White paper

Innovation Think Tank Prototyping Framework with real time customer feedback during MVP creation and validation

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Innovation Think Tank Prototyping Framework with real time customer feedback during MVP creation and validation in healthcare domain

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Abstract

Objective and goals: Time to market is crucial for medical devices. 1) It is strongly dependent on customer insights during requirements generation, co-creation, and validation of the minimum viable product (MVP). 2) A limiting factor is access to various healthcare system global stakeholders and inadequate understanding of the entire product lifecycle. In order to resolve these challenges, a prototyping framework was developed at Innovation Think Tank (ITT) Labs at Siemens Healthineers.

Materials and methods: Over 300 project modules for various technology and product definition projects, their KPIs, success factors, and tools for implementation at various ITT locations were analyzed.

Results: The resulting ITT Prototyping framework (ITT PF) consists of an editable clinical environment, workflows, pain points, best practices, systems, components, and objects etc. with interfaces to stakeholders for real time feedback. The ITT PF also interfaces with physical and virtual prototyping platforms including tools such as Unity, Siemens NX, blender, SketchUp, Lumion, Visual studio, MATLAB, TensorFlow, etc. The framework implementation has resulted in business impact: 1) savings due to knowledge reuse and agile processes, 2) creation of additional revenue potential due to new offerings and shortening time to market, and 3) enabled products to reach product-market fit and provide structured approach to analyze and evaluate business opportunities, risks for realization and value generation potential.

Keywords: Prototyping, Minimum Viable Product, Innovation Think Tank, Healthcare

I. INTRODUCTION

With growing global healthcare demand, successful medical device development requires a strong understanding of customer needs and synergy among transdisciplinary (interdisciplinary and cross-functional) teams that understand the nature of the clinical application and the capabilities of the technology [1]. Prototyping is a powerful tool in modern product and process development. It enables the virtual and physical 3D representation of the product or process that can be tested in simulated real-world applications for evaluation, cost estimation, and customer validation, which contributes to the efficient development of better products [2].

Prototyping begins with requirements analysis, which elicits the need for the product. This includes interviews and surveys with customers and

stakeholders to determine the exact need for the product, also according to the market trends. Based on the requirements, various solutions are reviewed in detail and an initial 3D illustrations and simulation models for the solution product is created using CAD (Industry standard Computer-Aided Design tools e.g., NX PLM) and other technical tools (ROS, Unity, MATLAB, C++, C#, Python, Sensors, Robotics, AR/VR etc.). The initial prototype helps to optimize the solutions and discussed during co-creation sessions with various stakeholders to get inputs on application/need in concept change and check the feasibility of the proposed solution. This brings solution to more customer centric with constant review of all features. The final prototype is further tested and analyzed in a simulated environment to evaluate the functional application of the product. This is done using physical/ virtual simulation tools for technical feasibility along with AR /VR visualization of the real application for usability testing. 3D printing helps in the physical realization of the prototype and the use case can be tested on a scaled-down model [3]. Prototyping documentation and version control are maintained throughout the process to ensure better management of overall concept.

Current challenges in developing an effective prototype in the medical field include the lack of real-time validation by the customer during development, a virtual and physical platform to test new ideas, and the engagement of an inter-disciplinary team that understands both the clinical application and the capabilities of the technology [3].

Founded in 2005, ITT [4] is a global infrastructure with 72 activity sites (conducted/established co-creation programs and labs) at Siemens Healthineers (SHS) and several of its partner universities and hospitals, e.g. [5,6,7]. ITT supports the host organizations in product and portfolio definition with project content including business models, technology, disease pathways, competitor analysis, presentations and feedback, customer workflow analysis, pain points, stakeholders' requirements, decision propositions, and results presentations. The prototyping framework developed is accompanied by a globally distributed trans-disciplinary teams, who provide support from the acquisition of the brief through the development of physical or virtual proof of concept for use case visualization. Several commercially available tools support the creation of proof-of-concepts at ITT and have been used in innovation and R&D projects. Customer insights are brought to these projects through site visits, expert interviews, etc. Gaining this customer knowledge is firstly costly and secondly requires a high degree of trusting cooperation with the stakeholders to jointly develop forward-looking solutions.

II. MATERIALS AND METHODS

Over 300 project modules for various technology and product definition projects, their KPIs, challenges, success factors, and tools for implementation at 20 ITT locations were analyzed.

The core approach on all projects follows the ITT methodology of acquiring the mandate, big picture analysis, co-creation on decision proposal and deployment and commercialization [11]. The project modules consist of the following areas and were categorized [Table 1]:

- Portfolio analysis and state of the art research by conducting trends and technology scouting
- Pain points/Key Opinion Leader (KOL) & customer interviews from ITT global infrastructure engagements to understand stakeholders' challenges and task analysis
- Workflow & pathway analysis to understand the current inefficiencies and care path of stakeholders
- Co-ideation workshops with cross-disciplinary teams internally and externally for ideation and implementation methods
- Competitive analysis and business modelling to conduct business potential research including services, products, and competitors in the market
- Value proposition analysis to investigate potential use cases and develop a list of key-value proposition
- Product and portfolio definition for defining requirements for new and existing products and portfolios
- Minimum Viable Product (MVP) creation for visualizing the proposed solution via iterative customer feedback based rapid prototyping and virtual prototypes, software prototypes, and algorithm testing & validation interfaces

Project category	Modules and content	KPIs
Medical Systems and Components (Focus: Imaging, Diagnostics and Therapy)	Requirement engineering, pathways analysis, MVP creation, testing and validation, business model, customer insights and feedback, product definition, product roadmap, strategy workshops, technology development and validation	# Additional revenue potential due to new product offerings # Additional revenue due to shortened TTM # Inventions and patents # Ideas brought to implementation # Institutions engaged # Key Opinion Leaders engaged # Projects # Revenue potential due to new product offerings # Public funding applications # Savings and cost avoidance # Hospital workflows and customer needs analyzed #Time to market
Digitalization, automation, and operational efficiency (Focus: Hospitals / Healthcare Systems)	Requirement engineering, MVP creation, testing and validation, business model	
Strategy, open innovation, co-creation (Focus: SHS/ Hospitals / Healthcare Systems, Expertise development, Entrepreneurship)	Co-creation, competitive intelligence, business model design and validation, market intelligence	

Table 1. Categories of projects and conducted modules within the Innovation Think Tank Prototyping Framework (ITT PF). These categories are based on experiential learning of different healthcare projects at 20 global locations of ITT global infrastructure. The overall KPIs identified also have been listed in the table to showcase the key value addition to customers, stakeholders, and medical device manufacturers.

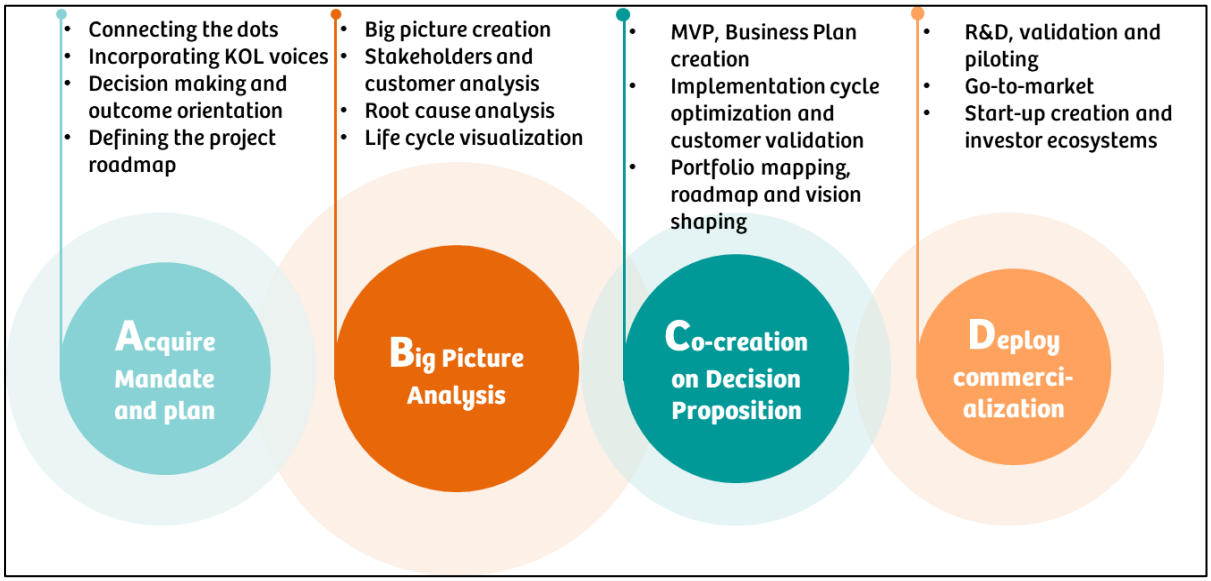

Figure 1. The Innovation Think Tank Methodology - enabling innovation across product life cycle with 4 steps. Acquire mandate as name signifies highlights the importance of defining the right project scope for maximizing impact. It comprises connecting the dots between various events, outcomes of the previous projects, key opinion leader voices, decision making and outcome orientation resulting in achieving project contacts that includes already a project roadmap defined by the team. Big picture creation highlights the importance of holistic view and includes observations of the customers environments and visualization of the lifecycle [Figure 3]. A decision proposition could be an MVP, a prototype or a business plan and results in portfolio mapping, roadmap and vision shaping and acquisition of further contracts. Deploying commercialization step could happen within R&D teams of the host organization or at a supplier or a start-up created out of the organization. The early engagement in investor ecosystem is provided with stakeholders:

III. RESULTS

An Innovation Think Tank Prototyping Framework (ITT PF) was developed by analyzing various past projects and 17+ years of customer interaction based experiential learning. ITT PF consists of various intrinsic elements from the global ITT infrastructure.

Real-time customer feedback plays an important and impeccable role in extracting key insights from various healthcare stakeholders. This helps in obtaining accurate key components/requirements for product definitions, product enhancements and need-based working mandate.

ITT PF has two working modules, one module at various ITT customer sites across the globe and another module at ITT site with trans-disciplinary teams. At ITT customer sites around the world, ITT teams extract key technology trends from the market, update their knowledge about clinical pathways and practices, identify pain points for product requirements, and validate new products at customer sites.

In ITT's global innovation labs and co-creation programs, trans-disciplinary teams translate the real-time customer feedback using a variety of ITT tools, which helps in the creation of minimum viable products and prototypes. These were further tested and validated in use case testing platforms.
When a new project request is received from business lines, the baseline project requirements are understood and discussed with the appropriate working groups to provide input, such as a Clinical, Robotics and automation, business model, Sensors, AR/VR, Digital twin, Industrial design & 3D printing, Quantum computing, AI/ML/DL Work Group for the clinical use case, workflow, and disease process. This helps define the requirements and ITT's global customer sites in hospitals and universities around the world help validate ideas and solutions with real-time feedback on technology trends, product requirements, pathways and provide validation for research. Based on the expertise required for the project, a trans-disciplinary team of members from different working groups is assembled for the project.

Prototyping templates and use case platforms are used to develop the project prototype with real-time feedback from customers and stakeholders. Project deliverables are curated and indexed for future use by the respective work groups. For example, if interviews are conducted in hospitals for the project, the results of the interviews will be stored in a clinical

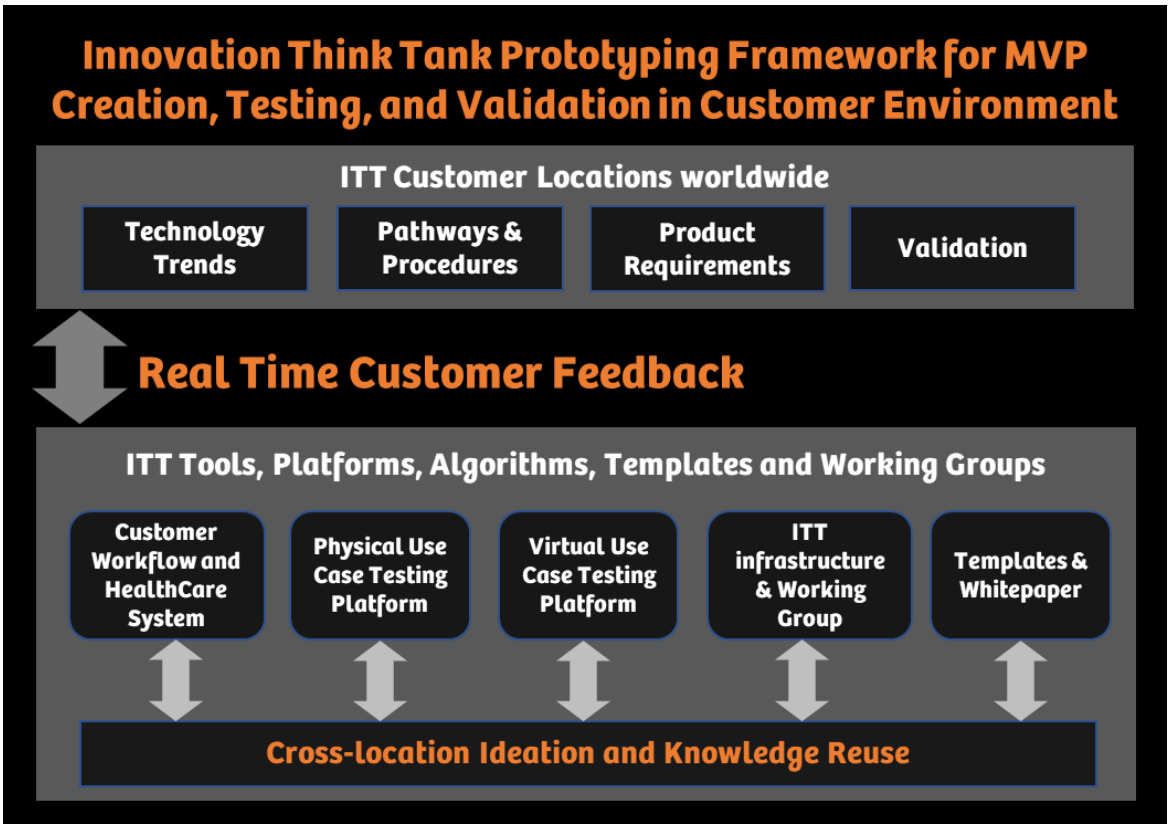

Figure 2. Innovation Think Tank Prototyping Framework for MVP creation, Testing, and Validation in customer environment which is empowered with Realtime customer feedback and ITT tools

Working Group database for future reuse for similar project topics. When a virtual use case platform is developed for a specific modality, the same platform is reused in the future with minor changes to adapt to the new use case, reducing project duration and increasing potential savings.

ITT prototyping framework modules have been applied throughout the product life cycle. After getting the real time customer insights, the trans-disciplinary team overlays the healthcare scenario into a customer healthcare model (Figure 3) showcasing the location, flow, interdependencies of the challenges, and different stakeholders associated which helps in realizing the requirement. Further several co-ideation sessions are conducted along with medical device manufacturers/ product managers, innovation managers, research, and development managers. These co-ideation to co-creation sessions with healthcare product managers powered with ITT real time customer feedback bridges the gap between the end customer and manufacturers.

These cycles of support continue throughout the whole product life cycle. To name a few modules of ITT PF throughout the product life cycle are: 1) Acquiring mandate 2) requirement generation 3) Ideation & conception 4) MVP creation & testing 5) Customer validation 6) Product specification 7) Training & education 8) User manual development.

In the first step of mandate acquisition, the previous projects developed by the framework build confidence among stakeholders and support for the acquisition of the project. During requirements development, the Framework draws on the global ITT infrastructure, i.e., the ITT labs at various health care facilities and trans-disciplinary Working Groups team members at various SHS sites, to help capture pain points and project requirements in the clinical setting. In addition, the global trans-disciplinary team brings ideas from a different perspective during ideation and conceptualization. During the MVP creation and testing, virtual prototyping Working Group has access to use case testing and virtual testing. This enables validation by customers/stakeholders in the early stages of development and reduces business unit R&D time. Based on the customer/stakeholder validation, the final product specification for the new product is developed using the use case testing platforms and visualization support from the working groups. In addition, the visualization module supports the creation of training and education materials in the form of simulation videos and documents, and in the development of user manuals. The Innovation Think Tank prototyping framework modules are interconnected to form a tight co-creation cycle where the product concept and its prototype is refined in each module with feedback from stakeholders and customers. It was observed from the example project, that the prototyping templates/modules used to develop solutions, combined with trans-disciplinary knowledge (medical, biomedical, medical procedures, mechatronics, electrical, data science, health management, innovation management, architecture, business management, economics) from ITT working groups from global locations, resulted in faster solution generation through co-creation sessions for ideation and brainstorming. Solution proof-of-concepts, implemented jointly with local ITT labs at various hospitals and medical universities, provided real-time customer feedback and validation. ITT's strength is based on diverse perspectives, backgrounds, and knowledge. The global and diverse team enables a better solution for innovation. The framework enables revenue potential through new product offerings, shortened time to market, increased savings potential, KOL engagements, public financing, inventions, patent applications, etc. The framework is derived from the ITT methodology and the global value proposition of the ITT innovation ecosystem and best practices [11].

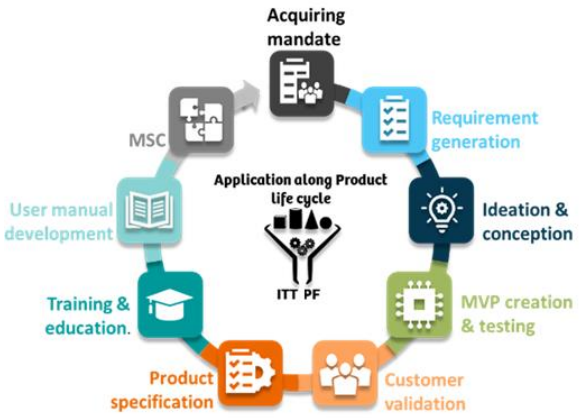

Figure 3. Applications of developed ITT prototyping framework along the product life cycle. The key driver throughout the product is real time customer feedback coming from ITT labs at customer sites and continuous hospital visits globally.

Figure 4. Customer workflow and healthcare system models: Healthcare customer models curated from customer insights in the real healthcare environment. These are the implementation examples into physical models for healthcare systems and departments at Innovation Think Tank Labs. These models play a foundational role in understanding the customer across ITT labs. These models provide a big picture in which we can visualize stakeholders and the interdependencies between them, hospital and departmental workflows, pain points, best practices, and potential solutions. Some of the models shown here are the precision medicine model, radiology infrastructure of the future, CT room, C-arm scenarios, laboratory diagnostics, MRI dependency model, etc.

Physical Use Case Testing Platform

These platforms are used to build and evaluate sensor integrated prototypes and other physical prototypes in a scaled simulated use case environment based on regular and on-demand customer engagements through global ITT functions. Thus, enabling real-time customer and stakeholder feedback on the application scenarios. Various types of projects that are validated such as collision avoidance, autonomy, capacitive patient table, evaluation of ambient conditions of Printed Circuit Board (PCB), new sensor testing, etc. They allow the ability to test various clinical scenarios that could be encountered by the product in the actual environment. Additionally, data tracking in real time can be ensured at an early stage. This allows the most accurate data to be acquired during the PLC, to make improvements as well as optimizations in an early stage. Furthermore, 3D printing for components and stakeholders, embedded sensors and robotic arms are extensively used and can be adapted to new changes. One of the examples of physical use case testing platform [Figure 5] is the radiography room which we developed to test technologies like collision avoidance with multiple depth cameras, digital twin use cases [13], 5G [14], and multiple sensors interacting with the simulated clinical environment [12].

Virtual Use Case Testing Platform

These platforms support product development in a virtual environment by using digital twins, animations, CAD models, AR / and VR, etc. of the components/systems and customers. To achieve customer-specific requirements for a virtual environment, suitable tools like Unity, ROS, NX PLM, SolidWorks, CATIA, etc. are used to simulate best use case development scenarios to test, improve, and validate new technologies.

Further Virtual prototyping portfolio element also includes the development of editable virtual environments such as 1) virtual hospitals with all the departments to visualize and understand the workflows 2) virtual manufacturing with all components and services to optimize and improve the workflows Also, these platform with augmented and virtual reality enables the overlay of new solutions on the existing product and virtual experience of the product use case validation.

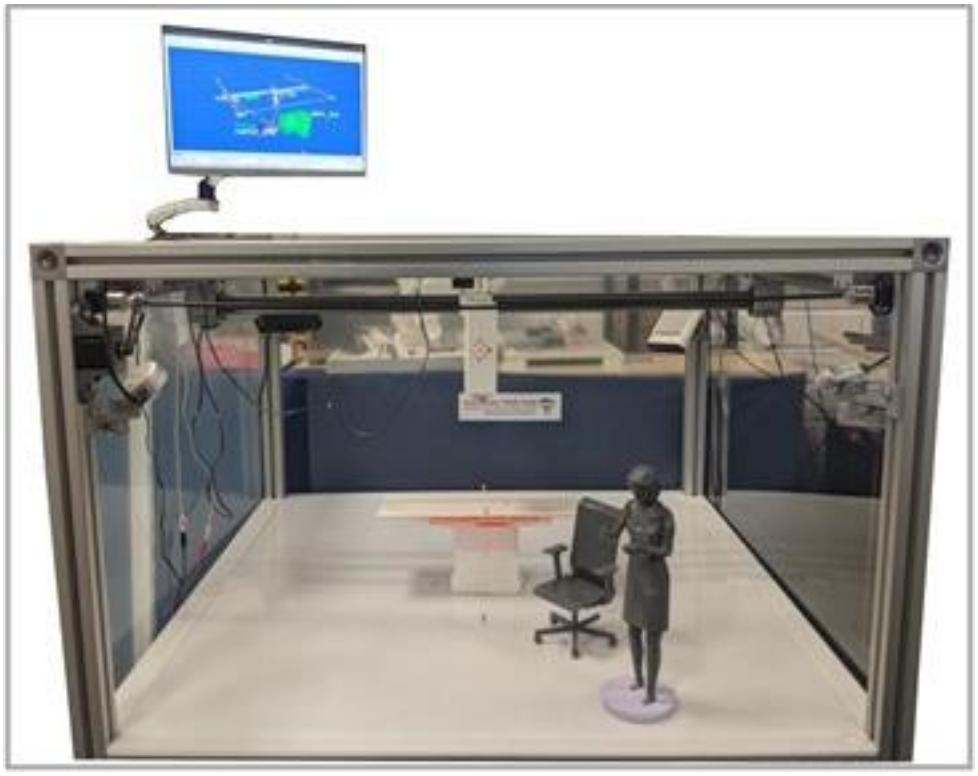

Figure 5. Innovation Think Tank Use Case Testing Platform (ITT-UCTP) of a Radiography room to test and validate technologies like collision avoidance with multiple depth cameras, digital twin use cases, and multiple sensors interacting with a simulated clinical environment

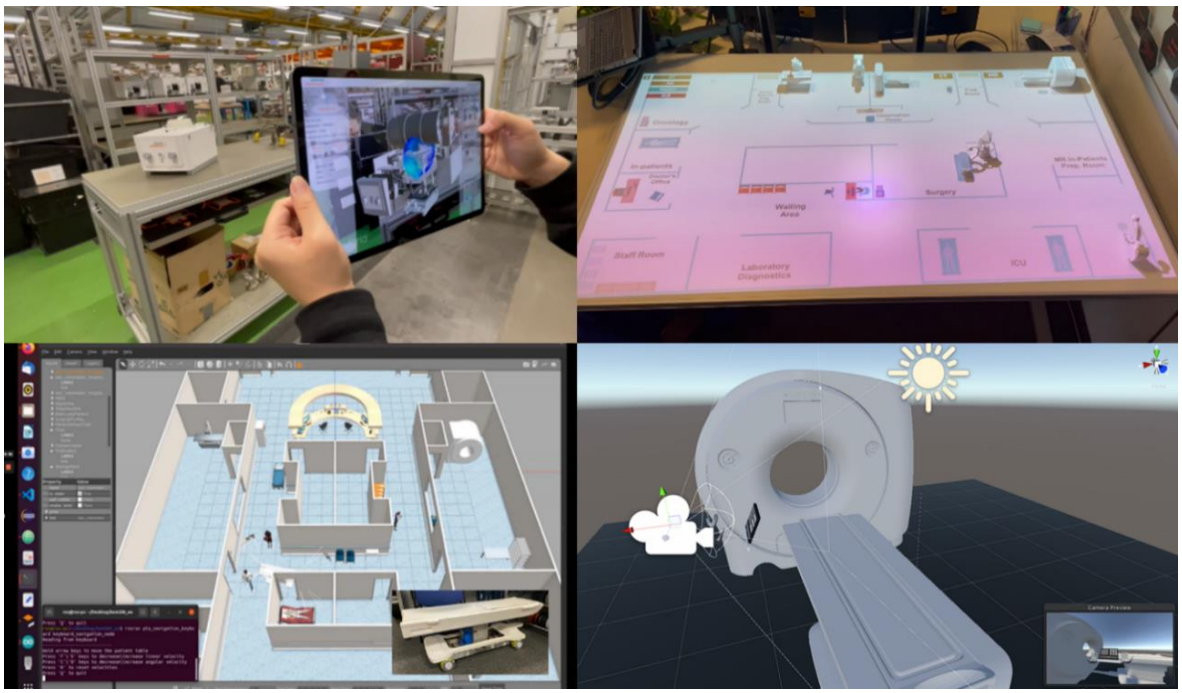

Figure 6. Virtual prototyping and virtual use case testing platform examples from various ITT lab locations. Virtual prototyping unlocks the advantages of the realization of a concept/ idea before getting into the solutions. Furthermore, ITT virtual use case testing platforms help in the testing and validation of technological solutions in virtual clinical scenarios. These ITT virtual use case testing platforms are flexible and have an editable environment that changes based on the real time customer feed coming from ITT customer sites and continuous hospital visits. Software prototyping in software engineering helps to visualize the final product before resources are invested in its creation. It will give customers a rough idea of the appearance and/or functioning of the Software and whether their app idea is worth the investment in development. Software prototypes also play a major role in making the final product as user-friendly as possible

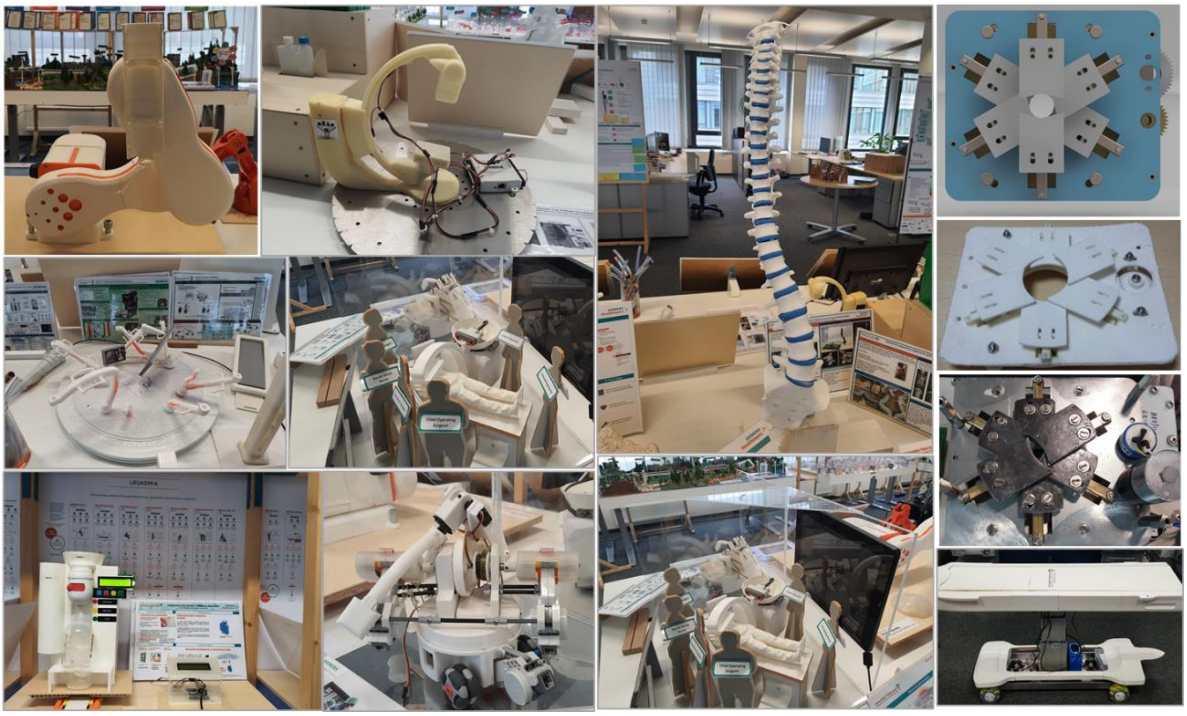

Figure 7. 3D/4D model of a conceptual idea for proof-of-concept and validation.

Figure 8. Virtual Hospital environment curated from real time customer insights which helps in visualize and understand the operational challenges and actual workflow realizations

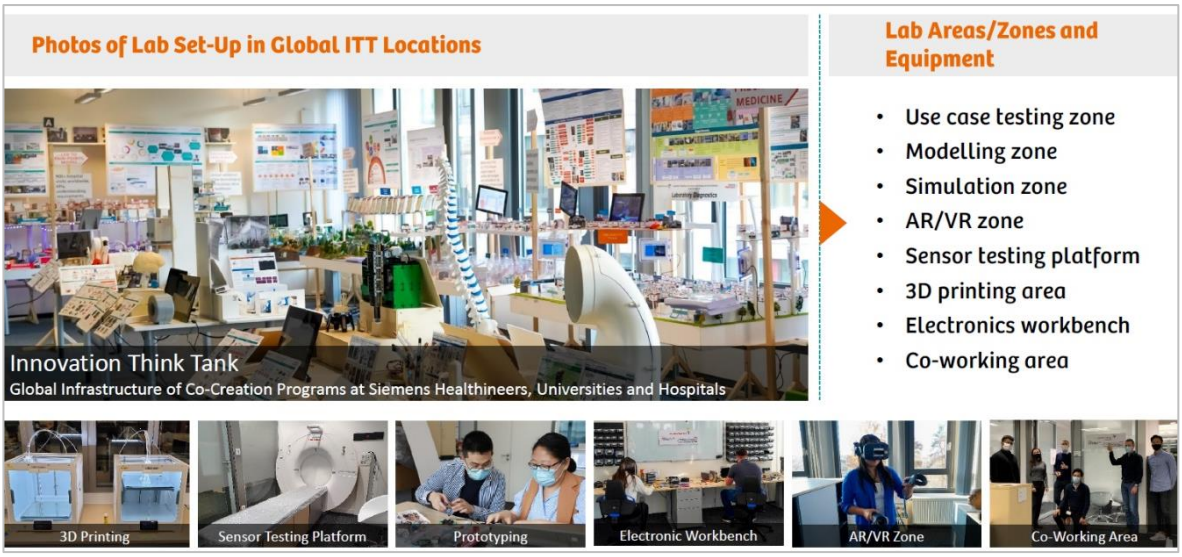

Figure 9. Impressions of Innovation Think Tank Labs

ITT infrastructure

The ITT infrastructure consists of various zones/areas and devices equipped with real-time customer feedback including more than 20 industry-standard 3D printers at Siemens Healthcare and at customer sites to incorporate customer insights into product definition. This enables ITT's transdisciplinary team to solve customer challenges and translate ideas into solutions with the best possible healthcare use cases in a timely and cost-effective manner.

The ITT Infrastructure consists of various customer connecting methods such as ITT quick connect corners, ITT incubation centers, and ITT labs with various zones and tools enabling real-time customer interaction and feedback on various prototyping topics. This enables ITT's transdisciplinary team to solve customer challenges and translate ideas into solutions with the best possible healthcare use cases in a timely and cost-effective manner.

ITT Working Group

Over the years, ITT has generated large know-how and experience from projects in close collaboration with customers, stakeholders, and partners through its labs and programs established at their sites.
This experience and data collected in various areas led to the formation of working groups where ITT cross-location teams at Siemens Healthineers with similar interests and backgrounds work together and support projects requiring their expertise and input. Working groups have curated data related to their field and indexed thus helping new projects in requirements definition and project roadmap creation. Another source of knowledge is ITT Alumni talks which connects the current program

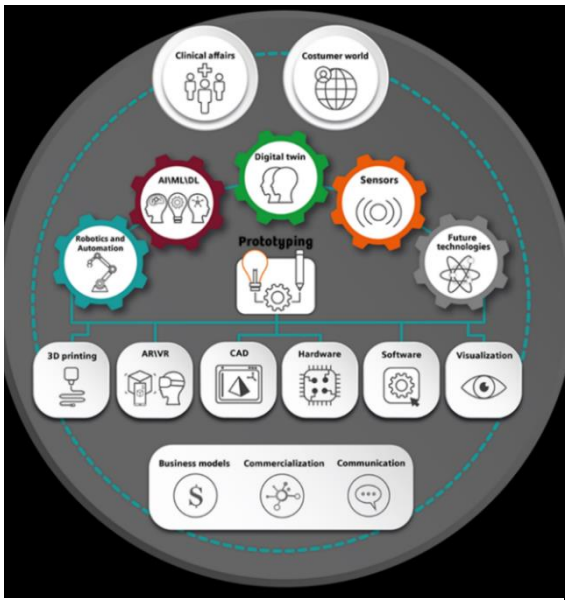

Figure 10. Innovation Think Tank Working Group clusters, which play a tangible and crucial role in leveraging customer insights and value during product prototyping and definition. It's connected to ITT customer locations worldwide and ITT global trans

participants with the previous ones and further enriches experiential learning.

Templates and Whitepapers

Various ITT templates are used to validate upcoming technology and healthcare trends, challenges, solution scenarios using survey questionaries which enable different stakeholder inputs. The inputs are taken from various ITT co-creation and certification events conducted at various partner healthcare institutions and universities where customer survey forms are created for each event based on the nature of participants. The survey outcomes are studied by

the global ITT teams and the results are published using whitepapers.

IV. DISCUSSION

Innovation is driven by breaking the obsolete patterns, by acting in new ways or by thinking differently. Sharing experiential learnings, collaborations, and stakeholder communication is the natural way to put across new innovative ideas. Manifestation (i.e., prototype) of feasible solutions by the understanding given ideas, concepts play a vital role in improving the proposed product by getting real-time feedback from customers before going to the actual realization of the product. Prototyping activities plays an important role in dedication towards learning about the customers and strategic implementation of the product to maintain the organizational momentum in the market. Furthermore

Prototyping has been widely used at ITT as an effective tool all over the product life cycle management. It helps in defining and development of the system at Siemens Healthineers. The transdisciplinary ITT methodology approach in prototyping framework helps in executive decision proposition during the product definition utilization the real-time customer insights coming from ITT global locations. ITT PF supports to identify requirements, conceptualize potential futuristic solutions, co-create, and validate with real time customer feedback. It has a modular environment that could be further extended. The ITT PF can be used to verify the importance of the respective topics with the involved stakeholders, convey the clinical context, and trigger joint co-creation activities.

The framework supports transforming the fragmented tools and skill landscape into an automated support system fostering reuse, streamlining the interfaces and engagement of teams along with the innovation lifecycle.

While it is important to enable innovative prototype, it is also crucial to keep stakeholder's feedback at the center of the prototyping process. Prolonged duration between stakeholder's experience for prototype and feedback collection not only can extend time to market but also may hinder future stakeholder engagements.

The global presence of the ITT program allows a direct interface to customers and other stakeholders which is now the key offering from ITT: Real time customer feedback with a holistic view and interdisciplinary competences across the product life cycle for medical device implementation and commercialization.

Through extensive investigation into the clinical and financial value propositions, as well as evaluation of the market demand and integration potentials into existing operational pathways, ITT PF allows for customer-validated conceptualization of completely new imaging systems, including potential shapes, footprint, application software features, & radiopharmaceutical handling requirements. Within this framework, customer workflow and healthcare system research, especially with regards to reimbursement and insurance coverage, are also addressed to quickly identify business potentials and market triggers.

V. CONCLUSION

ITT PF together with the ITT global infrastructure and real time customer insights, helps in understand product needs in the changing healthcare environment, develop solutions by collaborating with transdisciplinary global teams, and ensure validation by key stakeholders for various areas e.g., mechatronics and medical electronics components, medical devices, requirements generation and validation, workflow optimization, operational efficiency, business model development, commercialization, etc., to create a medical product or solution for healthcare providers.

Some of key success factor in Innovation Think Tank prototyping framework are 1) Real time customer feedback loop/mechanism 2) Trusted partnerships 3) Co-creation with customer and manufactures 4) ITT global trans-disciplinary team 5) Cultural diversity in ITT teams 6) ITT Fellowship and Certification Programs bringing new innovation ideas and fostering open innovation 7) Customer need based editable/ flexible virtual and physical use case testing platforms 8) Past project knowledge reuse 9) Continuous intellectual property fencing 10) Reporting business impact (Savings, cost avoidance and additional revenue potential generation due to new offerings)

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