share these items with other users	[62]
Computer Hardware	Users can create their own gadget with a toolkit by incorporating a variety of sensing and input modules that snap into a low-cost central Linux-based core	[81]
Mobile	Users could create events in a toolkit for mobile devices with a set of preconditions	[71]
Automotive	Cars have been known to implement interfaces that allow users to customize and control various aspects of the vehicle that go from engine performance to infotainment systems	[81]
Furniture	IKEA implemented a user toolkit called Home Planner where users could design a complete room, such as a kitchen, before placing an order	[47]
Jewelry	Toolkits such as Ponoko and Shapeways leverage 3D modeling to allow users to design their own products	[47]
Machining and Tooling	A toolkit allows a machining center to fashion almost any shape out of a machinable material through a combination of available machining options.	[70]
Plastics	GE provides a web-based toolkit to customers to design better plastic products	[72]
Service	Some websites incorporated toolkits to plan and customize events, such as weddings or vacations	[12]
3D Printing	Companies provide a large solutions space to users where certain shapes and materials limit their ability to create a product that meets their needs	[82]
HVAC	Toolkits exist that allow users to create their own air conditioning system based on features the company provides	[14]
Internet Service	Toolkits exist that allows users to share, manage, and create content and functionality	[75]
Security	Toolkits exist that allows users to create their own security system from a list of features online from a manufacturer	[14]
Gardening	Users can design a garden and receive feedback on the consequences they might experience based on their design decisions	[14]
Residential and Commercial Lighting	Lutron provided an embedded toolkit to allow users to make certain modifications to their product when they used it	[81]
Social Media	Social media providers, such as Facebook, provide certain customizable aspects to their product to users that capture specific information on user preferences	[83]
Toy	Lego developed a toolkit so users could develop and purchase their own custom Lego set	[84]

Table 1: Examples of Industries Implementing User Toolkits

Industry	Example	Source
Software	Users were able to manipulate the standard security software to meet their security needs	[35]
Semiconductor	LSI Logic implemented user toolkits to develop custom application specific integrated circuits	[9]
Culinary	Nestle implemented a toolkit of standard ingredients for executive chefs to use to create custom recipes that could be mass produced easily	[3]
Fashion	Customers can develop their own design for t-shirts, watches, or other apparel	[80]
Sporting Goods	Sport enthusiasts used existing toolkits to make their own prototypes for the sport they were interested in	[29]
Video Games	Users could develop their own items to use in a video game and could share these items with other users	[62]
Computer Hardware	Users can create their own gadget with a toolkit by incorporating a variety of sensing and input modules that snap into a low-cost central Linux-based core	[81]
Mobile	Users could create events in a toolkit for mobile devices with a set of preconditions	[71]
Automotive	Cars have been known to implement interfaces that allow users to customize and control various aspects of the vehicle that go from engine performance to infotainment systems	[81]
Furniture	IKEA implemented a user toolkit called Home Planner where users could design a complete room, such as a kitchen, before placing an order	[47]
Jewelry	Toolkits such as Ponoko and Shapeways leverage 3D modeling to allow users to design their own products	[47]
Machining and Tooling	A toolkit allows a machining center to fashion almost any shape out of a machinable material through a combination of available machining options.	[70]
Plastics	GE provides a web-based toolkit to customers to design better plastic products	[72]
Service	Some websites incorporated toolkits to plan and customize events, such as weddings or vacations	[12]
3D Printing	Companies provide a large solutions space to users where certain shapes and materials limit their ability to create a product that meets their needs	[82]
HVAC	Toolkits exist that allow users to create their own air conditioning system based on features the company provides	[14]
Internet Service	Toolkits exist that allows users to share, manage, and create content and functionality	[75]
Security	Toolkits exist that allows users to create their own security system from a list of features online from a manufacturer	[14]
Gardening	Users can design a garden and receive feedback on the consequences they might experience based on their design decisions	[14]
Residential and Commercial Lighting	Lutron provided an embedded toolkit to allow users to make certain modifications to their product when they used it	[81]
Social Media	Social media providers, such as Facebook, provide certain customizable aspects to their product to users that capture specific information on user preferences	[83]
Toy	Lego developed a toolkit so users could develop and purchase their own custom Lego set	[84]

Table 1 showcases how user toolkits can vary drastically from one another. For example, LSI Logic implemented one of the earliest examples of a user toolkit when understanding their customer's needs became a challenge. Companies encountered

Industry	Example	Source
Software	Users were able to manipulate the standard security software to meet their security needs	[35]
Semiconductor	LSI Logic implemented user toolkits to develop custom application specific integrated circuits	[9]
Culinary	Nestle implemented a toolkit of standard ingredients for executive chefs to use to create custom recipes that could be mass produced easily	[3]
Fashion	Customers can develop their own design for t-shirts, watches, or other apparel	[80]
Sporting Goods	Sport enthusiasts used existing toolkits to make their own prototypes for the sport they were interested in	[29]
Video Games	Users could develop their own items to use in a video game and could share these items with other users	[62]
Computer Hardware	Users can create their own gadget with a toolkit by incorporating a variety of sensing and input modules that snap into a low-cost central Linux-based core	[81]
Mobile	Users could create events in a toolkit for mobile devices with a set of preconditions	[71]
Automotive	Cars have been known to implement interfaces that allow users to customize and control various aspects of the vehicle that go from engine performance to infotainment systems	[81]
Furniture	IKEA implemented a user toolkit called Home Planner where users could design a complete room, such as a kitchen, before placing an order	[47]
Jewelry	Toolkits such as Ponoko and Shapeways leverage 3D modeling to allow users to design their own products	[47]
Machining and Tooling	A toolkit allows a machining center to fashion almost any shape out of a machinable material through a combination of available machining options.	[70]
Plastics	GE provides a web-based toolkit to customers to design better plastic products	[72]
Service	Some websites incorporated toolkits to plan and customize events, such as weddings or vacations	[12]
3D Printing	Companies provide a large solutions space to users where certain shapes and materials limit their ability to create a product that meets their needs	[82]
HVAC	Toolkits exist that allow users to create their own air conditioning system based on features the company provides	[14]
Internet Service	Toolkits exist that allows users to share, manage, and create content and functionality	[75]
Security	Toolkits exist that allows users to create their own security system from a list of features online from a manufacturer	[14]
Gardening	Users can design a garden and receive feedback on the consequences they might experience based on their design decisions	[14]
Residential and Commercial Lighting	Lutron provided an embedded toolkit to allow users to make certain modifications to their product when they used it	[81]
Social Media	Social media providers, such as Facebook, provide certain customizable aspects to their product to users that capture specific information on user preferences	[83]
Toy	Lego developed a toolkit so users could develop and purchase their own custom Lego set	[84]

several mistakes before the implementation of a user toolkit, such as incomplete or inaccurate user requirements, increased costs for correcting errors, and delays in the production schedule. LSI Logic developed a toolkit that included a set of proprietary software tools which allowed customers to design and develop their own products based on the capabilities that LSI Logic could offer. LSI Logic leveraged the fact that their customers had the knowledge to understand the design process for creating integrated circuits. The toolkit acted as a communication medium between the customers and the engineers at LSI Logic to translate requirements accurately. This concept became an industry standard based on its success and the market for custom integrated circuits grew by billions of dollars as companies reduced their development time by two thirds and achieved a significant decrease in development costs [9], [38]. This example also highlights how other industries, such as the defense industry, could implement user toolkits. Industries can leverage virtual environments and software to produce innovative solutions that satisfy unmet needs if users have knowledge of that industry and the technical tools and know-how to fashion effective and affordable solutions.

Companies also developed user toolkits that were not software focused like LSI Logic's user toolkit. Nestle USA's Food Service Division released a user toolkit that included a variety of different ingredients used in their industrial kitchens when they mass produced recipes for other restaurants. Nestle developed this toolkit for a few reasons. Nestle noticed the ingredients from other restaurants differed slightly from their ingredients. Additionally, Nestle's processes for mass producing recipes differed from how the restaurant kitchens prepared food. These differences resulted in significantly different tastes. Nestle understood they could not translate industrial kitchen processes to

those available in local restaurants. Instead, Nestle focused on controlling how different the taste and texture of the mass-produced food was when compared to what the restaurants created. Nestle provided their standard set of ingredients to those restaurants. Nestle's toolkit allowed executive chefs at these restaurants to develop unique recipes that Nestle could mass produce easily. Additionally, the use of this user toolkit allowed Nestle to focus more on the production of recipes versus the more complex problem of determining how to create food that met the chef's needs within the constraints of Nestle's existing production system. The implementation of this user toolkit allowed Nestle to shorten the time to develop custom food from 26 weeks to 3 weeks [70]. This example also highlights how firms can provide a variety of physical objects to users who have knowledge on the industry to create innovative solutions. Other industries, such as the defense industry, could implement user toolkits that offer existing physical components for users to experiment with in their design process.

The two previous examples highlight user toolkits that required users to have industry knowledge to develop solutions with virtual or physical user toolkits. However, there are other user toolkits that target general end users who do not have industry knowledge to create customized or individualized products. One empirical study analyzed the effect of a user toolkit that allowed users to create customized watches. The toolkit had a variety of components with different styles that users could mix and match to create a watch based on what they thought was best from the available options. Users reported the user toolkit was easy to use and the study found people were willing to pay more for an item they created versus choosing a standard offering of an item. This study highlights how a good user toolkit does not require users to be an expert in a certain

industry to create solutions. Users can select from a variety of available options to create an individualized solution. The study also reported improved user satisfaction among users who customized their own product [73]. Other industries, such as the defense industry, could benefit from implementing a similar user toolkit to improve the satisfaction of their own user base while leveraging the creativity that exists throughout the same user base.

Summary

Research on user innovation continues to receive a growing interest and the subfield of user toolkits for user innovation is growing with it. User innovation is a mature area of research with many demonstrated benefits in product design and development. There are a variety of reasons that motivate users to innovate instead of settling for products that do not meet their exact needs. In addition to satisfying their own needs, the communities that users are a part of benefit from user innovation. These communities also provide users with benefits and support throughout the entire design process.

Since user innovations can impact society in a revolutionary manner, a variety of concepts exist to harness the most relevant user innovations. One concept we explored was the use of user toolkits for user innovation. These toolkits have a few known characteristics that help with transferring sticky information from the firm to the user and from the user to the firm. A spectrum of user toolkits exists to transfer this sticky information. At the lowest level, there are simple mass customization toolkits that limit the design autonomy of users. At the highest level, there are toolkits that provide a very

large and almost limitless solution space that affords a high level of design autonomy to users. There is also a variety of research that advocates for or against the use of user toolkits. However, even with the proposed arguments against user toolkits, several industries have implemented user toolkits.

Overall, the literature on user toolkits for user innovation covers a wide variety of topics and continues to expand. However, even with all the research on user toolkits for user innovation, gaps in the literature exists. The existing literature on user toolkits explains why organizations should use user toolkits, but the literature does not provide clear guidance on how to successfully implement a user toolkit. There is currently no research that identifies and describes all the key roles, tasks of each role, and the information flows that exist among the roles in an environment that uses user toolkits. The next Chapter, Chapter III, details the methodology the researchers used to fill in this gap in literature.

III. Methodology

Chapter Overview

This chapter provides a description of the methodology used to conduct research including the data sources used, aspects of SysML, and the generation, analysis, refinement, and application of data. This chapter outlines how the researchers identified the roles, tasks of each role, and the information flows that exist among the roles in an environment that uses user toolkits. This chapter has eight sections. The first section is an overview of the overall research approach. The second section provides an overview on the data sources the researchers used. The third section provides an overview of Cameo Systems Modeler and the features this research employs. The fourth, fifth, sixth, and seventh sections go into detail on the four phases the researchers performed to collect, generate, analyze, refine, and apply the data they gathered. The final section provides a summary of this chapter.

Overall Research Approach

The methodology of this research includes performing a literature review on user toolkits for user innovation. The researchers use a set of search terms related to the topic to populate a dataset of relevant journal articles. They incorporate a model-based approach that Model-Based Systems Engineering (MBSE) influenced. The International Council of Systems Engineering describes MBSE as a formalized application of modeling that supports a system throughout its entire life cycle [85]. Based on this description, MBSE is a digital engineering method that assists with managing the complexity that is associated with the development and sustainment of complex systems.

The researchers assert the literature on user toolkits contains complex ideas and information. Additionally, they believe they can apply aspects of MBSE to manage the complex information that exists throughout literature.

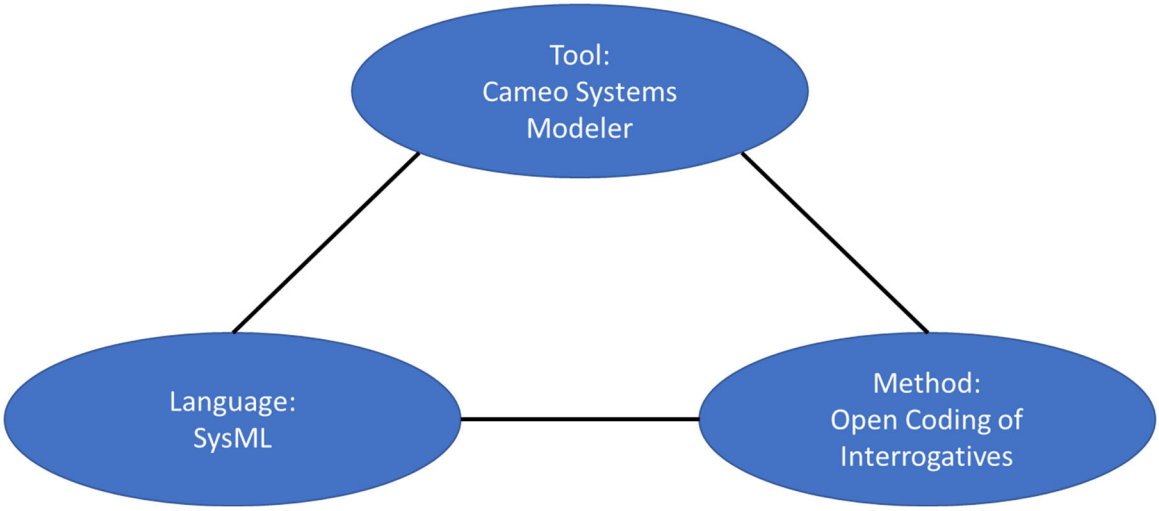

Figure 3: Managing Research Complexity

Figure 3 introduces the tool, language, and methodology of this research. The research tool was version 19 of Cameo Systems Modeler. This tool is a collaborative Model-Based Systems Engineering environment that allows users to define, track, and visualize all aspects of a system using SysML models and diagrams. This research leveraged SysML which is a graphical modeling language for systems engineering that offers a variety of features for creating models and visualizing data. Some of the SysML features and models this research utilized include blocks, item flows, stereotypes, packages, profile diagrams, and block definition diagrams (BDDs). The research methodology included managing complex ideas throughout the literature through the open coding of interrogatives. The open coding of interrogatives allowed the researchers to break down information into distinct ideas. Once the information was broken down, they could group similar ideas into clusters to draw conclusions from the data [86].

The phases of research began with a model-based literature review targeting available, peer-reviewed articles that focused on user toolkits and user innovation from two different databases. The researchers treated each article from each database as an individual case and captured the roles involved with user toolkits, the tasks that each role was responsible for, and the information flows that existed among each role using SysML. Additionally, the researchers captured the industries that implemented user toolkits to gain an understanding on the existence of user toolkits. Figure 4 highlights the model representations that the researchers used to capture information within each article. Roles represent different actors, tasks represent the actions of specific actors, item flows represent information flows that exist among the various actors, and the industry represents a product domain.

Information	Model Representation	Interrogative
Role	«stereotype» role [Element]	What roles are involved within an environment that uses user toolkits?
Task	«stereotype» task [Element]	What tasks do these roles perform within an environment that uses user toolkits?
Information Flow	information flow	What information is transferred among the different roles within an environment that uses user toolkits?
Industry	«stereotype» Industry A [Element]	What industries implemented user toolkits?

Figure 4: Open Coding of Research Interrogatives

The research incorporated a four-phased approach. In phase one, we analyzed each of the 10 articles to capture the roles, tasks, and information flows involved with user toolkits. The researchers analyzed and aggregated the data to form a baseline for the most prevalent roles, tasks, and information flows involved with the implementation of user toolkits. Since there are a variety of specific roles, tasks, and information flows contained within the literature, the researchers needed to create generalized terms to apply across the case articles. This allowed the researchers to identify common elements across a variety of different literature. The researchers formed a baseline model from the aggregated data to create an initial model-framework to describe user toolkits, which assisted with the next phase of the research.

In phase two, we used the model-framework on user toolkits from phase one to model and collect data on an additional 12 articles that focused on user toolkits and user innovation. As the researchers modeled and collected data on the roles, tasks, information flows, and industries mentioned in each of the 12 articles, they also captured any deviations from the initial framework. After modeling and collecting data from the 12 articles, the researchers re-evaluated and adjusted the initial model-framework on user toolkits to incorporate any of the deviations they found. In this phase, researchers also captured the frequency of each role, task, and information flow to explore how often the literature mentioned each model element. Additionally, the researchers sought the point of theoretical saturation as they analyzed the models of the 12 case articles. Theoretical saturation emphasizes "data adequacy," which indicates the point where the researchers stopped finding new information while collecting data [87]. In the case of this research,

the point of data adequacy is when the models of each case article are no longer changing and contributing new information that alters the model-framework on user toolkits.

Phase three used the updated model-framework on user toolkits from phase two. The researchers modeled 10 additional case articles from another database. This phase of research allowed the researchers to verify their claim of data adequacy from phase two. The researchers also continued to capture the frequency of each role, task, and information flow to explore how often the literature mentioned each model element.

Phase four consisted of applying the final model-framework to the Griffin, which is an existing organization in the DoD that does not currently use a user toolkit. This phase highlights the existence and lack of specific roles, tasks, and information flows around an organization that could benefit from a user toolkit. Additionally, if the roles, tasks, and information flows exist around the current organization, the researchers highlighted the similarities and differences between the current organization and the model-framework. The goal of phase four was to identify areas of interest around an organization by addressing any missing elements and deviations from the model-framework on user toolkits for user innovation.

Data Sources

This research uses a total of 32 articles from two databases: the AFIT EBSCO Discovery Service and Google Scholar. These articles describe user toolkits across a variety of different industries and settings. The researchers use each article as a source to generalize the roles, tasks of each role, and the information flows among the roles that

exist in an environment that uses user toolkits. Appendix A. – Data Set shows the specific articles that the researchers used in phase one, two, and three of this research.

AFIT EBSCO Discovery Service

To find relevant articles for this study, the researchers started with the AFIT EBSCO Discovery Service. This source is an online database that provided access to all the information the AFIT library has available. The researchers used specified queries and filtering to find unique case articles. The researchers used the "Boolean/Phrase" search mode to find articles with the exact phrasing. This research used the phrases "user toolkit" and "user innovation" to source articles with those exact phrases. The filtering initially returned 110 articles. The researchers also used additional filtering to return "Peer Reviewed" and "Full Text" articles. These filters assisted with sourcing higher quality and readily available articles. The additional filtering returned 23 articles. The next step involved analyzing the dataset to remove duplicate case articles; the researchers removed one article, which brought the total number of case articles from this data source to 22. From this point, the researchers selected the articles to use for both phase one and phase two of this research. Phase one used 10 case articles and phase two used 12 case articles from the dataset provided by the AFIT EBSCO Discovery Service.

Google Scholar

Google Scholar is another online database that researchers used to gather additional case articles for this research. On Google Scholar, the researchers used the same queries, "user toolkit" and "user innovation," from the AFIT EBSCO Discovery Service to return 118 results. The goal of using another database was to verify the possibility of reaching data adequacy with the model-framework on user toolkits. The

researchers sorted the 118 results by relevancy so the most relevant articles would appear first. The researchers selected the 10 most relevant articles that did not appear in the dataset produced by the AFIT EBSCO Discovery Service. Phase three utilized the 10 case articles provided by Google Scholar.

Cameo Systems Modeler

Cameo Systems Modeler is a collaborative Model-Based Systems Engineering environment that allows users to define, track, and visualize all aspects of a system using SysML models and diagrams. The researchers used version 19 of Cameo Systems Modeler to capture the roles, tasks, information flows, and industries involved with user toolkits across the 32 case articles. The tools Cameo Systems Modeler provided also allowed the researchers to capture and annotate significant details throughout the research process. The tools assisted researchers with collecting and analyzing data while performing a model-based literature review of all the case articles used in this research. The models the researchers produced provide additional context to help visualize significant aspects of the literature covered in this research.

Packages

Figure 5: Packages Example in Cameo Systems Modeler

The researchers use packages to organize their data and models throughout the digital environment that Cameo Systems Modeler provided. Figure 5 shows how Cameo Systems Modeler uses a manilla folder icon to represent packages. The purpose of a

package is to group all the elements that are related to a generalized purpose together in one location. For example, the researchers created packages to hold all the necessary models for each phase of research, as shown in Figure 5. Figure 5 highlights the *Article Models* package, which shows how a package (Article Models) can also contain other packages (Phases 1, 2, and 3).

Profile Diagram

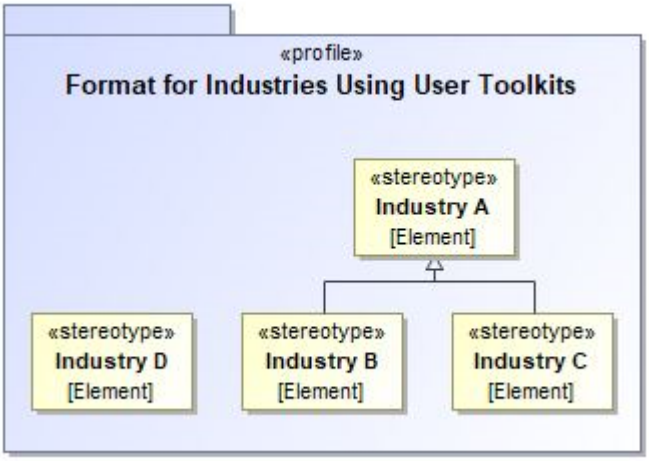

Figure 6: Profile Diagram Format for Industries Implementing User Toolkits

Profile diagrams are diagrams that allow users to create new and custom elements to apply throughout models. The researchers used profile diagrams to capture the various industries that implemented user toolkits in each case article. Researchers chose profile diagrams to encapsulate the different industries mentioned in each case article. Some industries act as a class of their own, which means their behavior is unique. Other industries act as a metaclass, which means they contain other classes and can generalize the behavior of those classes. Figure 6 shows the format the researchers followed for developing their own profile diagram. Industry A and D represent different industries

since there are no connections between one another. However, an overarching industry can act as a generalization for other industries as depicted with Industry A. An open arrowhead pointing to one industry that has one or more lines coming from other industries below the open arrowhead represents a generalization. Therefore, both Industry B and C are different industries, but Industry A is a generalized industry that represents all the behavior from Industry B and C. For example, Industry A could be the fashion industry that contains other industries, such as shoes (Industry B) or athletic apparel (Industry C) while Industry D could represent a different industry, such as the automotive industry.

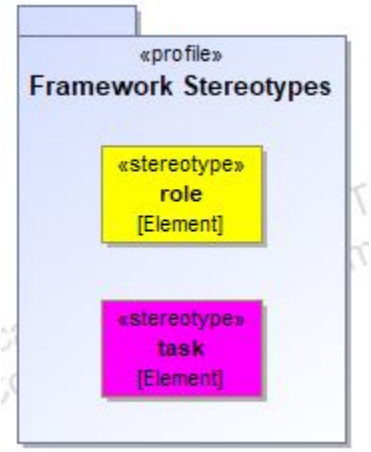

Figure 7: Profile Diagram of Framework Stereotypes for BDDs

The researchers also used profile diagrams to create stereotypes, which are custom elements that contain specific properties that users can apply to various model elements. The researchers applied these stereotypes to blocks in BDDs. A block is a unit that describes an element of interest. BDDs are diagrams that use blocks and other SysML features to visualize existing relationships among model elements. The next section of this chapter elaborates more on BDDs. The researchers chose to create

stereotypes to apply to other objects since the stereotypes could contain specific properties, such as a color, to represent data types. The researchers could apply a stereotype to objects, such as blocks, and those objects will inherit any of the properties contained within the stereotype. This research uses stereotypes to help distinguish different blocks from one another in BDDs. Researchers could apply a stereotype to a block to have that block inherit the characteristics of the stereotype. For example, if applying a stereotype with a color characteristic of yellow, then any block that has that stereotype applied to it will be yellow. Figure 7 shows the format the researchers used when they created stereotypes in the profile diagram. If a block represents a role, then researchers applied the role stereotype to the block, which caused the block to turn yellow automatically. If a block represents a task, then researchers applied the task stereotype to the block, which caused the block to turn purple automatically.

Block Definition Diagram

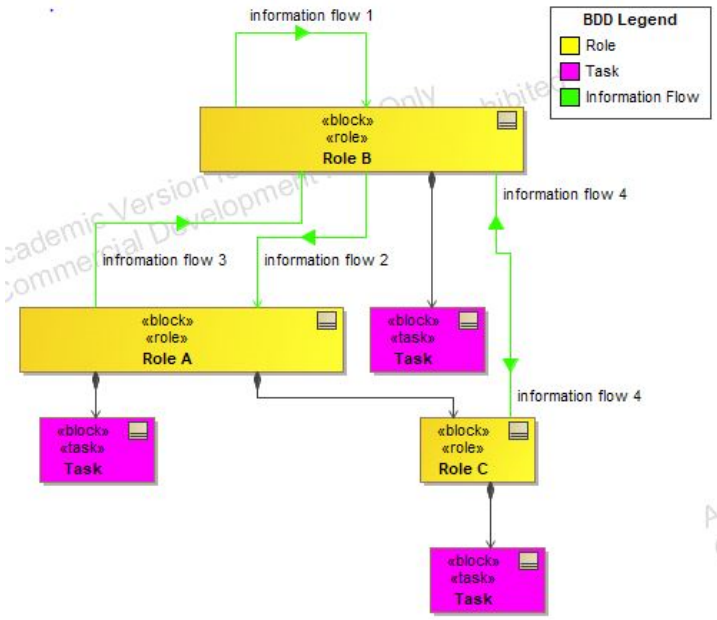

Figure 8: Block Definition Diagram Format for Case Articles

The researchers used BDDs, which are structural diagrams that show components, the contents of those components, and the relationships between components. The researchers used BDDs to model each case article. The researchers chose BDDs because the diagram assists with defining features and relationships between blocks. Figure 8 shows the format the researchers followed to develop BDDs that represent each case article. If a case article mentioned an actor that performed any tasks that related to user toolkits, the researchers created and applied the role stereotype to the block. The researchers also created and applied the task stereotype to the blocks that each role performed. A black diamond with an arrow coming out represents a directed composition relationship. The researchers used a directed composition relationship to highlight the composition of a role, which could consist of various tasks and possibly other roles. The block with the black diamond is composed of the blocks the arrow(s) point to. Figure 8 shows how Role A is composed of a task and Role C while Role B and Role C are composed of a single task.

The BDDs the researchers created also contain item flows. The researchers used item flows to highlight the transfer of information among various roles within a BDD. For this reason, the researchers refer to item flows as information flows. The green lines with arrowheads represent these information flows and the arrowheads provide context on the flow of information among various roles in a BDD. As shown in Figure 8, information flow 1 shows how information can flow among a single role, as shown with Role B. Information flow 2 and information flow 3 show how different forms of information can flow to and from different roles, as shown between Role B and Role A. Researchers also included bidirectional information flows, as shown by information flow

4, which highlights how the same information can flow to and from different roles, as shown between Role B and Role C.

Phase One

The first phase of research used the first 10 case articles from the AFIT EBSCO Discovery Service. The researchers focused on collecting the distinct roles, tasks those roles performed, the information flows among the roles, and the industries that implemented user toolkits. The researchers modeled each article with the BDD format shown in Figure 8. They also added any new industries the case articles mentioned to a profile diagram and tagged the BDD with any relevant industries from the profile diagram. The researchers used notes to comment on any significant findings or leave questions in each BDD to refer to. Additionally, researchers used generalizations between various roles when the literature noted similar behavior.

Categorical Aggregation of Roles

After the researchers modeled each of the 10 case articles, they categorically aggregated the roles, tasks, and information flows to generate abstractions to create the baseline model-framework for user toolkits. Categorical aggregation refers to when the researchers clustered data into categories or classes to find meaning and patterns among qualitative data [88]. The researchers started aggregating the roles first. They imported all the roles captured in the 10 case articles and clustered them based on task similarity. Once the researchers clustered all the roles, they established a generalized role to represent each cluster. The researchers created blocks to represent the generalized roles

in a package called *Master Roles* to reference when creating the baseline model-framework on user toolkits.

Categorical Aggregation of Tasks

The researchers performed a similar process with the tasks they identified. The researchers started by importing all the tasks that were associated with all the roles within a cluster. At this point, the researchers recognized some duplicate data among the tasks they imported. The researchers removed duplicate tasks from the set and created task clusters. Some tasks were unique on their own or a cluster of tasks emerged due to the similarity in behavior. The researchers either selected a task that best represented the cluster or created a generalized task to represent the cluster. The researchers created blocks for the unique tasks and tasks that represented clusters in a package called *Master Tasks* to reference when creating the baseline model-framework on user toolkits.

Categorical Aggregation of Information Flows

Finally, the researchers performed the same aggregation process with the information flows. The researchers imported the information flows from the first 10 case studies and analyzed the set in a similar manner as the tasks and roles. The analysis produced a set of information flows the researchers represented with blocks. The researchers placed the blocks into a package called *Master Information Flows*. The researchers would use these blocks to create the baseline model-framework on user toolkits.

Creating the Baseline Model-Framework on User Toolkits

The researchers created a BDD and followed the format shown in Figure 8. The researchers started by importing all the blocks from the Master Roles package first and

applied the roles stereotype to each block. The next step called for importing all the tasks from the Master Tasks package that were associated with the imported roles. The researchers selected a specific role and imported all the tasks associated with that role. Once the researchers imported the tasks, they applied the tasks stereotype to each task block. The researchers used a directed composition relationship to connect the roles with their specific tasks. This relationship helped show the tasks that each role was responsible for performing. The researchers performed this step until all the roles had connections to their specific tasks.

Once the researchers assigned the tasks to the proper role in the BDD, they reviewed the information flows from the case articles to create any necessary connections among the roles with the information flows. These connections highlighted the transfer of information among various roles. Additionally, the researchers reviewed the case articles to create any directed compositions among the roles to show if any roles acted as a group role that contained other roles. Once the researchers made all the necessary connections among the roles in the BDD, a model-framework emerged that described the roles, tasks, and information flows associated with user toolkits. The researchers used this framework in phase two of this research.

Phase Two

The next phase for this research included applying the framework from phase one to the 12 remaining case articles from the AFIT EBSCO Discovery Service dataset. Phase two had two purposes:

1. Track and incorporate deviations from the phase one model to produce a more accurate model-framework on user toolkits.
2. Understand if the researchers reached a point of data adequacy with their model.

The researchers used the same modeling conventions from phase one.

Tracking Deviations, Data Adequacy, and Model Elements

The researchers modeled each of the 12 case articles and created a centralized log to note deviations within each case article. If the researchers did not come across any changes to the model, then the researchers stated *NO CHANGES NOTED* in the log. If the researchers found any deviations or findings, then they created a note in a red box in the model and logged the change(s) in the centralized log. The researchers referred to the noted changes in previous case articles to ensure each subsequent case article reflected any significant deviations from the initial phase one model.

If the researchers encountered a string of *NO CHANGES NOTED* and reached the end of the log, then the article with the last change determined the point of data adequacy. The researchers highlighted this inflection point in green in the log.

As the researchers modeled each case article in phase two, they recorded which elements were present in another log. The researchers assigned a number between 1 and 12 to each case article and logged that number in a column. Each row contained every role, task, and information flow that the researchers included in any of their models for each case article. The researchers checked a box under each column to indicate if each case article contained an element shown in a specific row. Appendix B – Phase Two Data shows the data the researchers collected during this phase of research.

Adjustment and Review of the Model-Framework on User Toolkits

Once the researchers modeled the 12 case articles for phase two, they created another BDD following the format shown in Figure 8. They created the BDD by following the same procedure from phase one. This BDD incorporated any of the deviations noted throughout the 12 case articles.

In addition to creating an updated and more refined model-framework on user toolkits, the researchers produced quantitative data by analyzing the frequency of each model element across the 12 case articles. The researchers recorded the data in a table like the one shown in Table 2. Phase three used the refined model-framework on user toolkits and the table shown in Table 2.

Table 2: Framework Analysis Log

Article Number	List of Articles (n Columns)	Frequency
List of Existing Model Elements (m Rows)	☐ ☐ ☐ ☐ m x n Number of Check Boxes (ex. 14 x 4)	Value of 1-n recorded for each row

Phase Three

The third phase of this research applied the refined framework from phase two to the 10 case articles from the Google Scholar dataset. The purpose of phase three was to validate any claims of data adequacy for the model-framework on user toolkits from phase two. The researchers applied the same method mentioned in phase one, but they used the revised model-framework on user toolkits from phase two. The researchers analyzed the results from both phase two and phase three and reported their findings in Chapter IV. Appendix C – Phase Three Data contains the data the researchers recorded on phase three.

Phase Four

For phase four, the researchers applied the final model-framework on user toolkits for user innovation to The Griffin. The goal of applying the model to an organization was to highlight which roles, tasks, and information flows exist and do not exist around the organization. Additionally, the researchers sought to understand if any roles, tasks, and information flows around The Griffin matched or differed from the model-framework. Chapter IV provides more details on the information found by comparing The Griffin and the final model-framework.

Summary

The researchers implemented a four-phased approach for performing a model-based literature review to develop and assess a model-framework on user toolkits. The research approach used two databases that generated a qualitative dataset of 32 case articles. These articles focused on user innovation and user toolkits. The goal of this

research approach was to reach data adequacy with the resulting model-framework. Once the researchers created a stable model, they applied the model-framework to The Griffin to understand which model elements exist and do not exist around The Griffin. The researchers also identified any model elements that matched or deviated from the model-framework when they compared the model-framework to the structure around The Griffin.

IV. Analysis and Results

This chapter explains the results of applying the methodology outlined in Chapter III to the articles and The Griffin. First, we discuss the use of SysML to support a literature review and develop models from literature on user toolkits for user innovation. Second, we consider the model-framework the researchers generated from this process. Finally, we provide a demonstration on how to apply the model-framework by evaluating an existing organization within the DoD, The Griffin.

Using SysML to Perform a Model-Based Literature Review on User Toolkits

This section details the results of using SysML to perform a model-based literature review on user toolkits. The tool, Cameo Systems Modeler, the language, SysML, and the method of open coding afforded a variety of abilities to the researchers throughout their literature review. The tool, language, and method allowed the researchers to manage complex ideas with visual elements through a model-based approach that reflected information relating to their interrogatives throughout the literature.

The first ability was linking articles directly to the model they supported. This ability allowed researchers to reference the literature for a specific model in an expedited manner instead of sorting through a collection of physical or virtual copies of literature.

Another ability the researchers noticed was creating a visualization of the literature. These visualizations assisted the researchers with understanding the knowledge contained within the literature by allowing the researchers to model ideas and concepts. The researchers created notes, questions, objects, and connections throughout

their models. These visual elements also supported communicating clear and concise information. As the researchers read through and modeled the literature, they realized they could aggregate data to create generalized representations to apply across a variety of literature. This allowed the researchers to establish connections within literature that referenced similar aspects mentioned across other pieces of literature with different terms. For example, Figure 9 depicts all of entities that the researchers noticed in the first ten articles that represented the characteristics of a firm. The researchers imported all the entities and created a generalized term to apply throughout the remainder of the research. The section, *A Model-Framework on User Toolkits*, provides more details on additional generalizations the researchers created by aggregating the data they found from the literature they used.

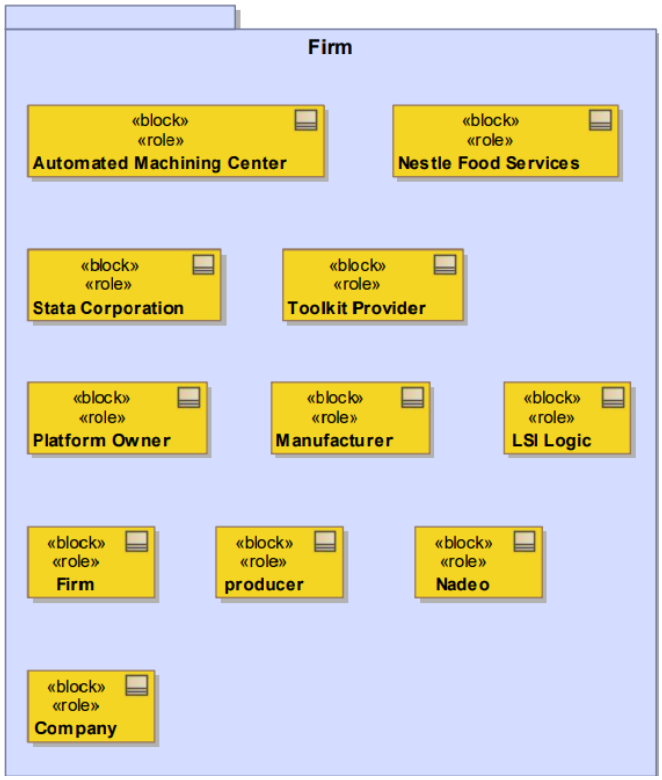

Figure 9: Aggregation of Different Entities that Represent Firms

In addition to creating visualizations, the researchers reused these same visualizations across a variety of models instead of creating new model elements for each new piece of information. The researchers dragged and dropped common elements into various models. Figure 10 shows the blocks the researchers created under the Master Roles package. The researchers used these blocks to capture information on any role within the literature that the generalized roles could represent.

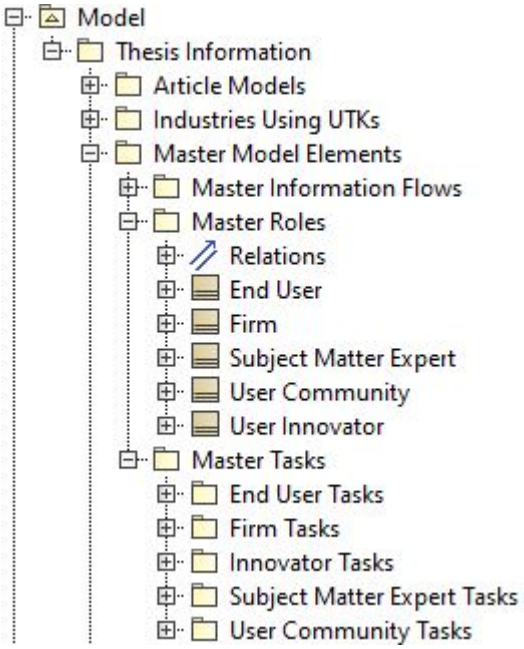

Figure 10: Depiction of Reusable Blocks as Generalizable Roles

The researchers also created visualizations that captured the movement of information within, to, and from entities mentioned in the literature with SysML. The researchers could also decompose model elements as well by using SysML. The ability to decompose and trace information allowed the researchers to understand the needed parts and information for a given entity. The section, *A Model-Framework on User*

Toolkits, provides more details on the decomposition of entities and the information flows involved with user toolkits for user innovation.

Cameo Systems Modeler and SysML also afforded researchers the ability to autogenerate and track a variety of data on the articles, model changes, model elements, and industries throughout their research process. These features allowed the researchers to understand where the model elements existed throughout the collection of models they generated. In addition to locating the model elements, the researchers could determine how often they used a model element. One specific example of autogenerated data was understanding which articles contained specific model elements, such as specific roles, tasks, and information flows, or industries throughout the dataset. Figure 11 shows how the researchers could select a model element or industry to view the various articles that contain the specified model element or industry. This was interesting since it allowed the researchers to explore how often the literature mentioned a specific model element.

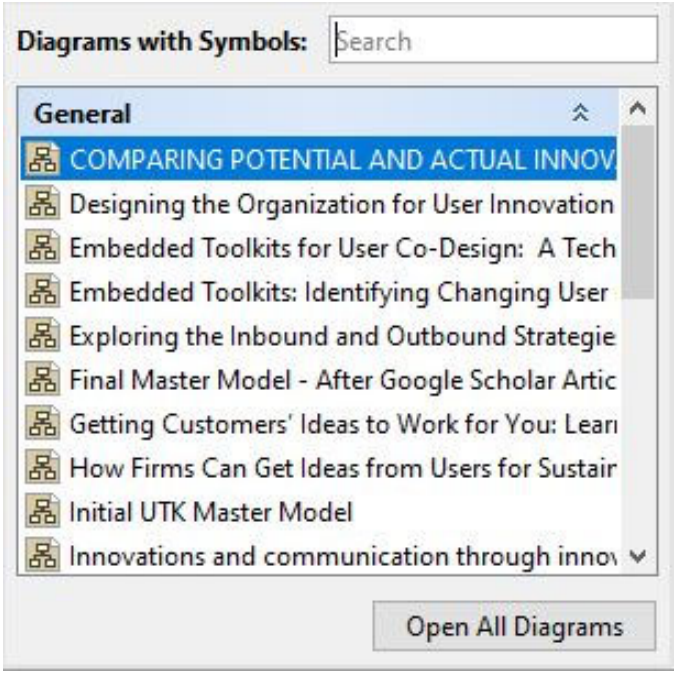

Figure 11: Tracking Models Containing Specific Model Elements or Industries

Data adequacy was another type of information the researchers tracked using SysML. The researchers tagged any deviations across any model as they took in information to create the model-framework on user toolkits for user innovation. These deviations signified a change from an original thought the researchers gathered from the literature. This process assisted the researchers with identifying a point of theoretical saturation during the literature review where no additional changes occurred, which signaled the model-framework was stable. After reading and modeling the 32 articles in the dataset, the researchers reached a point of theoretical saturation after reading and modeling 16 articles. The next section provides more details on the final model, composition of model elements, the industries where user toolkits exist, and when the researchers achieved data adequacy.

A Model-Framework on User Toolkits

This section explains and analyzes the model-framework the researchers developed from the model-based literature review on user toolkits for user innovation. Figure 12 depicts the model-framework, which contains 43 different model elements. The 43 model elements include 5 roles, 21 tasks, and 17 information flows to form the model-framework on user toolkits for user innovation.

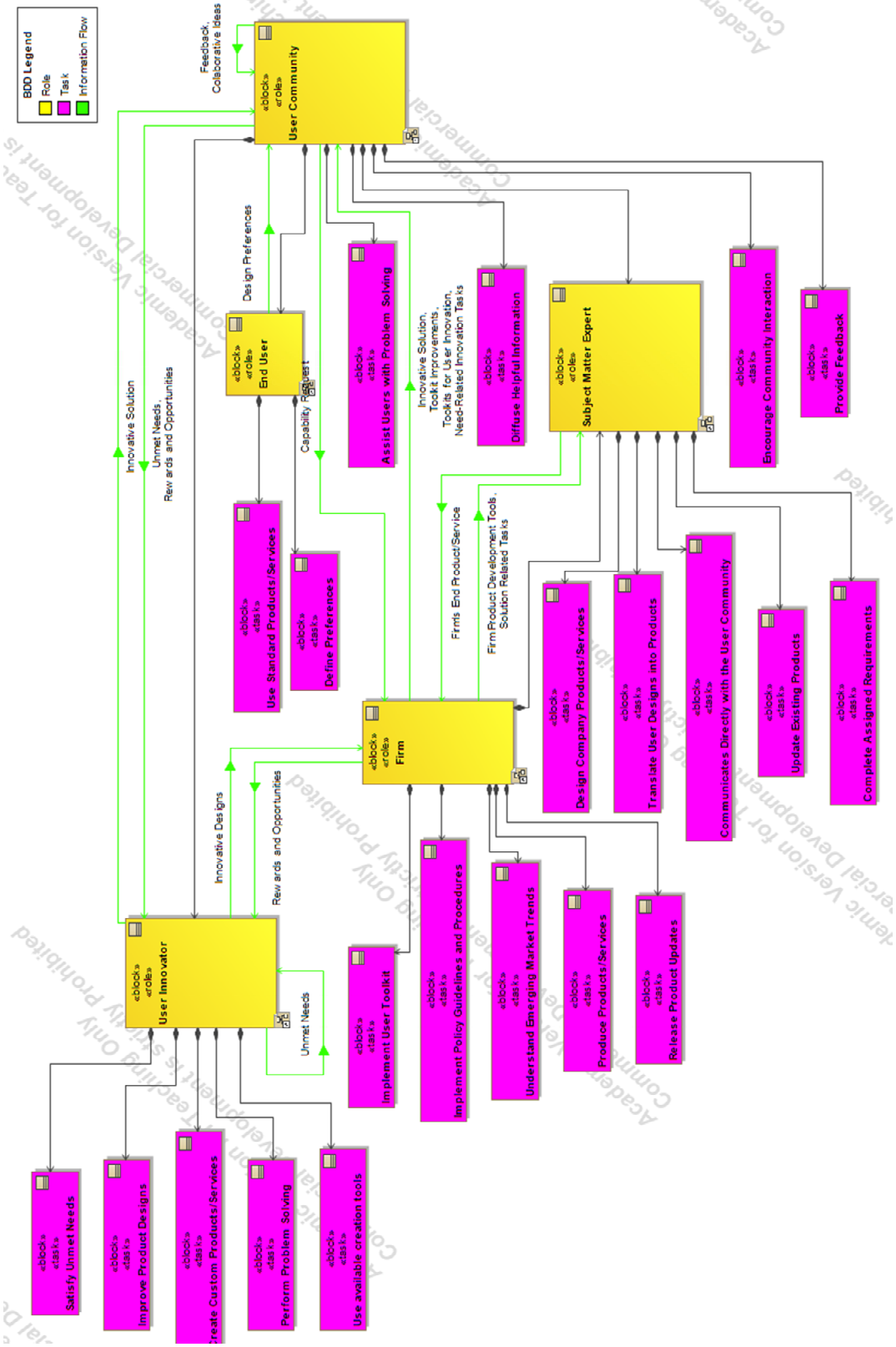

Figure 12: Model-Framework on User Toolkits for User Innovation

Roles and Tasks

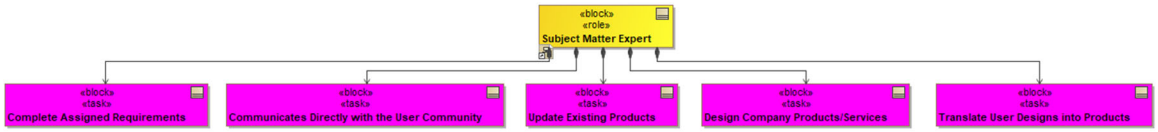

Figure 13: Subject Matter Expert Role and Tasks

The first role we will discuss is the subject matter expert (SME) as depicted in Figure 13. The literature summarizes this role as personnel who are experts in their field, that innovate based on the directions they receive from the firm they work for [14], [62], [68], [69], [72], [76], [80], [81], [83], [84], [89]–[95]. SMEs have a task where they complete assigned requirements [35], [68], [76], [84], [90], [93], [95]. This task means the work they perform usually aligns with satisfying requirements, so any innovations they create are because their career requires them to innovate [96]. Other tasks SMEs have is to design company products and/or services [14], [35], [62], [76], [81], [83], [84], [92], [97] and to update existing products, which includes the firm's user toolkit [62], [72], [76], [83], [90]. SMEs usually take in their assigned requirements and use their solution-based knowledge to create or update products and services for the firm they work for. There can be many different types of SMEs since they usually specialize in a particular field of interest. Some examples of different SMEs include experts in engineering who create a product, experts in marketing who sell the product, or even experts in management who manage the development and integration of a product. Another task SMEs have includes translating user designs into products [35], [68], [83], [90], [94]. This task means that if any users external to the firm submit innovative designs or concepts through the user toolkit, the SMEs are responsible for incorporating

them into new or existing products. Additionally, SMEs communicate directly with the user community [62], [68], [69], [72], [76], [83], [84], [90], [91]. This task means the SMEs are the role who bridge any communication gaps between a specified user community and the firm.

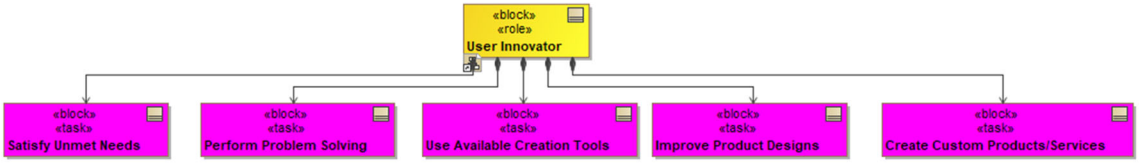

Figure 14: User Innovator Role and Tasks

The second role we will discuss is the user innovator as depicted in Figure 14. Based on the literature, this role highlights personnel who create innovative products to satisfy unmet needs when a solution does not currently exist [12], [14], [62], [68], [69], [76], [81], [83], [84], [89], [90], [92]–[95], [97], [98]. One of the tasks the user innovator must perform includes problem solving [12], [62], [68], [83], [97], [98]. This task highlights how the user innovator progresses through the design process to solve existing problems that do not have solutions by leveraging and building upon their existing knowledge. Throughout the design process, user innovators focus on satisfying unmet needs, which can be an unmet need of their own or an unmet need they witness within the communities they are a part of [12], [35], [69], [83], [84], [89]–[92], [95], [98]. User innovators also use creation tools as they go throughout the design process. These creation tools are anything the user innovator has access to that allows them to create tangible solutions throughout the design process [12], [35], [47], [69], [72], [80], [83], [84], [90]–[95], [97]. By performing these tasks, user innovators leverage and build upon their existing knowledge to create custom products or services that solve the unmet needs

they are faced with [12], [14], [35], [62], [69], [72], [80], [81], [83], [84], [90]–[93], [95], [97], [98]. With the use of user toolkits, user innovators can also improve existing product designs while leveraging other creation tools to develop new capabilities [12], [14], [35], [62], [76], [81], [84], [89], [91], [94], [97]. The product designs that user innovators manipulate can come from a variety of sources, such as firms or other innovators. The presence of other user innovators highlights how there can be many people who take on this role within a user community.

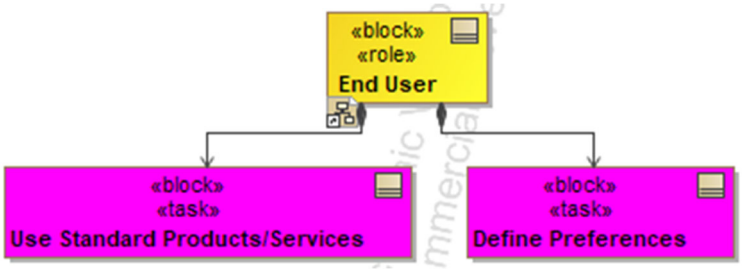

Figure 15: End User Role and Tasks

The third role we will discuss is the end user as depicted in Figure 15. Based on the literature, this role highlights personnel who act as general users of products [14], [47], [62], [68], [69], [76], [83], [84], [90], [92]–[95], [97], [98]. There can be many people represented by the end user role. Personnel who take on this role use a standard version of a product or service [12], [35], [47], [62], [68], [72], [76], [80], [89]–[92], [95], [98]. This task highlights how end users do not have the resources available to create a custom product to meet their exact needs. End users will use available products or services and they will not adapt those products or services beyond their original intent. End users will simply stay within the bounds afforded by the product or service. However, end users also have the task of defining their preferences [14], [47], [68], [69], [76], [80], [83], [89], [91], [93], [98]. Personnel who take on this role might not have the

knowledge or resources to meet their exact needs, but they can communicate the functionality they desire. For example, end users might want a more user-friendly product, or an item to be lighter or faster. These preferences do not reveal the specifications required to improve the product or service, but those preferences assist with signaling a desired feature or unmet need among end users.

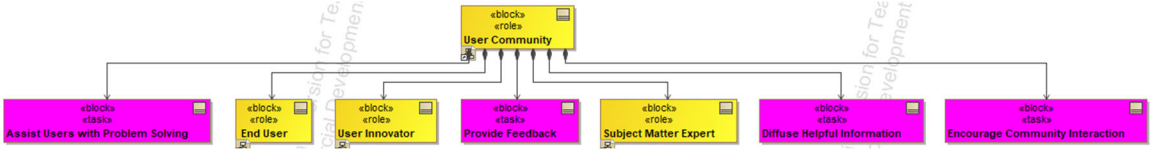

Figure 16: User Community Roles and Tasks

The fourth role we will discuss is the user community, which is composed of subject matter experts, user innovators, and end users as depicted in Figure 16. We can describe the user community as a group role since multiple types of roles are a part of a user community. Based on the literature, this role highlights a diverse group of users who come together to build upon their existing knowledge to push innovation further [12], [14], [35], [68], [69], [72], [80], [83], [84], [89]–[92], [94], [95], [97], [98]. Additionally, a user community is not just one type of community. A variety of sub user communities can exist within a single user community. For example, the sports community is composed of a variety of specific communities that are interested in a specific sport, such as baseball, football, soccer, skateboarding, windsurfing, etc. We can break these sub communities down further by looking at the different teams within the community of each sport. The variety of communities within a community shows how expansive these user communities can be.

The tasks shown below a user community are not unique to just the user community role. The roles contained within the user community inherit these tasks. These tasks represent the tasks that any role within the user community can perform since the roles contained within the user community often work together. The personnel within this role tend to encourage community interaction [35], [72], [83], [84], [89], [91]–[95]. Users within the user community tend to assist one another with problem solving to help satisfy unmet needs while avoiding the duplication of previous efforts [12], [14], [35], [68], [72], [83], [84], [90]–[92], [94]. The user community also diffuses helpful information [14], [35], [62], [68], [72], [80], [83], [84], [89]–[92]. Diffusing helpful information means the user community assists with identifying and providing relevant information to all the community members. For example, end users who might not have the ability to create their own solution can understand what solutions within the community are most helpful or useful. The role also has the task of providing feedback to others within the user community [14], [62], [68], [72], [80], [83], [84], [89], [91], [92], [94]. Since there are a wide variety of users within the user community, the feedback can range from general information to detailed technical design information.

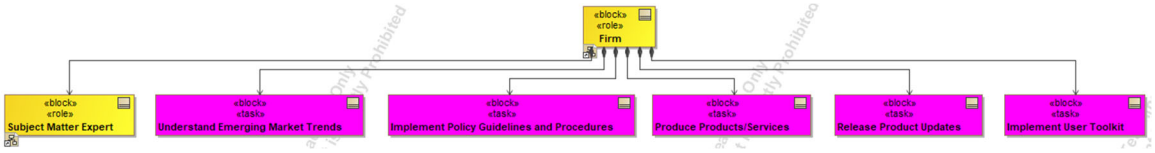

Figure 17: Firm Role and Tasks

The final role we will discuss is the firm, which is composed of subject matter experts as depicted in Figure 17. We can also describe the firm as a group role since multiple types of SMEs are a part of a firm. Based on the literature, there is usually just

one firm, but there can be multiple firms who compete against one another in a particular industry. For example, Apple competes with Google in the software industry. This role aims to understand a target community so they can gain important need-related information to create or update products and services the firm can profit from [14], [47], [62], [68], [69], [76], [81], [83], [84], [89], [90], [92]–[95], [97], [98].

Like the user community, the tasks shown below a firm are not unique to only the firm. These tasks represent the tasks that impact the work that any unique SME performs within the firm. The variety of unique SMEs within a firm often work together under a common entity that is the firm. The firm represents the culmination of the work the SMEs perform under that entity. The firm has the task of mass producing the products and services they provide to a targeted user community [12], [14], [35], [68], [69], [72], [80], [83], [84], [89]–[95], [97]. For this research, the firm also implements a user toolkit as a method of retrieving need-related information from the targeted user community [14], [47], [62], [68], [69], [76], [81], [83], [84], [89], [90], [92]–[95], [97], [98]. Firms also implement policy guidelines and procedures that effect personnel who interact with the firm's products or services; these personnel can be within or external to the firm [35], [47], [68], [69], [72], [84], [90], [93], [94], [97]. Additionally, firms need to understand emerging market trends to successfully do business [12], [14], [35], [68], [69], [83], [84], [89]–[91], [93]–[95]. These trends can lead to new products, updates to existing products, or updates to policies and guidelines that effect the firm's ability to do business. These updates also include user toolkit updates. These toolkits updates assist user community members by improving the design process while ensuring the firm can

effectively capture need-related information from the targeted user community [35], [68], [72], [83], [89]–[92].

For further context on the roles and tasks mentioned throughout this section, please refer to

Table 3.

Role	Task	Example	Source
Subject Matter Expert	Complete Assigned Requirements	The management level within a firm must lock down requirements throughout the development process	[76]
	Communicates Directly with the User Community	The managers from EA games maintained open lines of communication with the online community to understand what the community liked about the game and improvements the community wanted to see	[62]
	Update Existing Products	The product developers improved existing and future product lines	[62]
	Design Company Products/Services	The SMEs managed the research and development project	[84]
	Translate User Designs into Products	Managers ranked and implemented the best user submissions	[94]
User Innovator	Satisfy Unmet Needs	Users of the Apache Software modified the open-sourced software to better meet their security needs	[35]
	Perform Problem Solving	Most users need to play around a try different things to find out what works best for them in an iterative manner	[12]
	Use Available Creation Tools	Innovative users used other toolkits that were available to them to create more radical changes to standard files	[62]
	Improve Product Designs	Users of the Adidas toolkit could return to previous designs to improve upon them	[94]
	Create Custom Products/Services	Users could create their own truly unique wine flavors	[97]
End User	Use Standard Products/Services	Users who benefit from using the consumer goods they purchase	[12]
	Define Preferences	A user of a social network can articulate their personal opinions, experiences, and operations	[91]
User Community	Assist Users with Problem Solving	Users within the user community provided technical assistance to assist others with solving their problems	[66]
	Provide Feedback	User communities are shown to be a central hub for providing feedback for customized designs and personalization's	[83]
	Diffuse Helpful Information	Users in the IdeaStorm community were able to promote or demote ideas, which signal if the information was helpful or not	[68]
	Encourage Community Interaction	The social environment of Strava motivated users to compete and interact with one another since users could compare their performances among athletes who used the same routes	[95]
Firm	Understand Emerging Trends	Dell wanted to know what PC users wanted in a product	[68]
	Implement Policy Guidelines and Procedures	Apache had set technical and quality standards that submitted user designs had to follow before integrating them into the open-source software	[35]
	Produce Products/Services	Nestle mass produced food for restaurants	[3]
	Release Product Updates	Dell released computer hardware that incorporated desired updates from the user community	[68]
	Implement User Toolkit	Nadeo implemented their own user toolkit that allows users to build their own car racing environments	[75]

Table 3 lists the role, task, an example of the role performing the task, and the source of the example.

Table 3: Examples of the Tasks that Each Role Performs in the Model-Framework

Role	Task	Example	Source
Subject Matter Expert	Complete Assigned Requirements	The management level within a firm must lock down requirements throughout the development process	[76]
	Communicates Directly with the User Community	The managers from EA games maintained open lines of communication with the online community to understand what the community liked about the game and improvements the community wanted to see	[62]
	Update Existing Products	The product developers improved existing and future product lines	[62]
	Design Company Products/Services	The SMEs managed the research and development project	[84]
	Translate User Designs into Products	Managers ranked and implemented the best user submissions	[94]
User Innovator	Satisfy Unmet Needs	Users of the Apache Software modified the open-sourced software to better meet their security needs	[35]
	Perform Problem Solving	Most users need to play around a try different things to find out what works best for them in an iterative manner	[12]
	Use Available Creation Tools	Innovative users used other toolkits that were available to them to create more radical changes to standard files	[62]
	Improve Product Designs	Users of the Adidas toolkit could return to previous designs to improve upon them	[94]
	Create Custom Products/Services	Users could create their own truly unique wine flavors	[97]
End User	Use Standard Products/Services	Users who benefit from using the consumer goods they purchase	[12]
	Define Preferences	A user of a social network can articulate their personal opinions, experiences, and operations	[91]
User Community	Assist Users with Problem Solving	Users within the user community provided technical assistance to assist others with solving their problems	[66]
	Provide Feedback	User communities are shown to be a central hub for providing feedback for customized designs and personalization's	[83]
	Diffuse Helpful Information	Users in the IdeaStorm community were able to promote or demote ideas, which signal if the information was helpful or not	[68]
	Encourage Community Interaction	The social environment of Strava motivated users to compete and interact with one another since users could compare their performances among athletes who used the same routes	[95]
Firm	Understand Emerging Trends	Dell wanted to know what PC users wanted in a product	[68]
	Implement Policy Guidelines and Procedures	Apache had set technical and quality standards that submitted user designs had to follow before integrating them into the open-source software	[35]
	Produce Products/Services	Nestle mass produced food for restaurants	[3]
	Release Product Updates	Dell released computer hardware that incorporated desired updates from the user community	[68]
	Implement User Toolkit	Nadeo implemented their own user toolkit that allows users to build their own car racing environments	[75]

Information Flows

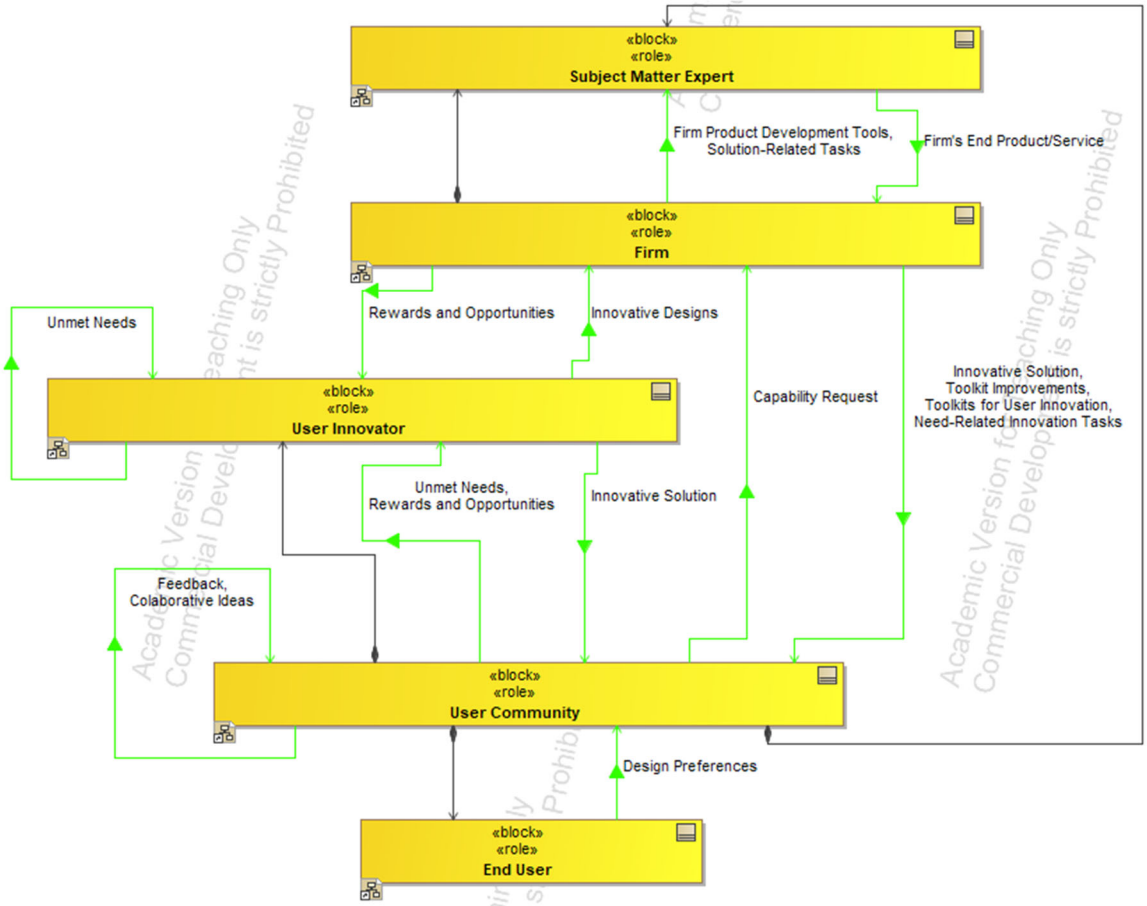

Figure 18: Information Flows Among Roles Using User Toolkits

The researchers learned several information flows exist among the roles mentioned in the previous section. Figure 18 depicts the flow of information among the roles within the model-framework. There are 11 pathways that represent 14 different information flows shown in the diagram. For the most part, different information flows exist among the roles depicted in Figure 18. However, there are a few information flows that do appear more than once since Figure 18 shows a total of 17 information flows.

Design preferences is one information flow that exists, which goes from the end user to the user community. The end user usually communicates a general idea of what

they would like to see in a product or service to the user community [47], [62], [68], [69], [72], [80], [83], [91], [94], [95]. End users provide this information to communicate what they want to those who have the resources available to create innovative solutions, such as user innovators and SMEs. For example, an end user could ask for a more fuel-efficient engine from those involved in the automotive community. At this point, the design preference is known, but the details to make the fuel-efficient engine are still unknown. The SMEs or user innovators who understand how to create a new engine can use the end user's preferences to assist with creating innovative solutions that flow back into the user community for end users to use.

Two information flows exist that go from the firm to the SME. These information flows are solution related tasks and firm product development tools. The solution-related tasks are related to the manufacturing and distribution of a firm's final product or service [35], [47], [68], [76], [81], [84], [90], [94]. The SMEs take in the solution-related tasks from the firm and create or integrate the components that form the final product or service for the firm. Additionally, the firm provides the SMEs with the necessary development tools to complete the solution-related tasks that are associated with delivering the final product or service [72], [76], [84], [97]. These product development tools make up the environment the SMEs work in to effectively accomplish their work.

One information flow that goes from the SME to the firm is the firm's product or service. The SMEs integrate all the components together to create the final product or service that the firm releases to the target community [14], [35], [68], [72], [76], [80], [84], [92]. This information flow highlights how a firm does not simply come up with a

final product or service; the SMEs are the personnel who use their expertise across specific areas to create a final product or service for the firm they belong to.

Four information flows exist that go from the firm to the user community: innovative solution, need-related innovation tasks, toolkit improvements, and toolkits for user innovation. The firm releases a user toolkit to a targeted user community as a method to capture information on what the community actually needs [12], [14], [35], [47], [62], [68], [69], [72], [76], [80], [81], [83], [84], [89]–[95], [97], [98]. The release of the toolkit aligns with transferring need-related innovation tasks to the user community since the firm expects the user community to perform these tasks to communicate the needs of the community [12], [14], [47], [62], [68], [72], [76], [81], [83], [84], [90], [92]–[95], [97]. These two innovation flows allow members of the user community to create innovative designs within the firm's toolkit so the firm can gain an understanding of what the targeted community needs in new or existing products. The firm gathers, adapts, and incorporates these innovative designs into an innovative solution to release into the user community [14], [35], [47], [68], [69], [72], [84], [89], [90], [93]–[95], [97]. Some of the information that firms gather about the user community include capability requests. These capability requests inform the firm on the features that community members would like to see in the user toolkit to improve the innovative design process. The firm decides which features are worth pursuing and releases updates for the user toolkit [62], [68], [72], [90], [91].

One information flow that goes from the user innovator to the firm is the user innovator's innovative designs. The user innovator creates designs for products or services that can satisfy an unmet need through the toolkit the firm provides. The user

innovator sends designs to the firm so the firm can produce or have SMEs adapt the design into a solution for the user community. This information flow allows firms to produce a product or service that users want while ensuring the user receives a product that can satisfy their unmet needs [12], [14], [35], [47], [68], [69], [72], [80], [81], [83], [84], [89], [90], [92]–[95], [97].

The innovative solution information flow also goes from the user innovator to the user community. The user innovator creates product designs that satisfy their unmet needs and releases their solution to the user community so all other users within the user community can use or modify the solution [14], [62], [68], [72], [80], [83], [84], [89]–[92], [94]. This information flow assists with limiting the duplication of work that users put into creating or finding solutions for their current needs. Anyone within the user community can use the innovative solution in its current form or other users can import the solution to manipulate it. This allows end users to find products that meet their needs while providing another module for other user innovators or SMEs to adapt for other potential uses.

A capability request is one information flow that goes from the user community to the firm. Members of the user community might face certain restrictions that slow or hinder their ability to innovate when they use the firm's user toolkit. At this point, the user community might have a list of features or products that community members would like the firm to incorporate or create for the user community. The user community provides these capability requests so the firm can understand what the target community wants, and the firm can release updates that satisfy the needs of community members. These capability requests allow community members to express how to improve the

design process to bolster their ability to innovate. The capability requests also allow firms to understand where and how they should apply their resources when creating or updating their products or services [14], [62], [68], [72], [76], [81], [84], [89], [90], [93]–[95], [98].

Rewards and opportunities are an information flow that travels from the firm to the user innovator. Since the user innovator submits innovative designs to the firm that the firm can use to develop new or update products, the firm provides rewards and opportunities to support the innovation of the user innovators. These rewards and opportunities are meant to incentivize user innovators to keep innovating or to recruit valuable talent for the firm [12], [14], [68], [72], [84], [90], [92], [94].

Two information flows exist that go from the user community to the user innovator: rewards and opportunities and unmet needs. The user community also provides rewards and opportunities to user innovators to incentivize innovation within the user community [12], [14], [68], [90], [92]. Additionally, the unmet needs of the user community flow to the user innovators. This flow represents how users within a user community have unmet needs they cannot satisfy with existing products or services. The user innovators have the resources, such as knowledge and creation tools, to create an innovative solution for the unmet needs they observe within the user community. The unmet needs that flow to the user innovators from the user community represents how user innovators are known for identifying emerging needs within the user community before the needs become widely adopted [35], [68], [84], [90]–[92], [98]. This flow of information signifies how user innovators can gather information from a user community without the user community realizing an unmet need exists.

The unmet needs information flow also flows within the user innovator role. This information flow highlights how user innovators have unmet needs of their own that they might experience before other members within a user community. User innovators recognize their unmet needs and use the information to create innovative solutions to satisfy those unmet needs [12], [14], [35], [62], [68], [69], [76], [81], [83], [84], [89]–[95], [98]. The user innovators can then share those innovative solutions with the user communities they are a part of.

Two information flows within the user community are collaborative ideas and feedback. The collaborative ideas information flow represents how all the members of the user community come together to understand and refine innovative ideas. Each role within the user community can work together on ideas that interest them [12], [14], [62], [68], [72], [83], [84], [89]–[91], [94]. Additionally, each role within the user community can provide feedback on ideas or solutions that are available within the user community. The feedback can vary from general feedback, such as end users commenting on the user friendliness of a solution, to design-specific feedback, such as user innovators or SMEs providing specific technical information [12], [14], [62], [68], [69], [72], [80], [83], [84], [89], [91]–[95], [97]. Each information flow shows how the roles can communicate openly with one another within the user community. Each information flow also highlights how each role benefits from one another by assisting one another throughout the innovative design process with the use of a user toolkit.

For further context on the information flows mentioned throughout this section, please refer to

Table 4.

Table 4 lists the information flow, direction and roles associated with the information flow, an example of the information flow, and the source of the example.

Table 4: Examples of the Information Flows Among Roles in the Model-Framework

Information Flow	Direction and Roles	Example	Source
Firm Product Development Tools	From Firm to Subject Matter Expert	The firm introduced flexible technologies for their employees to use.	[76]
Solution Related Tasks	From Firm to Subject Matter Expert	The firm assigned tasks to personnel to complete.	[90]
Innovative Solution	From Firm to User Community	The manufacturer creates innovative solutions for the general market.	[70]
Firm's End Product/Service	From Subject Matter Expert to Firm	The SMEs develop something into a viable product for the Firm to release.	[68]
Capability Request	From User Community to Firm	The Firm offered a variety of expansion packs that offered additional development options for the community to use.	[62]
Unmet Needs	From User Community to User Innovator	A community could have a capability gap that user innovators recognize.	[98]
Need-Related Innovation Tasks	From Firm to User Community	The firm asks the community to provide innovative ideas or solutions.	[94]
Rewards and Opportunities	From Firm to User Innovator	The firm provides employment opportunities to innovative users.	[90]
Feedback	Within User Community	Users within the community can provide technical or generic feedback on solutions.	[83]
Design Preferences	From End User to User Community	The end users express a strong demand for certain innovative objects created by others within that community.	[62]
Rewards and Opportunities	From User Community to User Innovator	User communities honor the top user innovators by listing them towards the top of the Idea Makers list.	[68]
Toolkits for User Innovation	From Firm to User Community	A firm provided a solution space where customers could design their own individual products.	[80]
Innovative Designs	From User Innovator to Firm	The firms recognize the user-created designs as a valuable source of market research data.	[62]
Innovative Solution	From User Innovator to User Community	Innovative solutions come from innovators and go to the user base for other creators and users to use.	[62]
Collaborative Ideas	Within User Community	the members of a community can work on product ideas in a collaborative manner by enhancing or commenting on the product designs.	[94]
Unmet Needs	Within User Innovator	A mountain biker was unwilling to compromise by using standard equipment that did not meet their exact needs, so they created their own equipment.	[98]
Toolkit Improvements	From Firm to User Community	The Stata Corporation provided improvements to a community of users through product releases.	[70]

Existence of Roles, Tasks, and Information Flows Within the Data

Once the researchers created generalized roles, tasks, and information flows in phase one of this research, they tracked each generalization across the 22 articles they used for phase two and phase three of this research. Figure 19, Figure 20, and Figure 21 depict the number of articles that mentioned each model element. Figure 19 focuses on the roles, Figure 20 focuses on the tasks of each role, and Figure 21 focuses on the information flows.

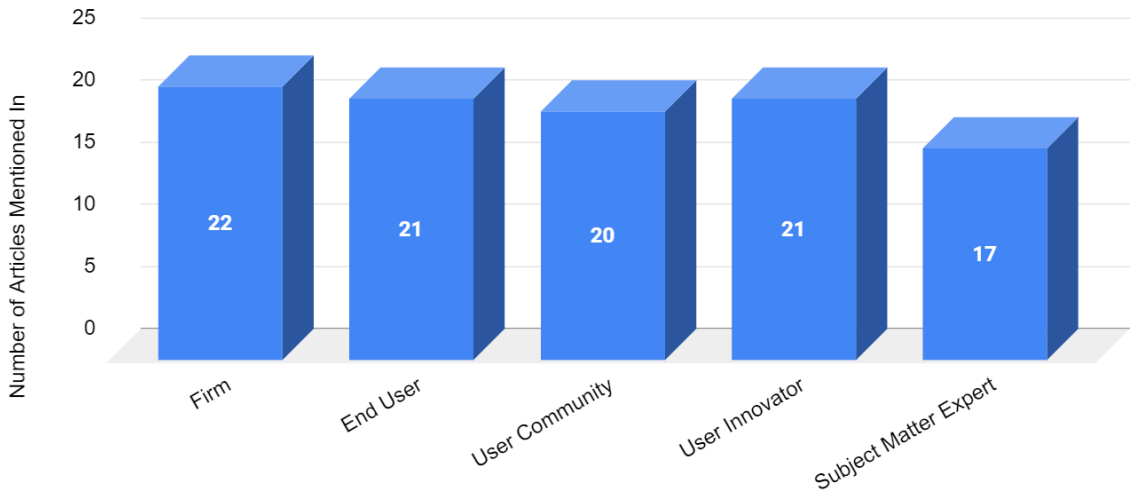

Figure 19: Existence of Roles Within the Data Set for Phase Two and Three

Figure 19 highlights the number of articles used in phase two and phase three of this research that mentioned each of the 5 roles. In 22 articles, researchers found: 22 articles mentioned the firm; 21 articles mentioned user innovators and end users; 20 articles mentioned the user community; and 17 articles mentioned SMEs. The data highlights how there is a similar spread among the roles within the model-framework. The researchers believe this data shows how each role is necessary to fill or identify when working in an environment that uses user toolkits. Additionally, it shows how the different pieces of literature almost reference every role.

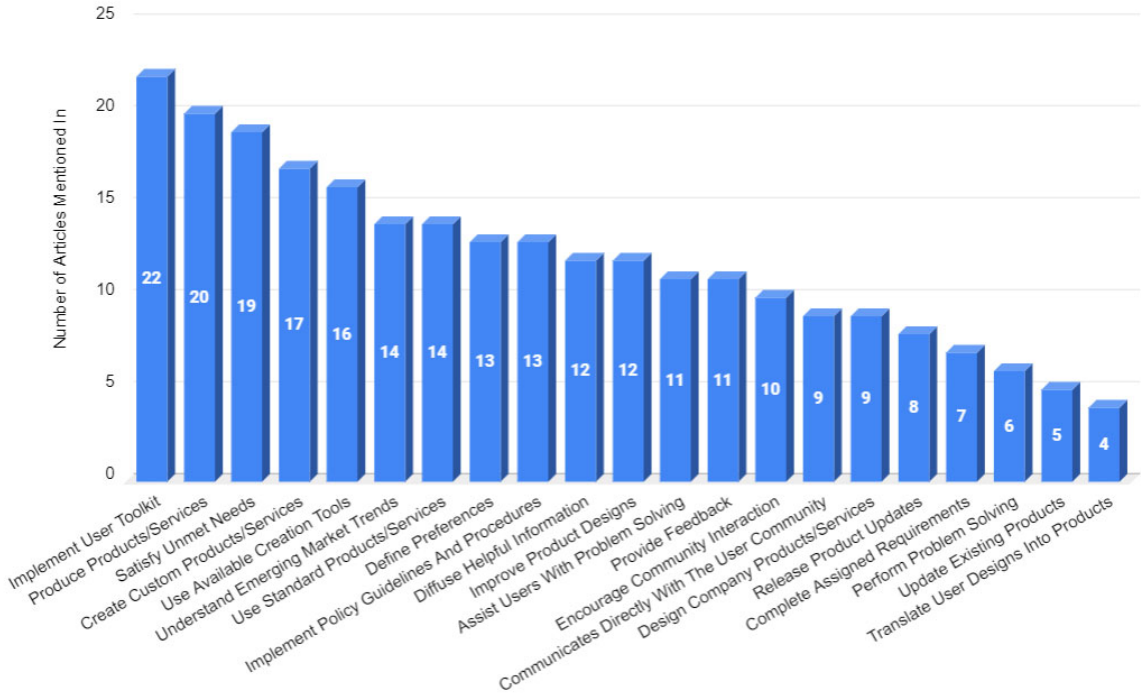

Figure 20: Occurrence of Tasks Within the Data Set for Phase Two and Three

Figure 20 depicts the number of articles that mentioned each of the 21 tasks across phase two and phase three of this research. In 22 articles, researcher found: 22 articles mentioned implementing user toolkits; 20 articles mentioned producing products or services; 19 articles mentioned satisfying unmet needs; 17 articles mentioned creating custom products or services; 16 articles mentioned using available creation tools; 14 articles mentioned understanding emerging market trends and using standard products or services; 13 articles mentioned defining preferences and implementing policy guidelines and procedures; 12 articles mentioned improving product designs; 11 articles mentioned assisting users with problem solving and providing feedback; 10 articles mentioned encouraging community interaction; 9 articles mentioned communicating directly with the user community and designing company products or services; 8 articles mentioned releasing product updates; 7 articles mentioned completing assigned requirements; 6

articles mentioned performing problem solving; 5 articles mentioned updating existing products; and 4 articles mentioned translating user designs into products. The researchers believe the variation among the number of articles that mentioned each task could show how some tasks might not be as necessary to include when establishing or using a user toolkit. The researchers also believe the spread in data shows how some tasks might not have been a topic of interest compared to others across the different pieces of literature. This information means that if an organization was trying to implement a user toolkit, they could potentially focus on ensuring the roles are performing a few tasks at first. The organization could work towards including any remaining tasks in an iterative manner to achieve all the benefits a user toolkit can provide.

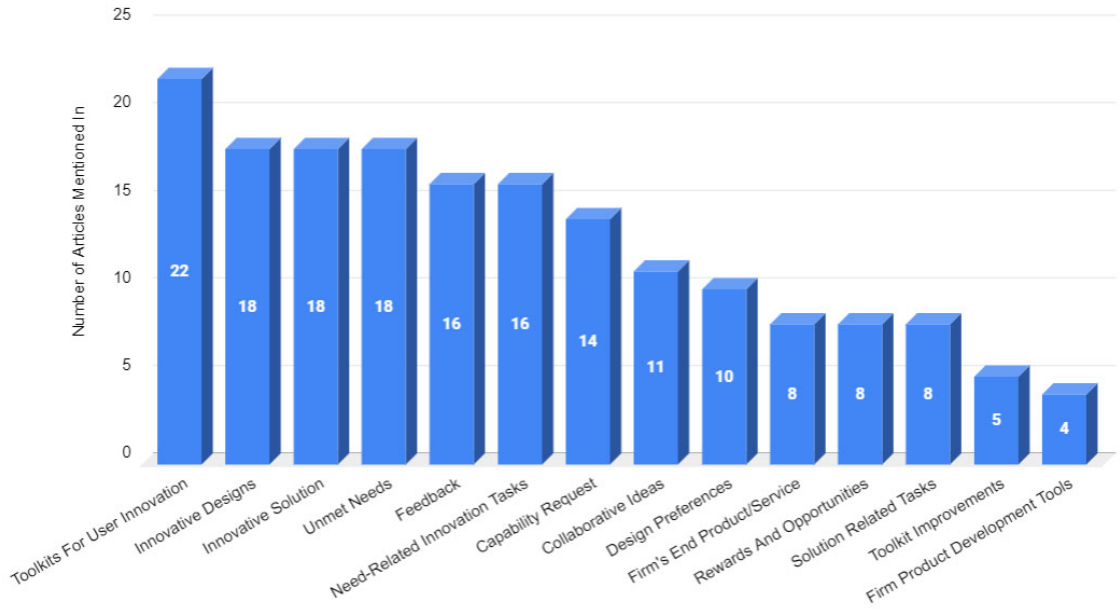

Figure 21: Existence of Information Flows Within the Data Set for Phase Two and Three

Figure 21 highlights the number of articles that mentioned each of the 14 information flows used in phase 2 and phase 3 of this research. In 22 articles, researcher found: 22 articles mentioned toolkits for user innovation; 18 articles mentioned innovative designs, innovative solutions, and unmet needs; 16 articles mentioned feedback and need-related innovation tasks; 14 articles mentioned capability requests; 11 articles mentioned collaborative ideas; 10 articles mentioned design preferences; 8 articles mentioned the firms end product or service, rewards and opportunities, and solution related tasks; 5 articles mentioned toolkit improvements; and 4 articles mentioned firm product development tools. The researchers also saw variation in the number of articles that mentioned each of the information flows. The researchers believe this variation shows how some information might not be as necessary to include when establishing or using a user toolkit. The researchers also believe the spread in data shows how some information flows might not have been a topic of interest compared to others across the different pieces of literature. This information also means an organization could focus on including a certain number of information flows among the roles if they are trying to implement a user toolkit. Once they have a baseline established, the organization could work towards including the remaining information flows in an iterative manner to achieve all the benefits a user toolkit can provide.

Existence of Industries Implementing User Toolkits Within the Data

The researchers logged the industries that implemented user toolkits to understand where user toolkits exist across the 32 articles used throughout phase one, two, and three

of this research.

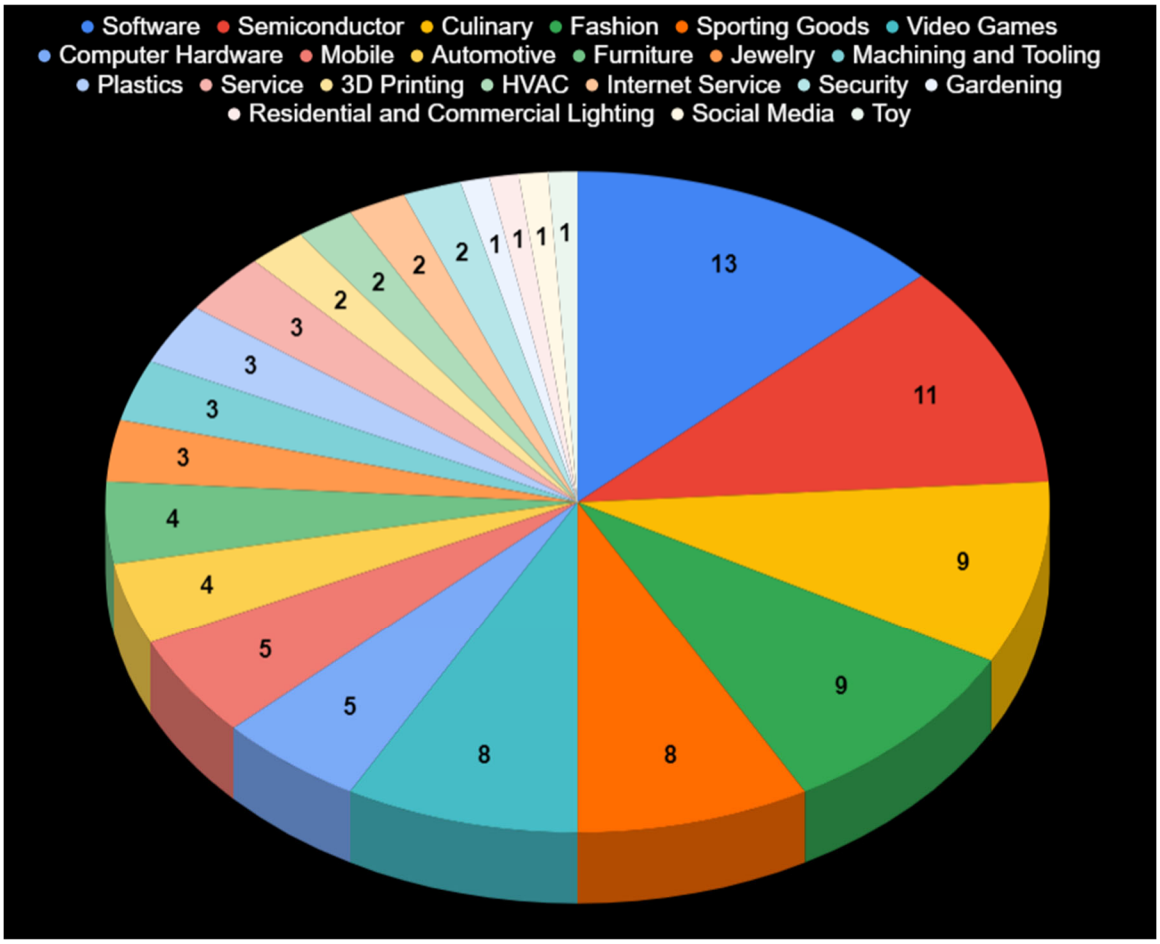

Figure 22 depicts the number of articles that mentioned an industry that implemented a user toolkit.

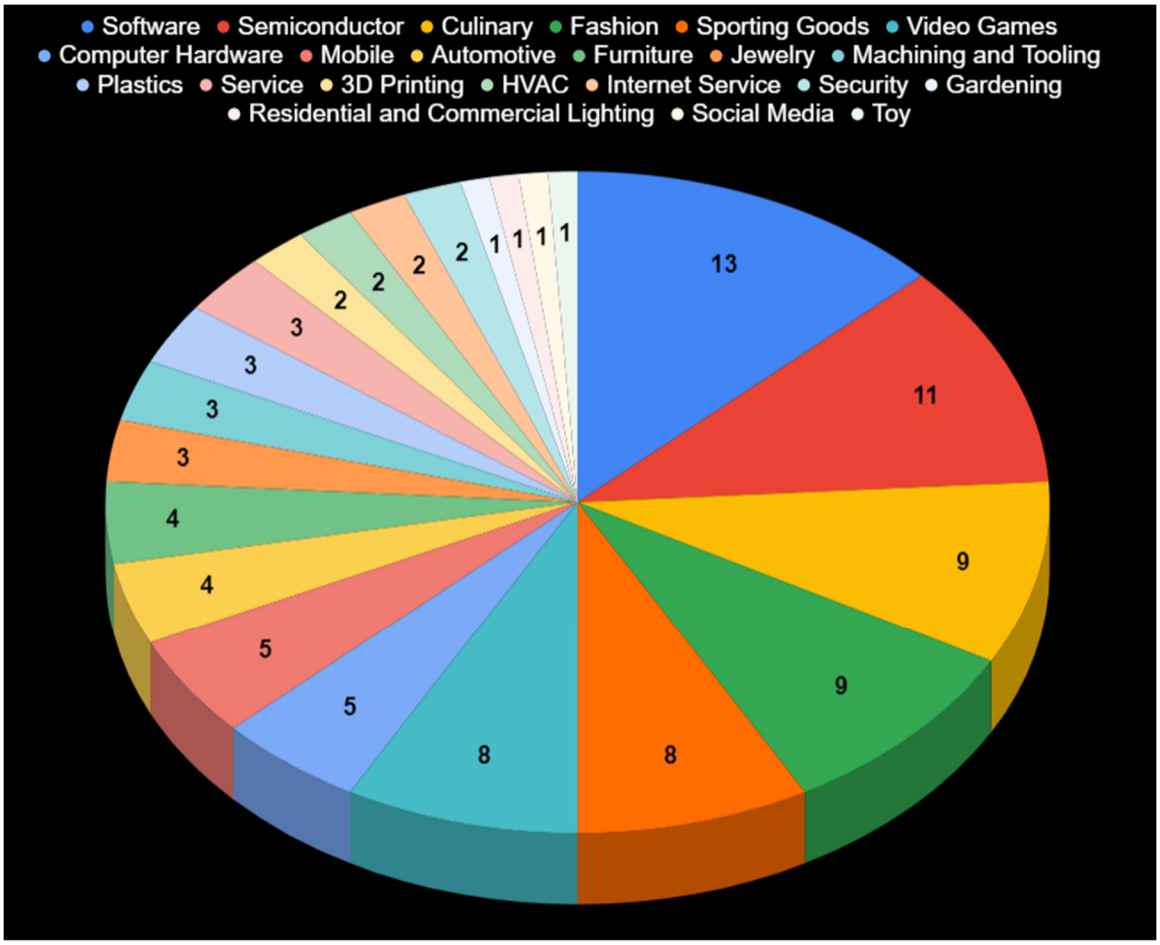

Figure 22: Existence of Industries Across 32 Articles

Across 32 articles, the researchers identified 22 different industries that implemented user toolkits: 13 articles mentioned the software industry; 11 articles mentioned the semiconductor industry; 9 articles mentioned the culinary and fashion industry; 8 articles mentioned the sporting goods and video game industry; 5 articles mentioned the computer hardware and mobile industry; 4 articles mentioned the automotive and furniture industries; 3 articles mentioned the jewelry, machining and tooling, plastics, and service industries; 2 articles mentioned the 3D printing, HVAC, internet service, and security industries; and 1 article mentioned gardening, residential

and commercial lighting, social media, and toy industries. The researchers believe this information shows how widespread the concept of user toolkits is since a diverse group of industries implemented the concept. The different industries could also signify how a lot of industries are starting to adopt the concept. Additionally, the researchers believe the information shows how user toolkits might be more common in some industries compared to others. For example, the articles mentioned the software industry the most when compared to the other industries. They also believe the concept of user toolkits might become a necessary feature within that industry due to the number of references. Another topic the researchers believe would be interesting to explore based on the information is looking at how refined these user toolkits are across these industries.

Another interesting detail the researchers noticed was how none of the articles mentioned the military or defense industry using user toolkits. The military uses a wide variety of different technologies from many of the industries mentioned throughout the articles. The researchers believe the DoD should explore implementing a user toolkit to assist with some of the missions they carry out, such as maintenance. If the DoD does have a user toolkit in place for some missions, the DoD should report the results of implementing the concept to build upon the body of knowledge that exists.

Applying the Model-Framework to a DoD Organization

This section explains the results of applying the model-framework to an existing organization in the DoD, The Griffin. The purpose of this section is to highlight what model elements do and do not exist around an organization that has not implemented a

user toolkit. Additionally, if the model elements do exist, the researchers can understand what aspects around the organization do and do not match the model-framework.

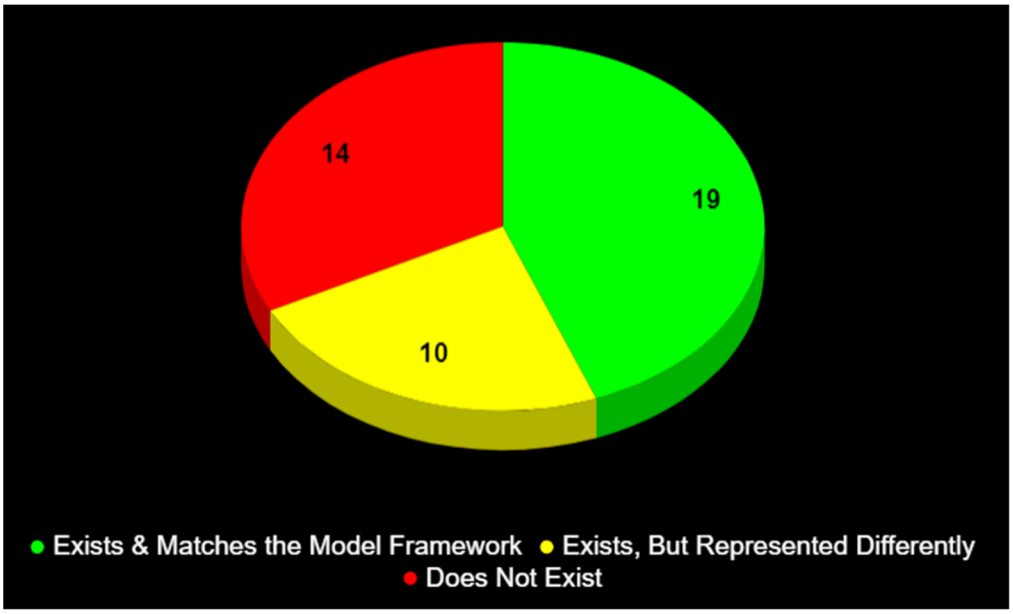

Figure 23: Existing and Non-Existing Model Elements from Applying the Model-Framework to The Griffin

Figure 23 depicts the number of model elements that exist and match the model-framework, elements that exist and do not match the model-framework, and elements from the model-framework that do not exist around the organization. Table 5 shows a stoplight chart that depicts the exact roles, tasks, and information flows from the model-framework that were and were not present around the Griffin. The *Model Elements* column shows the roles in yellow, tasks in purple, and information flows in green. The column on The Griffin used red to show if a model element from the model-framework did not exist around the organization, yellow to show if a model element from the model-framework existed around the organization but did not match the model-framework's representation, and green to show if a model element from the model-framework existed around the organization and matched the model-framework's representation.

Table 5: Stoplight Chart of Existing and Non-Existing Model Elements Around The Griffin

Model Elements	The Griffin
End User	
Define Preferences	
Use Standard Producst	
Firm	
Release Product Updates	
Produce Productrs/Services	
Understand Emerging Trends	
Implement Policy Guidelines and Procedures	
Implement User Toolkit	
Subject Matter Expert	
Design Company Products/Services	
Translate User Designs Into Products	
Communicate Directly with the User Community	
Update Existing Products	
Complete Assigned Requirements	
User Community	
Assist Users with Problem Solving	
Diffuse Helpful Information	
Encourage Community Interaction	
Provide Feedback	
User Innovator	
Use Available Creation Tools	
Perform Problem Solving	
Create Custom Products/Services	
Improve Product Designs	
Satisfy Unmet Needs	
Firm Product Development Tools [From Firm to Subject Matter Expert]	
Solution Related Tasks [From Firm to Subject Matter Expert]	
Innovative Solution [From Firm to User Community]	
Firm's End Product/Service [From Subject Matter Expert to Firm]	
Capability Request [From User Community to Firm]	
Unmet Needs [From User Community to User Innovator]	
Need-Releated Innovation Tasks [From Firm to User Community]	
Rewards and Opportunities [From Firm to User Innovator]	
Feedback [Within User Community]	
Design Preferences [From End User to User Community]	
Rewards and Opportunities [From User Community to User Innovator]	
Toolkits for User Innovation [From Firm to User Community]	
Innovative Designs [From User Innovator to Firm]	
Innovative Solution [From User Innovator to User Community]	
Colaborative Ideas [Within User Community]	
Unmet Needs [Within User Innovator]	
Toolkit Improvements [From Firm to User Community]	

The model-framework on user toolkits contains a total of 43 different elements that represent a role, a task of a role, or an information flow among the different roles. Of the 43 elements shown in the model-framework, 29 exist and 14 do not exist when comparing the model-framework to the structure around The Griffin. Of the 29 existing elements, 19 match the representation in the model-framework while 10 elements do not match the representation in the model-framework.

Existing Elements of the Current Organization that Match the Model-Framework

As shown in Figure 23, when the researchers applied the model-framework to The Griffin, they identified 29 elements that exist around The Griffin. Of the 29 elements, 19 match the representation shown in the model-framework on user toolkits. There are four roles from the model-framework that are associated with The Griffin: The Griffin acts as the firm, the maintenance community acts as the user community, the maintainers act as the end user, and the personnel within The Griffin act as the SMEs.

There are 10 tasks that match the representation shown in the researcher's model-framework. The Griffin acts as the firm that produces products and services by providing interactive multimedia to support task-based or subject matter training requirements. The Griffin implements policy guidelines and procedures that govern the way they operate. Additionally, The Griffin is responsible for releasing product updates. The Griffin must also understand emerging trends within the maintenance community to continue delivering effective products to support and train maintainers. The maintenance community has the task of providing feedback through a submission link provided by The Griffin. The maintainers have the task of defining their preferences by submitting information on what they would like to see through The Griffin's submission link. They

also have the task of using standard products, which is the content The Griffin releases for maintainers to use. The SMEs within The Griffin have the task of completing assigned requirements. They use the requirements to perform the task of designing The Griffin's products or services. The SMEs must also perform the task of updating existing products within The Griffin.

There are 5 information flows associated with The Griffin that match the model-framework. The Griffin supplies the SMEs within the organization with product development tools. Additionally, The Griffin provides solution related tasks to the SMEs so the SMEs can create and integrate portions of The Griffin's product. Once the SMEs complete a product, the final product goes through certain approval processes for The Griffin to release. Once a product receives approval, The Griffin releases the innovative solution to the maintenance community. The maintenance community can also provide capability requests to the firm through the idea submission link The Griffin has on its website.

Elements of the Current Organization that Deviate from the Model-Framework

Of the 29 elements the researchers identified around The Griffin, 10 do not match the representation shown in the researcher's model-framework. When the researchers applied the model-framework to The Griffin, they identified 5 tasks under the user innovator in the model-framework that fall under the SMEs in The Griffin. The SMEs use whatever creation tools they have available to perform their job. The SMEs are also the role that performs problem solving based on the requirements they receive and the information that people submit through the submission link. Additionally, the SMEs are the only entity who can create custom products or services and improve product designs

based on the current structure of The Griffin. The SMEs are also the personnel who aim to satisfy the unmet needs that come from personnel within the maintenance community who provide feedback and suggestions through the submission link on The Griffin's website.

The researchers identified 5 information flows that exist but do not match the representation shown in the model-framework. The design preferences that maintainers provide through the submission link flow from the end user to The Griffin. Additionally, the need-related innovation tasks exist in two forms. The Griffin wants the maintenance community to submit need related information through the submission link, so The Griffin tasks the maintenance community to provide information on what the user community needs. The Griffin also provides need-related innovation tasks to SMEs because The Griffin brings in maintainers to use their experience in maintenance to understand what maintainers in the field need. This means The Griffin needs the SMEs to perform both need-related and solution-related tasks. The rewards and opportunities flow from The Griffin to the SMEs within the organization. If a SME performs well in The Griffin, the firm can provide awards to incentivize the SME to continue innovating. Unmet needs also flow from the maintenance community to the firm when the researchers applied the model-framework to The Griffin. The maintenance community provides these unmet needs through the submission link. The feedback The Griffin receives also flows from the maintenance community to the firm in a similar manner since anyone in the maintenance community can provide information through the submission link.

Elements of the Model-Framework that Do Not Exist in the Current Organization

The researchers identified 14 elements from the model-framework that do not exist after applying the model-framework to The Griffin. The user innovator role was the only role missing. The Griffin currently relies on bringing maintainers into the organization, which means the maintainers act as SMEs within the organization who use their experience to innovate as part of their job. There was no information provided to detail how The Griffin might identify innovative personnel within the maintenance community. With the lack of information, the researchers assumed that the user innovator role cannot be present based on how the model-framework depicts the role.

When the researchers applied the model-framework to The Griffin, they identified 6 nonexistent tasks. The task of implementing a user toolkit does not exist since the organization does not have a user toolkit in place. Another missing task is the ability to assist users with problem solving. The current structure of the Griffin allows the firm to solve problems based on the information that users within the community provide through the submission link and the experience of the SMEs within The Griffin. There are avenues available for personnel to communicate with The Griffin, but there are no avenues available for those within The Griffin to communicate directly with all of the members within the maintenance community. In addition to not communicating directly with the user community, there are no methods available to diffuse helpful information or encourage community interaction among the users within the maintenance community. The Griffin releases innovative content, but users cannot distinguish which content other users within the community find helpful or valuable. The lack of interaction among community members also hinders the ability to communicate valuable information since

users with similar interests or problems are unable to connect. Additionally, there is no way for anyone outside of The Griffin to create designs for The Griffin to use, so the task of translating user designs into products cannot exist.

The researchers also identified 7 information flows that do not exist when they applied the model-framework to The Griffin. The Griffin does not have a user toolkit, so the organization cannot provide a user toolkit or updates to a user toolkit to the maintenance community. Since a medium does not exist to encourage community interactions on ideas or designs, collaborative ideas cannot form between those within the maintenance community and The Griffin. Without the ability to gather information from user innovators within the maintenance community, the user innovators cannot share their innovative solutions with the maintenance community, and they cannot share their innovative designs with The Griffin. The user community cannot provide rewards and opportunities to user innovators as well since they cannot access the solutions that user innovators can create. Additionally, The Griffin cannot identify user innovators within the maintenance community since user innovators cannot share their solutions that distinguish them from other end users.

Discussion on Applying the Model-Framework to The Griffin

As shown in Figure 23, the researchers identified the existence of 29 model elements and 14 nonexistent model elements when they applied the model-framework to The Griffin. This breakdown shows how roles, tasks, and information flows might exist already in an organization that does not have a user toolkit. Additionally, the breakdown shows how some of the model elements match the representation shown in the model-framework while representing other model elements in a different manner. The

researchers believe the different representations on existing model elements could highlight areas where the organization could restructure to achieve the benefits of a user toolkit, but researchers need to perform more research to prove that belief. The model-framework also allowed the researchers to identify a lack of certain model elements, which could identify areas the organization would need to create to successfully implement a user toolkit. Again, the researchers need to perform more research to prove that belief.

After the researchers applied the model-framework to The Griffin, they found the lack of user innovators interesting since most of the tasks associated with that role were present under the SME role. This finding shows how the SMEs have a lot more tasks to perform without a user toolkit in place since The Griffin does not have the ability to tap into the user innovators that exist in the maintenance community. Additionally, it shows how a bottleneck could form when creating innovative solutions for the maintenance community. With the current structure, the maintenance community only receives innovative solutions from the firm.

The Griffin's talent acquisition process also enhances the innovative bottleneck since the firm needs to spend more time identifying innovative personnel to carry out the necessary work. The current talent acquisition process means The Griffin is the entity that sources talent from the existing maintenance community instead of using the maintenance community to help identify innovative personnel. The sourcing of talent also means The Griffin spends more resources on acquiring the right personnel for the jobs they require, which limits the resources the organization can put towards accomplishing their mission.

The Griffin also limits the amount of innovation they can receive from the user community by only providing a submission link for ideas or feedback. It would be interesting to see how The Griffin could increase the innovative maintenance content they produce by implementing a user toolkit that could leverage the user innovators that exist in the maintenance community.

Summary

Over the course of four phases and 32 journal articles, the researchers captured data on the roles, tasks, information flows, and industries involved with user toolkits for user innovation. The researchers used the data to highlight the existence of user toolkits across 22 different industries while creating and refining a model-framework on user toolkits. This model-framework contained 43 different elements which consisted of: 5 roles, 21 tasks across all 5 roles, and 17 information flows that flowed among each of the 5 roles. The researchers applied the final model-framework to an existing DoD organization, The Griffin. The researchers identified 29 model elements that exist and 14 model elements that did not exist when they applied the model-framework to The Griffin. Of the 29 existing elements, 19 matched the representation in the model-framework while 10 deviated from the representation in the model-framework. The researchers used this information to elaborate on how a bottleneck in innovation can occur around The Griffin with the organization's current structure and suggested performing further research to explore their beliefs.

V. Conclusions and Recommendations

Chapter Overview

This chapter summarizes the research of this document. Additionally, this chapter details the significance of this research along with recommendations for action and future research.

Background

The DoD has constantly sought to understand and improve upon the processes involved in the development of warfighting capabilities [4]. The DoD also works with a finite number of resources to allocate towards their missions, which includes deploying service members and maintaining aircraft around the world [7], [8]. The DoD codes maintainers to maintain specific airframes based on their current maintenance structure. Additionally, the DoD operates aircraft based on the location of available maintenance. This structure causes a few issues by tying aircraft availability to maintainers and not allowing maintainers to perform tasks on other airframes that are outside of their specialty coding. These issues lead to problems, such as reactionary spending to deploy maintainers to maintain specific airframes and increasing the predictability of the DoD among potential adversaries.

The JIT MMA concept plans to leverage advancements in technology to better train and support maintainers to potentially solve these problems. This concept would allow maintainers to perform maintenance tasks on multiple airframes outside of their specialty coding at FOBs. An example of the JIT MMA concept includes enabling an F-15 maintainer to perform maintenance tasks on an MQ-9. The researchers believe the

DoD could explore user toolkits as one viable solution to support the capturing and sharing of knowledge within JIT MMA concept by better utilizing innovative maintainers within the maintenance community.

Conclusions of Research

The research objective was to develop a model-framework on user toolkits. The researchers performed a model-based literature review on user toolkits for user innovation to understand the roles, tasks, and information flows that exist in an environment that uses user toolkits. The contribution of this research resulted in a model-framework that organizations can use as an assessment tool to guide the implementation of user toolkits. The researchers answered the following research questions:

RQ 1: How can researchers use SysML to perform a literature review on topics, such as user toolkits for user innovation?

The researchers answered this question by developing the methodology mentioned in Chapter III of this thesis document. This methodology allowed the researchers to collect and aggregate data from literature that focused on user toolkits for user innovation.

RQ 2: What roles, tasks, and information flows exist in an environment that uses user toolkits for user innovation?

The researchers answered this question by using the methodology from Chapter III to model 32 articles on user toolkits for user innovation. This methodology assisted with producing the model-framework shown in Figure 12. The model-framework contains 43 elements that include 5 roles, 21 tasks, and 17 information flows.

RQ 3: What industries do user toolkits exist in?

The researchers answered this question by identifying the industries that the 32 articles mentioned. The articles mentioned 22 different industries that implemented user toolkits for user innovation.

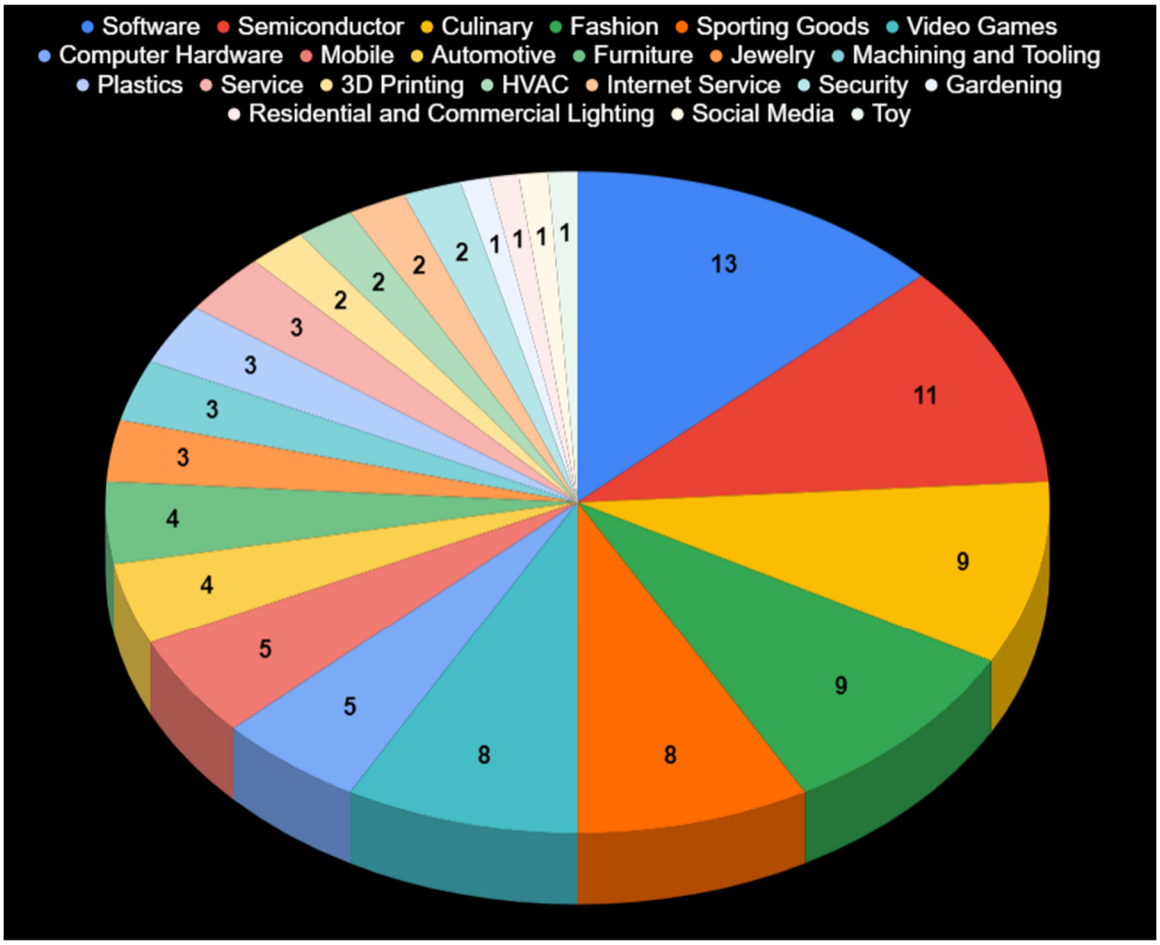

Figure 22 depicts how often the articles mentioned each industry.

RQ4: What information can researchers obtain from applying their model-framework to a DoD organization?

The researchers answered this question by applying their model-framework to The Griffin. They identified model elements that exist and match the model-framework, elements that exist and do not match the model-framework, and elements from the

model-framework that do not exist around the organization. Figure 23 shows, out of the 43 elements shown in the model-framework, that 29 exist and 14 do not exist. Of the 29 existing elements, 19 match the model-framework while 10 elements do not match the model-framework. Additionally, Table 5 uses a stoplight chart to show which model elements fall into the three categories. This table assisted the researchers with identifying bottlenecks around the existing structure of The Griffin. This table also assisted the researchers with identifying areas of improvement around the structure of the Griffin. These areas of improvement could guide the organization with implementing and fully realizing the benefits of user toolkits.

Significance of Research

This research expanded the body of knowledge in several ways. The researchers did not come across a meta-analysis method that would produce a model-based solution. The researchers responded to the lack of information by developing a methodology to perform a model-based literature review on user toolkits. The methodology assisted with generating, analyzing, refining, and applying the data from the literature the researchers used throughout this research. The researchers also believe they can apply this methodology to accumulate additional literature and identify opportunities or significant findings within other topics outside of the focus of this research.

This research also identified the key roles, tasks, and information flows that are involved in an environment that uses user toolkits. The researchers did not identify any previous literature that clearly identified these roles, tasks, and information flows, so this research assists with expanding the body of knowledge on user toolkits by clearly

defining this information. This research also expanded upon the number of industries that user toolkits are known to exist in. The DoD has a variety of systems that include products from a variety of industries mentioned in the literature, so implementing a user toolkit within the DoD could prove to be beneficial. Additionally, this research shows how organizations within the DoD, like The Griffin, already have some of the roles, tasks, and information flows in place. This means organizations within the DoD can explore using user toolkits to potentially collaborate more effectively and deploy innovative capabilities in a quicker manner with their industry partners.

Another significant finding from this research is the observation of self-induced innovation bottlenecks that are present within The Griffin based on the structure of the organization. This research highlights how personnel can apply the model-framework to assist with potentially improving the processes of an organization with a user toolkit. The model-framework can assist with guiding an organization through their existing processes and procedures to identify other bottlenecks or potential opportunities.

Recommendations for Action

This research produced a couple recommendations for action. For one, the researchers believe the DoD should explore implementing user toolkits across organizations that are trying to innovate. The DoD cannot ignore the potential benefits that user toolkits can provide based on the information the researchers gathered.

Additionally, the DoD should share any information on their existing user toolkits if they implemented the concept already. The researchers believe the DoD should share their information on user toolkits because none of the literature covered in this research

read mentioned the defense industry. The DoD could assist with expanding the body of knowledge on user toolkits further by sharing their experiences with the concept.

Recommendations for Future Research

The researchers provide several recommendations for future research based on the results of this research. Future research could include refactoring the model. The researchers developed the methodology, so there could be areas of the model that others could refine through refactoring.

Future research could also observe what aspects of SysML do and do not help with performing a model-based literature review. This research could also include exploring additional features that could assist with performing a model-based literature review.

In addition to refining the methodology, future research could include applying the methodology to other concepts. This research applied the methodology to user toolkits, but it would be interesting to see what information, such as frameworks, questions, or conclusions, other researchers can produce about other operational environments with this methodology.

Aside from applying the concept of user toolkits to other organizations, it would be interesting to understand how other organizations perceive the concept of user toolkits. Future research on organizational perceptions could include exploring the perception of reorganizing an organization to accommodate user toolkits.

The researchers could also perform a variety of cost benefit analyses in the future that focus on the effects of implementing a user toolkit. These analyses would provide

quantitative information that focuses on the value a user toolkit would or would not add to an organization. The researchers could focus on the costs associated with developing and implementing a user toolkit or even the costs associated with restructuring an organization to accommodate a user toolkit. This information could assist specific organizations with understanding if they would benefit or not from implementing a user toolkit.

An additional area of interest to explore in the future could be analyzing how user toolkits could assist with overcoming language barriers between different organizations and communities. This research mentioned how user toolkits are known for translating user designs into actual products and for reducing the back-and-forth communication between different entities. Different entities, such as communities or organizations, have different languages or terminology they understand that outside entities might not fully understand. It would be interesting to know how a user toolkit could assist with understanding and overcoming the language barriers between these entities. For example, organizations within the DoD have their own terminology that other organizations within the DoD might not know, so a user toolkit might assist with clarifying what the organizations mean as they define capability gaps or requirements.

Another area of future research includes analyzing the interactions among roles. What occurs if a role does not perform a task or send information to another role? This information could assist with building upon the model-framework by outlining the positive and negative effects that each role can have on one another.

This research focused on the existence of roles, tasks, and information flows among the literature, but it would be interesting to know how necessary some of the

model elements are for creating and implementing a user toolkit in specific circumstances. The researchers believe it would be interesting to know if they could add elements of the model-framework to an organization in an iterative manner, or if all the model elements need to be present from the start when implementing a user toolkit. Additionally, the researchers believe it would be interesting to know if some of these model elements are tailorable based on the industry the organization is a part of.

This research also mentioned the importance of user communities and their involvement with user toolkits. It would be interesting to see how large a community must be for a user toolkit to provide value.

This research also mentioned the importance of SMEs in the model-framework. This model-framework generalized the role, but it would be interesting to explore the specific tasks that SMEs need to perform across different industries to manufacture and distribute a product for a firm using a user toolkit. Additionally, it would be interesting to explore the tasks that specific SMEs need to perform in those industries, such as engineers, marketing experts, managers, etc.

The researchers also believe it would be interesting to understand the scalability of user toolkits. Some user toolkits are known as mass customization toolkits that do not afford users much design autonomy while other toolkits provide users with a seemingly limitless design space. Future research could explore what it would take to transition and scale a mass customization toolkit to provide more design autonomy to users.

Another future research topic could include exploring how users can transition from one role to another. Some of the previous research indicated that users could

become firms when they create innovative solutions. It would be interesting to explore the reasoning and events that allow users to transition between other roles.

The researchers applied their model-framework to The Griffin to understand what model elements did and did not exist within this DoD organization, which the DoD considers to be an innovative organization. The researchers recommended applying a user toolkit to organizations like The Griffin to support the JIT MMA concept. It would be interesting to understand what organizations, like The Griffin, would need to develop an actual user toolkit to support the JIT MMA concept. This research could explore areas such as technology, concepts, and structures that assist with satisfying the issues the JIT MMA concept aims to address.

Another area of interest future researchers could explore includes analyzing the policy and guidelines that impact the implementation of user toolkits within the DoD. This research could highlight existing policy and guidelines that support the implementation of user toolkits. This research could also identify policy and guidelines that user toolkits need to overcome to become a reality. This future research would provide an understanding on how the DoD would need to change or adapt to implement user toolkits.

Summary

Research on user innovation and user toolkits are both mature and growing fields of interest [12], [13]. However, the existing research fails to address all the roles, the tasks of those roles, and the information flows among the roles that exist in an environment that uses user toolkits for user innovation. The researchers performed a

model-based literature review to produce a model-framework to identify this gap in literature.

Additionally, it is unclear what technologies the DoD needs to implement to address the issues that the JIT MMA concept expects to solve. This thesis explored user toolkits for user innovation as one existing concept that organizations within the DoD can implement to support the JIT MMA concept. The researchers applied their model-framework to The Griffin to highlight how aspects of their model-framework exist and do not exist around organizations that do not have a user toolkit. The researchers believe their research can assist other organizations with outlining a plan to successfully implement user toolkits by applying the model-framework on user toolkits.

Appendix A. – Data Set

Phase One Articles

Phase	Article #	Article Title
1	1	Democratizing Innovation: The evolving phenomenon of user innovation
	2	EMOTIO – Design of a Toolkit Enabling User Innovation
	3	Managing Sustainable Innovation with a User Community Toolkit: The Case of the Video Game Trackmania
	4	Modularity in making: simplifying solution space for user innovation
	5	Shifting Innovation to Users via Toolkits
	6	The Value of Toolkits for User Innovation and Design
	7	User Toolkits for Innovation
	8	USER SERVICE INNOVATION ON MOBILE PHONE PLATFORMS: INVESTIGATING IMPACTS OF LEAD USERNESS, TOOLKIT SUPPORT, AND DESIGN AUTONOMY
	9	User toolkits for innovation - A literature review
	10	Value Creation by Toolkits for User Innovation and Design: The Case of the Watch Market

Phase Two Articles

Phase	Article #	Article Title
2	1	Satisfying heterogeneous user needs via innovation toolkits: the case of Apache security software
	2	User Toolkits for Innovation: Consumers Support Each Other
	3	Testing the moderating effects of toolkits and user communities in personalization: The case of social networking service
	4	Innovations and communication through innovative users: An exploratory mechanism of social networking website
	5	Embedded Toolkits: Identifying Changing User Needs During Product Usage
	6	COMPARING POTENTIAL AND ACTUAL INNOVATORS: AN EMPIRICAL STUDY OF MOBILE DATA SERVICES INNOVATION
	7	Testing the Value of Customization: When Do Customers Really Prefer Products Tailored to Their Preferences?
	8	Embedded Toolkits for User Co-Design: A Technology Acceptance Study of Product Adaptability in the Usage Stage
	9	Pulling String: How Users Can Shape Innovation
	10	Learning from leading-edge customers at The Sims: opening up the innovation process using toolkits
	11	Toolkits for idea competitions: a novel method to integrate users in new product development
	12	The “I Designed It Myself” Effect in Mass Customization

Phase Three Articles

Phase	Article #	Article Title
3	1	Getting Customers' Ideas to Work for You: Learning from Dell how to Succeed with Online User Innovation Communities
	2	USER TOOLKITS FOR INNOVATION: LINK BETWEEN THE KNOWLEDGE OF THE FIRM AND THE KNOWLEDGE OF THE USER
	3	Which effects are claimed with User-Toolkits for Innovation and Design?
	4	Exploring the Inbound and Outbound Strategies enabled by User Generated Big Data: Evidences from Leading Smartphone Applications.
	5	How Firms Can Get Ideas from Users for Sustainable Business Innovation
	6	Open Innovation Through Online Communities
	7	Key research issues in user interaction with user toolkits in a mass customisation system
	8	User-driven Innovation
	9	Designing the Organization for User Innovation
	10	User Innovation

Appendix B – Phase Two Data

Phase Two Model Changes & Deviations

Article Number	Comments		
Article 1	Moved "translate user designs into products" from firm to Subject Matter Expert	Unmet Needs flows from User Community to User Innovator AND within User Innovator	
Article 2	New item flow - Innovators and SMEs collaborate directly with another with collaborative ideas	New Items flow - Firms can provide rewards and opportunities to user innovators, such as money or employment	User innovators provide more solution-oriented feedback than the generic feedback from end users, later moved to user community
Article 3	User communities provide feedback, consists of both solution oriented and generic feedback from both end users and user innovators		
Article 4	Change item flow for collaborative ideas to between user communities and subject matter experts OR include SMEs under the user community and the firm with composition relationships and have collaborative ideas flow within the user community	Chose to change item flow for collaborative ideas to between user communities and subject matter experts	
Article 5	NO CHANGES NOTICED		
Article 6	Rephrased employment opportunities to rewards and opportunities	Rewards and opportunities also flow from the user community to user innovators	
Article 7	NO CHANGES NOTED - Focused more on user side vs firm side though		
Article 8	NO CHANGES NOTED		
Article 9	NO CHANGES NOTED		
Article 10	NO CHANGES NOTED		
Article 11	NO CHANGES NOTED		
Article 12	NO CHANGES NOTED		

Phase Two Article Elements

Article Number	1	2	3	4	5	6	7	8	9	10	11	12	Frequency
User Innovator	☑	☑	☑	☑	☑	☑	☑	☑	☐	☑	☑	☑	11
User Community	☑	☑	☑	☑	☑	☑	☑	☑	☐	☑	☑	☑	11
Subject Matter Expert	☑	☑	☑	☑	☑	☑	☐	☐	☐	☑	☑	☑	9
Firm	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	12
End User	☑	☑	☑	☑	☑	☑	☑	☐	☑	☑	☑	☑	11
Use Standard Products/Services	☑	☑	☑	☑	☑	☑	☐	☐	☑	☑	☐	☑	9
Use Available Creation Tools	☑	☑	☑	☑	☐	☑	☐	☑	☑	☑	☐	☑	9
Update Existing Products	☐	☑	☑	☐	☑	☐	☐	☐	☐	☑	☐	☐	4
Understand Emerging Market Trends	☑	☐	☑	☑	☑	☐	☐	☐	☐	☑	☑	☐	6
Translate User Designs Into Products	☑	☐	☐	☐	☐	☐	☐	☐	☐	☐	☑	☐	2
Satisfy Unmet Needs	☑	☐	☑	☑	☑	☑	☑	☑	☐	☑	☑	☐	9
Release Product Updates	☑	☑	☑	☑	☐	☑	☐	☐	☐	☐	☐	☐	5
Provide Feedback	☐	☑	☑	☑	☐	☑	☐	☐	☐	☑	☑	☑	7
Produce Products/Services	☑	☑	☑	☑	☑	☑	☐	☑	☐	☑	☑	☑	10
Perform Problem Solving	☐	☐	☑	☐	☐	☐	☑	☐	☐	☑	☐	☐	3
Improve Product Designs	☑	☐	☑	☑	☑	☐	☐	☑	☐	☑	☑	☐	7
implement User Toolkit	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	12
Implement Policy Guidelines and Procedures	☑	☑	☐	☐	☑	☐	☐	☑	☑	☑	☑	☐	7
Encourage Community Interaction	☑	☑	☑	☑	☐	☑	☐	☐	☐	☐	☑	☐	6
Diffuse Helpful Information	☑	☑	☑	☑	☐	☑	☐	☐	☐	☑	☐	☑	7
Design Company Products/Services	☑	☐	☑	☐	☑	☑	☐	☑	☐	☑	☐	☐	6
Define Preferences	☐	☑	☑	☑	☑	☐	☑	☐	☑	☐	☐	☑	7
Create Custom Products/Services	☑	☑	☑	☑	☐	☑	☑	☑	☐	☑	☐	☑	9
Complete Assigned Requirements	☑	☐	☐	☐	☑	☐	☐	☐	☐	☐	☐	☐	2
Communicates Directly with the User Community	☐	☑	☑	☑	☑	☐	☐	☐	☐	☑	☐	☐	5
Assist Users with Problem Solving	☑	☑	☑	☑	☐	☑	☐	☐	☐	☐	☑	☐	6
Unmet Needs	☑	☐	☑	☑	☑	☑	☑	☑	☐	☑	☑	☐	9
Toolkits for User Innovation	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	12
Toolkit Improvements	☐	☑	☐	☑	☐	☐	☐	☐	☐	☑	☐	☐	3
Solution Related Tasks	☑	☐	☐	☐	☑	☐	☐	☑	☑	☐	☑	☐	5
Rewards and Opportunities	☐	☑	☐	☐	☐	☑	☐	☐	☐	☐	☑	☐	3
Need-Related Innovation Tasks	☐	☑	☑	☐	☑	☑	☐	☑	☑	☑	☑	☐	8
Innovative Solution	☑	☑	☑	☑	☐	☑	☐	☐	☑	☑	☑	☑	9
Innovative Designs	☑	☑	☑	☐	☐	☑	☐	☑	☑	☐	☑	☑	8
Firm's End Product/Service	☑	☑	☐	☐	☑	☑	☐	☐	☐	☐	☐	☑	5
Firm Product Development Tools	☐	☑	☐	☐	☑	☐	☐	☐	☐	☐	☐	☐	2
Feedback	☐	☑	☑	☑	☐	☑	☐	☐	☐	☑	☑	☑	7
Design Preferences	☐	☑	☑	☑	☐	☐	☐	☐	☑	☑	☑	☑	7
Collaborative Ideas	☐	☑	☑	☑	☐	☐	☐	☐	☐	☑	☑	☐	5
Capability Request	☐	☑	☐	☑	☑	☐	☑	☑	☐	☑	☑	☐	7

Appendix C – Phase Three Data

Phase Three Model Changes & Deviations

Article Number	Comments
Article 1	NO CHANGES NOTED
Article 2	NO CHANGES NOTED
Article 3	NO CHANGES NOTED
Article 4	NO CHANGES NOTED
Article 5	Revisit Phase 2 Article 4 comment - NO NEW CHANGES TO MODEL
Article 6	Incorporated Phase 2 Article 4 comment - NO NEW INFORMATION DISCOVERED SO FAR
Article 7	NO NEW INFORMATION MENTIONED - CHANGED DESIGN UTK to DESIGN COMPANY PRODUCTS/SERVICES - does not signify any major change
Article 8	NO CHANGES NOTED
Article 9	NO CHANGES NOTED
Article 10	NO CHANGES NOTED

Phase Three Article Elements

Article Number	1	2	3	4	5	6	7	8	9	10	Frequency
User Innovator	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	10
User Community	☑	☑	☐	☑	☑	☑	☑	☑	☑	☑	9
Subject Matter Expert	☑	☐	☑	☑	☑	☑	☑	☑	☑	☐	8
Firm	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	10
End User	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	10
Use Standard Products/Services	☑	☐	☐	☑	☑	☑	☐	☐	☐	☑	5
Use Available Creation Tools	☐	☑	☑	☑	☐	☑	☑	☐	☑	☑	7
Update Existing Products	☐	☐	☐	☐	☐	☑	☐	☐	☐	☐	1
Understand Emerging Market Trends	☑	☐	☑	☐	☑	☑	☑	☑	☑	☑	8
Translate User Designs Into Products	☑	☐	☐	☐	☐	☑	☐	☐	☐	☐	2
Satisfy Unmet Needs	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	10
Release Product Updates	☑	☐	☐	☐	☑	☑	☐	☐	☐	☐	3
Provide Feedback	☑	☐	☐	☐	☑	☐	☐	☑	☑	☐	4
Produce Products/Services	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	10
Perform Problem Solving	☑	☑	☐	☐	☐	☐	☐	☐	☐	☑	3
Improve Product Designs	☐	☑	☐	☐	☑	☐	☐	☑	☑	☑	5
implement User Toolkit	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	10
Implement Policy Guidelines and Procedures	☑	☑	☑	☐	☐	☑	☑	☐	☑	☐	6
Encourage Community Interaction	☐	☐	☑	☑	☑	☐	☐	☐	☑	☐	4
Diffuse Helpful Information	☑	☐	☐	☐	☑	☑	☐	☑	☑	☐	5
Design Company Products/Services	☐	☑	☐	☐	☐	☐	☐	☑	☑	☐	3
Define Preferences	☑	☐	☑	☐	☑	☐	☑	☑	☐	☑	6
Create Custom Products/Services	☐	☑	☑	☑	☐	☑	☑	☑	☑	☑	8
Complete Assigned Requirements	☑	☑	☑	☑	☐	☑	☐	☐	☑	☐	6
Communicates Directly with the User Community	☑	☐	☐	☐	☐	☑	☑	☐	☑	☐	4
Assist Users with Problem Solving	☑	☐	☐	☐	☐	☑	☐	☑	☑	☑	5
Unmet Needs	☑	☐	☑	☑	☑	☑	☑	☑	☑	☑	9
Toolkits for User Innovation	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	10
Toolkit Improvements	☑	☐	☐	☐	☐	☑	☐	☐	☐	☐	2
Solution Related Tasks	☑	☐	☐	☐	☐	☑	☐	☐	☑	☐	3
Rewards and Opportunities	☑	☐	☐	☐	☐	☑	☐	☑	☑	☑	5
Need-Related Innovation Tasks	☑	☑	☑	☑	☐	☑	☐	☑	☑	☑	8
Innovative Solution	☑	☑	☑	☑	☑	☑	☑	☑	☑	☐	9
Innovative Designs	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	10
Firm's End Product/Service	☑	☐	☐	☐	☐	☐	☐	☑	☑	☐	3
Firm Product Development Tools	☐	☑	☐	☐	☐	☐	☐	☐	☑	☐	2
Feedback	☑	☑	☑	☑	☑	☐	☑	☑	☑	☑	9
Design Preferences	☑	☐	☐	☑	☐	☐	☑	☐	☐	☐	3
Collaborative Ideas	☑	☐	☐	☐	☑	☑	☐	☑	☑	☑	6
Capability Request	☑	☐	☑	☑	☑	☑	☐	☑	☑	☐	7

Appendix D – Model Framework on User Toolkits

UTK Thesis.mdzip

Bibliography

[1] C. Q. Brown, "Accelerate Change or Lose." Aug. 2020.

[2] M. McQuade and A. P. Hunter, "The Change We Need: Making Defense More Future Proof through Adaptable Systems," *Center for Strategic & International Studies*, p. 6, Mar. 2019.

[3] E. von Hippel, "User toolkits for innovation," *Journal of Product Innovation Management*, vol. 18, no. 4, pp. 247–257, 2001, doi: 10.1111/1540-5885.1840247.

[4] T. C. Lassman, *Sources of Weapon Systems Innovation in the Department of Defense: The Role of In-House Research and Development, 1945-2000*. DIANE Publishing, 2009.

[5] J. Mattis, "Summary of the 2018 National Defense Strategy," pp. 1–14, 2018.

[6] W. Roper, "There is No Spoon: _The New Digital Acquisition Reality," pp. 1–19, Oct. 2020.

[7] "Contents of the Historical Tables." Congressional Research Service, 2021.

[8] T. Harrison, "Chaos and Uncertainty: The FY2014 Defense Budget and Beyond," Oct. 2013.

[9] S. Thomke and E. von Hippel, "Customers as Innovators: A New Way to Create Value," *Harvard Business Review*, vol. 80, Apr. 2002.

[10] D. Roza, "How one airman fixed the Air Force's night vision problem with a 4-cent chunk of plastic," *Task & Purpose*, Nov. 17, 2021. https://taskandpurpose.com/news/air-force-security-forces-night-vision/ (accessed Jan. 10, 2022).

[11] S. Hebert, "Make training great again!," *Hill Air Force Base*, May 18, 2017. https://www.hill.af.mil/News/Article-Display/Article/1186076/make-training-great-again/ (accessed Jan. 07, 2022).

[12] N. Franke and C. Lüthje, "User Innovation," *Oxford Research Encyclopedia of Business and Management*, pp. 1–32, Jan. 2020, doi: 10.1093/acrefore/9780190224851.013.37.

[13] R. Goduscheit and J. Jørgensen, "User toolkits for innovation - A literature review," *Int. J. of Technology Management*, vol. 61, pp. 274–292, Jan. 2013, doi: 10.1504/IJTM.2013.052671.

[14] N. Franke, "User-driven Innovation," *The Oxford Handbook of Innovation Management*, Jan. 2014.

[15] M. Bogers, A. Afuah, and B. Bastian, “Users as Innovators: A Review, Critique, and Future Research Directions,” *Journal of Management*, vol. 36, no. 4, pp. 857–875, Jul. 2010, doi: 10.1177/0149206309353944.

[16] E. von Hippel, “The dominant role of users in the scientific instrument innovation process,” *Research Policy*, vol. 5, no. 3, pp. 212–239, Jul. 1976, doi: 10.1016/0048-7333(76)90028-7.

[17] E. von Hippel, *Democratizing Innovation*. Cambridge, MA, USA: MIT Press, 2005.

[18] H. W. Chesbrough, *Open Innovation: The New Imperative for Creating and Profiting from Technology*. Harvard Business Press, 2006.

[19] A. Smith, *An Inquiry into the Nature and Causes of the Wealth of Nations*. 1776.

[20] T. Burns and G. M. Stalker, *The management of innovation*. London: Tavistock Publications, 1961.

[21] S. Myers and D. G. Marquis, *Successful industrial innovations: a study of factors underlying innovation in selected firms*. Washington: National Science Foundation, 1969.

[22] R. Rothwell, “The Characteristics of Successful Innovators and Technically Progressive Firms,” *R&D Management*, vol. 7, pp. 191–206, May 2007, doi: 10.1111/j.1467-9310.1977.tb01334.x.

[23] G. Foxall and J. Tierney, “From CAP 1 to CAP 2: User-Initiated Innovation from the User’s Point of View,” *Management Decision*, vol. 22, no. 5, pp. 3–15, Jan. 1984, doi: 10.1108/eb001358.

[24] C. A. Voss, “The role of users in the development of applications software,” *Journal of Product Innovation Management*, vol. 2, no. 2, pp. 113–121, Jun. 1985, doi: 10.1016/0737-6782(85)90007-4.

[25] E. von Hippel, *The sources of innovation*. New York: Oxford University Press, 1988.

[26] C. Herstatt and E. von Hippel, “From experience: Developing new product concepts via the lead user method: A case study in a ‘low-tech’ field,” *Journal of Product Innovation Management*, vol. 9, no. 3, pp. 213–221, Sep. 1992, doi: 10.1016/0737-6782(92)90031-7.

[27] S. Slaughter, “Innovation and learning during implementation: a comparison of user and manufacturer innovations.,” *Research Policy*, vol. 22, no. 1, pp. 81–95, 1993.

[28] P. D. Morrison, J. H. Roberts, and E. von Hippel, “Determinants of User Innovation and Innovation Sharing in a Local Market,” *Management Science*, vol. 46, no. 12, pp. 1513–1527, Dec. 2000, doi: 10.1287/mnsc.46.12.1513.12076.

[29] S. Shah, “Sources and Patterns of Innovation in a Consumer Products Field: Innovations in Sporting Equipment,” p. 27, Mar. 2000.

[30] P. Oliveira and E. von Hippel, “Users as service innovators: The case of banking services,” *Research Policy*, vol. 40, no. 6, pp. 806–818, Jul. 2011, doi: 10.1016/j.respol.2011.03.009.

[31] S. Conway, “The role of the users in the innovation process,” in *Business School, Aston University*, 1993, pp. 1–23.

[32] W. Riggs and E. von Hippel, “The Impact of Scientific and Commercial Values on the Sources of Scientific Instrument Innovation,” *Research Policy*, pp. 459–469, 1994.

[33] E. von Hippel, J. P. J. de Jong, and S. Flowers, “Comparing Business and Household Sector Innovation in Consumer Products: Findings from a Representative Study in the United Kingdom,” *SSRN*, May 2012.

[34] E. von Hippel, S. Ogawa, and J. P. J. de Jong, “The Age of the Consumer-Innovator,” *MIT Sloan Manage. Rev*, vol. 53, Mar. 2013.

[35] N. Franke and E. von Hippel, “Satisfying heterogeneous user needs via innovation toolkits: the case of Apache security software,” *Research Policy*, vol. 32, no. 7, pp. 1199–1215, Jul. 2003, doi: 10.1016/S0048-7333(03)00049-0.

[36] C. Lüthje and C. Herstatt, “The Lead User Method: An Outline of Empirical Findings and Issues for Future Research,” 2004.

[37] E. von Hippel, “‘Sticky Information’ And the Locus of Problem Solving: Implications for Innovation,” *Management Science*, vol. 40, Feb. 1993.

[38] E. von Hippel, “Economics of Product Development by Users: The Impact of ‘Sticky’ Local Information,” *Management Science*, vol. 44, pp. 629–644, May 1998, doi: 10.1287/mnsc.44.5.629.

[39] M. Polanyi, *The Tacit Dimension*. 1983.

[40] N. Franke, H. Reisinger, and D. Hoppe, “Remaining within-cluster heterogeneity: A meta-analysis of the ‘dark side’ of clustering methods,” *Journal of Marketing Management*, vol. 25, pp. 273–293, Apr. 2009, doi: 10.1362/026725709X429755.

[41] M. C. Jensen and W. H. Meckling, “Theory of the Firm: Managerial Behavior, Agency Costs, and Capital Structure,” *Journal of Financial Economics*, vol. 76, pp. 323–339, Jan. 1976.

[42] P. McCabe, “A Chump at Oxford,” *The Princeton University Library Chronicle*, vol. 72, no. 1, pp. 251–264, 2010, doi: 10.25290/prinunivlibrchro.72.1.0251.

[43] T. Schweisfurth, “Comparing internal and external lead users as sources of innovation,” *Research Policy*, vol. 46, Nov. 2016.

[44] C. Lüthje, “Customers as co-inventors: An empirical analysis of the antecedents of customer-driven innovations in the field of medical equipment.,” Glasgow, 2003.

[45] J. Füller, “Refining Virtual Co-Creation from a Consumer Perspective,” *California Management Review*, vol. 52, pp. 98–122, Feb. 2010, doi: 10.1525/cmr.2010.52.2.98.

[46] J. Füller, H. Mühlbacher, K. Matzler, and G. Jawecki, “Consumer Empowerment Through Internet-Based Co-creation,” *Journal of Management Information Systems*, vol. 26, pp. 71–102, Oct. 2009, doi: 10.2753/MIS0742-1222260303.

[47] Y. M. Ooi, “Pulling strings: How users can shape innovation,” *University of Auckland Business Review*, vol. 18, pp. 48–57, Sep. 2015.

[48] G. Hertel, S. Niedner, and S. Herrmann, “Motivation of Software Developers in Open Source Projects: An Internet-Based Survey of Contributors to the Linux Kernel,” *Research Policy*, vol. 32, pp. 1159–1177, Mar. 2003, doi: 10.1016/S0048-7333(03)00047-7.

[49] K. Lakhani and R. Wolf, “Why Hackers Do What They Do: Understanding Motivation and Effort in Free/Open Source Software Projects,” *Perspectives on Free and Open Source Software*, Sep. 2003.

[50] S. S. McPherson, *Tim Berners-Lee: Inventor of the World Wide Web*. Minneapolis: Twenty-First Century Books, 2010. Accessed: Jan. 10, 2022. [Online]. Available: https://archive.org/details/timbernerslee0000mcph

[51] R. Cooper, “Winning at New Products: Accelerating the Process From Idea to Launch,” Jan. 2001.

[52] C. Crawford, “New Product Failure Rates — Facts and Fallacies,” *Research Management*, vol. 22, pp. 9–13, Sep. 1979, doi: 10.1080/00345334.1979.11756557.

[53] E. von Hippel, “Lead Users: A Source of Novel Product Concepts,” *Management Science*, vol. 32, pp. 791–805, Jul. 1986, doi: 10.1287/mnsc.32.7.791.

[54] C. Baldwin, C. Hienerth, and E. Hippel, “How User Innovations Become Commercial Products: A Theoretical Investigation and Case Study,” *Research Policy*, vol. 35, pp. 1291–1313, Nov. 2006, doi: 10.1016/j.respol.2006.04.012.

[55] J. H. Block, J. Henkel, T. G. Schweisfurth, and A. Stiegler, “Commercializing user innovations by vertical diversification: The user–manufacturer innovator,” *Research Policy*, vol. 45, no. 1, pp. 244–259, Feb. 2016, doi: 10.1016/j.respol.2015.09.007.

[56] S. Haefliger, P. Jaeger, and G. Krogh, “Under the radar: Industry entry by user entrepreneurs,” *Research Policy*, vol. 39, pp. 1198–1213, Nov. 2010, doi: 10.1016/j.respol.2010.07.001.

[57] S. Shah and M. Tripsas, “The Accidental Entrepreneur: The Emergent and Collective Process of User Entrepreneurship,” *Strategic Entrepreneurship Journal*, vol. 1, pp. 123–140, Nov. 2007, doi: 10.1002/sej.15.

[58] J. Füller, “Why Consumers Engage in Virtual New Product Developments Initiated by Producers,” *Advances in Consumer Research*, vol. 33, pp. 639–646, Jan. 2006.

[59] Y. Benkler, *The Wealth of Networks: How Social Production Transforms Markets and Freedom*, 9/23/07 edition. New Haven, Conn.: Yale University Press, 2007.

[60] N. Franke and M. Schreier, “Why Customers Value Self-Designed Products: The Importance of Process Effort and Enjoyment,” *Journal of Product Innovation Management*, vol. 27, pp. 1020–1031, Dec. 2010, doi: 10.1111/j.1540-5885.2010.00768.x.

[61] D. Harhoff, J. Henkel, and E. von Hippel, “Profiting from Voluntary Information Spillovers: How Users Benefit by Freely Revealing Their Innovations,” *Research Policy*, pp. 1753–1769, 2003.

[62] R. Prügl and M. Schreier, “Learning from Leading-Edge Customers at The Sims: Opening Up the Innovation Process Using Toolkits,” *R&D Management*, vol. 36, pp. 237–250, Jun. 2006, doi: 10.1111/j.1467-9310.2006.00433.x.

[63] G. Krogh and E. von Hippel, “Open Source Software and the ‘Private-Collective’ Innovation Model: Issues for Organization Science,” Mar. 2003.

[64] E. Raymond, *The Cathedral & the Bazaar: Musings on Linux and Open Source by an Accidental Revolutionary*. 1999.

[65] N. Franke, P. Keinz, and M. Schreier, “Complementing Mass Customization Toolkits with User Communities: How Peer Input Improves Customer Self-Design,” *Journal of Product Innovation Management*, vol. 25, pp. 546–559, Nov. 2008, doi: 10.1111/j.1540-5885.2008.00321.x.

[66] K. Lakhani and E. von Hippel, “How Open Source Software Works: ‘Free’ User-to-User Assistance?,” *Research Policy*, vol. 32, pp. 923–943, May 2000, doi: 10.1016/S0048-7333(02)00095-1.

[67] C. Terwiesch and Y. Xu, “Innovation Contests, Open Innovation, and Multiagent Problem Solving,” *Management Science*, vol. 54, pp. 1529–1543, Sep. 2008, doi: 10.1287/mnsc.1080.0884.

[68] P. Di Gangi, M. Wasko, and R. Hooker, “Getting Customers’ Ideas to Work for You: Learning from Dell how to Succeed with Online User Innovation Communities.,” *MIS Quarterly Executive*, vol. 9, pp. 213–228, Dec. 2010.

[69] N. Franke and F. Piller, “Key research issues in user interaction with user toolkits in a mass customisation system,” *International Journal of Technology Management*, vol. 26, p. 578−599, Jan. 2003.

[70] E. von Hippel and R. Katz, “Shifting Innovation to Users via Toolkits,” *Management Science*, vol. 48, no. 7, pp. 821–833, Jul. 2002, doi: 10.1287/mnsc.48.7.821.2817.

[71] S. Humphrey, M. Laass, B. Falk, D. Drobny, and R. Schmitt, “EMOTIO – Design of a Toolkit Enabling User Innovation,” *Procedia CIRP*, vol. 16, pp. 181–186, Jan. 2014, doi: 10.1016/j.procir.2014.02.005.

[72] L. Jeppesen, “User Toolkits for Innovation: Consumers Support Each Other,” *Journal of Product Innovation Management*, vol. 22, pp. 347–362, Jun. 2005, doi: 10.1111/j.0737-6782.2005.00131.x.

[73] N. Franke and F. Piller, “Value Creation by Toolkits for User Innovation and Design: The Case of the Watch Market,” *Journal of Product Innovation Management*, vol. 21, no. 6, pp. 401–415, Oct. 2004.

[74] M. Schreier, “The Value Increment of Mass-customized Products: An Empirical Assessment.,” *Journal of Consumer Behaviour*, vol. 5, pp. 317–327, Jul. 2006, doi: 10.1002/cb.183.

[75] G. Parmentier and R. Gandia, “Managing Sustainable Innovation with a User Community Toolkit: The Case of the Video Game Trackmania,” *Creativity and Innovation Management*, vol. 22, no. 2, pp. 195–208, 2013, doi: 10.1111/caim.12021.

[76] F. Steiner, C. Ihl, F. Piller, and R. T. Tarman, “Embedded Toolkits: Identifying Changing User Needs During Product Usage,” *Engineering Management Journal*, vol. 23, no. 4, pp. 3–13, Dec. 2011, doi: 10.1080/10429247.2011.11431915.

[77] M. Agrawal, T. V. Kumaresh, and G. A. Mercer, “The false promise of mass customization,” *The McKinsey Quarterly*, vol. 3, pp. 62–71, Jan. 2001.

[78] P. Zipkin, “The Limits of Mass Customization,” *MIT Sloan Management Review*, vol. 42, Mar. 2001.

[79] J. Teresko, “Mass customization or mass confusion,” *Industry Week*, vol. 243, pp. 45–48, Jan. 1994.

[80] N. Franke, M. Schreier, and U. Kaiser, “The ‘I Designed It Myself’ Effect in Mass Customization,” *Management Science*, vol. 56, pp. 125–140, Jan. 2010, doi: 10.2307/27784096.

[81] F. Piller, C. Ihl, and F. Steiner, “Embedded Toolkits for User Co-Design: A Technology Acceptance Study of Product Adaptability in the Usage Stage,” in *2010 43rd Hawaii International Conference on System Sciences*, Jan. 2010, pp. 1–10. doi: 10.1109/HICSS.2010.178.

[82] H. S. Naik, A. Fritzsche, and K. M. Moeslein, “Modularity in making: simplifying solution space for user innovation,” *R&D Management*, vol. 51, no. 1, pp. 57–72, 2021, doi: 10.1111/radm.12427.

[83] Y. Wang and D. Li, “Testing the moderating effects of toolkits and user communities in personalization: The case of social networking service,” *Decision Support Systems*, vol. 55, no. 1, pp. 31–42, Apr. 2013, doi: 10.1016/j.dss.2012.12.045.

[84] P. Keinz, C. Hienerth, and C. Lettl, “Designing the Organization for User Innovation,” *Journal of Organization Design*, vol. 1, no. 3, Art. no. 3, Dec. 2012, doi: 10.7146/jod.6346.

[85] International Council on Systems Engineering, “Systems Engineering Vision 2020,” *INCOSE-TP-2004-004-02*, Sep. 2007.

[86] S. H. Khandkar, “Open Coding,” *University of Calgary*, 2009, Accessed: Mar. 01, 2022. [Online]. Available: https://www.academia.edu/7430038/Open_Coding

[87] J. Morse, “The Significance of Saturation,” *Qualitative Health Research - QUAL HEALTH RES*, vol. 5, pp. 147–149, May 1995, doi: 10.1177/104973239500500201.

[88] R. Stake, *The art of Case Study Research*, vol. 80. 1995.

[89] C. Cho and S. Lee, “How Firms Can Get Ideas from Users for Sustainable Business Innovation,” *Sustainability*, vol. 7, no. 12, Art. no. 12, Dec. 2015, doi: 10.3390/su71215802.

[90] P. Di Gangi and M. Wasko, “Open Innovation Through Online Communities,” in *Journal of Knowledge Management and Organizational Learning*, vol. 4, 2009, pp. 199–213. doi: 10.1007/978-1-4419-0011-1_13.

[91] C.-L. Hung, J. Chou, and T.-P. Dong, “Innovations and communication through innovative users: An exploratory mechanism of social networking website,”

International Journal of Information Management - INT J INFORM MANAGE, vol. 31, pp. 317–326, Aug. 2011, doi: 10.1016/j.ijinfomgt.2010.12.003.

[92] A. Kankanhalli, H. (Jonathan) Ye, and H. H. Teo, "Comparing Potential and Actual Innovators: An Empirical Study of Mobile Data Services Innovation," *MIS Quarterly*, vol. 39, no. 3, pp. 667–682, 2015.

[93] D. Lindner, "Which effects are claimed with User-Toolkits for Innovation and Design?," in *Proceedings of Umea's 18th Student Conference in Computing Science*, Umea, Sweden, Jan. 2014, vol. 18, pp. 1–15.

[94] F. Piller and D. Walcher, "Toolkits for Idea Competitions: A Novel Method to Integrate Users in New Product Development," *R&D Management*, vol. 36, pp. 307–318, Jun. 2006, doi: 10.1111/j.1467-9310.2006.00432.x.

[95] D. Trabucchi, T. Buganza, C. Dell'Era, and E. Pellizzoni, "Exploring the inbound and outbound strategies enabled by user generated big data: Evidence from leading smartphone applications," *Creativity and Innovation Management*, vol. 27, no. 1, pp. 42–55, 2018, doi: 10.1111/caim.12241.

[96] H. Ye and A. Kankanhalli, "User Service Innovation on Mobile Phone Platforms: Investigating Impacts of Lead Userness, Toolkit Support, and Design Autonomy," *MIS Q.*, 2018, doi: 10.25300/MISQ/2018/12361.

[97] P. Arenius, T. Mäkitalo-Keinonen, and S. Liikala, "USER TOOLKITS FOR INNOVATION: LINK BETWEEN THE KNOWLEDGE OF THE FIRM AND THE KNOWLEDGE OF THE USER," in *Creative Futures Conference Proceedings*, Pori, Finland, Oct. 2007, pp. 205–216.

[98] N. Franke, P. Keinz, and C. J. Steger, "Testing the Value of Customization: When Do Customers Really Prefer Products Tailored to Their Preferences?," *Journal of Marketing*, vol. 73, no. 5, pp. 103–121, Sep. 2009, doi: 10.1509/jmkg.73.5.103.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 074-0188

PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From – To)*
24-03-2022	Master's Thesis	August 2020 – March 2022

TITLE AND SUBTITLE
DEVELOPMENT AND ASSESSMENT OF A MODEL BASED FRAMEWORK ON USER TOOLKIITS

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)

Koury, Brandon J, 1st Lieutenant, USAF

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAMES(S) AND ADDRESS(S)
Air Force Institute of Technology
Graduate School of Engineering and Management (AFIT/EN)
2950 Hobson Way, Building 640
WPAFB OH 45433-7765

8. PERFORMING ORGANIZATION REPORT NUMBER
AFIT-ENV-MS-22-M-219

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Air Force Research Lab, Airman Systems Directorate
Readiness Product Line Lead, Dr. Winston R. Bennett Jr.
2558 Fifth Street Building 852, Area B WPAFB, OH, Wright Patterson AFB, OH 45433-7905
937-938-2550, winston.bennett@us.af.mil

10. SPONSOR/MONITOR'S ACRONYM(S)
AFRL/RHW

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
DISTRUBTION STATEMENT A. APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED.

13. SUPPLEMENTARY NOTES
This material is declared a work of the U.S. Government and is not subject to copyright protection in the United States.

14. ABSTRACT
The Department of Defense (DoD) has a limited number of resources to accomplish a variety of missions which involve deploying personnel to support and maintain aircraft operating throughout the world. The DoD's maintenance structure codes maintainers to perform maintenance on specific airframes. This structure limits the flexibility of maintainers and leads to deploying resources in a reactionary manner to address capability gaps in deployed environments. The Just-In-Time Multi-Mission Airman (JIT MMA) concept aims to resolve these issues. Currently, the necessary technologies are unknown, but user toolkits are a concept to consider. A user toolkit is a concept that allows users to create, test, and share potential product designs within an experimental environment that is based on an existing production system. The DoD could explore using user toolkits to better utilize innovative maintainers within the maintenance community. However, current literature does not define the roles, tasks, and information flows that exist within a user toolkit environment. This research addresses the gap in literature by performing a model-based literature review to develop a model-framework on user toolkits. Additionally, this research applies the model-framework to The Griffin show how organizations can use the model-framework as an assessment tool for implementing user toolkits.

15. SUBJECT TERMS
User Toolkit, User Innovation, Just-In-Time Multi-Mission Airman, Model-Based Literature Review

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			Lt Col Amy Cox, AFIT/ENV
U	U	U	UU	121	19b. TELEPHONE NUMBER *(Include area code)* 937-255-3636, Amy.Cox@afit.edu

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. Z39-18