2019

Soilar Architecture Document

THIS DOCUMENT DESCRIBES THE ARCHITECTURE OF THE SYSTEM “SOILAR” MADE BY LUCIDY.

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Versions of the document

Version	Date	Mutation
0.1	02-02-2019	Template and styling of document
0.2	04-02-2019	Added product name “Soilar”
0.3	28-05-2019	Scope, Introduction, Stakeholders, SCD
0.4	29-05-2019	Functional requirements,
0.5	30-05-2019	Non-Functional requirements, constraints, Architecture drivers
0.6	31-05-2019	UseCase diagram, Requirment Tracability, Functional decomposition

Validation list

	Date	Name	Function	Mutation
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Scope

The target demographic for this paper are professionals in the agricultural sector like farmers, consultancy agencies and large corporations making technology for this sector. Former knowledge about UML, Embedded systems, Programming in an OO-langue and the term “IoT” should be known before reading this document.

Terms, acronyms and abbreviations

Because the CAFCR model states that you should avoid using too many definitions or abbreviations there is no need to make a separate section for each one. All the following can be put underneath the same section.

Name	Explanation
MT	Acronym for the word Module Template, which is the frame where submodules are attached to.
MFC	Acronym for the work Mainframe computer, which is the main computer that handles all the data coming in from the MT with submodules and uses the data for extensive calculation which are in turn then shown on the user interface.
MCU	Acronym for the word Micro Controller Unit, which is a computer on a single chip
Mechanical Manual Labour	In the context of this document I define this as manual labour with the use of mechanical machines or vehicles which still require a human to operate it.

TABLE OF CONTENTS

1: INTRODUCTION

Lucidy is company which specializes in the development of complex IoT systems, embedded systems, computer vision, game technology, AI or other customized IT systems in the field of agriculture and finance. Soilar is the first modular precision farming system for the soil and air where the functionality can be expanded with sub-modules and personalized responses that occur with pre-set preconditions. This product is perfect for local or larger farmers in an dynamic environment which want to expand or change desired functionality quickly without having to require extensive software/hardware development knowledge.

To best describe the system, I choice to work along the CAFCR model[1] with the help of field, desk and theoretical research. I also contacted a bunch of professionals in the field of Agriculture and Horticulture and interviewed some local and larger farmers in the Netherlands (see the research paper Introduction). I will not be working along the traditional 4+1 Architectural Design principle[2] due to the layered complexity of the systems which makes it impossible to generalize the entire system in a few components. In chapter 4, I will go through what method I will be using.

1.1: CONCEPT OVERVIEW

Soilar consist of five parts:

1. Module Template (MT): This is the base frame where all the submodules get attached to. It its battery powered with a solar panel and wind turbine, but an external power source can be attached to the top. The MT can have submodules placed underneath the ground or above it through an extension pole. The farmer will place multiple of these devices in the ground throughout his farm.
2. Submodules attached to the MT: These submodules can contain sensors, actuators, added power or anything else that is required to provide some added functionality. For example a submodule have the functionality to measure the soil pH using different sensors and actuators or a submodules can do something simple as adding more power storage to the MT. So in that sense anything that provides some kind of added functionality to the MT can be considered a submodule.
3. Mainframe computer (MFC): The main computer that handles all the data coming in from the MT with submodules and uses the data for extensive calculation which are in turn then shown on the user interface. This ensures that the MT with submodules can be barebones are reduces the stress and energy consumption on these two devices. This computer is also modular as it processing power can be expanded with attachable blocks named GridNodes. Each GridNode can support x amounts of sensors, camera's, submodules used by all of the MT's.
4. User interface: In the user interface the user can see all the MT pinned in a map of the farm. By simply tapping on a MT pinned in the map, you can see a more detail overview of all the different submodules present in that particular MT and their indicator stats. It also possible to see global overview of the different kinds of measurements made in the field like temperature, pH, moisture, etc. So for instance the user can select to preview a temperature map which will show a map with the different temperatures measured by all the MT by location.
5. Online platform: Here the user can buy MT's submodules, software, parts from the store. Customers can also post projects the need help with where special clients (freelancers, consultancies) can react on by paying us a fee.

In chapters 2.4 and 6 you can see a more detailed explanation of the system.

2: ARCHITECTURE OVERVIEW

2.1: ARCHITECTURE DRIVERS

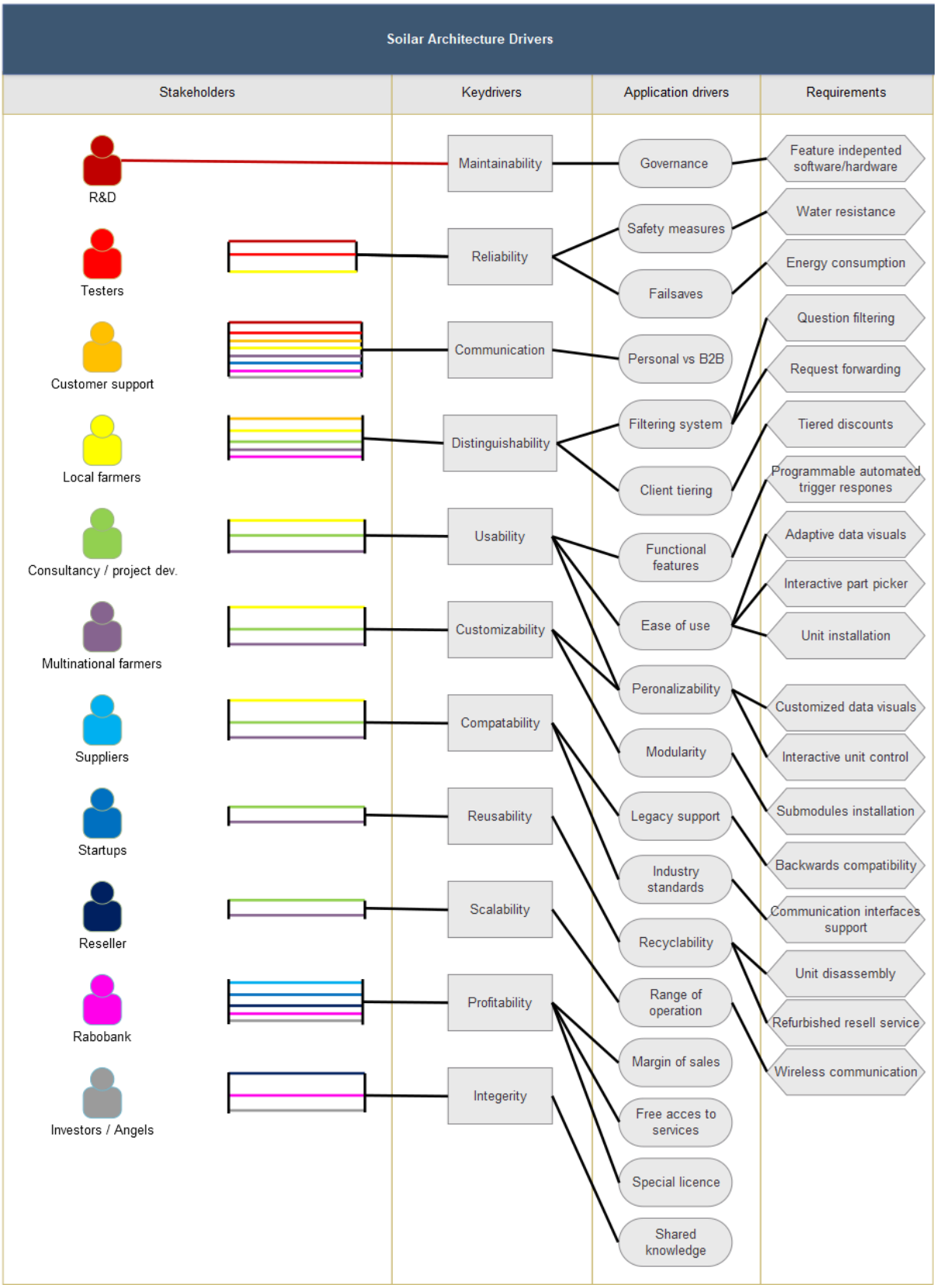

Figure 1: Architecture Drivers

2.2: STAKEHOLDERS

We define a stakeholder as a group or individual person which influences the system directly or indirectly. To best classify these stakeholders, we use the stakeholder onion diagram to separate each stakeholder per layer. These being:

1. System layer: This layer contains all the stakeholder who control and develop the system
2. Containing layer: This layer represent the users of the system outside the organization which directly can make changes to the system in the form of feedback.
3. Wider environment layer: This layer shows the stakeholders outside of the organization. People that invest money, supply assets or help with administrative tasks. These stakeholders can make indirect changes to the system by providing services.

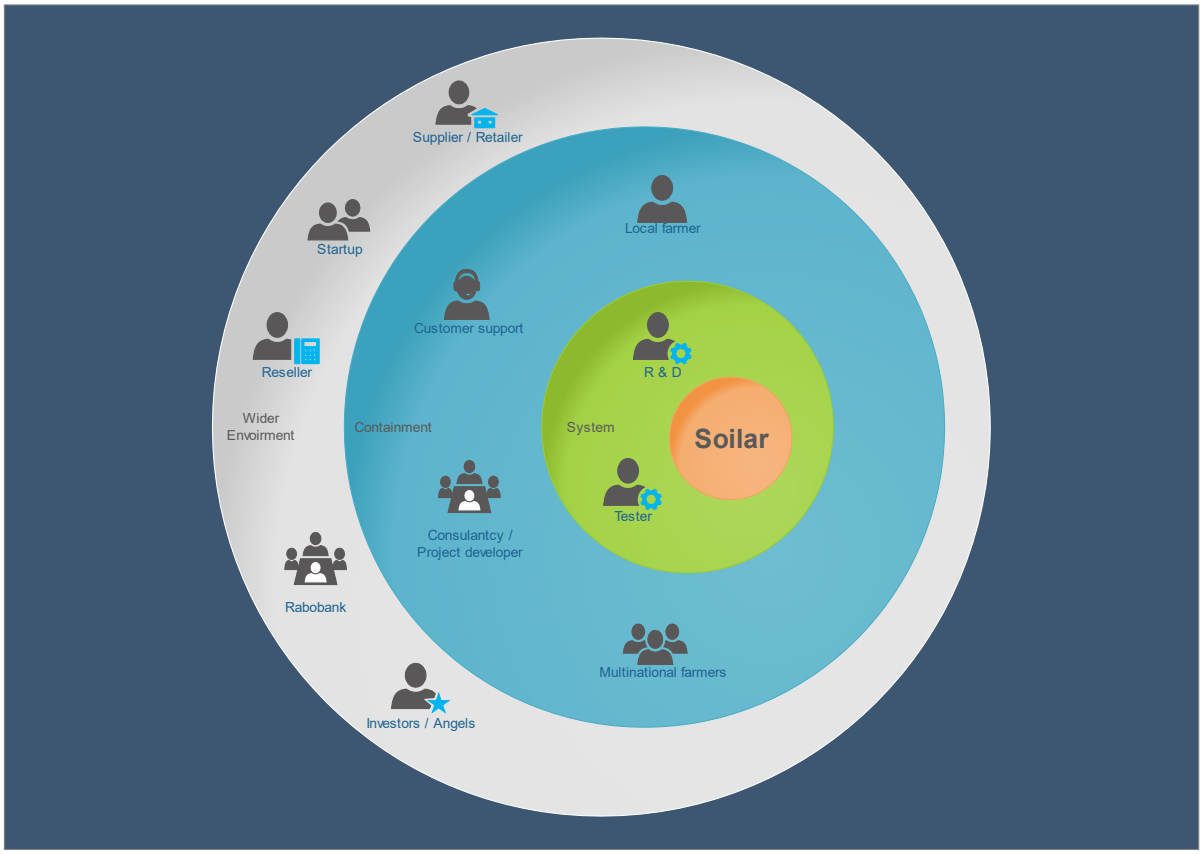

Figure 2: Stakeholder analysis using the Onion model

2.2.1: STAKEHOLDER INVOLVEMENT

All the stakeholders for each layer are further categorized by label, these being:

Label	Color
Customers	
Organisation	
Investors	
External parties	

Stakeholder	Involvement
R&D	They are responsible for directly adding and finding features to the system, developing the system as a whole and maintaining everything used by the system like IT, hosting, software, hardware, etc.
Testers	These people get early access to the software, hardware and new parts of the system to test and give feedback so the system can be improved. These testers can be separated between: - Technical testers: Testing hardware/software specific parts of the system - Usability testers: Testing how user friendly and functionally usable the system is.
Local farmers	These are a group of small clients which buy our products. They only have small farm area around 100-300 ha2 in the Netherlands and do not buy products in a regular pattern. They rarely ask for new features but have a lot of questions.
Customer support	This branch of the company handles all the questions and request asked by the customers online or through the phone. They also forward requests and issues directly to R&D if they are too technical.
Consultancy and project developers	These are the 2nd largest customers which buy our products. They buy allot in bulk but do this irregular (whenever they have a new project). This stakeholder can use our products for their own projects and ask for new features.
Multinational farmers	These are our largest customers and are most times comprised of larger companies running them in the background. They buy allot of product regularly and are constantly requesting new features.
Suppliers / Retailers	These are the big companies which supply us with parts, materials, hardware, software and other things needed to release the system.
Start-ups	These are smaller companies which develop new submodules or software which can be used with our system. They can advertise their product on our platform and we get a margin of their sales.
Reseller	This is an external firm with handles the logistics with the belonging financial aspects of the products sold. Things like storage, distribution, stock logging, sales, etc.
Rabobank	Invest money for R&D, provides marketing and promotion with their existing clients. Has no equity, but it allowed to use our system at a large discount for their own clients.
Investors / Angels	Invest money in the company it self and have some equity.

2.3: CONCERNS

Because each type of stakeholder has a different importance to the system a scale from 1 to 5 will be used to identify how much influence or impact the stakeholder has overall. Where 1 means no impact at all and 5 means they are very important for the system overall. We will also mention what their concerns and desires are within the system directly or indirectly. This based on the field, desk, theoretical research and the interviews.

Stakeholder	Concerns	Rating
R&D	- Scalability on a hardware perspective. - Scalability on a software perspective. - Cheap to produce.	5
Testers	- Simple way to perform unit, hardware, accuracy and functionality tests. - Results be logged and send automatically to R&D. - Test units and required tools are free.	4
Local farmers	- Able to buy a trial unit for a period of 1 month to see if it works correctly. - Having cheaper price options which can be expanded in the future. - Simple and interactive way to know how much units are necessary for the plot of land and what submodules are needed for specific plant types. - Get discounts when buying spare parts or when being a loyal customer. - Simple user interface that can work on the PC and or tablet. - At least 5 year warranty on software failure.	3
Customer support	- Having a direct communication line between R&D. - Having an easy CRM packet.	2
Consultancies and project developers	- Being able to buy products in bulk with a discount. - Having a licence to the software/hardware. - Being able to add personal submodules to the system. - Being able to rebrand product. - B2B communication about new feature requests. - Good QA and product quality - Expandable and customizable warranty program	4
Multinational farmers	- Being able to buy products in bulk with a discount. - Tiered discount program (the more you buy, the less you pay) like AliExpress. - B2C or Personal communication about new feature requests - Good QA and product quality - Expandable and customizable warranty program - Easy refund program - Good privacy regulations and integrity of data collected	5
Suppliers / Retailers	- Minimum order of parts	3
Start-ups	- Customized product page to advertise their product on our platform. - Easy communication tools with their own clients through our platform. - Having to pay a small commission (max 10%). - Having a licence to the software/hardware. - Being able to add personal submodules to the system. - B2B communication about new feature requests. - Not being tied to a contract with us. - Access to our suppliers and retailers to buy parts at a discount.	3
Reseller	- B2B communication with R&D. - Access to our financial numbers.	3
Rabobank	- Personal communication with R&D. - Access to our financial numbers. - Being able to buy products with a large discount. - Having a licence to the software/hardware. - Their personal clients get unlimited access to the platform and receive new features first.	5
Investors / Angels	- Personal communication with R&D. - Access to our financial numbers. - Have some equity of at least 12%.	3

2.4: SYSTEM CONTEXT

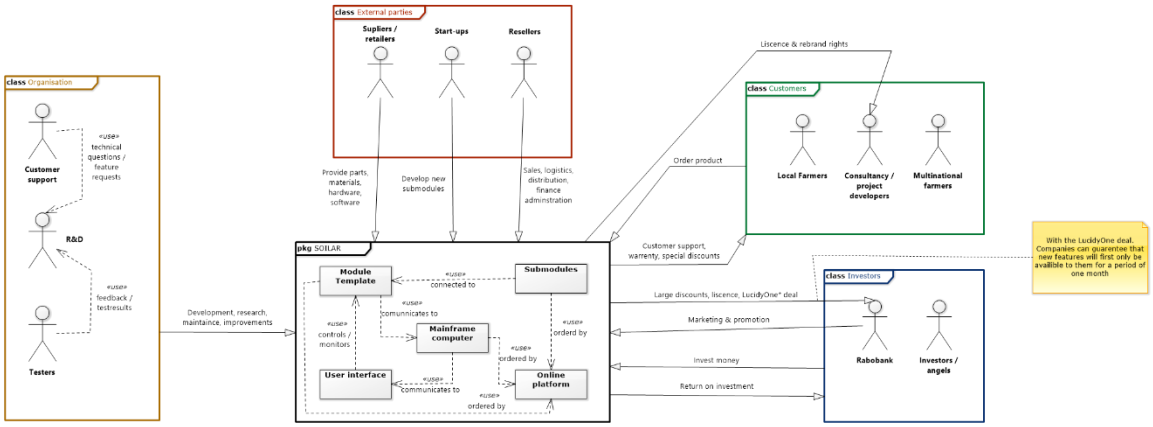

Figure 3: System context of Soilar

The system works in a closed loop, where suppliers provide parts and manage the product sold, the investors help with building the brand and get compensated for it, the organisation (Lucidy) developing and maintaining the system en the customers making this all possible by buying products.

Some customer expect extensive customer support where they can ask detailed technical questions. These kind of question should be directly forwarded to the R&D team through the customer support service. Testers should also have a direct contact to the R&D team to ensure new changes an bug fixed can be implemented quickly.

Suppliers can either provide parts or help sell products (MT, submodules, etc). These product are sold through the online platform. The customer can control and configure the products though the user interface. This is a simple tablet device with an application on top of it, which can also be separately installed on other devices.

Investors ensure that the system has enough funds to operate and there is enough stock to sell. They get a direct return on their investment and the special investor Rabobank also gets additional benefits.

The whole system is designed in such a way that each stakeholder get exactly what they need, but at the same time they all provide each other needs indirectly through Soilar.

3: ARCHITECTURE REQUIREMENTS

Due to the complexity of the system, all requirements will be separated into the following categories:

- Product requirements: These are requirements based on the MT and submodules, which specifies how the core product should work overall.
- User requirements: The are requirements based on the user interface and online platform, which specify how user interaction with the system needs to be handled.
- Relationship requirements: The are requirements based on how the communication with customer, suppliers, investors and all other external parties should be handled.

For the business priority we will use the MSCoW[3] models and for the QC we will use ISO25010[4]

3.1: FUNCTIONAL REQUIREMENTS

3.1.1: PRODUCT REQUIREMENTS

Name	Unit installation
Description	The MT with submodules needs to be installed in the ground with the help of automated devices (mechanical manual labour) like vehicles or UAV's (Unmanned Arial Vehicle).
ID	pr_install_01
Rationale	From researches estimates, there can be 5-10 MT's placed for each ha2. This means the average farmers would need to place hundreds of these devices on the field. This can be very time consuming for some, so the casing should allow it to be installed in an automated process.
Business Priority	M

Name	Submodules installation
Description	Submodules need to be clicked in the MT by hand with a sliding mechanism without on screws and complex tools.
ID	pr_install_02
Rationale	The average farmer has mentioned that they are annoyed on the different kind of screws and bolt used to secure their existing system, which means they have to carry a large toolbox with different types of screwdrivers to install or uninstall parts. Another issue is that most screws and bolt are corrosion sensitive.
Business Priority	C

Name	Unit disassembly
Description	Disassembling the MT with submodules should be a twostep unscrew and unplug process to ensure new replacement parts can be installed easily.
ID	pr_uninstall_01
Rationale	On modern precision farming systems it is almost impossible to replace parts or disable the different units with the way they are designed. This means farmers had to replace their entire system in stead of a single part with their existing systems.
Business Priority	S

Name	Backwards compatibility
Description	The submodules plugged in the MT need to be backwards compatible with new revisions of the MT by the help of physical adapter or brackets that can installed on the submodules.
ID	pr_install_03
Rationale	The last pains farmers had with their existing systems was that they would become obsolete too quickly by the introduction with new technologies, which makes their initial investment not worth it.
Business Priority	M

3.1.2: USER REQUIREMENTS

Name	Interactive part picker
Description	The online platform needs to have and interactive tool where customers can indicate the amount land they have alongside with its shape, type and what crops they are using for specific zones of land. This tool should then graphically show in a map they amount of MT's they need, how it should be laid down for optimal spread and what submodules each MT's should have
ID	ur_advice_01
Rationale	From the interviews it can be noted that many farmers are unaware what different technologies can benefit the production of certain crops within their farmland. Many also don't know it can be best laid down for optimal range spread.
Business Priority	S

Name	Interactive unit control
Description	The user needs be able to select individual MT's through a graphical map interface where the MT's are pinned. Clicking on the pin will bring up a second interface where the user can change settings of the entire MT or submodules individually and turn these off/on individually or all at once.
ID	ur_control_01
Rationale	In the interviews farmers indicated that one of the biggest reasons they don't want to buy smart farming solution is because it limited their ability to change crops per season. For instance there are times they don't use plot of land or don't need to measure specific parameters in the soil for a type of crop. From their experience with other farmers they heard it can become very tedious to manually turn off/on or remove specific units in their farm by hand and having this flexibility with each MT and submodule is really desired.
Business Priority	M

Name	Adaptive data visuals
Description	The user needs be able to see a graphical visualisation of the data collected by all the MT's with attached submodules in the form of maps, graphs, grids, tables and be able to get detailed data from a zones or specific MT with submodules.
ID	ur_visual_01
Rationale	With the quantity and wide set of different data collected by the MT's with attacked submodules it can become disorienting to look at the data in the form of pure numbers. Therefor a more human readable visualization helps best to give good indication about the status of a certain parameters of the entire farm or specific zone of the farm.
Business Priority	M

Name	Customized data visuals
Description	The user needs be able to create his own data visuals within the user interface based on personals formulas or code that can take multiple parameters (which are measured by the MT's) into account.
ID	ur_control_02
Rationale	Although many farmers rarely use more complex visualizations than what will be available by default, some farmers want to mix and match parameters with custom algorithms to give more detailed feedback. For instance a farmer could make a custom "soil erosion" map that uses the measured pH values and NH4+ with an algorithm to determine what zone is more susceptible to soil erosion.
Business Priority	S

Name	Programmable automated trigger response
Description	The user needs be able add personalized triggers for custom or predefined conditions for different zones in the users farm. These triggers should then execute a personalised set of predefined instruction or custom code.
ID	ur_control_03
Rationale	There is a trend in smart farming or precision farming IT systems, where allot of useful data is collected, but there is no way to easily configure the system to react upon certain conditions. For example with the current systems the farmer would not be able to water its crops if the sensor pick up soil drought, which means he has to manually engage his watering system which defeats the whole purpose of the sensors in the first place. Therefore as a gain creator we noticed that we have to include a way to execute a custom task whenever a trigger is activated. An example would be: "Whenever the pH level of Zone A1 (part of land reserved for potato's) is below 4.5 and the moisture level is less than 100mol/g activate the watering system.". - Activating this watering system can differ per brand or application method, which means the user has to add some custom code that activates set watering system. Doing this ensure the system is more than just a gimmick and can be used for deeply customizable automated process which can differ per farmer.
Business Priority	M

3.1.3: RELATIONSCHIP REQUIREMENTS

Name	Question filtering
Description	The system needs to filter non-technical from technical questions to ensure only the non-technical questions are handled by customer support
ID	rr_filter_01
Rationale	To reduce the stress of the R&D team, it is important that only valid technical question about the MT, MFC and submodules will need to be answered by the R&D team. All other trivial non-technical question like legal questions, questions about the different services or how the user interface works can be handles by customer support.
Business Priority	S

Name	Request forwarding
Description	The system needs to follow a strict protocol regarding request for feature updates, bug fixes or other general requests to change the system by the different stakeholders. This protocol should help by ensuring the most important requests (based on the type of stakeholder) will have priority.
ID	rr_filter_02
Rationale	Allot of stakeholder have different types of requests. This can range from anything like adding new feature or submodules, reducing prices or fixing bugs. The priority is given by how important the stakeholder is (see Curry model) and how important the request is. For example a bugfix request from a less important stakeholder can have a larger priority than one from a important stakeholder, if the side-effects of the bug are more severe.
Business Priority	M

Name	Tiered discounts
Description	The customer needs to get different amount of discounts based on their tier to encourage them to buy more.
ID	rr_filter_03
Rationale	There are different types of customer who buy product from the online platform. Some buy in bulk un-periodically, whilst other buy small amounts of product periodically. This means there should be given different amount of discount to different kinds of clients. For example a large farmer would be more interested in yearly discounts when he buys in bulk, than having a large discount just once.
Business Priority	S

Name	Refurbished resell service
Description	Customers need to be able to sell their old submodules and parts for a reduces amount on the online platform, so these can be bought by another customer at a discount.
ID	rr_recycle_03
Rationale	According to our research ecologic recycling is big trend in the agricultural sector. Following the guidance of the Doughnut economic model one of the quadrants the system could easily tap into is reducing the amounts of chemical pollution needed to produce set submodules and parts. By allowing an open marketplace where customers can sell their unused products easily we directly contribute to this economic model. Following trends can also provide positive PR for the company.
Business Priority	C

3.2: NON FUNCTIONAL REQUIREMENTS

3.2.1: PRODUCT REQUIREMENTS

Name	Energy consumption
Description	The MT with submodules needs to be efficient enough to be powered by a small solar panel and wind turbine which needs to also research an internal battery.
ID	pr_power_01
Rationale	The average farmers has about 100-300 ha2 of land. This means having to run wires directly under or above the ground will be too expensive. To ensure the MT with submodules can operate properly a low powered MCU has to be used. The solar panel and wind turbine needs to provide enough power to charge the internal battery and the internal battery needs to have enough capacity to allow the MT to work completely on it reserves when charge can be given for a long time.
Business Priority	M
Quality characteristics	[Capacity -> Ensuring its operational] Indicator 1: Minimum time the MT with crucial submodules needs to be operational on only battery power Measurement requirement: Asking customers Norm: Minimum of 24 hours Indicator 2: Minimum power needed to provide the MT with crucial submodules Measurement requirement: Measuring the maximum load the MT with crucial submodules can have in Watts. Norm: Minimum of 10Wh needed with a constant 5V throughput Indicator 3: Minimum power needed to provide the MT with all submodules Measurement requirement: Measuring the maximum load the MT with power hungry submodules can have in Watts. Norm: Minimum of 50Wh needed with a constant 12V throughput Indicator 4: Minimum storage capacity needed by internal battery for MT with crucial submodules. Measurement requirement: Measuring how much Ah battery capacity are needed for 240Wh (consumption x minimum uptime) of usage by the MT and system Norm: Minimum of 20Ah of battery capacity needed.

Name	Wireless communication
Description	The MT with submodules needs to able to communicate full duplex with the MFC wirelessly on large open spaces and small indoor spaces.
ID	pr_communication_01
Rationale	In pr_power_01 I mentioned pure wired communication is too expensive and undesired by farmers. Lots of data needs to be transmitted to the MFC and the MT's with submodules can be used indoors (glass house) or outdoor (farm land).
Business Priority	M
Quality characteristics	[Install ability -> Making it suited for different environments] Indicator 1: Minimum distance MT and MFC need to operate outdoors Measurement requirement: Looking at the average ha2 local farmers have Norm: range between root(100)ha … root(300)ha = (1000 … 1732)m Indicator 2: Maximum distance MT and MFC need to operate outdoors Measurement requirement: Looking at the average ha2 largest farmers have Norm: range between root(2000)ha … root(5000)ha = (4472 … 7071)m

Name	Communication interfaces support
Description	The MCU used in the MT needs to support multiple communication interfaces (like i2c, spi, uart) to support a multitude analogue and digital hardware used by the submodules.
ID	pr_communication_02
Rationale	From the theoretical research it was noted that there allot of different aspect of the soil and air that need to be measured by different sensors. These all use a different communication interface which the MCU in the MT needs to support to be truly classified as fully modular and compatible with smart farming devices.
Business Priority	M
Quality characteristics	[Adaptability -> Ensuring all kinds of hardware is supported] Indicator 1: How many different interfaces the MCU in the MT needs to support Measurement requirement: Listing all known sensors, cameras, hardware used in smart farming solutions. Norm: Needed to support: - BNC/US/DIN/S7 connector - Analogue interface, Digital interface - 3-pin Molex KK (Tx3 Connecting interface) - SPI, I2C, CSI, UART (UCHAR) - SDI-12, M12, PXS4XX, RS-485 - Modbus, CAN Bus

Name	Water resistance
Description	The MT with submodules needs to be water resistant enough to survive periodic rainfall.
ID	pr_safety_01
Rationale	The MT with submodules will be installed deep in the ground and can be exposed to the outdoors environment. Here the device will be exposed to the climate where is can rain. Water from rainfall can also travel through the soil, so extreme water resistance is important
Business Priority	M
Quality characteristics	[Environmental Risk Mitigation -> Ensuring its operational] Indicator 1: What IP rating is needed to ensure the system is operational inside the soil 2m deep with differential temperatures. Measurement requirement: Looking at all already available smart farming systems and combining these requirements with what clients wanted Norm: IP58W (Dust protected, water resistance up to 3m and temperature cycling)

3.3: CONSTRAINTS

To ensure the system as a whole is operational, there a couple of constraints that need to be followed based on the requirements.

Requirement id	Constraint
pr_install_01	The automated install process must only take 10 minutes for each ha2.
pr_install_02	The airgap between the submodules and the sliding mechanism needs to be smaller than 1 mm.
pr_uninstall_01	Only one type of screws must be used, these being 4-40 screws.
pr_install_03	Older submodules must be backwards compatible with newer MT's for at least 5 years.
ur_advice_01	The user must be able to change or remove recommended from the list with less than 2 clicks.
ur_control_01	The user must be able to access the submodules specific page in less than 3 clicks.
ur_visual_01	The user must be able to choice between at least 4 different visualizations.
ur_control_02	The user must be able to include custom formulas in the form of Latex, MATLAB, Python and R.
ur_control_03	- There must at least 4 predefines conditions present to choose. - The user must be able to upload custom C++ and python code as a response. - The user must be able to program with Soilar supported devices in a graphical flowchart interface.
rr_filter_01	- The time between receiving a question and a the filter forwarding it to the right person must not take longer than 15 minutes.
rr_filter_02	- The time between receiving a request and a the protocol forwarding it to the right priority must not take longer than 30 minutes.
rr_filter_03	- Discounts must automatically adjust based on prices from competitors in real time. - Discounts must never be larger than the allowed cap for each product.
rr_recycle_03	- The resell price of a product must be calculated based on its age, condition and type. - Users must directly receive payment in the form of a discount for the web shop when the products have arrived. - The time between the user submitting refurbished and Lucidy receiving it must be less than 1 week locally and 1 month internationally.

pr_power_01	- The user must be able to see the total power draw of a MT with submodules in the user interface. - The user must be able to see an estimate of the total power draw of a MT with submodules when buying it from the online platform. - The user must be able to add additional power sources or battery storage systems in the form of submodules.
pr_communication_01	- The MT's must communicate through an hive network to increase range of they system. - The users must be able to choice its preferred long range communication protocol out of a selection of at least 4 options.
pr_communication_02	- The MT's MCU must have at least 10 free digital and 5 analogue pins that are not used to ensure the user can add its own connector.
pr_safety_01	- The user must be able to design a better water resistant MT and submodules casing if that is desired.

3.4: USE CASE DIAGRAM

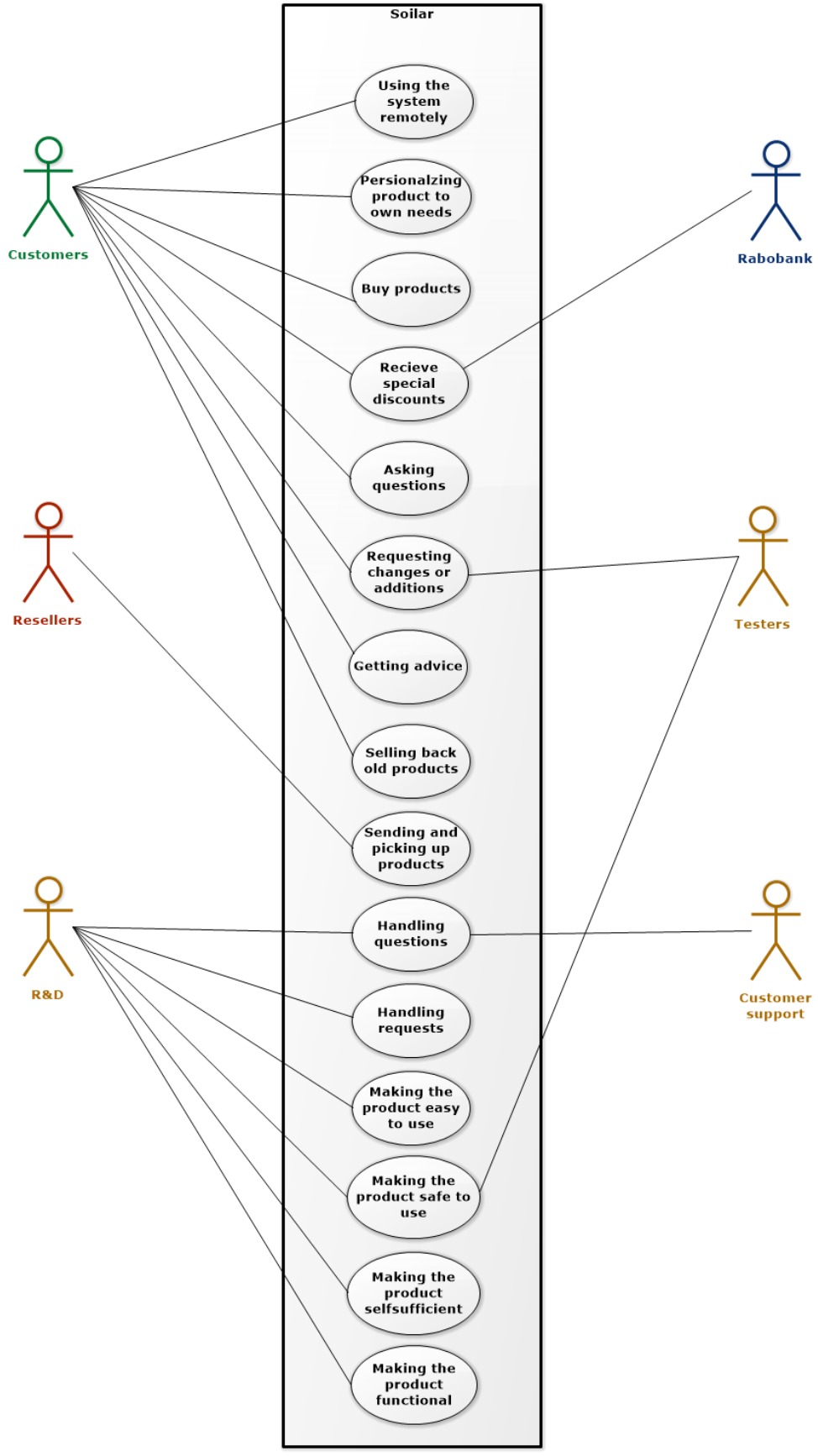

Figure 4: Use case diagram of Soilar

3.4.1: ACTORS

Name	Purpose
Customer	Combination of the three types of clients (local farmers, consultancies and multinational farmers). This actor will physically use products of Soilar and provide income, which means the use cases of the system should benefit him.
Resellers	Resellers are mainly responsible for the logistics and distribution within Soilar. They must ensure products arrive to the customers and handle the resell service.
R&D	These are the founders of Soilar and are responsible for implementing new features, fixing bugs, doing research and answering technical questions.
Rabobank	Large investor in Soilar, which helps with the marketing and promotion. Rabobank will receive special discounts for their own clients buying products from Soilar.
Testers	These are on of the most important actors within the system. Testers are responsible for finding new bugs, requesting changes based on user experience or pointing out structural flaws with the design of products.
Customer support	External firm with handles questions and requests of customers through the online platform, telephone or email. They are the direct bridge between the customers and R&D team. Any non-technical question/request can be handled by themselves, but more technical ones will be forwarded to the R&D team. This ensures the R&D team knows that the customers need to know, want to see implemented or are struggling with.

3.4.2: USE CASES

Using the system remotely	
Description	Accessing features from, controlling and monitoring the MT with submodules remotely using an device (Remote display with UI).
Purpose	Ensuring ease of use for the customer

Personalizing product to own needs	
Description	Ability to change and customize certain aspects of the system. This can be hardware or software based.
Purpose	Ensuring customer is satisfied and able to personalize the system for its desire.

Buy products	
Description	Ability for the customer to buy products on the online platform.
Purpose	Ensuring system is profitable.

Receive special discounts	
Description	Each customer will obtain different discounts based on its tier and the amount of products bought.
Purpose	Ensuring the customer can be easily separated in classes so only attractive discount for the customer will be available to him/her.

Asking questions	
Description	The ability of users to answer questions about the products sold or other parts of the system on the online platform.
Purpose	If there is no easy way to answer questions, customer may look elsewhere.

Requesting changes or additions	
Description	The ability of the system to handle and separate requests and forwarding this to the right person.
Purpose	Ensuring new desired functionality or changes are implemented quickly to reduce the chance of customers going elsewhere.

Getting Advice	
Description	Customers should be getting advices before making a purchase so they know what they need and get realtime advice/insight about the condition of their farm in such a way that it is easy to understand.
Purpose	Ensuring customers know what they need and get the feeling the system is helping them in a positive way.

Selling back old products	
Description	Customers are able to resell their second hand parts/submodules from Soilar if they want to use better parts. These parts can then be resold as refurbished on the online platform.
Purpose	Ensuring farmers are not stuck with just their old parts/submodules and can upgrade for a small fee in the future.

Sending and picking up products	
Description	The ability of Soilar to handle the logistics and distribution of products bought though the online platform within predefined timeframes and deadlines.
Purpose	Ensuring customer will receive their products on time without any complications.

Handling question	
Description	The ability of the system to separate technical and non-technical questions so the right person can answer them.
Purpose	Ensuring only qualified people within the company will answer the right question.

Handling requests	
Description	The ability of the system to separate requests on priority so the most important requests are handled first.
Purpose	Ensuring important requests are handled, and to reduce the chance for customer to look elsewhere.

Making the product easy to use	
Description	The usability of the system for users and the ability to quickly change parts that need to be simplified.
Purpose	If the system becomes too complex for users the use, Soilar should be able to make changes quickly.

Making the product safe to use	
Description	The product sold by Soilar follow strict safety rules and resistance codes (like IP58W) to ensure they are operational in real life scenarios like windstorms, rainfall, etc.
Purpose	Ensuring the customer do not have to worry about their product breaking or being destroyed too quickly.

Making the product self-sufficient	
Description	The products allow for deep levels of automation, this means that you can just keep it running without human intervention. The products can also be run on the internal battery for a prolonged time if there is no way to recharge the units.
Purpose	Ensuring the customer is not forced to constantly monitor the system and can be assured the system will still be operational for a prolonged time if there is no energy source available for a moment.

Making the product functional	
Description	The ability for the customer to use the system for other used besides what is was designed to do (monitoring and measuring the soil/air) to combine it with its already present smart farming equipment.
Purpose	Ensuring the product become more than just a gimmick.

3.5: REQUIREMENT TRACABILITY

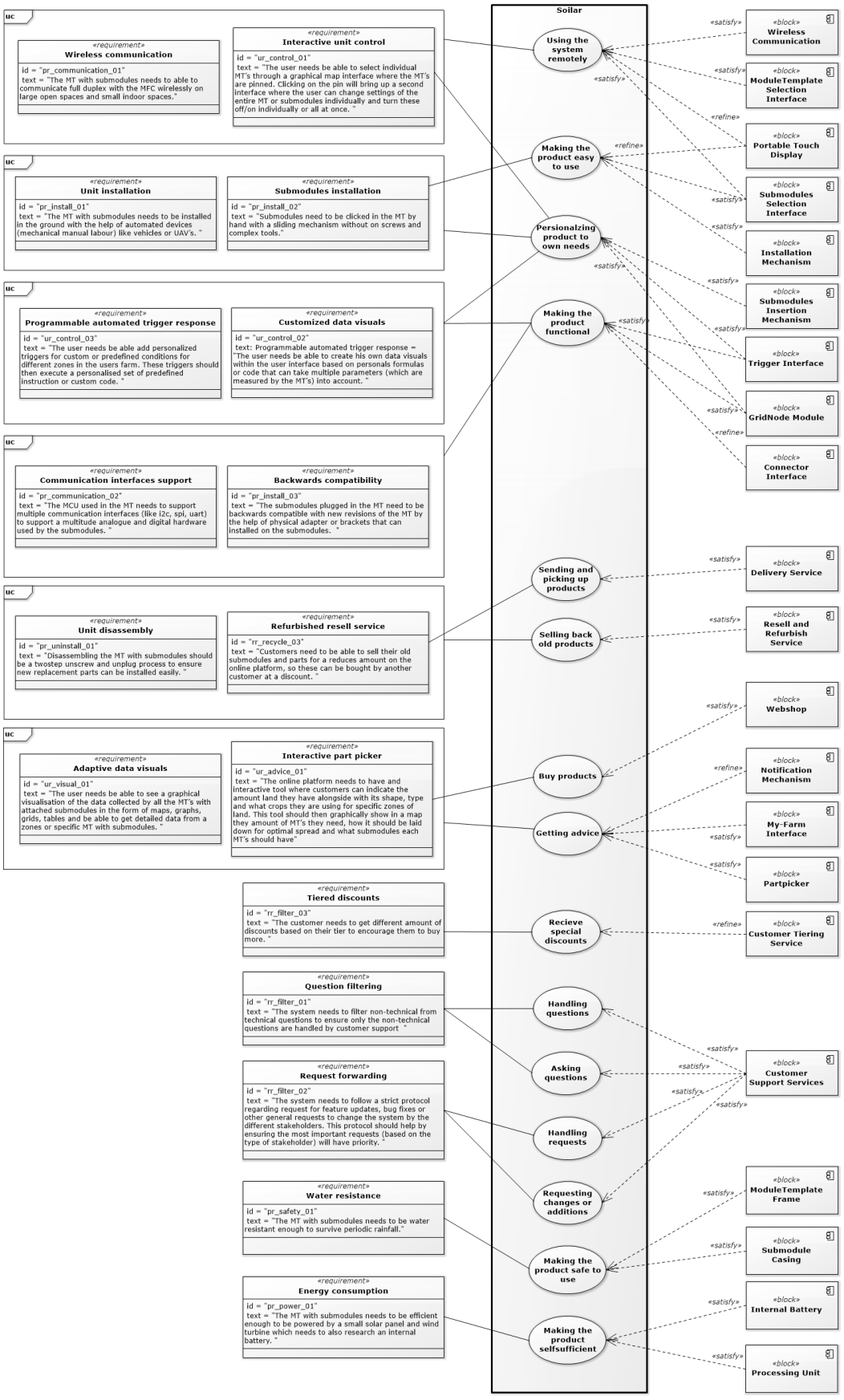

Figure 5: Tracability diagram

4: SYSTEM OVERVIEW

To best represent the logical view a nested functional decomposition diagram has been made. Here each "Block" describes a specific functionality of the system and double clicking on it will reveal the correct nested software, hardware, networking or other diagrams. This is only possible when the diagram[1] is opened with a program named "Software Ideas Modeler" [2]. I am currently using the latest version (11.96).

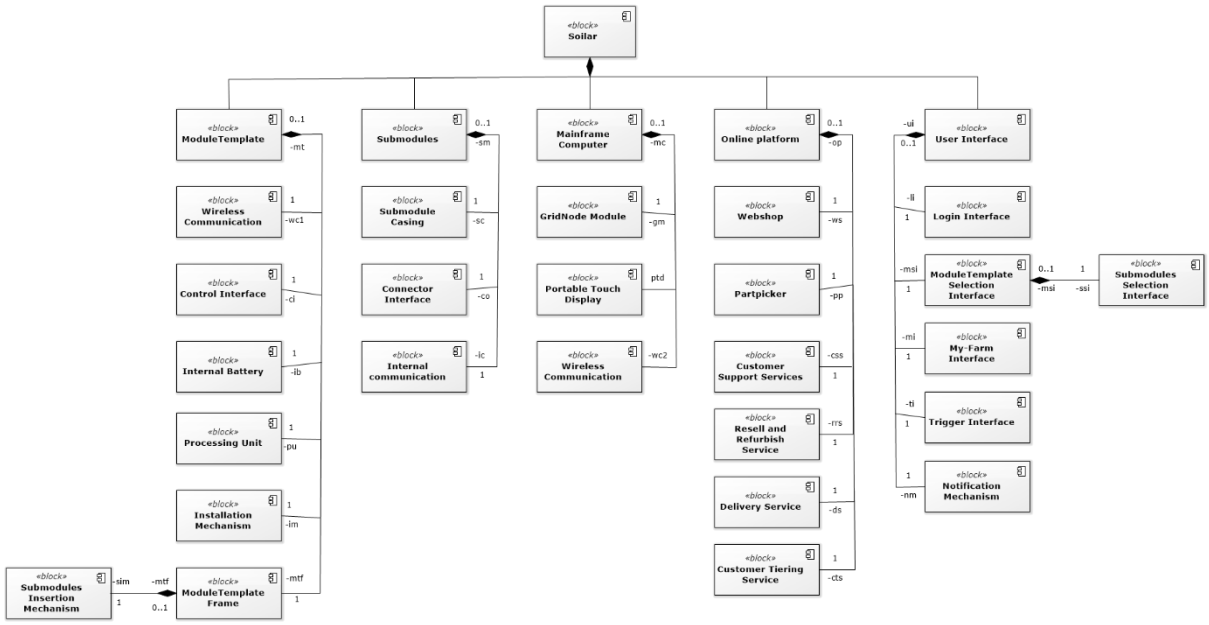

Figure 6: Functional decomposition

In the figure above you can see the version of the functional decomposition that has not been color-coded.

When opening the diagram in Software ideas Modeler, you might come across these kinds of blocks:

Here each color represent what kinds of nested diagrams are inside the block. These can be hardware software, networking or any other diagrams. Nested diagrams can be opened by either double clicking the entire block or clicking on the small arrow on top of it (see figure below).

The color code works as followed:

Code	Meaning
	Combination of all diagram types
	Hardware diagrams (Timing diagrams, Block diagrams, Electrical circuits, etc)
	Software diagrams (Class, State machine, Interaction, Object, Package diagrams, etc)
	Networking diagrams (Deployment diagrams, etc)
	Mechanical diagrams (3d/2d Designs, etc)

For this reason, the traditional 4+1 architectural design principle does not work due to the fact that each individual block can have networking, hardware, software diagrams layers inside them which are specific to themselves. I will however list how the 5 parts of the system communicate with each other in respect to the kind of users belonging to that specific part.

5: COMMUNICATION OVERVIEW

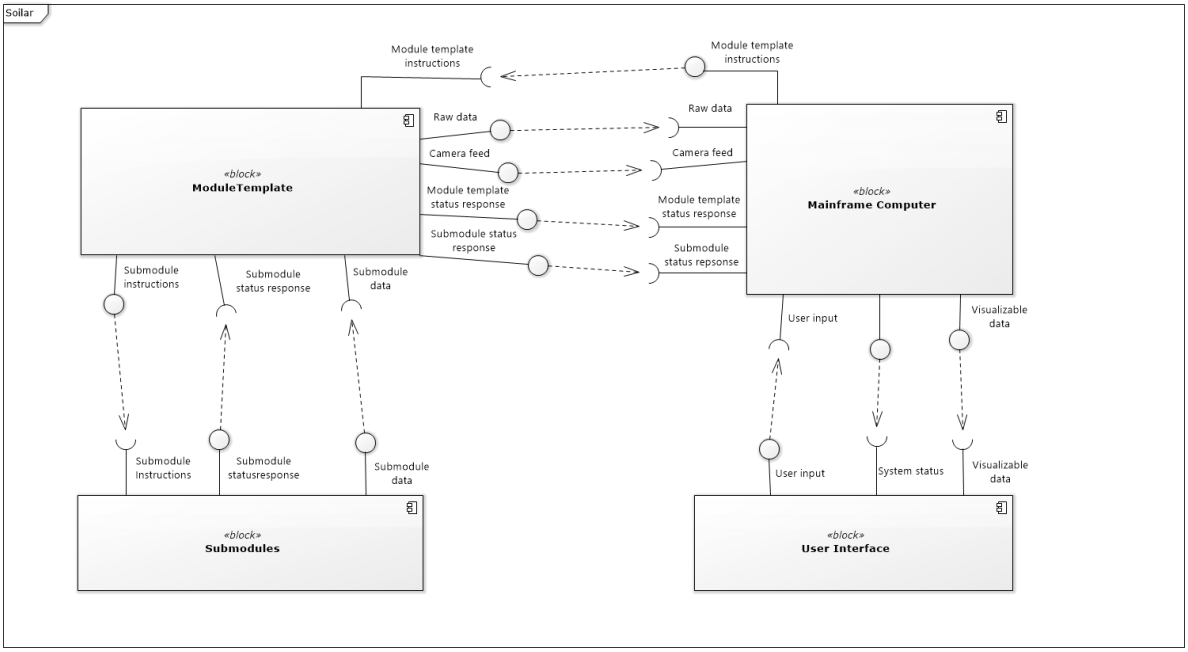

Figure 7: IDB communication diagram

There are only 4 parts (**MT, MFC, Submodules, User Interface**) in the system that directly communicate with each other as the online platform is only used to buy the system and for the other online customer services. Here you can see that most of the true data communication happens between the **MFC** and the **MT**.

The submodules can therefore be considered boundary objects which only perform a simple task (like measuring the soil pH) and send this data through a wired connection to the **MT**. A submodule can also give a *status response* to the **MT** which can be used by the **MFC** to send a *system status* to the **User Interface**

The **User Interface** simply gives commandos to the **MFC** in the form of *user input* which the **MFC** uses to determine what to send to the **User Interface**. This can be:

- *visualizable data*: data in a specific format which the **User Interface** can use to graphically portray measurements made by the system. For example, the **MFC** can send a JSON package which represent the soil temperature measured throughout the farm, which the user interface can then use to draw a graphical map.
- *system status*: the user is also able to change settings or see indicating statuses of an individual **MT** with **Submodules**. Through a *user input*, the **MFC** knows what to do and will request a *module template status response* or *submodule status response* from the selected **MT** with **Submodules**.

5.1: DATA TRANSMISSION

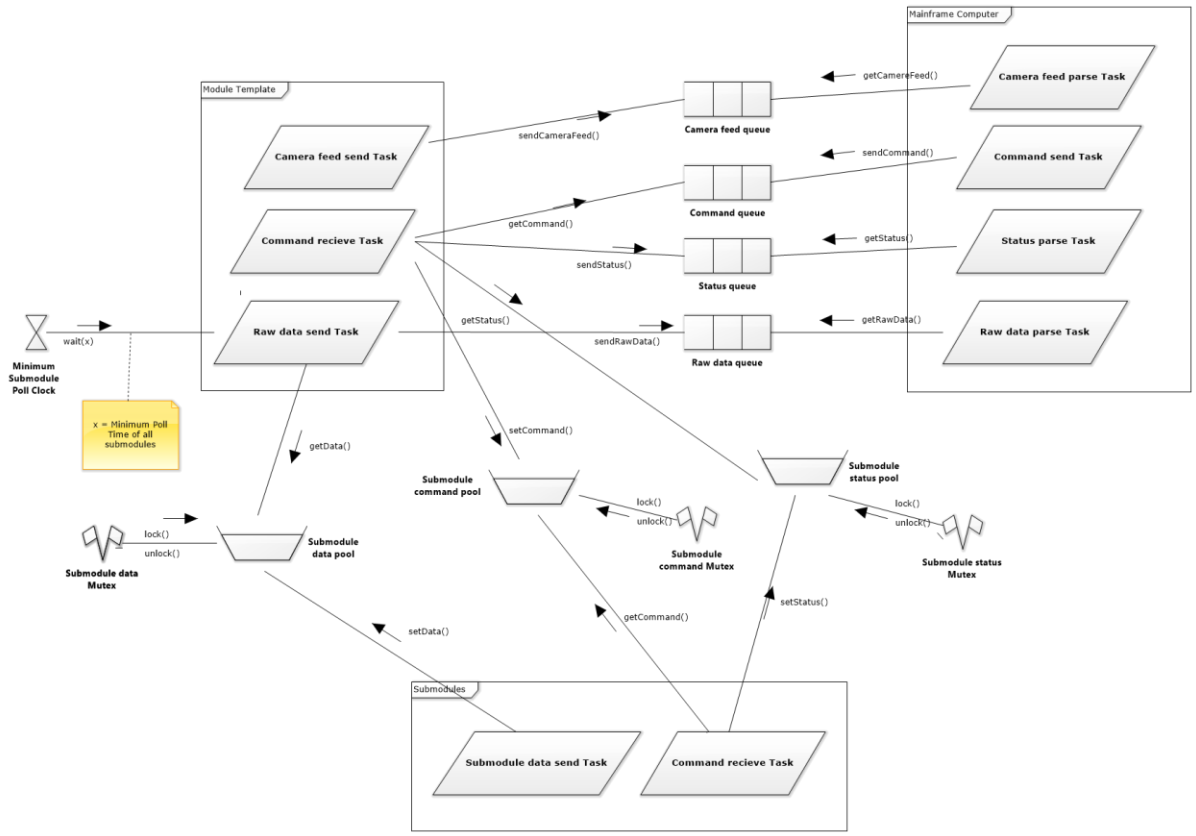

Figure 8: Concurrency diagram between system components

Both the MT and Submodules are waiting on instructions by the MFC to perform a specific task. But are in the same time sending raw data and a camera feed to the MFC. The MFC can send any regular command like “turn on, turn off, pause, resume” but can also send more complex commands like “give me the status of submodule A1” or “change the camera feed FPS to 21”.

If such a special command is sent by the MFC, the MT will determine if the command is concerned for itself (like changing the timers used, etc) or is about one of the Submodules connected to it (for example change sensitivity of sensor in submodule A1 to 80%).

- In reality the, Submodules used are just basic logic gates with some sensors attached and are not really able to process such commands through software. This all done by the MT and by setting some pins high or low which are connected by the IC’s used in the submodules.

5.3: WIRELESS MESH NETWORK & LORAWANN

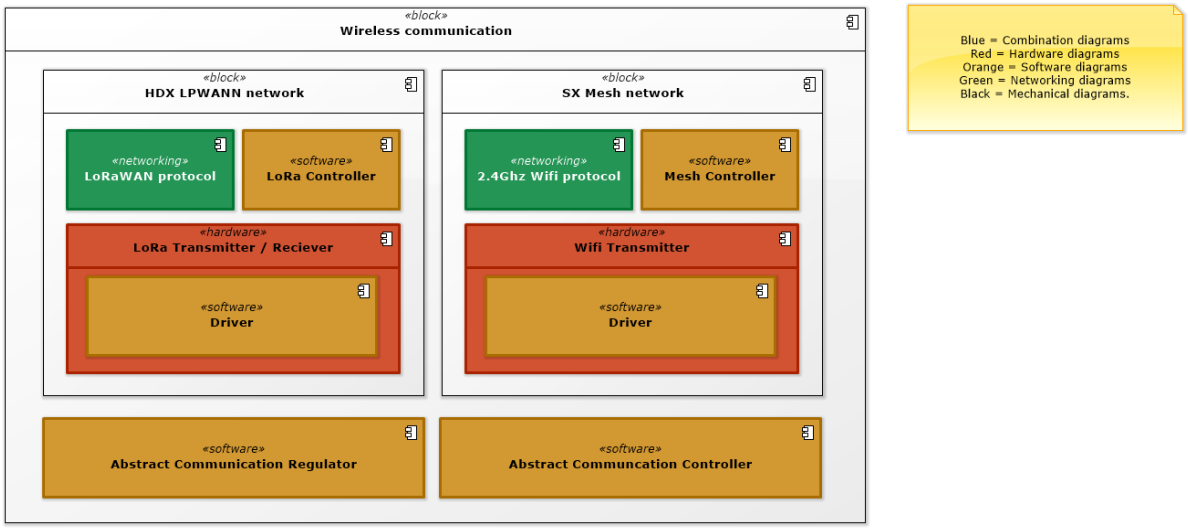

Figure 9: Overview Wireless communication subblock

There are two communication networks between the MT with submodules and the MFC. These being a low powered LoRaWAN based network and a high powered WIFI mesh network.

The first one can only communicate Half-Duplex (HDX) because its only used to send and receive commandos, system statuses and small data packets in the form of raw data from the submodules. So whenever a commands is send the raw data can be stored locally in cache until the execution of the command is done.

The second one can only communicate Simplex because it only needs to send large data-packets from the MT to the MFC at reliable speed. So, this communication network will only be used to send packages from A to B. This network is primarily used to send the camera feed to the MFC and to send any additional raw data from submodules which is too big for the first network.

Both communication networks work under the Abstract Communication Controller which simplifies the communication between the MFC and MT to simple “Send” “Receive” commands. This Controller also used the Abstract Communication Regulator to determine what network should be used for the specific data type, size and purpose.

5.4: INTERNAL COMMUNICATION BETWEEN MT AND SUBMODULES

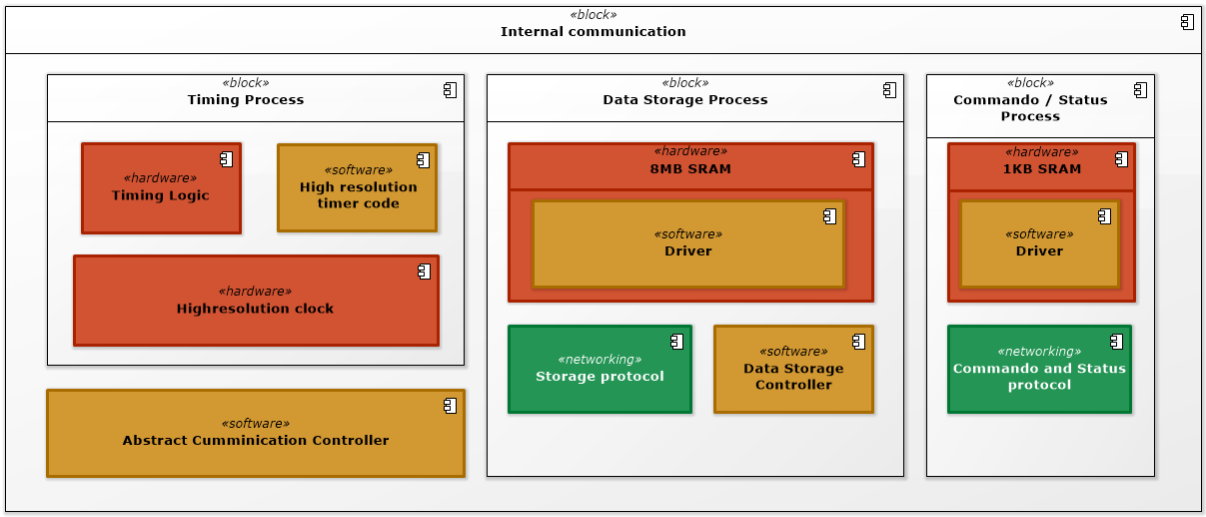

Figure 10: Overview Internal communication subblock

Internal communication between the MT and submodules happened through two small SRAM chips placed in the MT frame. Each submodule has a connector interface with a bunch of different analogue/digital/other types of pins where the hardware inside the submodule can connect to. Multiple submodules use the 8MB chip to store their measurements and this is handled by the *Data Storage Controller* where the MT can just read all the data at once. The 1KB chip is only used to store commands to the MT or statuses from the submodules

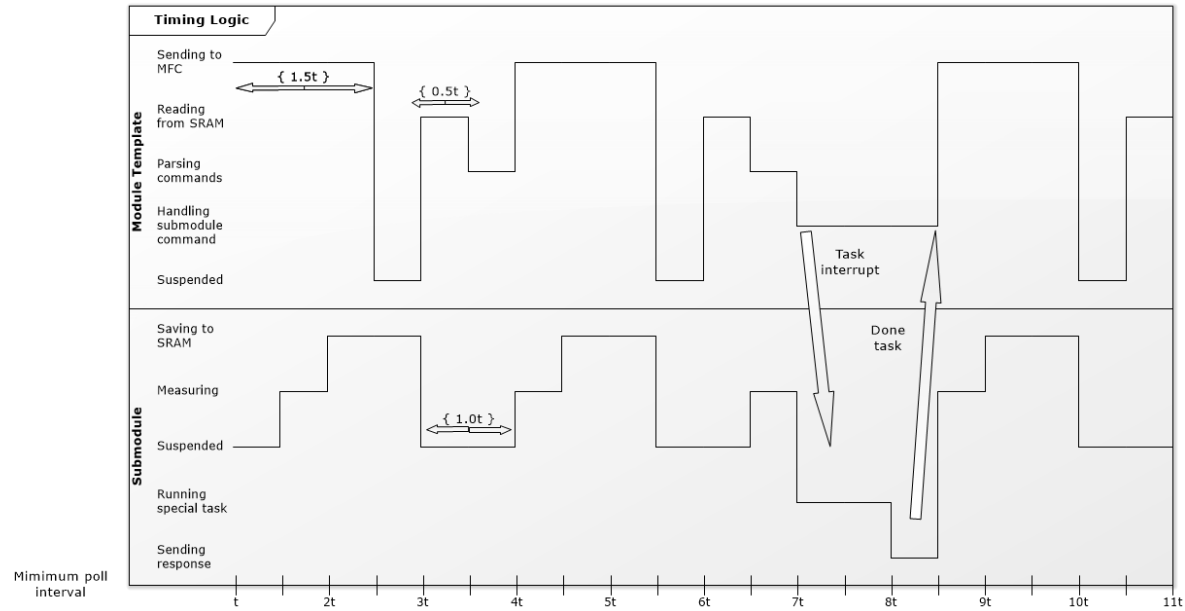

Figure 11: Timing logic of Internal Communication block

The MT knows how often each submodule needs to be polled when a new submodule is inserted by the *Submodule Insertion Mechanism* and it takes the smallest time frame of all the submodules which is named the *minimum poll interval* and uses this at the default value of *t*. By using an *high resolution clock* the MT is able to accurately measure each *t*.

The submodule periodically reads measurements and stores data in the 8MB SRAM chip. The MT periodically sends data stored in the 8MB chip to the MFC and read the new data inside the 8MB chip. After each read, the MT quickly checks if any commands have been sent by the MFC. If the command is targeted to one or more submodules it can send an interrupt signal to the(se) submodule(s).

The cycle of the submodule can be interrupted by the MT. When ever this happens, the MT goes into a special state, where is just waits for a response. The submodule also goes into a special state where is just performs whatever task I given by the MT. This however cannot take longer than 1.5*t*. If no response is sent by the submodule by that time, the MT will just assign a NULL value. During the *running special task,* the submodule has some time to access the 1KB SRAM chip to store its status as a simple binary datatype.

- In reality the submodule is unable to send data or statuses itself to the MT because it is nothing more than a simple boundary object. So, this process is actually handled by the MT by setting some pins high or low. This diagram is merely a high-level view of how the protocol works.

The entire process can be summarized with the following state machine diagram.

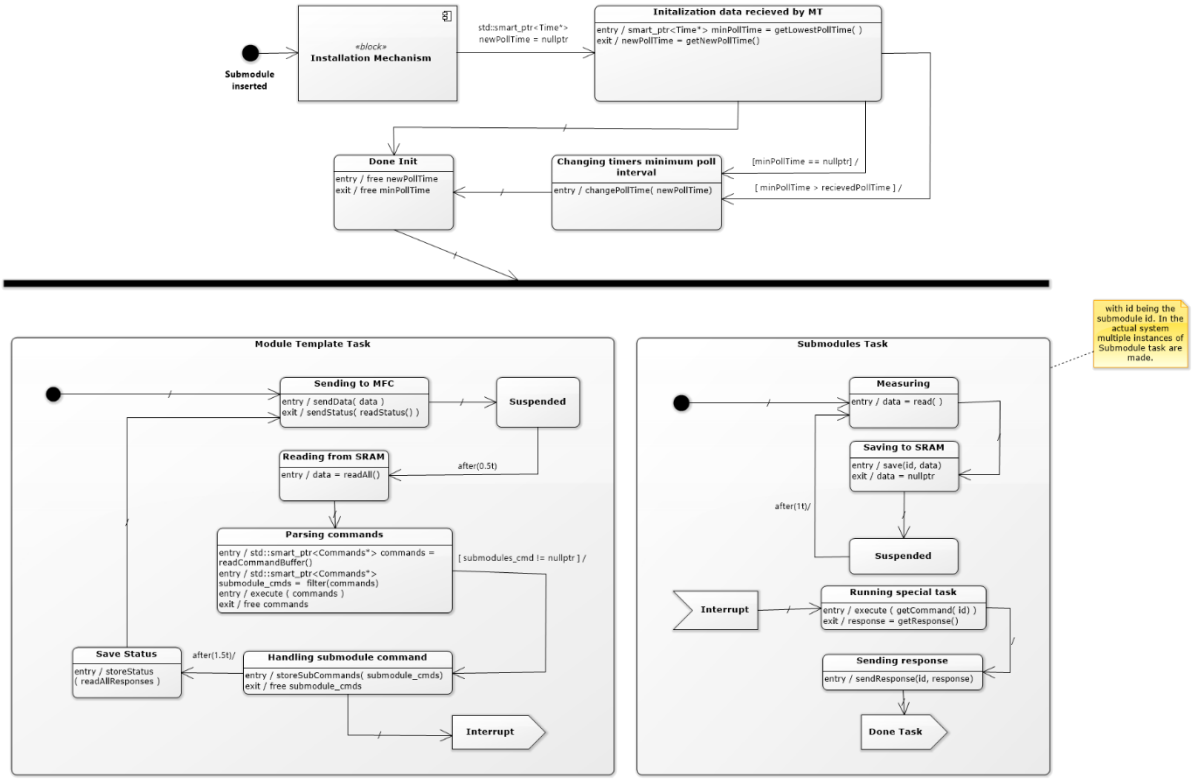

Figure 12: State machine diagram of Commando/Data/Status communication process

6: ACCEPTANCE TEST

To ensure the main loop of the system (the main process from finding out about Soilar, ordering the unit to finally reselling old parts for new ones) is perfectly suited to the customer, a long acceptance test was run where each step in the process was monitored to see how easy or how well the customer was able to perform the predefined task on a scale from 1 to 5. The entire system is not yet complete so not every feature can be tested.

Step	Action	Expected response	Actual response	Rating
1	Find Soilar through Google by typing in "soilar"	Soilar would appear as the first corresponding result	Soilar was not mentioned	1
2	Easily knowing what parts are needed for the farm. A: Finding the part picker within 2 min B: Using the part picker C: Getting valid results from the part picker D: Customizing the results after the part picker	The user would be very happy with the ease of use A: Within 1 min B: 20% of the users having trouble on the first try C: 90% of the results would be valid D: This would be and 2 click process without any hick ups	The user found the part picker quickly but hard to use. The result where very accurate with what their expert told them they would need. A: Within 30sec B: 40% of the users having trouble on the first try C: 95% of the results would be valid D: Nobody edited the results after the partpicker	4
3	Ordering the parts through the platform with IDEAL and PayPall	The payments would proceed with both services and a response will be send to the user by email	Paypall seemed to not work, it kept getting an invalid token error. Ideal worked perfectly and a response email was sent in the first few minutes	2
4	Placing the MT with submodules in the user's farmlands with the automated machine	The automated machine would complete all of the installation of all MT's within 10 hours.	The automated machine took 12 hours and 10% of the installations where not correct. This was become some parts of the soil where a bit loose and the MT could not be properly mounted.	3
5	Checking the data/ settings of the MT's with individual submodules through the user interface	All of the MT would be present in the user interface and their data/settings could be read	-	5
6	Changing settings or sending commands to individual MT's	Settings would be applied to the MT's and this would be visible in the user interface	It worked but the user interface would experience a lot of lag for a short period after each change. This was due the MFC running at 80% normally and at 100% during each change.	4
7	Changing settings or sending commands to individual submodules through the user interface	Settings would be applied to the submodules and this would be visible in the user interface	It worked but the user interface would experience a lot of lag for a long period after each change. This was due the MFC running at 80% normally and at 100% during each change.	3

For each step that has a low rating (<= 4) a execution plan has been made.

Step	Execution plan
1	Fixing the SEO's of the website and adding in some social media accounts.
3	Contacting PayPal to fix the issue quickly.
4	Change the design of the MT so it can be installed 1m deeper.
6	Use a more powerful CPU and GPU (with more CUDA cores) for the MFC.
7	See 6

7: SYSTEM DESIGN

These are pre-productuon scetches, the actural design will vary drastically.

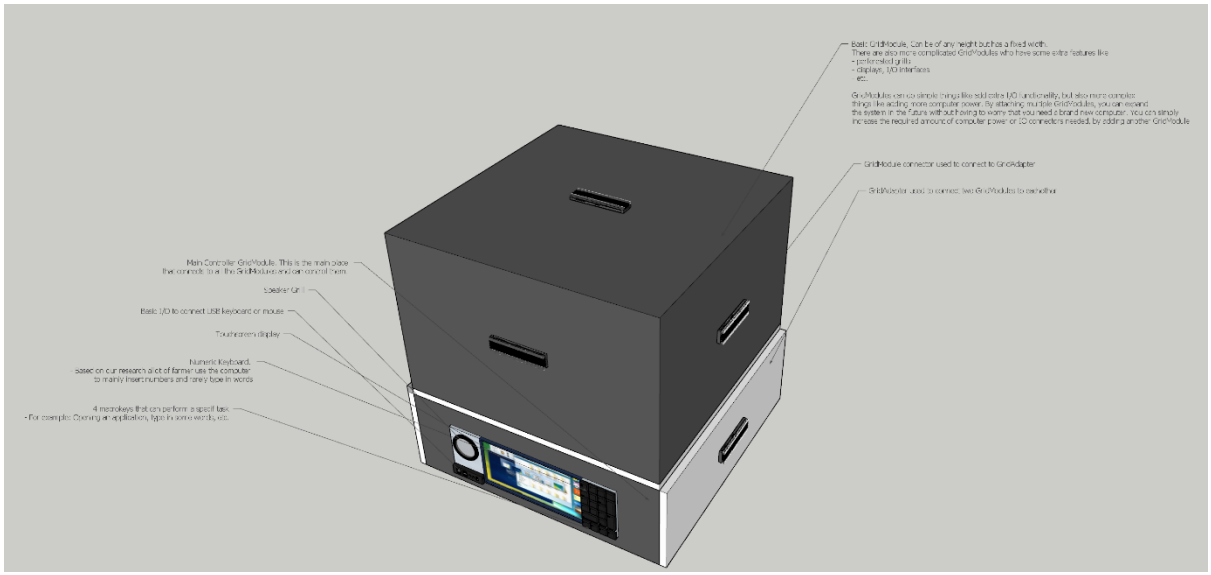

Figure 13: Main Frame Computer Overview

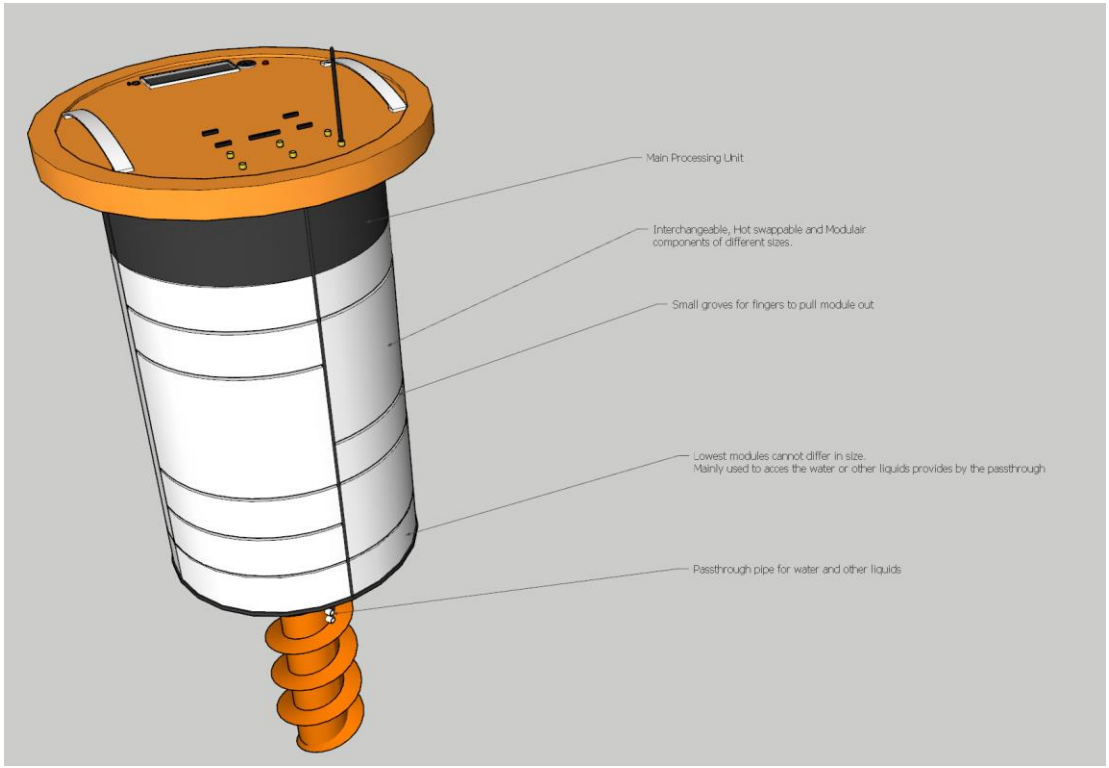

Figure 14: Complete Module Template Overview

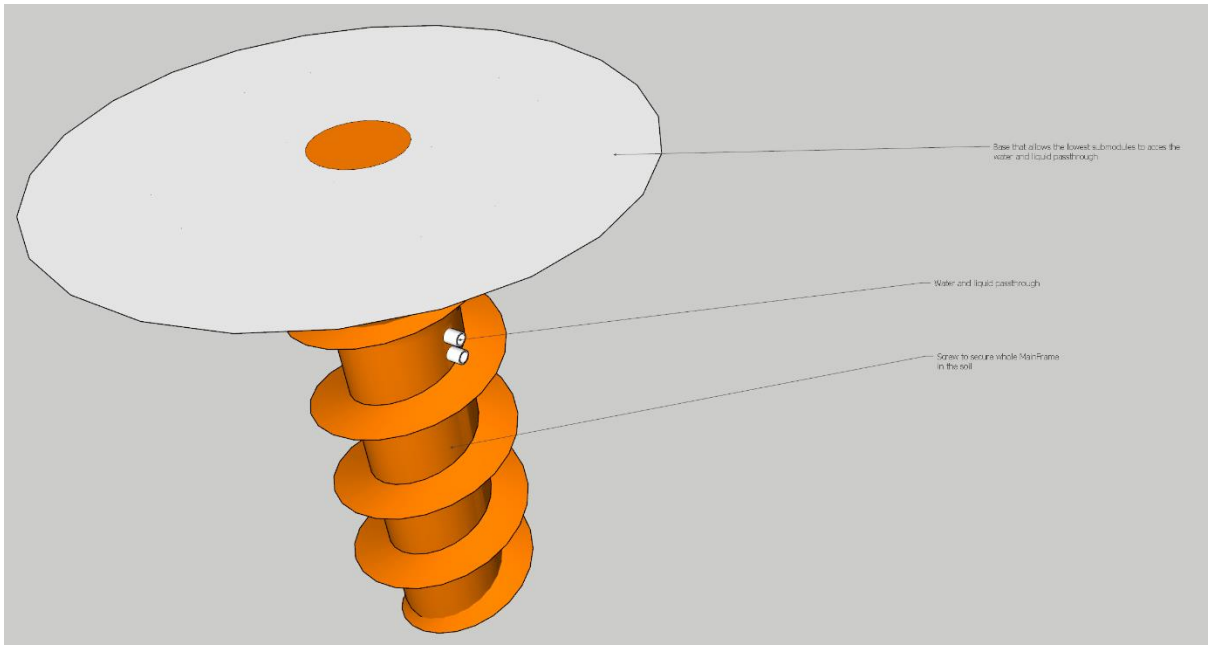

Figure 15: Module template Installation screw overview

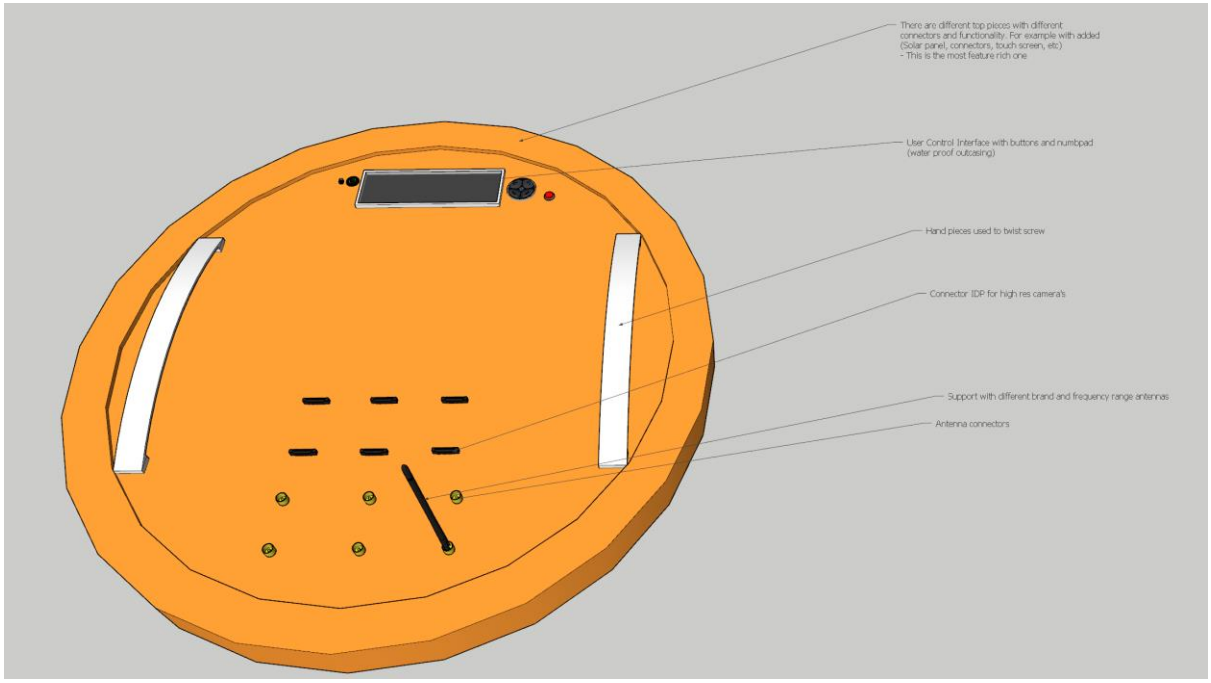

Figure 16: Module Template top view

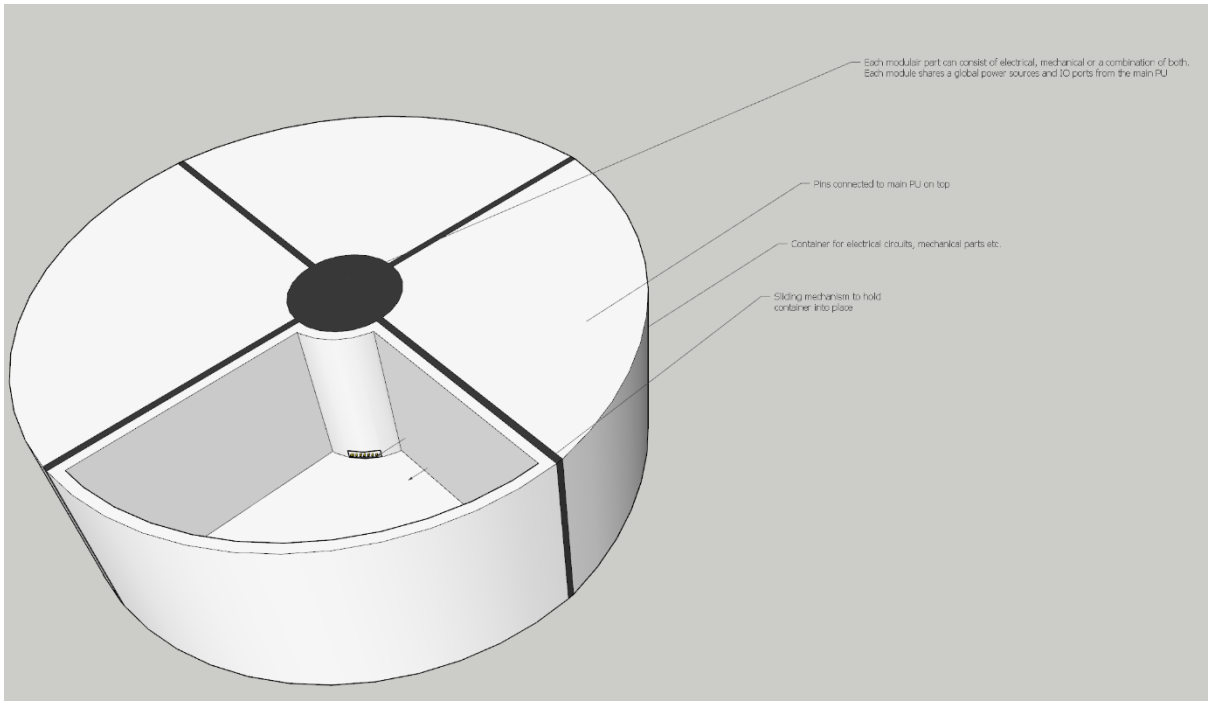

Figure 17: Submodules base overview

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[1] http://gaudisite.nl/BasicCAFCRPaper.pdf

[2] https://en.wikipedia.org/wiki/4%2B1_architectural_view_model

[3] https://en.wikipedia.org/wiki/Moscow

[4] https://edisciplinas.usp.br/pluginfile.php/294901/mod_resource/content/1/ISO%2025010%20-%20Quality%20Model.pdf

APPENDICES

{1} Research rapport

{2} Interviews

{3} Field research

{4} System Models in Software Ideas Modeler