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Магістерська робота

на тему:

Developing Smart Construction, a software and hardware solution for better management, control, and safety at the construction

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CONTEXT

1. EXECUTIVE SUMMARY

Starting any type of business is always risky and not predictable since there are so many factors founders can miss when creating a business plan. The last couple of years just proved this thesis multiple times with the COVID-19 pandemic, world crisis, multiple escalations of war conflicts, and many other things a small business can hardly impact.

But when someone starts a technological startup, that's even riskier and more unpredictable. On a one hand, there is so much capital in the field and investors are reviewing thousands of pitch decks trying to chase that unicorn. On the other hand, the competition is just incredibly aggressive and founders can send their pitch deck to investors a day after the competitor, and their competitors will get funding and a chance to implement their idea.

Nonetheless, thousands of entrepreneurs are still willing to make a try and build something valuable, profitable, and sometimes even industry-changing.

All the research, analysis, and strategy planning outlined in this project was majorly influenced by multiple courses of the MS in Technology Management program. This work was conducted to help minimize and neutralize potential risks and threats a startup could possibly face. The startup is called Smart Construction and it's dedicated to solving several problems of the construction industry by bringing technology and modern management approaches together.

The Emerging Technology module by Steven Russo has motivated an author to embed IoT technology into the product; Scott Sehlhorst, with the help of Competitive Matrix, taught how to analyze competitors and assign priorities to the features in the startup's roadmap. Marketing strategy and persona identification were introduced by Joe Pons and Ihor Didok, and a general overview of the startup's lifecycle from idea validation to the due diligence process and exit strategy was given at the New Technological Entrepreneurship module by Princeton graduates: Vsevolod Onyshkevych, Jack Henneman, Howard Nelson, and Joseph Studholme.

During the period of studying at LvBS, Smart Construction raised from just an idea to POC and MVP versions built, tested, and prepared for pitching to potential partners and investors.

The resulting document is organized as follows. **Chapter 2** provides market research, the actual problem statement the startup decided to focus on, competitor analysis, and the insights from the interviews with the domain experts, as well as the research conclusions drawn from these findings. **Chapter 3** gives a description of the solution, product architecture, and the methodology to use for product implementation. Despite the fact the solution has already been built, **Chapter 4** does the necessary job of explaining the choice of Smart Construction's business model, the possible channels the team is going to use to promote the product to the market, and technical roles, assigned to different team members in product development and business strategy departments. **Chapter 5** is about Strategy planning, roadmap, and timeline prognosis; it outlines the calculations of investments Smart Construction needs for the first round. **Chapter 6** summarizes all the completed research and offers a number of managerial conclusions by the author.

2. INTRODUCTION AND RESEARCH

2.1 The purpose of the project

This project is an attempt to create a viable and successful startup for the construction industry using the knowledge that was obtained during the Technology Management program at LvBS.

Background information:

Having several partners in the Israeli construction industry, the author of this thesis found out several important problems which could be solved with the help of technology. With direct access to potential Israeli customers and recognizing the lack of technology knowledge in local stakeholders, Israel was selected as the main geolocation for this project. The startup was called Smart Construction and at the time of thesis submission, the company is officially registered as LLC.

2.2 Market Research

Israel's construction industry is forecast to recover by 3.5% in 2021, after contracting by an estimated 8.9% in 2020. In 2022, the industry is projected to continue to improve, growing by 3.1%, and then expand by 2.9% over the remainder of the forecast period (2023-2025). Over this period, the industry's output is expected to be supported by the government's focus on the development of infrastructure, as well as energy and utilities construction projects. Improvements in consumer and investor confidence and positive developments in regional economic conditions will also provide momentum.

The industry's output value in real terms is expected to rise at a compound annual growth rate (CAGR) of 2.63% over the forecast period [1].

The construction industry in Israel still caters to traditional practices, and that makes the projects redundant and limits their capacity to accelerate. The construction industry's needs drive technology advancements, which include software for optimization of existing processes on the site, software for different aspects of project management, and development of productive and innovative methods of construction,

materials, and state-of-art equipment. Partnering with the Israel Builders Association, the Israeli Ministry of Construction and Housing, and the Ministry of Economy and Industry, developed an innovation zone for the construction industry called ConTech. Its goal is to facilitate business relationships between startups and well-established industry players in Israel and internationally.

The construction industry is also characterized by incredible worker shortage (because it's a known fact that working on the construction is dangerous) and workers overtime (because the planning often underestimates the scope of work.) ConTech's participants have been addressing all these and other pain points, though there are not enough startup products being adopted on a large scale — they will be discussed later in the "competition" section.

Opportunities

Currently, the infrastructure industry in Israel is underfunded in comparison to other countries with similar or the same level of technological development. The Israeli government plans to implement large-scale infrastructure projects among all industries in the country to close this gap, and releases Infrastructure for the Growth work plans annually — these are documents outlining a national strategy for infrastructure development that consolidate all projects related to the infrastructure with more than 100 million shekels (~$30 million) valuation, that are currently in work, budgeted, or have been approved by the government. In 2019, the corresponding work plan contained 207 projects with a $56 billion valuation that have been founded across different industries, and this number included few startups operating in the design and construction areas. Largely, projects have been operating under a public-private partnership model [2].

2.2.1 Problems of the industry

There are several main problems stakeholders and construction managers face at different stages of project development, starting from the planning of the project to the actual completion of construction. Below, we outlined some of the main ones:

1. Traditional non-technological management approach

Israel is known as a digital startup nation around the world but the construction industry is surprisingly far from being digitized. Top managers of construction companies mostly work using waterfall methodology which is slow and ineffective: the project has to follow the plan that has been established at the beginning of the development and the stress-testing and user-testing is planned at the very end, right before the release. The rigidness of the process and the bureaucracy involved in allowing right-at-the-moment interactions that could fix some of the problems occurring in project development also contributes to the slowness. On every second Israeli construction set, deadlines for each phase of project development are never passed over to lower management, which renders the planning meetings and the planning process ineffective, as the employees are not aware of the timeline and scope of work related to it. Instead of online tools managers still use flip charts and whiteboards, and the delay of each project usually is calculated not by days but by months. Apart from adding redundancies into the construction process, those delays are very expensive for the construction stakeholders.

2. Safety issues

Dozens of workers in Israel are killed on construction sites because of dangerous working conditions: the number of deaths is 2.5 times higher than in European Union (per 100.000 workers). The government doesn’t supervise the safety on the construction sites and doesn’t act to prevent occupational hazards, and the only inspection for the safety violations happens once in three years. At the same time, stakeholders of the construction sites often fear even those inspections, as they may result in fees and penalties, and while accidents on the construction sites are preventable, the infrastructure for the prevention process needs to be put in place at the

start of the project and it's often considered too costly to implement when the project is already running [3].

When prevention of the hazards is concerned, there are several factors for the construction enterprises to address. Experienced worker tend to overlook dangers because they underestimate the risk of being hurt, new workers — who often come on-board right in the middle of the construction process due to incredibly high workforce turnover in the industry — tend to not know where risk is, the constant pressure to keep with the deadlines makes people stressed and they make mistakes, and, finally, the lack of communication makes often results in managers and other workers even not knowing about the hazard or danger that has occurred. In Israel, the majority of the deaths is caused by falling from heights; fewer people are hit by falling objects or pressed under the falling cranes, or electrocuted. The solution that will enforce marking of the danger zones and remind people to wear a safety belt when they're using the elevator — as well as a solution that helps managers plan and communicate efficient safety training is clearly necessary.

3. Lack of technological knowledge among stakeholders and construction top management on how to automate, optimize and control the process with provided solutions on the market. Often, the personal incompetence of the construction manager who doesn't want to adopt new solutions just because they don't know how to use them also slows down the construction process. That being said, lack of technological knowledge prompts biases in the cost-benefit analysis and discourages stakeholders from even trying new products, which is a common issue for the majority of conservative industries. Besides, stakeholders' opinions are being influenced by the experiences of other construction companies all over the world, where digital transformation has occurred to be a burdensome and extremely expensive step that brought little to no results.

4. Communication problems due to the absence of means that allow reacting to delays quickly and address problems and potential dangers on the construction site. This partially stems from the waterfall methodology implemented when planning and working on construction projects, and partially — from an inflexible traditional

hierarchy that establishes such a way of delegating responsibilities that removes the contractor's top management from what's happening on the site.

Having a construction plan with real-time status in the smartphone with a well-thought, the comprehensive notification system is something managers are missing nowadays.

2.3 Problem Statement

As the market research shows, there are plenty of opportunities in the niche and multiple problems that need to be solved to boost the construction industry in Israel. The defined problem statement for this project is this:

Lack of real-time employee control and safety during the construction process.

The construction site changes rapidly on the various stages of execution. As a result, management of the project is complex and often inefficient with the addition of multiple safety issues that affect the timing and budget of the project negatively.

2.4 The Attractiveness of the Industry

The strength of competition and profitability before entering the market was determined by Porter's 5 forces model [4]:

Table 2.1

The Attractiveness of the Industry

	Now	After entering
Barriers to entry	Low	No change
Bargaining power of suppliers	High	No change
Bargaining power of buyers	Medium	Increase
Substitutes	Low	No change
Rivalry	Medium	Increase

Barriers to entry into the market are considered to be low since there are no major regulations or permissions needed in order to start operating in this industry —

which also means that more competitors might join the market fairly easily. After Smart Construction enters the market, the entry barrier to the market will remain low.

The bargaining power of suppliers for our specific product is high since there is a large demand for hardware components around the world so there is a big chance the prices will continue to grow. Smart Construction will have no major impact on the power of suppliers after entering the market.

The bargaining power of buyers is controversial. On one hand, there are not that many big construction companies in the Israeli market, and none of them want to fall behind their competitors in terms of digital development. On the other hand, companies are not ready to spend a lot of money on software licenses on a monthly basis so the bargaining process will be complicated.

The more competitors there are on the market, the more power buyers get to negotiate prices and terms of cooperation and choose between them, so by entering the market the startup gives more power to potential customers — stakeholders of the construction industry.

Multiple substitutes are possible for task management tools but most of them are not construction domain-focused, and real-time positioning systems can't be substituted in order to solve the problems the industry faces. The situation will not change after Smart Construction enters the market.

Rivalry is fairly low on the Israeli construction market at the moment, even though Smart Construction is far from the first player with a similar solution. Considering low barriers to entry, this situation can be easily changed in the near future. After Smart Construction enters the market, the rivalry will definitely increase and motivate each startup to move faster and add more features that could help differentiate from the others.

According to the 5 forces model, the conclusion is that it's a good time to enter the market until there is much more competition on the market, but it is important to implement a high-quality and easy-to-use solution to be prepared for the potential strong rivalry.

2.5 Competitor Analysis

There are multiple competitors in the construction market with different solutions somewhat similar to Smart Construction.

Competitors could be divided into three main categories:

1. RTLS (real-time location system) products
2. Management and control software for the construction industry
3. A combination of the first two where a system has both hardware and software solutions

Let's describe in detail each of the categories, common and must-have features, and most relevant competitors.

2.5.1 RTLS

Real-time locating systems (RTLS), also known as real-time tracking systems, are used to automatically identify and track the location of objects or people in real-time, usually within a building or other isolated area. Wireless and trackable RTLS tags are attached to objects or worn by people, and in most RTLS, fixed reference points receive wireless signals from tags to determine their location [5].

Real-time location systems (RTLS) are rapidly becoming an integrated part of everyday life. From the GPS tracking system in smartphones to the RFID tag in an employee badge, the world is making use of RTLS in big ways. It only makes sense that companies start using these Internet of Things (IoT) devices in construction to streamline their everyday operations.

Through the use of an IoT construction network, it's possible to track the movement of thousands of assets and people on a building site.

Currently, there are dozens of RTLS solutions around the world. Such solutions are usually created to cover multiple industries and fulfill different goals, but there are a few specifically focused on the construction industry:

Table 2.2

Competitive Analysis, RTLS

Feature	Pozyx	Jobtrackers	Sewio
RTLS	+	+	+
Easy to set-up	-	-	+
Real-time visualization	+	-	+
User Management	+	+	+
Safety Alarms	+	-	+
AI to analyze the historic data	-	+	+

All these competitors entered the market during the last 5 years and have experience with RTLS, its set-up, and maintenance. Even though all these companies are trying to add some kind of software for task management features, for now, they remain focused on positions of employees and assets. Sewio is the main competitor in this category since they have an easy-to-set-up system which is an important advantage among other startups though they mostly try to focus on indoor positioning and target different warehouses, and plants, and factories that have been already built and are now in operations than the construction sites.

2.5.2 Management software with construction domain focus

This category could be divided into two subcategories:

LPS (Last Planner ® Systems) and Task Management Systems

2.5.2.1 Last Planner Systems

The Last Planner System (LPS) is a collaborative planning process that involves trade foremen or design team leaders (the last planners) in the planning process more and more as the final deadline for a construction project comes closer.

LPS was developed by Glenn Ballard and Greg Howell who later founded the Lean Construction Institute at the behest of a number of constructors who had benefited from their use of LPS.

Last Planner is seen as a managerial approach on how to efficiently run a construction project. The guiding principle of the system is to ensure that each contractor and subcontractor on a construction site can manage their workload while holding them responsible for the work they promised to complete [6].

2.5.2.2 Task Management Systems

There are more classic task management systems developed with a construction domain focus. They have a much bigger feature set than LPS: it includes lots of visualizations, reports, and analytics, which makes the software more complex and sometimes inaccessible for construction managers who usually need just a few specific features.

Table 2.3

Competitive Analysis, Task Management Systems

Features	Planradar	Exigoconsult	Procore	Autodesk	Fieldwire
Task Management	+	+	+	+	+
Reports	+	+	+	+	-
Analytics and Forecasting	-	-	+	-	+
Real-time communication	-	-	-	-	+
Mobile App	+	-	+	-	+
Photo Documentation	+	+	-	-	-
Integration with other software products	-	-	+	-	+

All these and similar solutions are developed by late-stage businesses with multiple big clients, well-tested systems, and maintenance teams. It's a big advantage over Smart Construction, but the absence of RTLS and complex UX that is abundant with features construction managers don't need make the rivalry with startups that develop Task Management Systems more indirect than direct. The startup that releases the best product and, therefore, Smart Construction's main competitor among those selected above is Procore. It has a very strong analytical part of the system with well-developed predictive algorithms.

2.5.3 A combination of hardware (RTLS) and management software

Companies from this category are direct competitors to the Smart Construction company. Research showed that there are just a few startups with similar products and most of them are in the early stages of development, which helps to understand the direction they are moving in and what priorities are established on their roadmap.

Table 2.4

Competitive Analysis, RTLS + Management Systems

Features	Tracktio	Trusstor
RTLS	+	+
Easy to set up	-	-
Task Management	+	+
Smart Reports	+	+
Predictive Analytics	+	+
Safety Supervision	+	+
Construction Domain Focus	-	+
Integration with other software products	+	-
Customized Alerts	+	-

Tracktio is a working international business that was founded in 2016. The company is using the same technology as Smart Construction for position tracking, and RTLS solution is the core of their business. Later on, management software, smart reports, and predictive analytics were added though the quality of these products remains uncertain. The company does not have a construction domain focus and the system has a complex installation process. Tracktio is currently operating mostly in Europe and the US.

Trusstor is the main competitor at the moment. According to the investigation the startup has about a half-year advantage in development compared to Smart Construction and has already successfully raised funds for further development. Another similarity is that it is an Israeli company created for this market with plans to scale to other industries later on. The technology that is used by Trusstor is based on Bluetooth, needs continuous addition of hardware that needs to be set up along with the construction of new floors in the building, and the setup process itself is complex.

Below, in the Strategy Section of this thesis, there is a Competitive Matrix created based on this research.

2.6 Focus groups and results of the study

After the market and competitor analyses were completed, 23 interviews with domain leaders, top managers of different construction companies from Israel, the US, and Germany were conducted. Questionnaires were sent to the interviewees prior to the call (example in Annex A and B).

Some of the most important insights from the conducted interviews:

1. Construction stakeholders and managers are willing to adopt new technologies but there are few concerns that became a show-stopper for the implementation of them:

- The complicated setup process for suggested solutions. Most of the competitors need their representatives to install multiple devices all over the

construction site and continuously maintain their work. Once a new floor of the building is added, more devices should be installed on it to track the position of each employee. This is a very time-consuming and expensive process most of the domain leaders are not willing to start.

- The majority of solutions existing on the market do not have a construction focus and have a lot of functionality managers will never use. The UX is very complex and it would take a lot of time for them to adjust and get used to provided interfaces.
- Another big problem of some of the competitors' solutions is hundreds of tables, reports, and aggregated data provided to the managers with no explanation of how to apply them for managers. That is why it's very important to focus on the results of the analysis and forecasting based on those results and provide actionable insights for managers to utilize in their work.

2. Several interviewees mentioned that they don't think there is an urgency to adopt new technological solutions on the Israeli market, but on another hand, no one wants to fall behind their competitors who can become early adopters of any software or hardware products. This is a common sentiment expressed by stakeholders of traditional industries: stakeholders want incentives to adopt new solutions that will make the work simpler, more productive, and accessible.

3. Predictive analytics is something most of the interviewees are anticipating more than any other functionality. Most professionals in the field are vaguely aware of insights that could be harnessed from a thoroughly developed analytics engine, but there are few people who have demonstrated its utility for the construction industry. The fragmentation and decentralization of construction projects are one of the main reasons for it — while most data tracking systems are installable, it takes a habit and accessibility to adjust and customize them for each new project; the other reason is unusable UX design with the functionality managers don't require — a direct consequence of vendors developing generic software instead of focusing on a single vertical or niche. Apart from the actual construction process, there's a possibility to utilize data analytics in the pre-construction: when estimating budget and deadlines.

4. Most of the domain experts emphasized that they would like to have a mobile app with access to the system rather than a web solution.

5. The functionality of analyzing the performance of each subcontractor can be very useful for decision-making: stakeholders want to use it to make an informed, data-based judgment about which subcontractors to choose for collaboration in the future. While subcontractors would not be the main target audience of Smart Construction, a possibility to demonstrate one's own performance when presenting to the stakeholders of the construction company can become a selling point to leverage when incentivizing the subcontractors to try the product.

6. The ability to not just track each employee on the site but to identify them according to their name, position on the site, and specialization—the functionality that recognizes the occupation and position of each employee according to their job responsibilities— is a good advantage and unique feature among all the solutions interviewees have seen.

7. The stakeholders are not ready to pay a lot of money for software licenses until they actually experience the value of the solution which means the revenue model based exclusively on the license fee is not the best option for the sales cycle.

8. The majority of Israeli experts emphasized that the business in the country depends a lot on personal connections so it should be taken into consideration while planning the sales cycles.

2.7 Conclusions of the Research

Even in such a small country like Israel, the construction market is very large; the worldwide market, though, is just enormous. There are already multiple players trying to solve some of the industry problems but there is no unquestionable leader with the biggest market share. Also, just a few solutions that are able to solve all of the defined problems exist.

Just a few domain experts from the Israeli market shared information about any construction companies which are actively using some kind of RTLS solutions or

management software during focus group research. Still, most of the businesses remain very conservative and are far from being digitized.

The research shows that there is a definite positive dynamic that indicates an increase in the demand for such solutions and opens up plenty of opportunities for startups like Smart Construction.

Contractors operate within thin profit margins, and the fluidity of the costs of the solutions they might want to implement can have a large impact on their business, even within 1% increase (then, they lose money) or 1% reduction (then, they gain money) in the costs. Location data and the optimization capabilities the software that utilizes it provides can positively impact a company's bottom line. With Smart Construction, contractors could track how much time workers spend running an elevator or waiting in the queues. Then, they could reduce the number of elevators (if one is just not used by the workers) or rent another one (if people spend a lot of time waiting for it.) As the most anticipated feature, Smart Construction will need to make sure the UX of dashboards and actionable power of data analytics can be demonstrated without burdening the product’s most active users — managers of the construction.

Time-to-market, though, is very critical for the startup, so it is important to move fast and start the sales process once a few pilot projects are completed. Being agile is also essential: startup founders should be ready for a specific custom request from a construction company since the managerial process varies from site to site, city to city. That makes the creation of a lean, anti-fragile process of setting up the project very important: if Smart Construction is to be implemented on different projects with different teams, it needs to become site-agnostic and instantly scalable. The goal for the board is to compile common and most needed personalized requests from the client and implement them while keeping the focus on unique features of the Smart Construction solution. While the customization is vital, it’s also important to make sure users themselves can choose between additional features and turn off the features they don’t need. Moreover, custom requests should be taken into consideration only after a set of features that provide clients with an unfair advantage among their competitors are released and well tested.

One of the reasons construction companies would benefit from digital transformation, despite stakeholders not feeling the need to implement new solutions, is that there's a large blank space in communication between office workers — subcontractors and managers — and workers on the site, which makes the whole construction process extremely slow. There is a niche to be addressed here: the one that can close the gap in communication between workers on the construction site, their managers, subcontractors, and stakeholders of the construction company. The willingness to adopt a solution that will identify employees on-site signals about the willingness to address personal inefficiencies, but there's a certain blindspot — as signaled by the favor of predictive analytics solutions, — in how to manage worker team's collective performance and how to make it as productive and cost-effective as possible. Human error reductions are connected to this factor as well.

It's important to note, though, that under no circumstances the introduction of technology to the construction site would instantly improve workers' performances and prevent all adverse events. Any startup in any industry must work to help smoothen the adoption and usage of its products and system — otherwise, clients will see no delivered value.

Conclusively, there is definite potential in this market and the appearance of similar solutions just over the last couple of years confirms this fact. Starting with the Israeli direction also seems a correct strategy since American and European markets look more advanced and digitized at the moment.

3. SOLUTION

3.1 Product Description

Smart Construction is a technological startup created to solve the problem of control and safety in construction sites.

It is a real-time IoT solution for monitoring, control, management, efficiency, and safety.

Smart Construction enables the efficient and safe management of construction resources, humans and machinery, through the integration of our unique monitoring devices that are able to track geolocation indoor and outdoor in 3D, user-friendly web and mobile interfaces, and easy-to-understand actionable insights and notifications from the system. Our solution does not stoke up users with data, but rather provides workers and construction contractors, and managers with the specific, digestible, and applicable information to make correct, safe, and efficient decisions.

The product is based on three main concepts:

- Data collection
- Control
- Decision making

Data collection

Data collection is based on RTLS which uses LoRa® technology. LoRa is a 'Long Range' low power wireless standard intended for providing a cellular style low data rate communications network. Aimed at the M2M and IoT market, LoRa is ideal for providing intermittent low data rate connectivity over significant distances.

Apart from the RF elements of the LoRa wireless system, there are other elements of the network architecture, including the overall system architecture, backhaul, server, and application computers. The overall architecture is often referred to as LoRaWAN [7].

For position location, there are several gateways located on a construction site. The technology can cover indoor and outdoor activities. While entering the construction site daily, each employee will get a location tag that, depending on the

worker's role, has several kinds of devices in different forms and sizes built-in. Gateways receive a signal from devices and can track people and machines located at the construction site. Unlike the other devices on the market, Smart Construction tags are being monitored not only in 2D dimensions but also within heights. Applying this feature, the system can track, display, and analyze the exact 3D location of employees and machines. Such particular and precise 3D positioning enables many innovative features that dramatically increase the employees' safety and work efficiency.

The devices are generic and not personal, and after the workday is over, employees just need to drop the devices at the wireless charging box.

The accuracy of RTLS is still to be tested during the pilot project on a real construction site.

Decision making

The system contains web and mobile interfaces that visualize the collected data and provides managers with insights for better decision-making. For instance, the bad performance of one of the subcontractors might be a good reason for the substitution of them. Standing idle near one of the elevators alerts a manager to move it to another site for better productivity. Slowing down the task completion provides advice to possibly increase the number of workers, so the project's timeline remains the same. These are just a few examples of how the Smart Construction system can help make fast decisions that can help to make better decisions and reduce costs of mistakes and safety hazards by easily finding the root of them.

Control

Control is the code part under the hood that is responsible for the aggregation of collected data, real-time analytics, and predictive analytics.

Among the main features that are planned to be installed in the system are:

- Analytics
- ML
- Reports
- Alerts
- Forecasting algorithms

The control part provides construction managers with relevant data and provides background information for decision-making. That is why it is necessary to reach a good accuracy level of the RTLS system and visualize the data in a friendly and easy-to-understand manner through interfaces on the web- and mobile platforms.

Safety

Another important part of the system includes several safety features. Security Officers can mark a danger zone on the map of the construction site and notify every manager who needs to know this information. There is a functionality that allows users to add a photo of the zone and to mark it safe once the dangerous object or dangerous environmental effects are removed. That will not only warn off every worker who isn't specialized to deal with the hazard but also signal a confirmation of danger to experienced workers who tend to brush off precautions and underestimate the probability of being hurt. Adding cameras integrated into the system should give a possibility to track outsiders who shouldn’t be at the construction site and notify the security about unwanted presence. With Smart Construction, dealing with hazards on the site will become visible and the incidents will be presented in a system that can be systematically addressed rather than one-by-one “accidental” issues. That will make hazard prevention and risk assessment more accessible, which makes safety training much easier.

The idea of a final vision for Smart Construction’s startup is the system that introduces managers of the construction site to agile and data-based decision-making and provides significant cost reduction for stakeholders. As signified by the preliminary user’s interview, while the stakeholder’s hesitance to adopt new technological product stems from not feeling the urgency to digitize the company, they can be persuaded if a) product demonstrates the financial benefits for the company, b) the competitors start to adopt the same or similar product and report seeing the benefits for themselves. Smart Construction plans to cater to them by offering investors-backed tests of the system. Construction managers, though, would be able to a) better track what’s happening on the site and understand people’s flow and their performances as a whole, b) better manage resources that are needed to improve performance, c)

communicate both with workers and with stakeholders referencing data from the site itself. Again, if the research shows that stakeholders are not willing to adopt changes if they haven't seen the evidence change will bring improvements, it will be fair to assume subcontractors and managers are held under the same standard. Thus, Smart Construction's data analytics will simplify communication between managers and subcontractors, and stakeholders, as they will see the data, they need to make more beneficial decisions.

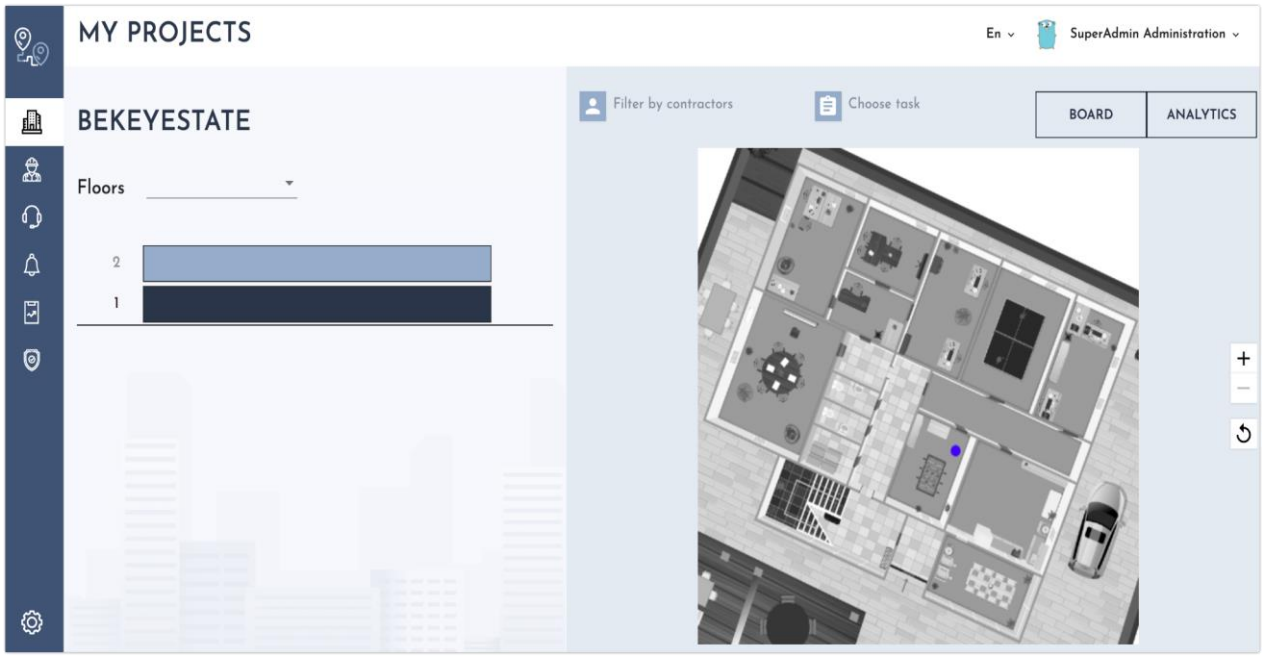
3.1.1 The current state of the project

At the time of thesis defense, the current state of the Smart Construction project is the following:

1. The MVP (Minimum Viable Product) version of the product is developed and released. It consists of several modules:

- RTLS system with up to 3-5 meters accuracy
- Task Management system which includes functionality such as:

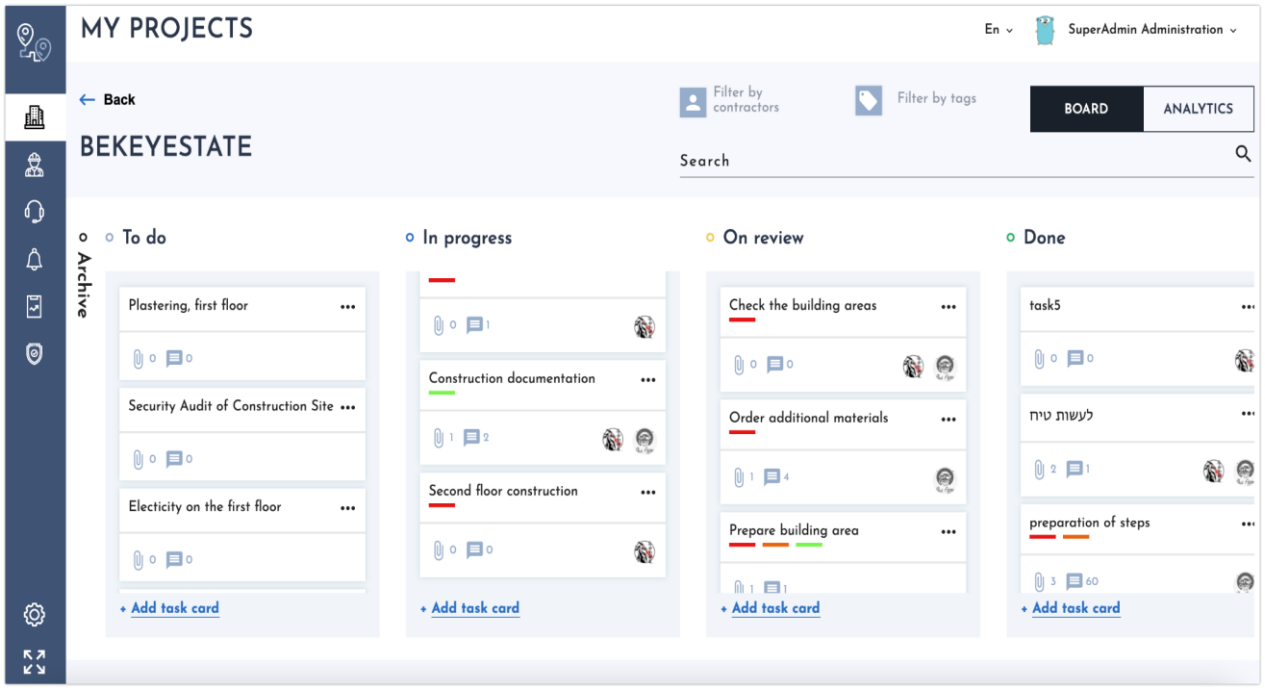
➢ List of projects with each a detailed view for each of them



Img. 3.1. Detailed View of the Project

➢ List of contractors

➢ Task Management Board



Img. 3.2. Task Management Board

- ➢ Basic notification center
- ➢ Statistics Summary
- ➢ Safety Dashboard
- ➢ Settings
- ➢ RBAC (role-based access control) developed for several different roles of management, including super admin, common admin, and subcontractor roles; the latter doesn't allow viewing other projects or subcontractors.

- Mobile app with safety features

2. Up to $100,000 was already spent on the project development
3. The team is ready with the pitch deck and the first meetings with investors are scheduled for June of 2021.
4. The team consists of 4 people working full-time and 5 people working part-time.

3.1.2 SWOT Analysis

Table 3.1

SWOT Analysis

Strengths	Weaknesses
● Software usability & functionality focused on construction business only ● Expert level of knowledge for construction domain ● Low-effort setup & easy-to-use	● Late to market with the product ● Lack of focus on the product internally ● Big dependency on the third-party hardware
Opportunities	**Threats**
● Low level of digital knowledge in the industry ● Ability to save a lot of money for businesses through using predictive analytics ● Huge market with fairly small competition	● The technology doesn't work good enough on a big construction ● Mass production of hardware components takes much more money than expected ● Inability to raise funds

3.1.3 Unique proposition

Startup founders believe that Smart Construction isn't just a set of features. It's a solution that helps the managers simplify the management process and shift some of the responsibilities connected to making difficult decisions to the data and algorithms the product provides.

Smart Construction will provide control over the whole construction process from any location on the planet just by opening a smartphone app, and such a unique proposition should bring lots of value to each target audience group.

The main unique proposition points are:

- Effective management of all resources and assets involved in the construction process that is supported by a real-time location tracker
- Analytics, task manager, roadmaps, burn-down charts, — all in a single UI-friendly product
- High level of safety

Smart Construction expertly highlights every pain point construction managers and stakeholders face and suggests smart solutions to them. With the system evolving, more unique value propositions will be added.

3.1.4 Unfair advantage

Having unfair advantages is crucial in winning the race for the market. Hardly any startup can succeed without any advantages at all. At the moment, Smart Construction is focusing on three main unfair competitive advantages:

1. Software usability & functionality focused on construction business only

The development team has already redesigned and reorganized some parts of the system according to the feedback of the domain experts, the behavior map of how the system is used, and competitor analysis. What is more important, the team is ready to make as many rounds of changes as needed in order to develop UI/UX that is as convenient as possible.

2. Expert level of knowledge for the construction domain

Even though two systems can solve similar problems, if the systems were built for two different industries - they are absolutely different in terms of interface, workflow, and usability and are not interchangeable. Constant consultation with domain experts and having one of the domain leaders on the board of the startup provides one of the most important competitive advantages.

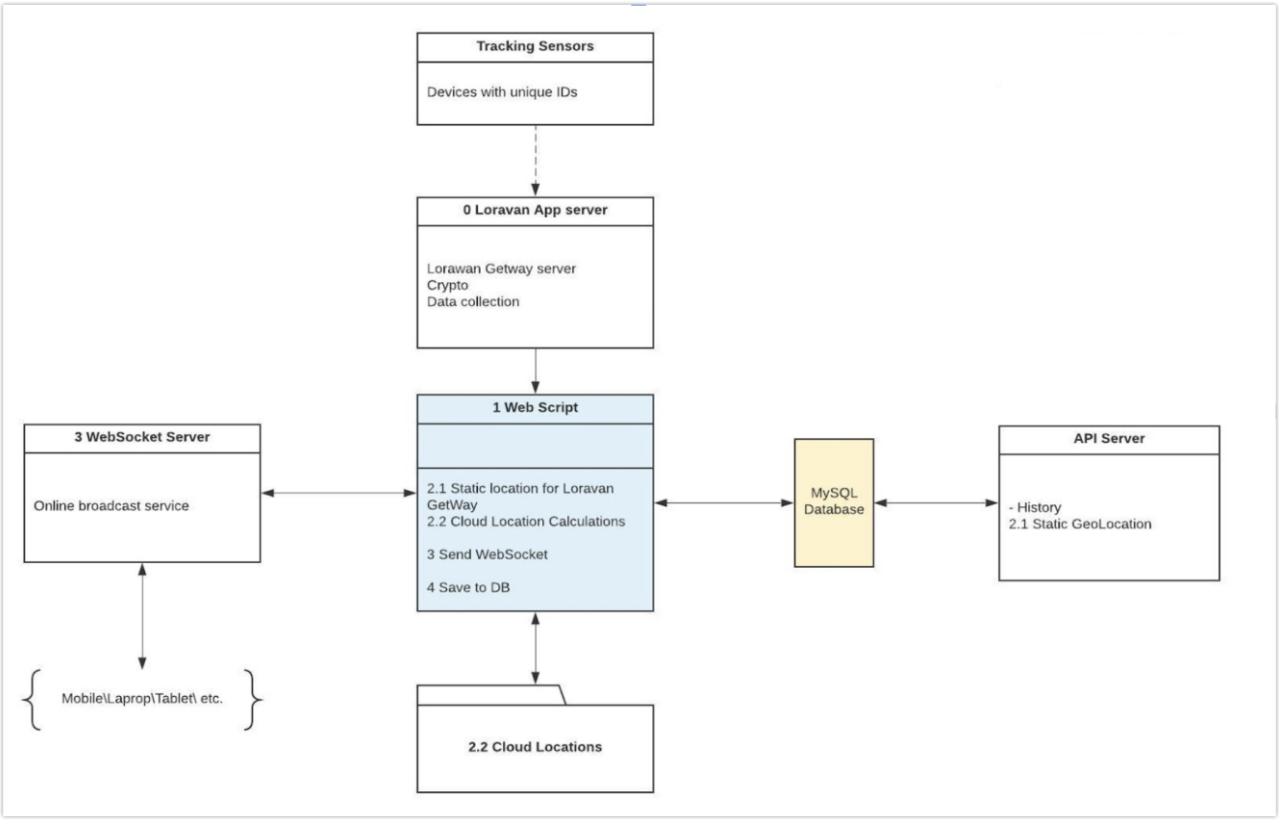
3. Low-effort setup & easy-to-use interface

This unfair advantage is the most important one since the long setup of the system on a construction site is one of the main barriers to adopting new technological solutions in the industry. Solving this problem and providing a low-effort setup along

with an easy-to-use interface will give Smart Construction the most valuable unfair advantage on the market.

3.2 Product Architecture

3.2.1 UML System Structure:



Img. 3.3. UML System Structure

3.2.2 Technology stack

Backend: PHP framework Laravel, RabbitMQ for queues management

Database: MySQL

IoT: LoRa

Frontend: Angular, Material design

Mobile: Flutter

Task management: Jira

Repository: Bitbucket

Hosting: Cloud (Amazon)

Containerization: Docker, orchestration by Kubernetes (AWS EKS)

CI/CD: Jenkins

Design: Figma

3.2.3 Security Requirements

1. The system must run over the HTTPS – TLS 1.2 protocol.
2. The system must follow OWASP Top 10 guidelines throughout the whole development process.
3. Private cloud is set up in AWS (or similar).
4. Three-tier architecture. It is a well-established software application architecture that organizes applications into three logical and physical computing tiers: the presentation tier, or user interface; the application tier, where data is processed; and the data tier, where the data associated with the application is stored and managed.

The chief benefit of the three-tier architecture is that because each tier runs on its own infrastructure, each tier can be developed simultaneously by a separate development team, and can be updated or scaled as needed without impacting the other tiers [8].

3.2.4 Methodology of Development Process

The team follows Agile methodology for Smart Construction product development and deployment [9].

The process is iterative. Each iteration (sprint) is usually 3-4 weeks long. The main benefit of such an approach is that the team has short specifications to follow while working on a specific part of the system that is covered by one sprint which makes development more focused and fast.

This methodology minimizes the risks and provides maximum product management flexibility.

Basic sprint structure:

Phase 0 – Specing, planning, and estimation (this part is usually prepared by the product and project managers during the previous sprint)

Phase 1 – Development (DEV Team) and Test Cases writing (QA Team)

Phase 2 – Development (DEV Team) and Testing (QA Team)

Phase 3 – Testing and bug fixing

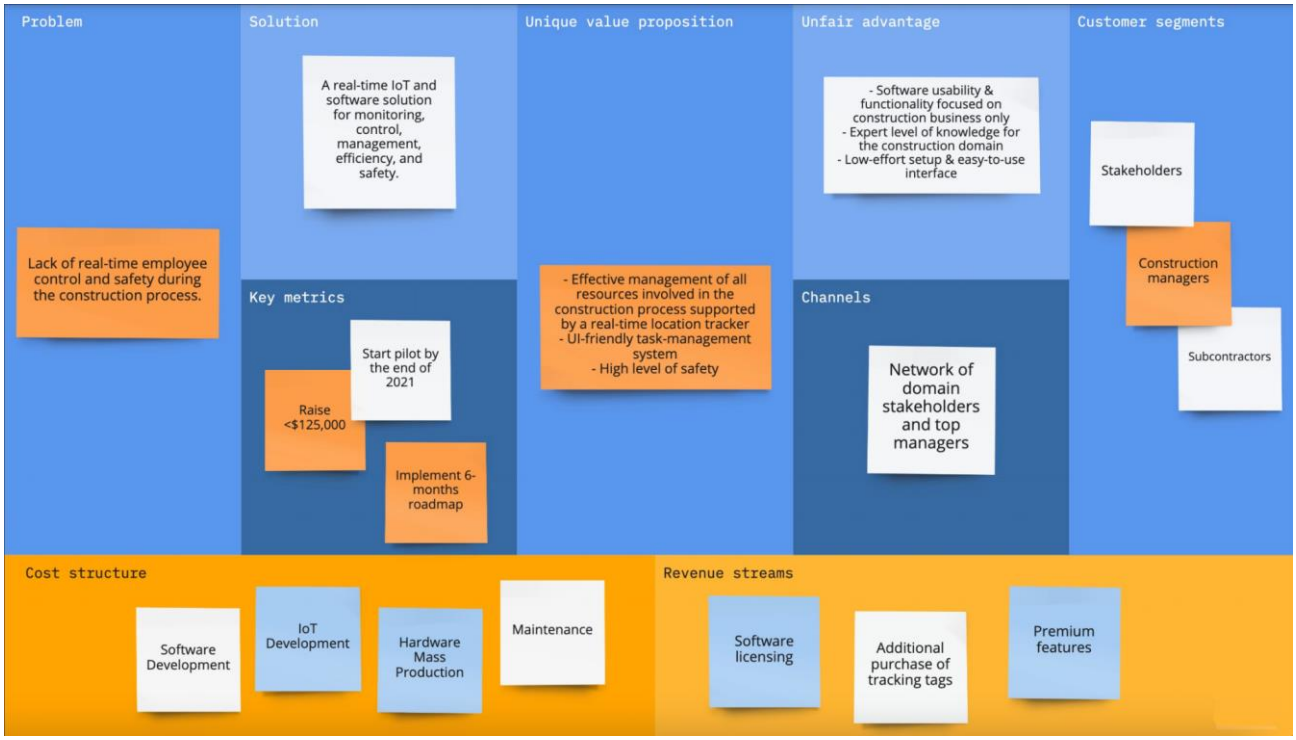
Phase 4 – Fine-tuning, automation, release, and reporting.

Agile methodology helps to make immediate adjustments to any changes on the market, clients' requests and helps investors understand the progress of the development with monthly demos.

4. BUSINESS MODEL

4.1 Lean Canvas

In order to explain the business model and summarize sections from above, it's appropriate to use a Business Model Canvas (BMC) by Alexander Osterwalder. For startups specifically, a customized version of BMC - Lean Canvas by Ash Maurya – exists [10]. It's a one-page business plan template that helps to deconstruct the idea of the business into its key assumptions about the problem it solves, solutions it uses to solve the problem, key metrics that are used to validate the success or failure, channels of promotions, and so on. It replaces elaborate business plans with a single-page business model.



Img. 4.1. Smart Construction Lean Canvas

Lean Canvas gives a great possibility to aggregate all main business model aspects and provides a short description of how the system works, what processes are there and who is the main customer. Lean Canvas model explains what this business is built on and what key metrics of success need to be reached in order to consider Smart Construction as a successful startup in an understandable way that is easy to get at the first glance. Each section of this thesis provides a more detailed description of each

concept, outlined in the canvas, and explains why some of the managerial decisions were made.

4.2 Revenue Model

The revenue model is complex and might be changed at the later stages of the startup's lifecycle. The interviews with domain experts showed that even large construction companies are not willing to pay a lot of money for the software license on a monthly basis. This might change once top managers understand the actual value and cost reduction thanks to the benefits provided by the system.

4.2.1 Razor Blade Business model

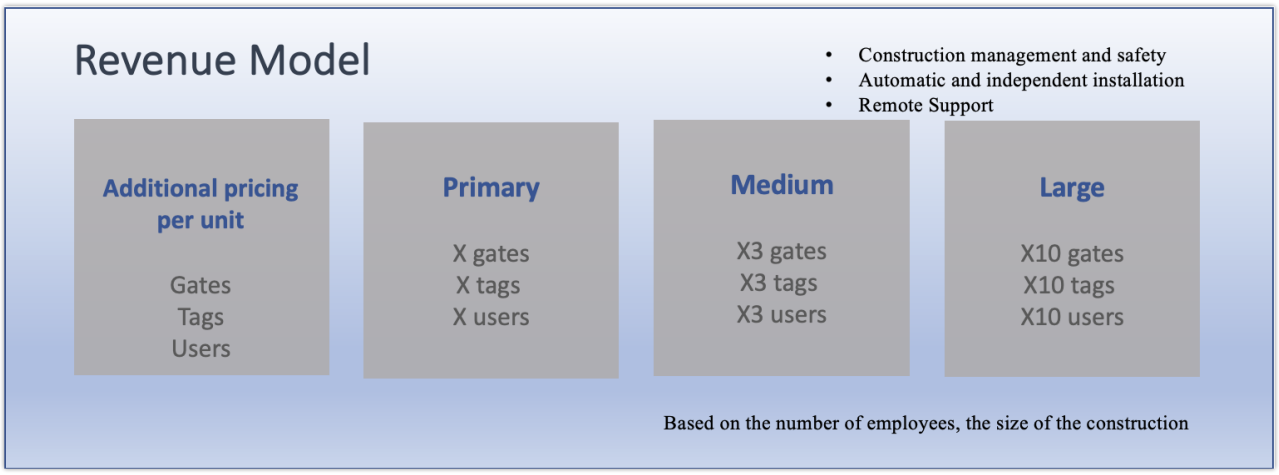
The model is close to the classic Razor Blade business model. The razor-razorblade model involves selling a product at a low price, maybe even at a loss, to sell a related product later for a profit. The model owes its name to King Gillette, founder of the namesake company, Gillette. The story goes that Gillette's idea for creating disposable razors stemmed from his personal experience with a straight razor that would become so worn, it was rendered useless [11].

Gillette reasoned that if he could offer consumers a sturdy, permanent razor supplemented by cheap, easily replaceable blades, he could corner the facial hair grooming market and create a massive base with repeat customers. Although some consider him an adoptive father of the model, he was the entrepreneur who developed the idea of selling the razors themselves cheap while capitalizing on the repeat business of replaceable blades.

Such an approach seems to fit well for the Smart Construction solution considering the specifics of the market and customer persona.

Each client will get a standard package according to the size of the construction site. The package will include a number of gateways, a number of location tags, and access to the management web and mobile software.

The package would cost just about 30% higher than the cost to manufacture it, but the additional purchase of the tags would be calculated at a different price.



Img. 4.2. Revenue Model

There are several sources of revenue:

1. Software licensing
2. Additional purchase of tracking tags
3. Premium features

1. Software license

Depending on the size of construction the license fee might vary from $1500 to $4500 per month.

2. Additional purchase of trackers

A calculated guesstimate is that the amortization for purchase trackers is 100% annually or 8.33% monthly.

Since the company sells packages, and the minimal package will be 50 items, we assume that at least every 3-4 months clients will require more tracking tags to provide enough devices to each employee.

3. Premium features

Premium features will include all the AI forecasting and data analytics results. The rest of the features, including Last Planner, charts, alerts, and safety features will be a part of the standard package covered by the license fee. The question of whether or not to divide premium features into several packages (depending, for instance, on the size of the enterprise and the number of active users) remains and will be considered when the next portion of customers' interviews arrive.

The time period of 4 months was taken to model a potential revenue budget with 3 clients of different sizes. Premium features were not included since it's difficult to simulate the potential cost of their implementation and potential revenue that can stem from them. Estimates will be calculated after the first portion of data is collected on the first pilot.

			Client 1 (100 employees)			Client 2 (300 employees)			Client 3 (500 employees)					
#	Month	Unit	Price per unit	Amount	Total price:	Price per unit	Amount	Total price:	Price per unit	Amount	Total price:	Revenue	Cost to manufacture	Profit
1	May	Gates	$1 000,00	4,00	$4 000,00	$1 000,00	6,00	$6 000,00	$1 000,00	8,00	$8 000,00	$22 500,00	$7 425,00	$15 075,00
		Location tracker	$5,00	100,00	$500,00	$5,00	300,00	$1 500,00	$5,00	500,00	$2 500,00			
2	June	Additional purchase of trackers	15	0	$0,00	15	0	$0,00	15	0	$0,00	$0,00	$0,00	$0,00
		License	0		$1 500,00	0		$3 000,00	0		$4 500,00	$9 000,00	0	$9 000,00
3	July	Additional purchase of trackers	15	50	$750,00	15	50	$750,00	15	50	$750,00	$2 250,00	$346,50	$1 903,50
		License	0		$1 500,00	0		$3 000,00	0		$4 500,00	$9 000,00	0	$9 000,00
4	August	Additional purchase of trackers	15	50	$750,00	15	150	$2 250,00	15	200	$3 000,00	$6 000,00	$660,00	$5 340,00
		License	0		$1 500,00	0		$3 000,00	0		$4 500,00	$9 000,00	0	$9 000,00
TOTAL												$57 750,00	$8 431,50	$49 318,50

Img. 4.3. Estimated budget

Signing approximately 10+ clients should make the startup's balance positive with no additional investments to operate needed.

For the first sales phase, Razor Blade's revenue model should help to involve more customers to try out the system. If the solution proves itself to be productive and easy to use, customers will definitely request more tracking tags and even agree to a different price.

4.3 Marketing Strategy

The Smart Construction project is a pure B2B company, and the marketing strategy is straightforward and doesn't consist of different creative ads campaigns or offline activities: the initial plan is to use networking and referrals to build up the base of the first adopters.

Israel business in any industry, either it's high-tech or low-tech, is based on connections and the first clients for startups mostly come through referrals. Focus groups proved this thesis. Often, even startups with a great value proposition or unique features fail to establish first partnerships if there is no one who can recommend their product for the board or provide them with the reference.

Taking into consideration this point, there is a very small possibility to get to work with any construction company, if there is no connection to people on the executive board or stakeholder of that business. So, launching a traditional marketing campaign, calculating CPAs, or setting up various google analytics metrics will most likely occur to be insufficient.

For the later-stage marketing, there is an opportunity to collaborate with digital transformation consultants and risk managers who construction stakeholders invite when inefficiencies start visibly affecting the bottom line: if Smart Construction proves to be a resilient and flexible tool for safety and better management on-site, it would be viable to market it as such and collaborate with people who can later recommend the product to site's stakeholders as the part of more global digital transformation efforts. At this stage of the project development, initiating cooperation with established consultants supposedly won't be fruitful, as there is no evidence of the product cutting costs and delays, increasing productivity, and preventing hazards — and therefore no incentives for them to risk their reputation.

However, all of it doesn't mean that it's not necessary to research different customer personas and test and strategize ways to communicate with people presented within the startup's audience.

4.3.1 Persona Identification

There are three main target audiences for the Smart Construction product and each one of them has a slightly different customer persona. The three target audiences are:

- Stakeholders of the construction companies.

Stakeholders would be the people who make the final decision and approve the adoption of the system. UX of the system, easy-to-use functionality, fast set-up of RTLS won't interest stakeholders because they will not be active users of Smart Construction. However, they'll be interested in cost reduction and optimization that can be demonstrated via extensive usage of the product, predictive analytics capabilities, and the decrease of hazards that happen on the construction. That stems

from their most common pain point: money and hesitance to invest it in the new technology. They are hesitant to adopt any technological solution, because, a) there are not a lot of successful use cases around, b) it's mostly a black box investment until proven otherwise, c) they don't see the urgency to do so — to invest their money in the venture with an unknown value for the enterprise. The fragmented nature of the construction industry makes even thinking about digitization harder, and, despite the fact stakeholders are not dealing with the consequences of the fragmentation, that factor contributes a lot to their doubt. On the other hand, not adopting any consistently working tools for safety precaution, not making executive decisions to train the workforce, and not learning from the previous mistakes forces stakeholders to deal with the consequences of poor performance and safety management practices. It's been mentioned that both safety hazards and inefficient management methodology hurt construction project's pipelines and, therefore, stakeholders' profits. So, it's fair to assume that once optimization benefits and preventive solutions for occupational hazards are in place and their value reflects on the site's profits, stakeholders will get on board.

- The management team of a construction

This is the group that will be actively using the system, test interfaces, and rely on the provided data for managerial decisions such as adding or removing extra workforce, renting the machinery, sticking to the timeline, and solving security issues that constantly happen, and much more. Managers are the main target audience the development should focus on. It is essential to implement customizable elements in the interface of the Smart Construction solution. Also, it is important to make dashboards with data-based insights as understandable and comfortable to use as possible. There are also questions of occupational hazards, rework, lack of collaboration between different worker divisions, gaps in communication between clients, managers, and workers that result in unhelpful feedback, defects in materials and corresponding performance delays, and so on — the development team should obtain insights into how to help close these gaps via Smart Construction product to provide a truly beneficial product. If managers enjoy using this product, they will become brand

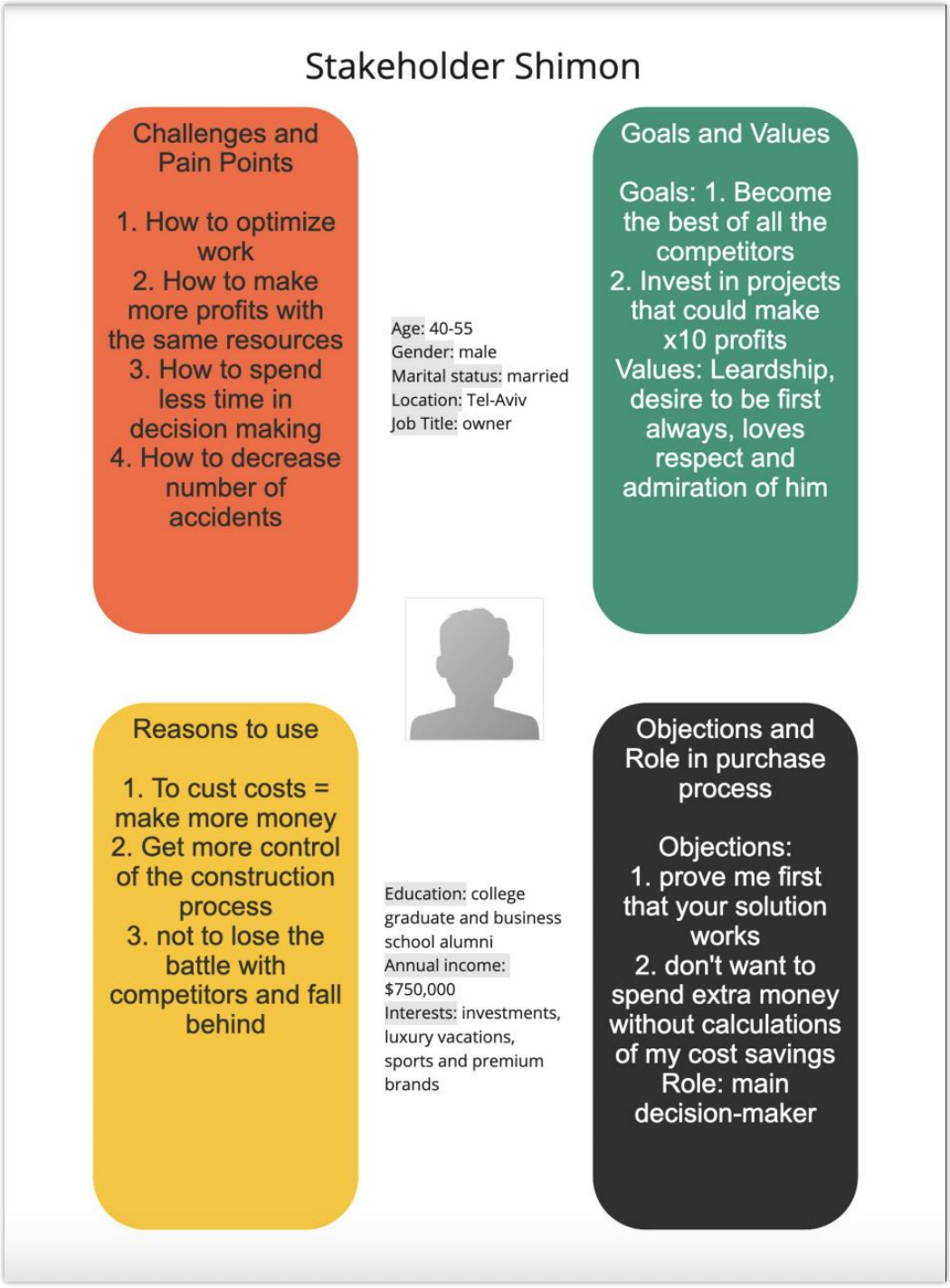
ambassadors at the stakeholder meetings where they will try to convince the board to use the solution they tried and saw real value to the construction process which solves their pains and problems. The additional benefit this group will gain from using the Smart Construction products is empowerment in the workplace, so the system will need to provide actionable insights, clear recommendations, and be as precise in its data gathering and predictive capabilities as possible.

- Subcontractors

Subcontractors are, while not being the main user of the product, also suffer from a lack of collaboration in construction projects: for instance if the change needs to be implemented on-site and the managers asked for it, but the message to stakeholders informing or requesting approval for a change got lost in their email — and subcontractor, as they sometimes do, did it anyway — that will bring the conflict to a site. At the same time, subcontractors also suffer from a lack of data availability, — they are often made aware of how things are going on the site verbally. The lack of data makes it harder to get to the root of the issues on the site: four notices of shortage in a certain raw material might seem unconnected if provided one by one, but a data analytics system that tracks these things might come in handy to uncover trends and change the process of estimation or look more closely at workers' resource management. Their feedback on the system will be transferred to the stakeholders of the site, — so it's important to cater to them, too, by addressing their challenges, related to productivity, resource and people management, and delays — and Smart Construction product addresses them as well.

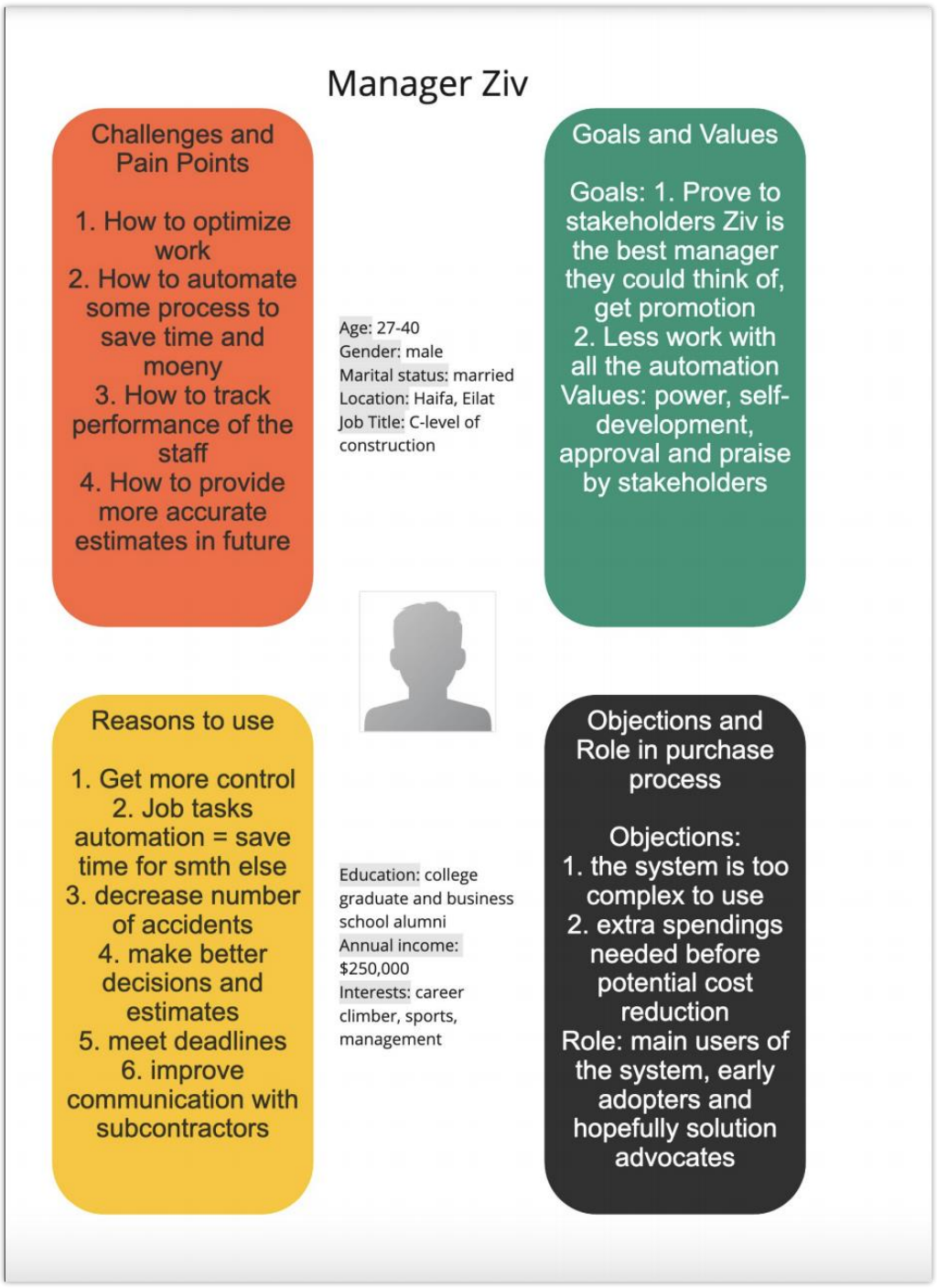
Let's identify the persona of each target audience described above. Personas are developed according to customer research and they help to understand users' experience, pains, behaviors, and goals. Personas will help the product team to identify the core audience of the product and to understand what solutions are needed for them.

Persona's identification will help while pitching the product to the target audience to understand the values, goals, and main challenges of each group [12].



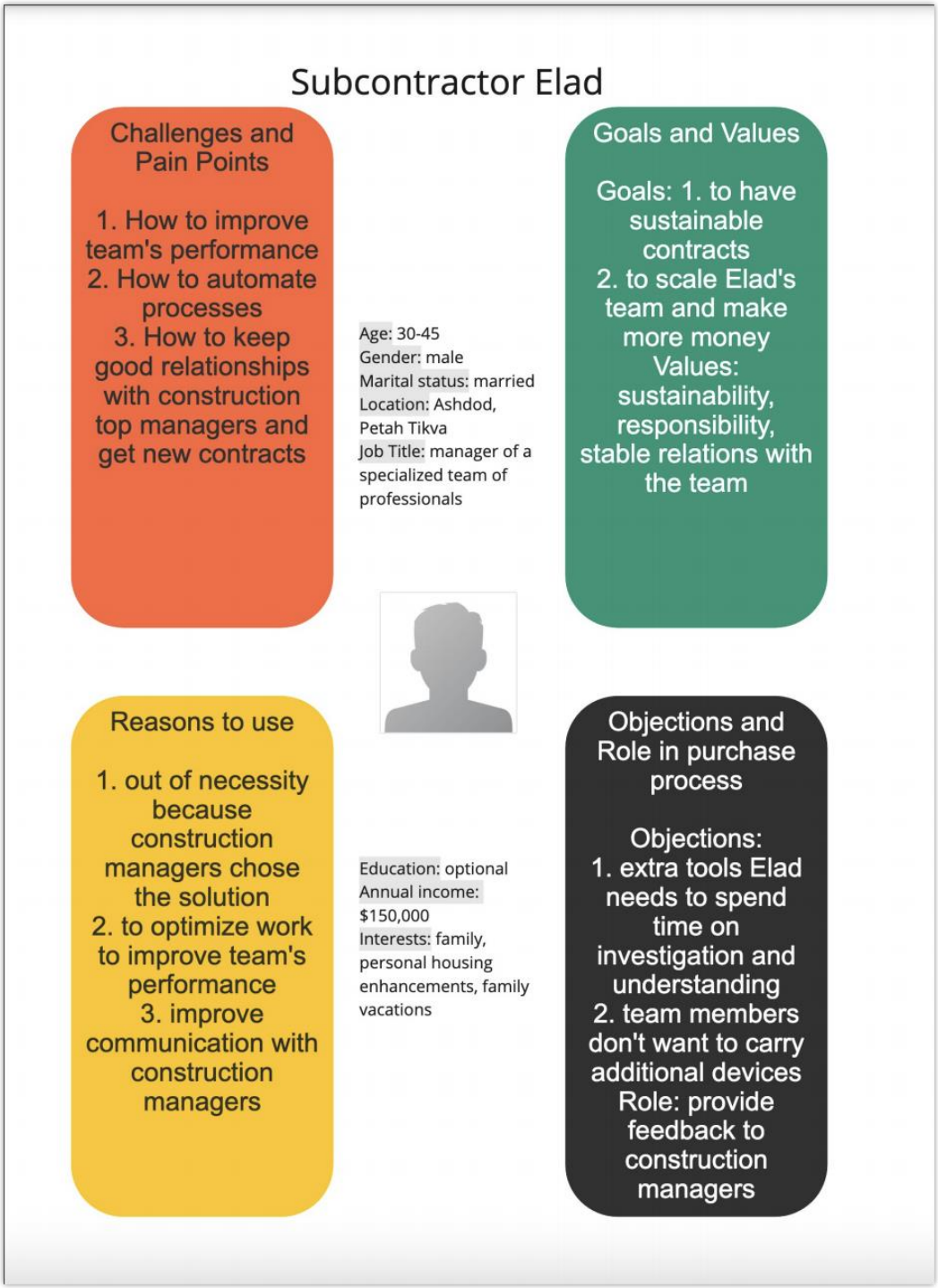
Img. 4.4. Customer avatar Shimon, stakeholder of a medium construction company

While preparing to pitch to Shimon, the team needs to be aware what are the main pain points and values for him. During the actual presentation, all of the main challenges should be addressed and the speakers themselves should refer to the goals and values of Shimon. For instance, it's important to say that adopting such an innovative solution will make him the first one on the market to do so. Since stakeholders enjoy being first, it can be a good sales point.



Img. 4.5. Customer avatar of Ziv, top manager of a big construction site

Ziv is a typical top manager of a construction site. He wants to make his stakeholders happy and meet the deadlines. Ziv might become a great product advocate if he sees all the benefits of the product. In that case, he'll be the first one to promote the Smart Construction solution to the stakeholders in order to become a more successful manager and perform better. While pitching to Ziv, the team needs to understand how the product solves all his pains and helps to make difficult decisions.



Img. 4.6 Customer avatar of Elad, a manager of a small team of specialists, subcontractor

Elad is generally happy with his life. His team is working hard and all he needs to do is just to make sure everyone shows up at work, the performance of the team is acceptable. He really isn't fond of innovations and doesn't want to learn how to use any software or hardware systems. But adoption of such systems is a part of the contract with the construction, so he has to at least try understanding it and use it to his ability.

The team will not pitch the actual product to Elad but he still needs to be interviewed to find out his feedback and help to understand the most suitable UX for the product. Positive feedback by Elad can convince Ziv to start the pilot project.

Evidently, everyone from stakeholders to workers is hurt by insufficient, not sustainable working processes on the construction sites. Taking into account the fact that construction projects of the same stakeholder — large construction companies — are often quite different, there's an additional point to be made: it’s not enough to establish the process that will work when constructing one specific building but break up when installed within the other one, with another subcontractor.

The design thinking course provided the information to understand that a pitch to a stakeholder and a pitch to a construction manager are two different pitches since these two personas have different goals and challenges, and their pain points should be addressed differently.

4.4 Board Members & Team Structure

4.4.1 Board of the Project

Oleksandr Koshykov, CEO & Product Manager

Evgeniy Berkovich, CTO

Yoav Grinstein, Business Development Manager

Eyal Nisim, Domain Expert, top manager of one of the Israeli construction companies.

4.4.2 Cap Table

Table 4.1

Cap Table

Oleksandr Koshykov	80%
Evgeniy Berkovich	
Yoav Grinstein	10%
Eyal Nisim	10%

After the successful round of investments, the board is planning to issue options to all the team members who are participating in product development.

4.4.3 Team structure

1. Project manager
2. Backend + DB developer
3. Frontend developer
4. Mobile Developers (iOS and Android, or two Flutter developers)
5. QA Manual
6. Designer
7. Automation QA

Team structure may vary depending on the need of the project at the specific time. Most likely the team of IoT developers will grow but the web- and mobile teams will get smaller after the pilot project is completed. Once the data collection starts, the AI developers and data scientists will be added.

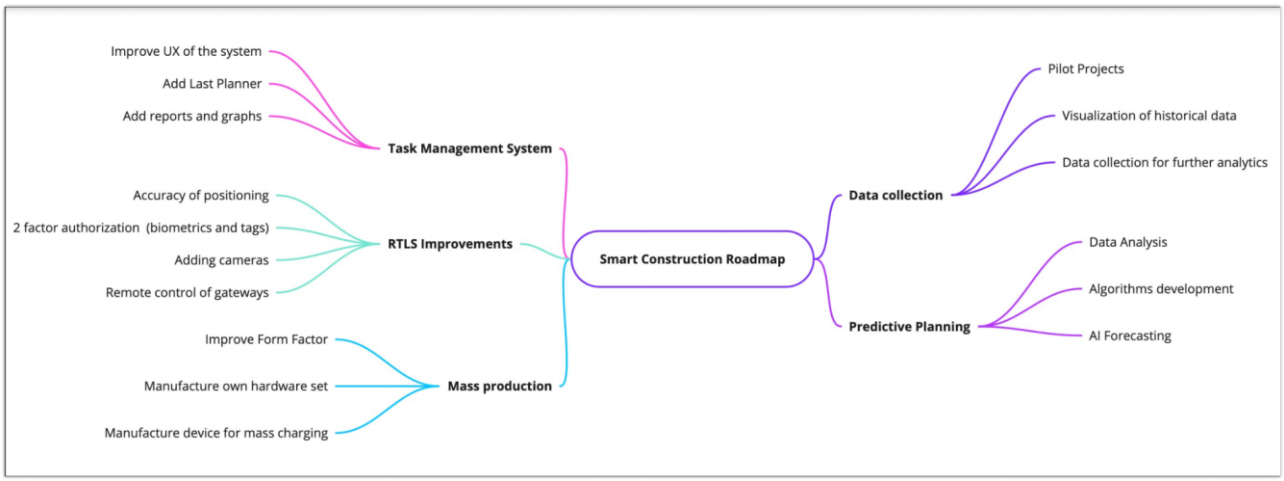
5. STRATEGIC PLANNING

The strategy of product development will depend a lot on the level of first-round investments the board is able to raise, but the roadmap and timeline are already set according to the results of focus-group research and competitor analysis. Still, the priorities of each task and feature can be easily changed at the monthly board meeting.

As Smart Construction operates on the field where stakeholders are very skeptical to innovations, and managers are often unhappy with the existing solutions, it's obvious that the roadmap of digital transformation — and that, in part, is what the application is doing — has to first and foremost fix the most common pain points of the main target audience: managers of the construction site. That's the root of the Smart Construction roadmap.

5.1 Roadmap

The roadmap of Smart Construction was built based on market research, interviews' conclusions with domain experts, and competitive analysis. Since the company is using an agile approach, the roadmap can easily be adjusted and modified depending on competitors' moves, changes in regulations, overall market changes, and problems that may occur in any part of the product development that needs to be prioritized and solved.



Img. 5.1. Smart Construction Roadmap

5.1.1 Task Management System

1. Improve UX of the system

Once several domain experts tested the current system, the product manager has already created a list of improvements and UX enhancements to make it an easy-to-use and understandable interface.

2. Add the Last Planner

A Last Planner is a lean approach for construction (see more details in Section X, Competitive Analysis) which is necessary to help managers with planning and controlling the progress of construction. The task for UX designers and a product manager is to come up with the most convenient interface of the Last Planner, so managers don't need any guidelines on how to use it.

3. Add reports and graphs

Development of multiple reports and graphs including:

- Financial reports
- Productivity reports
- Report of each employee's attendance at the construction site, workload, working hours
- Gantt chart
- Burndown chart
- Assets workload (elevators, cranes, bulldozers, etc.)

5.1.2 RTLS Improvements

1. Accuracy of positioning

One of the highest priorities in the upcoming development is the improvement of RTLS accuracy.

2. Two-factor authorization entering the construction

In the first version of the system, there is no functionality for employee identification. The idea is that every day employees take any random tag, and the system only pinpoints the location of this tag without providing personal information on the worker. It is planned to start installing a biometric system (fingerprint

identification) in the later stages of product development: to identify employees through two-factor authentication. The system's tags will be integrated with biometric check-in points. That will contribute both to the security endorsing side of Smart Construction — and to the site management, as the system will more precisely track what's happening on the site on the individual level.

3. Adding cameras

Adding cameras and connecting them to the system solves one of the safety problems:

If there are people caught by the camera and they do not have a SC tag with them, the system immediately sends an alert to the security officer about outsiders who shouldn't be there.

Human detection will not be developed by the SC team, as it has been decided to use a third-party SaaS solution for the implementation of this feature. Once the camera detects a person, it sends a request to the database of the SC system to verify if there should be a person with the tag. If this person doesn't have the tag, then the system sends an alert about the intrusion to the Security Officer of the construction site.

4. Remote control of gateways

On the long-term roadmap, there is also a task to provide remote access to gateways to monitor their work and configure some of their parameters.

5.1.3 Data Collection

1. Pilot projects

Pilot projects are the key to test the system and start collecting data for predictive planning. The plan is to start with just one pilot, test the RTLS, and provide access to all the managers of that construction site to the management system. Getting feedback from real users and enhancing the system before the sales process starts is critical for the overall success of the startup. The pilot project should be fully sponsored by the investors and not the construction company.

2. Visualization of historical data

The system collects plenty of various data which should be visualized in the system for construction managers.

3. Data collection

This part of the system should be implemented once the first pilot project starts. All the data would become a source for future predictive planning.

5.1.4 Predictive Planning

1. Data analysis

The analysis of the historical data on productivity, costs, the performance of contractors and subcontractors, missing working hours, security violations and much more should be implemented for machine learning algorithms to identify and highlight trends and search for ways of optimization.

2. Algorithms development

The next step would be the development of algorithms that will use the collected data to generate actions, process analysis, or reports to achieve predefined goals.

3. AI forecasting

AI forecasting would be a premium feature for top managers of construction to identify trends, test assumptions, and finally estimate and plan future projects based on the analyzed data. Another task for the AI team would be to look for different anomalies which could cause delays or potential improvements in performance and productivity.

5.1.5 Mass Production

Once several pilot projects are completed, the next phase of the product is to manufacture gateways and tags for large projects. For the first mass production, the team should aim for at least 100 gateways and 10,000 tags. This should be a completely different task compared to the current volume, but it should also cut the cost per unit to $5-7.

1. Improve form factor

Currently, the tag construction workers need to carry is in the form of a small box about 5x5cm. For the pilot projects, the size should not be a problem but for mass production, the form factor should be changed. There are two best options so far: a form of a bracelet and a card. Once this task will get a higher priority, those two options will be investigated.

2. Manufacture own hardware

One of the possible constraints of the project is the dependency on third-party hardware, and in the long run, manufacturing startups' own hardware solutions might tremendously cut costs and help to become fully independent from other vendors. Also, IoT specialists are not confident that they will be able to improve the form factor with third-party chipsets at the moment. The potential budget for building such production is still to be determined and calculated.

At the moment the situation with the availability of required hardware components is getting worse since lots of companies decided to push R&D departments to engage in IoT development and there is a noticeable shortage of hardware. The pricing went up due to high demand, as well as the timing of receiving one's order: so instead of 2-3 weeks of waiting, the startup needs to add 3 to 4 months of delay to its supply and delivery schedules. This is a reason why the priority of this task might get revisioned soon and changed on the product's roadmap.

3. Manufacture a device for mass charging

On a big construction site during one day there are, at times, around 300 to 400 employees. Charging all the tags overnight might be a complex task so manufacturing a device for mass charging is also on the long-term roadmap.

5.2 Timeline

Startups survive if they are agile and flexible in terms of their adjustments to every day changing conditions in their environment: market, competitors, technological improvements, available budget, and many more. The ability to pivot at the right moment or change the priorities of the roadmap is critical for overall success. The first year of the Smart Construction project has already proven that multiple times.

Nonetheless, it doesn’t mean there should be no plan and timeline at all. As for now, the board of the project envisions such a timeline:

Img. 5.2. Smart Construction Timeline

The priorities for the next 6 months are fine-tuning of the system, UX updates, adding Last Planner functionality, and accuracy improvements for the positioning.

Once these enhancements are completed, the pilot project or projects need to start. That is when all the data collection starts and the team moves on with preparation for building forecasting algorithms.

In parallel with data collection, the IoT department needs to start mass production of all the RTLS components and think about what tags' form is the most suitable and reconsider the current one.

Two-factor authorization for employees entering construction sites (integration of the SC system with the biometrics system) should start in 3-4 months from now and can become a good differentiator from main competitors.

5.3 Competitive Matrix

Based on the roadmap of the product, competitor analysis, and persona identification the author of the thesis completed a Competitive Matrix.

Competitive Matrix Smart Construction

	47	90	57											Us (long term)
	31	64	46										Us (near term)	
How good each competitor is	24	69	49								Sewio			
overall, from each	34	72	54					Tracktio						
customer's point of view	43	71	43			Trusstor								
	Stakeholders	Construction Managers	Subcontractors	Problems	Us (right now)	Now	Future	Now	Future	Now	Future			
	2	4	4	Real-time location + history	4	5	5	5	5	4	5	5	5	
	3	5	3	Safety Alerts	3	3	4	4	4	2	3	3	3	
	5	5	0	Reports & Predictive Planning	0	2	4	0	2	0	0	2	5	
Importance of each problem	0	3	5	Last Planner	3	0	2	3	4	1	3	3	5	
to each customer	1	5	1	Easy-to-set up	0	1	1	1	2	5	5	2	3	
Importance of customer to our strategy	3	5	1											

527	129	355	43	Trusstor	(future)
516	102	360	54	Tracktio	(future)
466	72	345	49	Sewio	(future)
459	93	320	46	Us	(near term)
648	141	450	57	Us	(long term)

Overall relative strengths of all competitors, given relative importance of each customer group as a function of our selected strategy

Img. 5.3. Competitive Matrix

Construction managers are the primary target audience since they are responsible for successful project delivery, timeline, and cost. Stakeholders are the ones who actually make final decisions, but the decision should be fairly easy to make if the evidence of potential savings and productivity improvement are provided. Subcontractors are also going to be using the system, but only out of necessity, as per the preliminary research among them. It should be noted, though, that there's an opportunity to involve subcontractors more heavily in the process by addressing their pain points first stated above: they, as well, suffer from falling short on deadlines, inefficient resource management, and so on. While currently the issue is managed through high manager turnover in the contractor's team, it might change to a more comprehensive and sustainable solution, made possible with data analytics and continuous communication.

According to Smart Construction, the implementation of the short-term goals should help SC reach the level of main competitors, and long-term features will provide unfair advantages over them.

The Competitive Matrix provides great insights on why that specific business is the main competitor at the moment. It should be carefully followed to grasp the

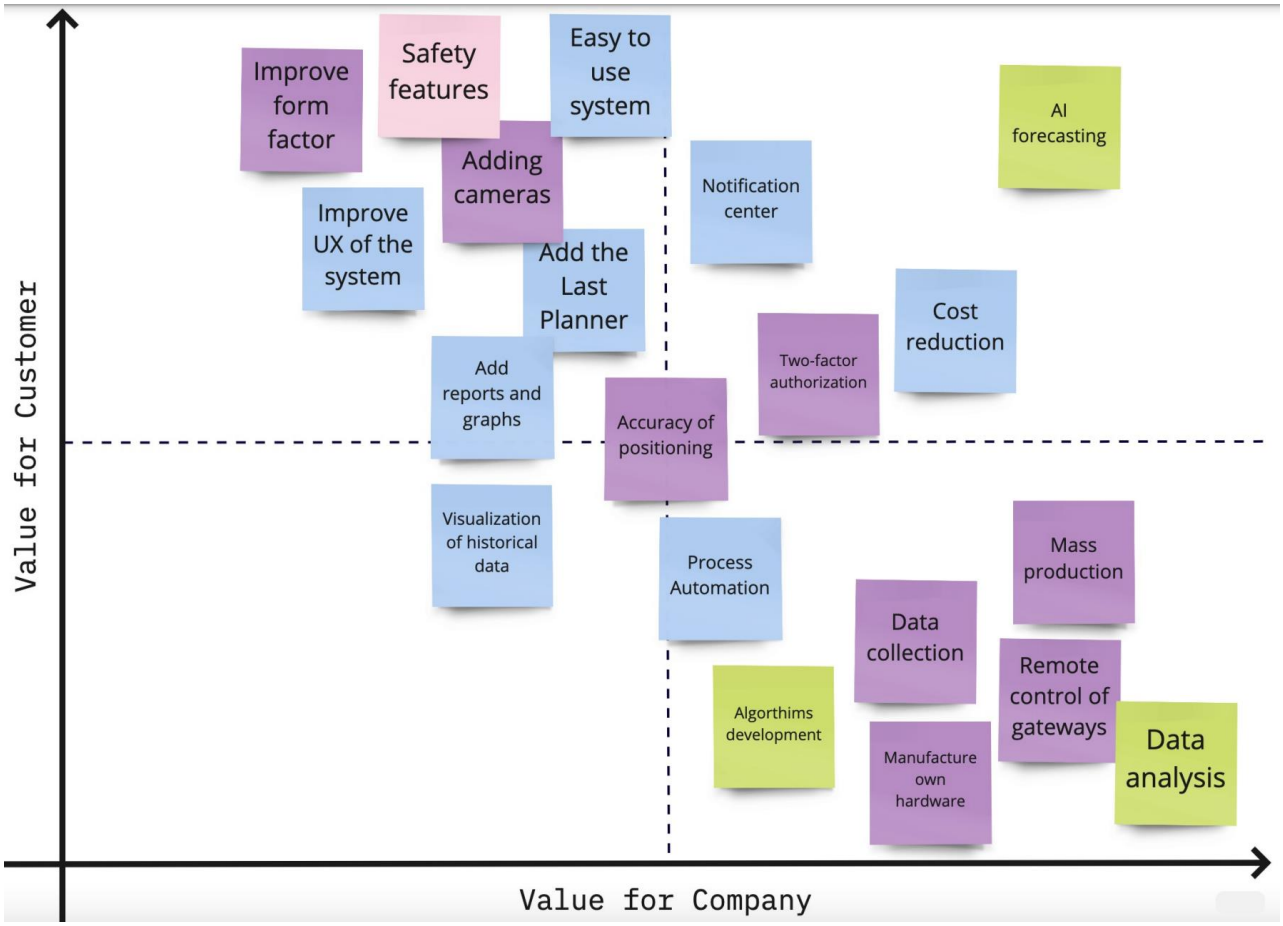
current state of the market, but it also gives an understanding of what features, both short-term and long-term, should be implemented to help differentiate a startup from its main competitors on the market.

5.4 Innovations

A roadmap of the product is undoubtedly important, but according to Doblin's research, "the most certain way to fail is to focus only on products" [13]. Successful innovators use many types of innovations.

Before describing the innovations in the Smart Construction project, let's take a look at the 2x2 matrix that defines which features, characteristics, and services are important for a customer and which are vital for a company.

5.4.1 2x2 Matrix



Img. 5.4. 2x2 Matrix

The clusterization of the 2x2 matrix for Smart Construction is similar to the main concepts we've discussed in Chapter 3 - Product description. The main clusters

are Data collection (purple stickers), Control (green), Decision-Making (blue). Safety issues stand as a separate cluster (pink).

As it's shown on the matrix, customers would value the features that bring real outcomes from the very beginning. Company values are different. The company would want to focus more on data collection and analysis to have enough data for AI forecasting since it's a premium feature that will bring more profits to the business. AI forecasting is also important to customers since they can make better plans and estimations using it and facilitate and prioritize more precise and productive decisions.

5.4.2 Ten types of innovation

Moving to the 10 types of Innovation framework, it is important to understand what innovations are planned to be implemented within the Smart Construction project.

Img. 5.5. Ten types of Innovation

Profit Model:

- Installed base: a package of gateways and location tags will be sold to customers with a small margin, but purchasing the additional tags would cost more
- Freemium: Some of the features are a part of the standard system set-up, but premium features, such as predictive planning, would cost extra
- Licensing: The license fee at the beginning of operating would start at just $1500 to $4500. Later on, the pricing might be changed

Process:

- Predictive Analytics: all the collected data will be used for better planning and forecasting on new construction sites.

Product performance:

- Ease of use: the system will be both easy to set up and easy to use and this is one of the main product differentiators among competitors' offerings.
- Feature aggregation: the system aggregates several unique features that could be found separately in different other products, such as task management boards, RTLS, etc.
- Conservation: the system is built in a way that aims to reduce time and resources spent on construction and allow to make decisions faster and easier.

Product system:

- Product bundling: Smart Construction provides solutions to several problems within one product. All of these features come in a bundle with no need to pay extra for each of them separately

Service:

- Total Experience Management: unification of UI/UX, agile management board, and notification center provide a friendly and convenient experience while using the product.

Customer Engagement:

- Process Automation: Once the task is created on the board and a subcontractor is assigned to it, there is no need to make a phone call, or gather a meeting to discuss different aspects of operations - the subcontractor will get a notification with task details and deadlines. The automated process saves lots of time and increases efficiency.

These are just a few innovations that are planned to be implemented in the next couple of years, but in order to continue to scale and create a sustainable model, new innovations should be added as well.

5.5 Success Criteria

There are several markers the project needs to reach in order to become successful:

Table 5.1

Success Criteria for Smart Constuction

Task	Responsible	ETD
Raise funds for further development	Yoav Grinstein & Evgeniy Berkovich	end of June 2021
Start the pilot project	Evgeniy Berkovich and Eyal Nisim	mid-August 2021
Implement 6-months roadmap plan	Alex Koshykov	end of the year 2021
Start data collection and algorithms development	Alex Koshykov	November 2021
Adding AI forecasting	Alex Koshykov	February 2022
Hardware Mass Production	Alex Koshykov	March 2022
Start sales	Evgeniy Berkovich and Eyal Nisim	May 2022
Second Round of Investments	Yoav Grinstein & Evgeniy Berkovich	September 2022

Two of the most important success criteria are raising funds and starting the pilot project on a real construction site by the end of 2021. These are the short-term goals the whole team is focused on at the moment.

5.6 Scaling and Market Share Increase

There is a definite potential for the Smart Construction product on other markets outside of Israel. Considering some cultural specifics there is customization work to be done first, but after collecting and analyzing data from Israeli market pilot projects, a big advantage in starting sales processes anywhere around the world while

having real evidence of potential optimization, cost reduction, and progress control have been discovered.

There are several possible strategies for expanding:

1. Cooperation with some of the Israeli construction companies that operate internationally. Partnerships with them might become a good option for receiving a referral entry point to other construction companies in the target market. It's highly probable that, once they will recognize the value of our product's optimization mechanisms and get to see saved costs, its adoption will be expanded to the local sites in other countries. International networking comes later. This is the most affordable and, at the same time, most efficient option for the startup: if used, Smart Construction will get a well-informed product advocate for local markets outside of Israel. Partnerships with construction facilities in other countries that are established within a collaboration with a known, loyal client also allow the startup to figure out what changes need to be implemented within the localization, how to optimize operations better, and what are the specifics of legal and regulatory systems — in a relatively low-risk environment.

2. Entering some of the local accelerators and adding local domain experts from the construction and engineering industries to the board of the startup. Since the industry is very conservative, the sales process might be very challenging without having a domain leader with a large network on the market. Reaching out to the top managers of local construction companies is a good option to start such relationships. Such a choice of communication channel significantly reduces spendings on expensive marketing campaigns and rounds of cold calls — however, if overdone, the startup will face major equity losses.

3. Creating an entirely new company in another country from the grounds up — opening up new offices in different countries, hiring local sales and marketing managers, renting an office, and setting up a full-scale working facility with the goal of both researching the market from the ground up and building up the network of local connections without risking equity. While tech startup-heavy communities in, for instance, the USA offer many opportunities to connect with experts in almost every

industry and find enthusiastic first adopters of the localized product, the whole set-up is the most expensive option among those that are considered for market expansion and the slowest in terms of real lead generation. If the first two options fail, this is the approach to choose.

Priority directions would be markets of the US, United Arab Emirates, and several European countries, such as Germany, France, and the Scandinavian countries.

There is much room for scaling but at the current stage of the project, it is too early to plan new market expansion before the target market isn't fully covered. However, it is worth noting that the worldwide construction industry suffers from very similar pains as the Israeli one. Engineering and Construction is one of the least digitized sectors in the world [14]. While there are more and more software vendors and IoT companies in, for instance, the United States, the success rate for digital transformation is still really low. While promising productivity gains and subsequent cost reduction, vendors often offer non-specific IT solutions that don't bring results to the table. If Smart Construction scales as the safety-first productivity-driving solution in Israel, there's a lot of pros in going international.

It's important to keep in mind, though, that one of the major reasons startups fail is that they lose the structure that has been successful in the early stages when scaling. Scaling becomes especially difficult for hardware-heavy startups because the increase in production usually means that more money should be invested in orders for mass hardware production. If Smart Construction would be able to solve the issue with hardware supply at the early stage of operations (either by establishing long-term relationships with reliable supplier companies or by switching to in-house manufacture), a large part of scaling danger can be avoided.

5.7 Project Constraints

There are several project constraints that could threaten the Smart Construction startup.

Among many there are some major ones:

1. Inability to raise funds

For most of the board members, the process of startup fundraising is novel and intriguing. Even though there is already a working MVP version of the product with several advantages over competitors, there is always a risk of failure in finding investments. Having multiple connections to domain leaders and top managers should increase the chances of getting the first investments.

2. The technology doesn't work well enough on a big construction

The MVP version was tested on a smaller three floors building. The accuracy of the positioning is from 3 to 5 meters which can definitely be improved during the next sprints of development. But the technological solution wasn't tested on a big construction site which usually could occupy up to 5 square kilometers. The digital transformation that is unusable for large construction is one of the major pain points of construction industry stakeholders, so it's vital to be able to scale the technology without creating an additional burden on the operation processes. To do well on the market and with big industry players, Smart Construction needs to be both easily scalable and easily customizable, so companies would be able to introduce it within projects of different sizes and types fast. Research showed that such technology is also being used by some of the indirect competitors which means that it should be fine on a big construction site as well, possibly with more expensive hardware components.

3. Shortage of hardware components around the world

As mentioned above in the Roadmap section, there is a shortage of hardware components, so the cost and time of delivery went up [15]. Before starting the sales process the Smart Construction management team needs to make sure that enough components were purchased and received upfront. If the startup manages to do that, this constraint might be turned into a competitive advantage: when the shortage is experienced by everyone in the industry, the company that efficiently plans for such a shortage wins.

4. Mass production of hardware components takes much more time and money than expected

This is the first IoT project for the whole team, so there is a lack of experience working with hardware. At this moment even calculating the budget for mass

production is complicated since there is no final hardware chipset that needs to be used, the supplier is yet to be determined and more team members are needed to turn the process into mass production. Though there are more and more IoT companies appearing on the market which could be involved in the production of a large number of gateways and location tags.

5. High level of competition

The technological and startup world is moving incredibly fast and hundreds of startups appear on a daily basis, so considering low barriers to enter the market, the competition might get more intense. Time to market is essential to get some piece of the market share as soon as possible. There's a point to be made here, though, that if Smart Construction takes up the niche of making the construction both efficient and safe, the processes should continue to stay both fast — to keep up with the competition — and thoughtful — to truly protect construction workers from harm.

6. Lack of talent

The competition for talent in the Ukrainian market got much stronger since the end of 2020 due to the high demand for software and hardware services. The stats (djinni link) say that there are 5 job propositions for 1 developer who is looking for a job. The web development team most likely will not become a bottleneck for the hiring efforts, but IoT developers are in incredibly high demand. Such Ukrainian unicorns as Ajax and Ring are rapidly opening new offices around the country and aggressively hunting hardware developers. (need to find stats to prove this) Outsourcing hardware work usually is not an option since there are additional problems that accompany the process, such as saving the IP of the product, transportation of ready-to-use hardware, and higher costs. Raising and educating young talent might be a good solution for this constraint. Young IoT specialists for Smart Construction would actually be more beneficial for the project, as they'd be trained to first do risk management and then programming.

5.8 Investments Plan

The POC and MVP versions of the product were fully covered by the investment of the Smart Construction startup's co-founders. Up to $100,000 were invested so far, and now the board of directors is looking for the first round of external investments.

Before addressing angel investors, venture capital firms, or accelerators, the primary phase of pitches is scheduled with the top managers of several Israeli construction companies as the potential clients of the system. This is the audience that should fully appreciate the domain focus of the product which solves some of the main pains managers faced over the last decades. The pitch deck was designed and prepared in the format of the most commonly used template, created by Sequoia Capital.

The estimated budget required for the next 6 months of operating that are needed for implementation of the planned functionality from the roadmap is around $125,000. All the money will go to the software and hardware development teams and cover the additional expenses for purchasing new hardware components, bills for servers, and travel expenses that are needed to bring an IoT team to Israel to set up and launch a pilot project by the end of 2021 at the real construction site. Business development will be done by the board, so no extra budget needed.

Here is an estimated budget:

Budget for Upcoming 6 months of Smart Construction Product Development						
Months	1	2	3	4	5	6
Main tasks	* Design * Specifications of the new build * Last planner	* Design continue * Last Planner Development * RTLS Improvements	* Last Planner * Positioning fine tuning * RTLS Improvements * QA	* RTLS Improvements * Last Planner Mobile * QA	* RTLS Improvements * Start Pilot * Optimization * Reports & Graphs D	* end2End testing * System Improvements * Start Data Collection * Reports & Graphs Dev
Designer	1 fulltime	1 fulltime	as needed	as needed	as needed	as needed
PM	1 fulltime	1 fulltime	part time	part time	part time	part time
BE	part time	1 fulltime	1 fulltime	1 fulltime	1 fulltime	part time
FE	part time	1 fulltime	part time	as needed	as needed	as needed
Flutter		part time	1 fulltime	1 fulltime	1 fulltime	part time
IoT		1 fulltime	1 fulltime	1 fulltime	1 fulltime	1 fulltime
Manual QA	part time	part time	part time	part time	part time	part time
Auto QA	part time	part time	part time	part time	part time	part time
~ month cost in USD	10000	18000	22000	22000	22000	10000
Additional expenses						
Hardware components for the pilot				10000		
Travel expenses for the IoT team to start the pilot in Israel					5000	5000
Servers expenses	700	700	700	700	2500	2500
					Total in USD:	**121800**

Img. 5.6. Estimated 6-months budget

In terms of the industry and startup standards, the first round of fundraising is considered to be very small, which increases the chances to find the investments for the next 6 months of product development and testing.

6. CONCLUSIONS

According to the conducted research, Smart Construction startup has a good potential and high chances of gaining a foothold on the Israeli market. Expanding to other markets is definitely considered but it's a matter of completely different research, calculations, and marketing strategy from the starting point that are outlined above.

There are key aspects to help the startup survive the competition and seize a portion of the market early:

- Time to market. There are multiple construction companies that are still trying to adopt any software or RTLS solutions, so whoever comes first and starts the on-site project will have a huge advantage; the first player in the field would be difficult to substitute.
- Focus on differentiators of the product. Short-term roadmap implementation would provide an initial competitive advantage and help convince main decision-makers to try out the system
- Delivery of the UI-friendly and bugs-free solution. Even for the pilot project, having a buggy product might put at risk the startup's lifecycle since convincing partners to do another pilot after all bugs are fixed could be challenging.
- Staying agile. It's very important to make prompt changes that may arise from additional product research, the appearance of a new player on the market, or a specific request from a potential customer. Refusing from the priority-based transformations and sticking to the initial roadmap could disastrously affect customer relationships and potential investors' attitudes.

While studying at the MSTM program, there were multiple pivots of the roadmap of Smart Construction. For instance, the first version of the management part of the system turned out to be inconvenient for construction managers, so additional research showed that the Last Planner interface is more suitable and easier to get for the domain leaders. After the research, the UX designer reorganized the management board, and new interviews confirmed that the new interface works better for the target audience.

Another example was a technology selection. The Bluetooth solution seemed to be much cheaper and easier to develop, but market research showed that such solutions have a complex and long installation process that requires an on-site specialist to configure the whole system and test. Such an approach is very redundant and expensive, and it might have become a big barrier for construction managers to start a pilot project. Due to these issues, the Smart Construction prototype was built with different technology, and the package could be easily delivered to the construction site and installed by local managers within a few hours. This approach already gives a valid competitive advantage and domain leaders are very excited to hear how easy it is to set up the whole system.

With a startup world being as it is, Smart Construction met a new competitor with a very similar solution on the same market that has appeared recently. When the first competitor analysis was made, Trusstor didn't even have a landing page, so it stayed unknown. On the one hand, it's a good sign. If more competitors appear, that means a good market was chosen as a primary one, and it has financial attractiveness. On another hand, time-to-market becomes even more critical if Smart Construction wants to be the first player on the market with real customers.

That is why the list of success criteria was generated. Though the timeline for it looks intense, all the tasks are still realistic and should help bring a product on time. Trusstor has already raised the first round of investments, so raising funds is the top priority for the board to continue development and not to increase the gap between them and Smart Construction company.

Once the funds are raised, the next immediate step would be to start the pilot project. The partners of the startups are willing to start the project on their construction site whenever everything is ready so the only barrier that is left is the transferring of all the hardware chip-sets to Israel and successfully installing the system. The pilot solves a lot of important tasks:

- Test the system and check the tracking accuracy on a large construction
- Start collecting data to develop algorithms and search for anomalies during different processes on the construction sites

- Get feedback from real users and adjust the system before starting the sales process
- Demo the system to potential customers on a real construction
- Start the word of mouth promotion among competitors

If the pilot project goes well, it’s time to start selling the system to customers. Addressing the main pain points of stakeholders and construction managers should increase the chances of closing deals and allow the board to start generating profits for further development and expansion.

As mentioned in the Business Model chapter, the revenue model could be pivoted soon after the several first projects are started. Once the stakeholders and construction managers see the value and real results in saving costs, the model could be shifted to a subscription-based approach with the additional fees for premium features. But as of now, an additional purchase of location tags should be the main revenue channel. The exact profit margin is yet to be calculated after the cost per unit is determined during mass production.

Just a few steps divide the startup from being successful on paper to a working sustainable business. All the knowledge received during the MS program in Technology Management should help to bring this product to life.

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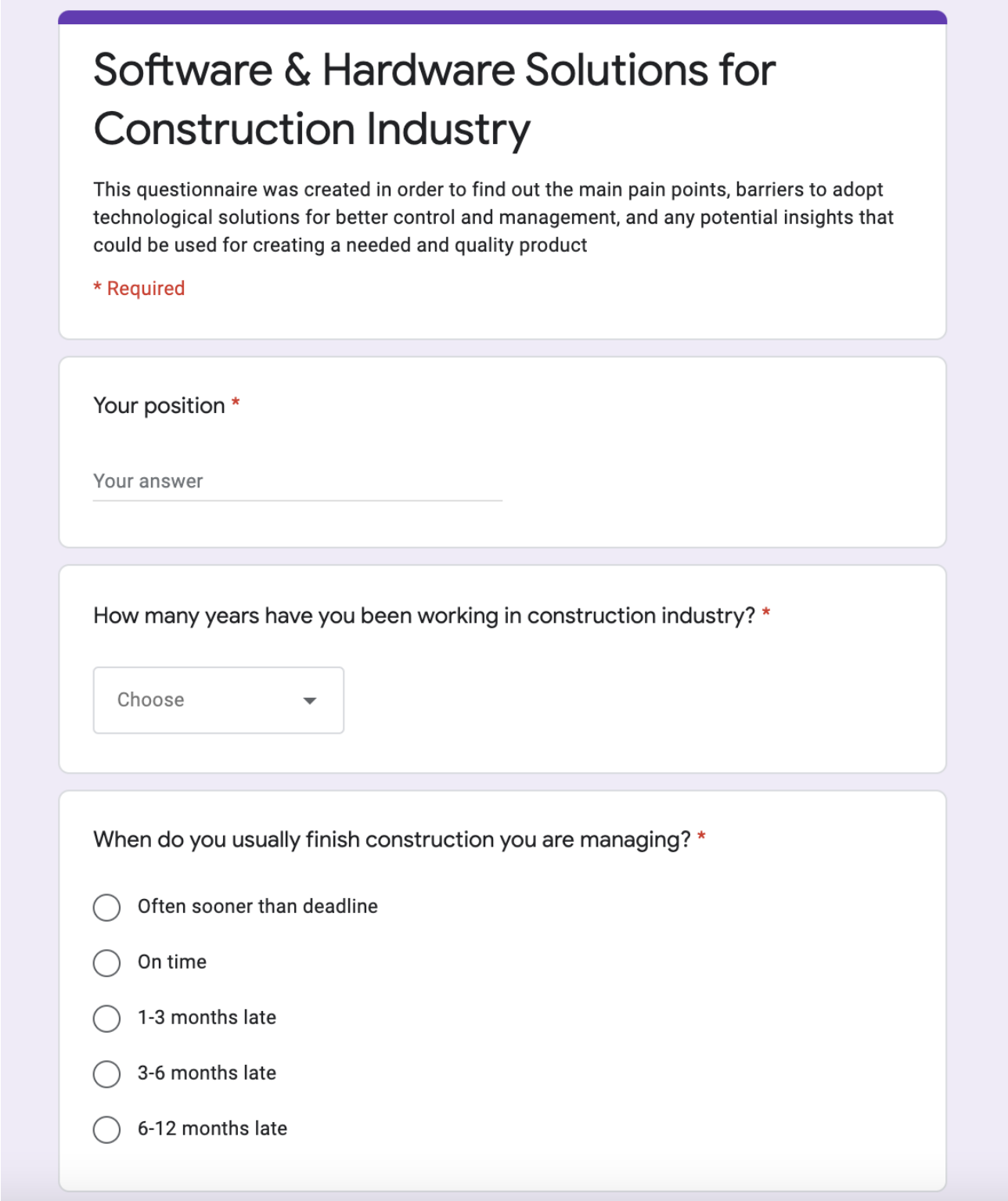
ANNEXES

Annex A. Focus group questionnaire, p. 1



Software & Hardware Solutions for Construction Industry

This questionnaire was created in order to find out the main pain points, barriers to adopt technological solutions for better control and management, and any potential insights that could be used for creating a needed and quality product

* Required

Your position *

Your answer

How many years have you been working in construction industry? *

Choose

When do you usually finish construction you are managing? *

- Often sooner than deadline
- On time
- 1-3 months late
- 3-6 months late
- 6-12 months late

Annex B. Focus group questionnaire, p. 2

What are the main pain points you face during the construction process?

Your answer

Have you or your company been using any software or hardware solutions? If yes, what are they?

Your answer

What do you think are the main barriers to adopt new technological solutions for better control and management of construction?

Your answer

What would be the best motivator for you to adopt a software/hardware solution

Your answer

If you have such a control and management solution, would you rather use a web version or mobile?

- [ ] Web
- [ ] Mobile
- [ ] Both