Aalto University
ELEC-D0301 Protopaja
Year 2018

Project plan

Project #8 / Safera
Test Sensor Package and Data Logger

Date: 20.6.2018

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Information page

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Sponsoring Company

Safera Oy

Starting date

4.6.2018

Submitted date

20.6.2018

1) Background

Safera is a Finnish startup that develops and sells sensors intended to prevent fires in a kitchen environment. In order to develop their products the company simulates ordinary cooking situations as well as potential causes of fire such as unattended pans or pots. To gather data, the test engineers require a suite of temperature sensors as well as cameras and other measurement devices. This data is then used to improve the algorithms within the product in order to more accurately determine if a situation is potentially dangerous. However, many pre-existing measurement solutions tested by the company proved to have issues. Some related to drivers, others due to the black box nature of some commercial systems. Due to this Safera was motivated to work with the Protocamp course in order to develop a prototype sensor solution that is tailored to their specific needs.

2) Expected output

The project as explained by Samuli Lintonen of Safera is quite open ended, although each potential focus of the project has the unified goal of improving the company's measurement solutions. After a meeting discussing potential expectations and potential focuses for the projects it was determined that the minimum viable product for the prototyping project was to develop a thermocouple sensor interface that is both better documented than the commercial option as well as more easily repaired. An additional benefit of the project is that the developed solution is potentially cheaper than the commercially available solution. This thermocouple interface should either output measurement data over a standard serial port or by usb. In order for this to be successful the prototyped design should be comparable in accuracy to the commercial model while being better documented.

During the discussion it was determined that a design utilizing a microcontroller would be preferable as it would allow for further expansions to the system should the project have time. Suggestions for further sensors to include in the sensor package included a laser particle counter, the suggested model being a PMS5003, a camera to record video with timestamps allowing those reviewing test data to view the state of the experiment during a particular time, a thermal imaging camera (such as a FLiR Lepton) allowing for viewing of hot and cold areas as well as a microphone to allow for narration of the experiment as well as other potentially useful auditory information. Due to the availability of these secondary sensor functions as add-on boards for the Raspberry Pi platform it was determined to be the most likely solution.

The system is designed to be used by a test engineer in either the laboratory kitchen within the the company's research division or within the exterior lab built for experiments involving smoke. The sensor solution is designed to be a self-contained package that can be placed at a safe distance from the stove without requiring the user to place multiple pieces of sensor equipment aside from placing thermocouples at desired locations. On the software side, the expected outcome is one where the test engineer can easily begin recording video as well as logging data for the experiment. A possible way to demonstrate both the functionality, practical applications and ease of use during the fina gala is to simulate test using a hot plate boiling water.

3) Phases of project

Although it is often hard to give a proper set of phases and the sequence in which they should be completed early on in the project, it can often prove quite helpful during the planning stage. On a general conceptual level, the project could be broken up into the following phases:

- Phase 1: Planning and Project Scoping
- Phase 2: Research and Studying the Underlying Theory
- Phase 3: Learning Project Related Skills
- Phase 4: Concept Development and Iterative Improvement
- Phase 5: Prototyping and Development of Thermocouple Interface
- Phase 6: Engineering and Development of User Interface
- Phase 7: Completion of Thermocouple Interface Subsystem
- Phase 8: Prototyping and Development of Additional Sensor Subsystems
- Phase 9: Completion of Additional Sensor Subsystems
- Phase 10: Completion of User Interface and Data Logging and Visualization
- Phase 11: Final Delivery
- Phase 12: Presentations
- Phase 13: Reporting

These 13 phases can be broken down into the following general stages:

- Stage 1: Initial Project Work
  - Covers phases 1 to 4 of the project.
  - Major milestones include defining the scope and general concept of the project as well as finishing and submitting the project plan.
- Stage 2: Hardware Development
  - Covers phases 5 to 8 of the project
  - Major milestones include finishing the Thermocouple Interface and then integrating the cameras and microphone to the system.
- Stage 3: Software Development
  - Covers phases 9 and 10.
  - The only major milestone for this is finishing the data logging and visualization software as well as the user interface.
- Stage 4: Reporting and Delivery
  - Covers phases 11 to 13.
  - Milestones for this phase are the final report as well as presentation of the project results to the company and rest of the course during the final gala.

The deadlines for the second and third stages of the project are somewhat nebulous with stages 2 and 3 being prime for parallel development. The hard deadlines that were given were the turn-in dates for the project plan and report. In addition to this the date of the final gala is set in stone. This project plan is due to be submitted on 20.6 and the final deadline for the entirety of the project is 23.8, with a mid-project report being due on 26.7. Stages 2 and 3 will be worked on in parallel and compromise the majority of the content of the project.

Due to the nature of the work, the true time constraint is that some tasks must be complete before others. Without a working thermocouple circuit it is hard to develop and test the code for reading, transmitting and recording the data. The sooner the initial hardware tasks are completed, the more time there is to deal with potential setbacks and the sooner the integration tasks can begin. Based on previous experience, setting hard deadlines will not do much good as in the early phases of the project it is hard to judge the difficulty of each task.

4) Work breakdown structure (WBS)

- Planning
    - Planning the Project Scope
    - Initial Research
- Research
    - Hardware
        - Sensors
            - Thermocouple
            - Temperature
            - Air Particle Count
        - Raspberry Pi
        - Microphones
        - Cameras
            - Thermal
            - Normal
        - Interfaces
    - Software
        - User Interface
        - Raspberry Pi to Computer Interface
        - Multiple Raspberry Pis
        - Information Related to Programming
- Hardware
    - Planning
    - Prototyping
        - Rapid Development
        - Testing Parts
    - Picking Components
        - Picking Suitable Components
        - Researching Options
        - Finding Budget and Use Friendly Components
    - Circuit-board Design
        - Designing the Circuit board
        - Prototyping Circuit board Designs
        - Ordering Board for Final Prototype
    - Assembly
        - Assembly of Components
        - Verification of Functionality
    - Testing
        - Testing the Final Prototype
        - Ensuring Code Works with Hardware
    - Integration
        - Assembling the Final Product
- Software
    - Requirements and Specifications
        - Meetings and Planning
        - Writing Specifications Document
    - Design
        - User Interface / Experience
        - Architecture
    - Programming

        - Raspberry Pi
        - Data Logging
    - Testing
        - Testing with Simulated Data
        - Testing with Hardware
        - Code Reviews
        - Iterative Improvement
    - Integration
        - Ensuring Hardware Works with Software
- Reporting
    - Initial Report
        - Planning
        - Writing
    - Mid-Project Report
        - Planning
        - Writing
    - Final Report
        - Planning
        - Writing
- Gala
    - Poster Design
        - Layout
        - Contents
        - Pictures
    - Presentation
        - Slides
        - Content
    - Final Gala
        - Preparation
        - Gala
        - Presentation
- Meetings
    - Weekly Group Meetings
        - Memos and Agendas
    - Regular Meetings with Safera
        - Emails and Other Communication

5) Work packages and Tasks of the project and Schedule

5.1) Work packages and tasks

Work Package	Milestone	Total Man-hours
WP1	Management	32
WP2	Planning	90
Task 1	Thermocouple	20
Task 2	User interface	20
Task 3	Raspberry pi two cameras	5
Task 4	Air quality sensors	10
Task 5	Multiple raspberry pi’s	30
Task 6	Microphone	5
WP3	Thermocouple Hardware	110
Task 1	Comparing possible components	15
Task 2	Designing the circuit board	40
Task 3	Develop the required software	15
Task 4	Iterative testing and improvement	40
WP4	Software Design and Implementation	260
Task 1	Connection between raspberry pi and computer	20
Task 2	Data displaying and saving	80
Task 3	Implementing commenting	40
Task 4	Ensuring easy installation	40
Task 5	Multiple raspberry pis on the same computer	80
WP5	Cameras	50
Task 1	Working camera feed	10
Task 2	Sending the feed from the Raspberry Pi to the computer	10
Task 3	Adding infrared cameras	30

WP6	Air Quality Sensor and Microphone	75
Task 1	Getting reliable readings from the air quality sensor	10
Task 2	Recording with the microphone	10
Task 3	Designing the circuitboards and connections	25
Task 4	Sending the data to the computer	30
WP8	Integration and Testing	88
Task 1	Software integration	20
Task 2	Hardware integration	20
Task 3	Preparation of final prototype	20
Task 4	Final testing	28
WP9	Project demo and reporting	86
Task 1	Writing the mid-project report	10
Task 2	Writing the final report	20
Task 3	Preparing a demonstration and presentation	12
Task 4	Preparing a gala poster	12
Task 5	Final gala	28
Task 6	Returning keys and borrowed materials and tools	4

Table 1: Work packages and estimated man-hours required for their completion

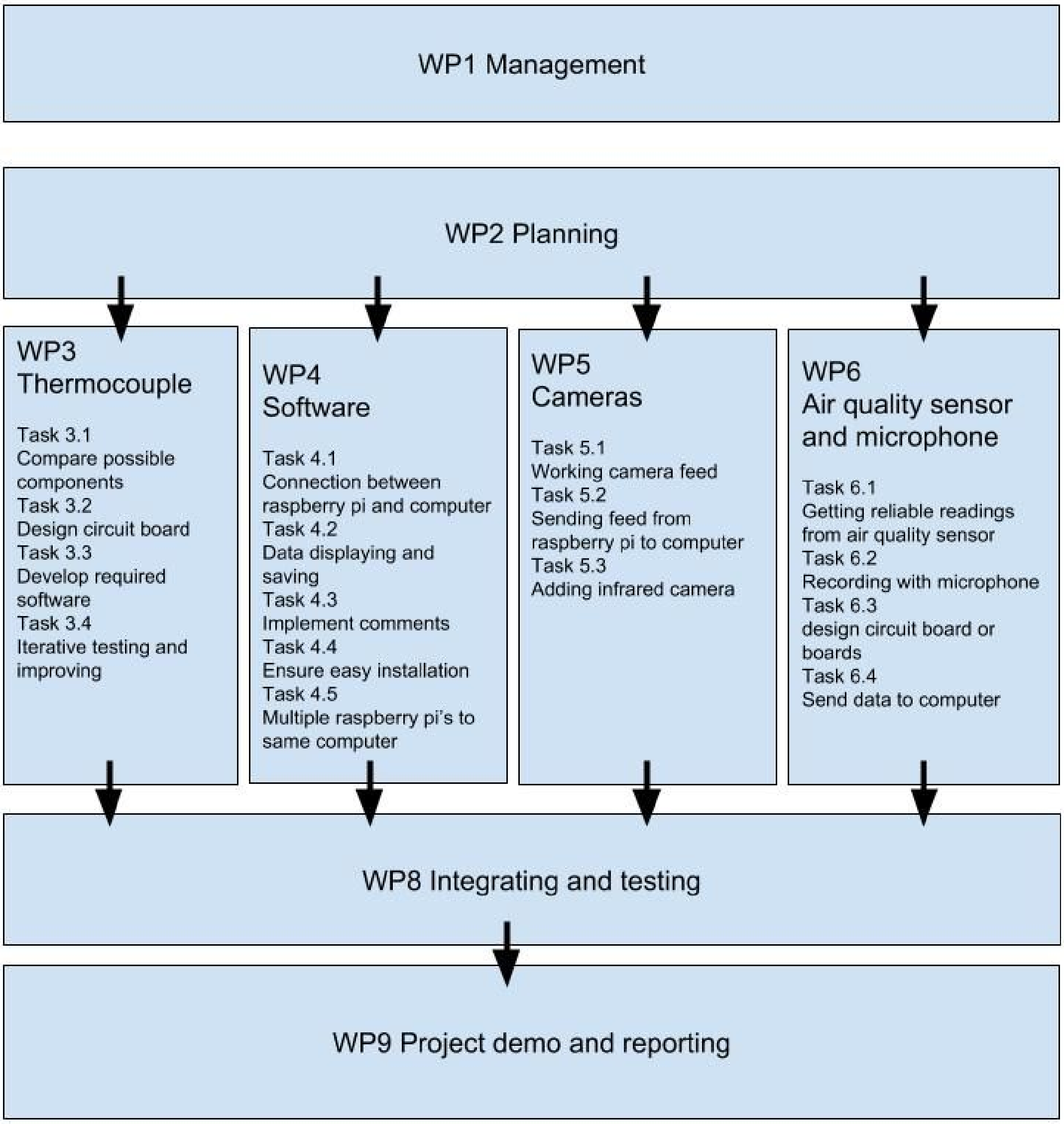


Image 1. Chart representing order of completion for the project work packages

5.2) Detailed schedule

Although the actual amount of time spent per tasks is still unclear to a degree, the order in which they are to be performed is quite clear. Software and hardware can largely be performed in parallel. This will, however, require a way of simulating the communication protocols between the Raspberry Pi and the computer. As such, both portions of the project converge towards the later stages. Within each stage the tasks must largely be performed in order with the exception that Raspberry Pi software and computer data logging software can also be developed in parallel. The schedule is roughly based on the man-hours assuming a 22-24 hours per week schedule. Ideally the team will have a fully featured prototype of the product roughly a week or two before the end of the course.

- WP3 will be handled by Jyri
- WP4 will be handled by Antti and Anton
- WP5 will be handled by first to complete their first WP
- WP6 will be handled by Vladimir

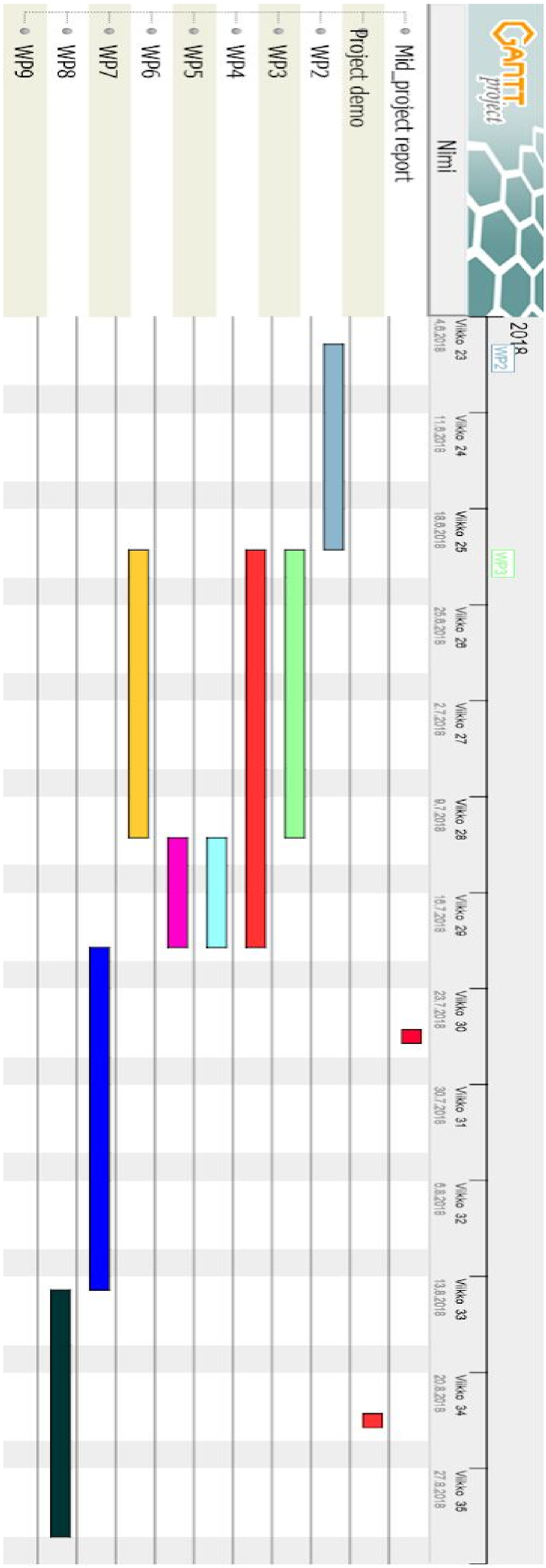


Image 2. Gantt chart of the project work package dates

6) Work resources

6.1) Personal availability during the project

	Antti	Jyri	Anton	Vladimir
Week 23	24	23	23	24
Week 24	24	23	23	24
Week 25	24	23	23	24
Week 26	24	0	23	24
Week 27	24	12	0	23
Week 28	24	23	0	0
Week 29	24	23	23	0
Week 30	24	23	23	23
Week 31	24	23	23	23
Week 32	24	23	23	23
Week 33	24	23	23	23
Week 34	24	23	23	24
Week 35	24	23	23	24
Total	**312**	**265**	**253**	**259**

Table 2. Number of hours available for the project (excluding lectures and seminars) per week.

These are rough estimates of availability, actual number of man-hours spent will vary depending on the challenge of the project and potential setbacks. Due to the nature of the project being somewhat unfamiliar to members of the team, estimating a precise amount of hours per task is quite challenging.

6.2) Personal goals

Jyri Korhonen: My main focus on this project will be creating an accurate and durable thermocouple. To do that I will need to learn about circuit board design, operational amplifiers and analog to digital converters. In addition I'm expecting to learn more about basic data acquisition with raspberry pi.

Antti Matikainen: As with the Project Work course, the mandatory equivalent to this course without the trappings of prototyping for a company, my personal goal for this course is to develop practical skills. The nature of the AEE line is that in addition to automation, the courses cover the basics of a variety of topics from electrical engineering to assorted programming languages. While many of these are quite useful, the truth of the matter is that they are the basics upon which the practical skills learned in the workplace are built upon. As with the Project Work course, I am hoping and expecting that this course help me both learn the process by which these skills are developed as well as a set of skills that my be used in future work.

Anton Demin: My own goal is try to create project that will be useful for company. Interesting in programming mostly.

Vladimir Kurazhev: My aim is to develop any Electrical engineering and programming skills.

7) Cost plan and materials

For any potential purchases required by the course the team has been given an initial budget of 900 euros. This budget is to be spent on the required components, hardware and services required to develop a product that fits the requirements of the company. The budget has been provided by the company to the university, with purchases being handled by course staff. The practicalities of the purchasing process have been detailed on the wiki. The long and the short of it is that the project team gives the course staff a list of components which they require as well as the source from which it can be ordered. The course staff orders the components and they are delivered to the prototyping workshop where the team checks that everything is present. In addition to this, during initial meetings with the Safera representative they volunteered to assist in procuring components in case the university was unable to acquire a required part.

The team is collectively responsible for handling the budget and any potential purchases must be discussed either on the group's communication channels or during a weekly meeting. After the team discusses the components, most likely with the course assistant, the order can be sent to the course staff. Nominally the project manager is intended to handle the budget, but in this case the budget can be handled as a team. A spreadsheet has been created on the share drive folder to mark purchases and to sum up the expenses. This is something that the project group determined to be a good solution during one of the weekly meetings.

During initial research, planning and meetings, the team was able to determine some of the required purchases in advance. In addition to the following expenses, it is almost guaranteed that there will be unforeseen expenses. Some of the expenses are only marked as rough estimates as the team was unable to determine specific components in advance. For other services or components the team was unable to determine a specific price as they were unable to estimate size or shape of the circuit boards and electronics enclosures.

The following table contains a list of components and prices based on initial research and plans as well as information available to the team at the time.

Part, Component or Service	Price and Quantity	Reasoning
Raspberry Pi 3 model B+	30 euros. 1-2 pieces	The microcontroller used for readings and for doing the necessary calculations. Also functions as the interface to the computer. A second one may be required if the first fails.
PMS5003 Air Particulate Sensor	18 euros + taxes + shipping. 3 pieces	Air particulate sensor. Ordered 3 to have spares in case one breaks. Even if a single one is enough, havings spares is good due to delays involved in ordering from China.
ADT7320 Temperature Sensor	8.1 euros. 1-9 pieces.	A temperature sensor for cold junction compensation. Single sensor ordered for initial tests, may require more.

DS18B20 + T&R Temperature Sensor	3.8 euros. 1-9 pieces.	Temperature sensor for cold junction compensation. Single one ordered at first, may require a further 8 for later models.
PCC-SMP-K Thermocouple Socket	7.5 euros. 1-9 pieces.	Thermocouple socket. Single one ordered at first for testing. May order an additional 8 for later models.
IM-K-PCB Thermocouple Socket	3.7 euros. 1-9 pieces.	Thermocouple socket. Single one ordered at first for testing. May order an additional 8 for later models.
IM-K-M Thermocouple Plug	2.5 euros. 2-10 pieces.	Thermocouple plugs. Used for testing and demonstrating features of the later model.
AD7793 Analog to Digital Converter	10.8 euros. 2-10 pieces.	Analog to digital converter used for converting sensor readings into a digital format for use by the microcontroller.
USB Camera or Raspberry Pi Camera Board	20-50 euros. 1-2 pieces.	Used for video recording capability. Unable to pin down actual price due to the team being unable to decide on a specific model at this time.
Microphone	Unknown	Used for recording audio data. Price unknown due the lack of information about which models work well for purpose.
FLiR Lepton	260-300 euros. Hopefully only a single on is needed.	The thermal camera most suited for taking thermal camera video recordings of the experiment. Potential lower resolution options can be explored.
Case / Enclosure	10-30 euros depending on size and quality, only a single one is needed.	Although a 3d printed case can be used during the prototyping case, it would help presentation if the later versions used a proper case.

Circuit Board Manufacturing	20-50 euros for the required amount for the project.	Although it is possible to manufacture boards in the lab, their quality will be lesser compared to ones ordered from a company specializing in them.

Table 3. Breakdown of initial estimate of components required for the project

8) Other resources

The majority of the work for the project can be done at the workshop using the tools there. There is a shelf with boxes in the shop which can be used to store components in a labeled container. The course staff has mentioned that they will begin work on getting members of the team access to the workshop outside of the daytime later on during the course of the project by helping the team acquire keys. Because of the variety of tools available at the workshop it is unlikely that the team will require any additional work locations or tools. Members of the team have their own laptops and the workshop also has computers which may be used for programming work.

In order to complete this project, the team will require the use of soldering irons and circuit board manufacturing equipment. These are the primary tools required to manufacture the prototype. The enclosure can either be 3d printed, or more likely simply purchased, meaning that there is little need for other manufacturing equipment.

In addition to the tools and equipment at the workshop, another important factor to take into account is the availability of knowledge resources. There are several aspects of the course that simply have not been taught in any of the courses available such as circuit and pcb design. The course assistants informed that they were available to ask questions. During a meeting with the Safera representative they also volunteered to assist the team by answering questions.

9) Project management and responsibilities

A multi-layer management structure would be quite overkill for a group with only 4 members. That being said, each member of the team has their own role to play in the completion of the project. In addition to each member being responsible for working on one or several of the project work packages, there are several administrative roles that must be taken into account. In addition to this, the Safera representative and course assistant have their own tasks and responsibilities when it comes to the course and project.

The Safera representative, Samuli Lintonen, is in essence the client for whom the product is being made. In addition to this they are our primary point of contact within Safera should we require advice with the project or there is a matter requiring their approval. In addition to this there are practical course matters they are most likely responsible for, but that is between the university and Safera. The project team and company representative are also going to hold regular meetings regarding the project.

The course assistant assigned to the group is Juha Biström. In addition to practical course matters such as grading and lectures, their responsibilities include giving advice to the team. In their own words, the assistants are there to give advice to the project teams as well as to help them with the tools in the workshop. In addition to their role as an advisor, the team has a weekly meeting for which the course assistant will also be present. This is to take notes for grading purposes as well as to give advice.

The role of the project manager is somewhat ceremonial in a project with such a small team. They do have several roles related to course proceedings as well as small tasks like keeping track of general progress. Other than this, they are like any other member of the team. Other members can also take care of matters such as tracking the budget and communications with Safera. Everyone in the group is responsible for working on the project tasks and ensuring the results are good.

10) Weekly Project Meetings

In addition to holding meetings with Safera regarding the project, the project team will hold weekly meetings in order to discuss the project and to make sure everyone is on the same page. These weekings will also be a good time to plan what should be worked on and when as well as to keep track of progress. These are separate from meetings with the Safera representative, however the course assistant will be present in order to answer questions. This will also be a good time to discuss potential purchases as well as how to deal with setbacks so that issues can be avoided before they become more serious.

The meetings are to be held on wednesdays at 14:15 as per the schedule on the workshop wall, and will predominantly be held in the meeting spaces within the automation building library / learning hub. While having a strict agenda per meeting is slightly excessive, it is still important to hold regular meetings. In addition it allows each member of the team to ask questions if they are confused or unsure what to do. A short memo of each meeting would likely be good practice as it allows those who were not present to keep track of what was talked about.

Although the memo can be quite freeform, for the sake of ease of access, it is likely best that it be stored on the project group google drive. Another option is to use a tool such as Trello.

11) Communication plan

In addition to the weekly face to face meetings with the project group, the group will have to have a method of communicating in a quick and efficient manner during the week. Another important thing for the smooth functioning of the group is for everyone to be able to share code and other such matters in a fast and efficient manner.

Internal communications within the group are handled via Telegram as each member of the group was already used to using it. A telegram chat is sufficient for most casual conversation and people are able to read through the log if they need to look up an earlier conversation. A shared Google Drive is used to share images and links in a common "Notes" document. Google Drive also has the benefit of allowing multiple people to simultaneously write into the same document. To share code for the code based aspects of the project the team will use version.aalto.fi.

Communication with the course assistant will happen either by email or during the regular weekly meetings. In addition to this members of the team can ask the assistants questions in the workshop should they need help with something they are working on at that point in time. Should it be necessary, further methods of communicating with the assistant can be discussed during one of the weekly meetings.

Communication with Safera will happen through the Safera representative Samuli Lintonen. The group will hold regular meetings at the Safera offices located conveniently not far from the university. These are good for both shared brainstorming as well as to keep track on progress. The group also worked to set the scope of the project during the first several meetings held with Safera. In addition to these meetings, or when the Safera contact is on vacation, communication can take place by email.

12) Risks

Risk	Severity	Mitigation
Budget Overflow	Medium to Critical - Due to the nature of the project, the team will require an amount of components such as instrument amplifiers, analog-digital converters, and other sensors. In addition to this camera boards will add further expenses. During later stages of the course an infrared thermal camera may be integrated to the system which will be a significant expense. Although small overflows are unlikely to be an issue, significant ones may force the team to scrap features.	Budget overflows as a risk can be mitigated by keeping careful track of spending, as well as paying attention to if the component used has a cheaper alternative which would work just as well. In addition to this, during early meetings with the Safera representative, this risk was brought up. They stated that in cases of budget overflow they would be willing to provide further funds for components as long as they were spent responsibly and the project has not gone over budget to a significant degree.
Project Delays	High - The project has a fairly limited amount of time allotted to it. Roughly two and a half months. Because of this delays can hinder this, and at worst can force a re-scoping of the project and scrapping of some of the features.	Project delays can only truly be avoided by making sure everyone is working effectively and everyone is on the same page regarding the project plan and the state of the project. If it becomes clear that a work package is not seeing any progress, other members of the team can provide assistance. In case of severe delays, the project scope may have to be changed.
Team Member Unavailable Due to Injury or Illness	Medium - The team is composed of 4 people. Having a team member unable to work for a significant period of the time allotted to the project will mean that everyone else has to comparatively work harder to stay on track.	The risk of this happening is quite low. Due to the nature of the project, a team member who has the flu can still contribute by performing research or coding from home. However, if it becomes clear they will not be able to continue with the course it may force a rescoping due to delays caused.
Delay in Ordering Components	Low - A majority of the components required for the project are readily available. However, some such as the air particle count sensors will have to be ordered from China. If a component is unavailable, it may lead to delays.	In most situations, a component will be available from multiple sources or an alternative component can be used to perform the same task. The only component that may cause this issue is the air particulate counter. In order to avoid this from cause issues, the team ordered 3 so that they would have all the sensors required.

Table 4. Breakdown of potential risks and methods for their mitigation

13) Quality plan

The quality management plan for the project is quite simple as each portion of the project has a purpose and set of criteria it should fill. Although being able to do what it is meant to do is not always an indicator of quality, it is often a step in the right direction. In addition to simply verifying that something functions, ensuring quality also includes making sure that the work done is well thought out and well done in practice.

Members of the team should work together with the course assistant to ensure the quality of their work packages. In addition, milestone meetings may include minor quality control discussion. For hardware, this involves making sure that the components used make sense for the purpose and that the circuit design and assembly are up to par. For code it will involve code reviews to ensure the code follows a set of quality standards.

In addition to this, discussion during the weekly meetings can be seen as a form of quality control. By ensuring everyone is on the same page and any possible questions are answered problems can be solved before they become a hindrance. Observed problems should be taken up during meetings or over the team's other communication channels.

14) Changing this plan

Any possibility of a change to the project plan or scope must first be discussed during one of the weekly meetings. It is, to put it quite simply, not a matter to be taken slightly, and should only be considered if the project is meeting significant delays or difficulties. Any member of the team can take the initiative to bring it up. In order to avoid issues of members not wanting to do so out of embarrassment or fear of rocking the boat they may do so anonymously to the course assistant. Should they do so, it will be brought up during the following group meeting.

If this meeting regarding changing the project plan or scope of the project leads to the group concluding that rescoping the project is a necessity then the process can continue. The first part of this process is to compile a document containing the change as well as the reasons for it. This document is then given to the course assistant and Safera representative for approval. If they agree with the changes, the project can continue according to the new revised plan.

A new project plan document can also be drafted should it be necessary. Like the project plan, this document containing the changes and the reasoning behind them is to be placed in the drive and course wiki as well as being backed up.

15) Measures for successful project

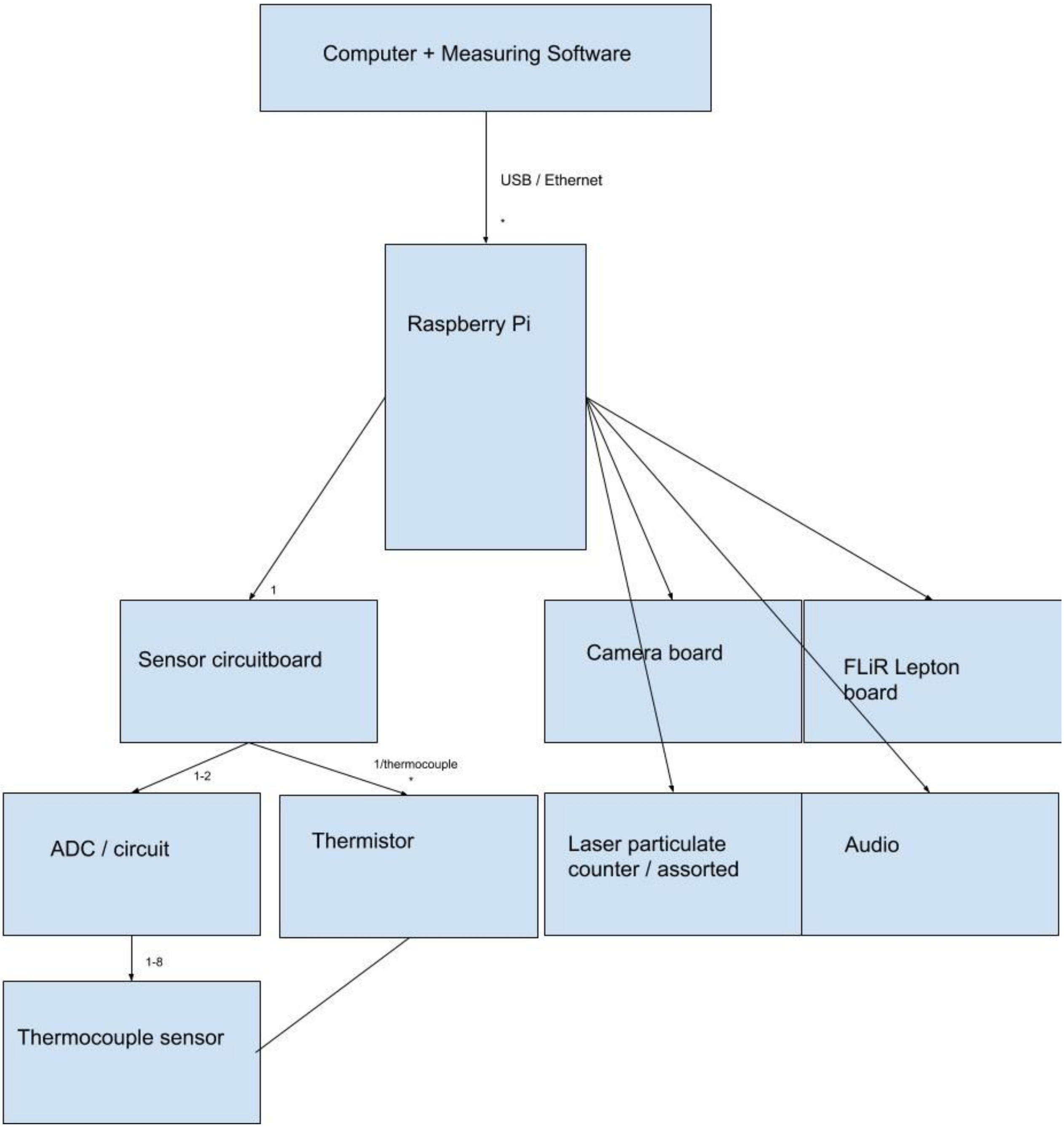
When it comes to determining project success there are a variety of factors to take into account. The aim of the project is to create a practical sensor package and data logger to be used by Safera's test engineers.

In addition to this, components of the project can also be judged on their own merit as well as parts of the whole. For example, the thermocouple solution must be as accurate or better than the commercially available solution. In addition to this, it must be used in a similar manner with the thermocouples being replaceable in an easy manner using standardized connectors. An additional consideration of the thermocouple temperature sensor implementation is that it must be cheaper than the commercial solution while being well documented enough that it can improved or repaired should it be necessary. The functionality can be tested by taking readings with the prototype solution and comparing them to readings taken with the commercial model with the price being simply a case of comparing the price of the parts with the cost of the commercial model.

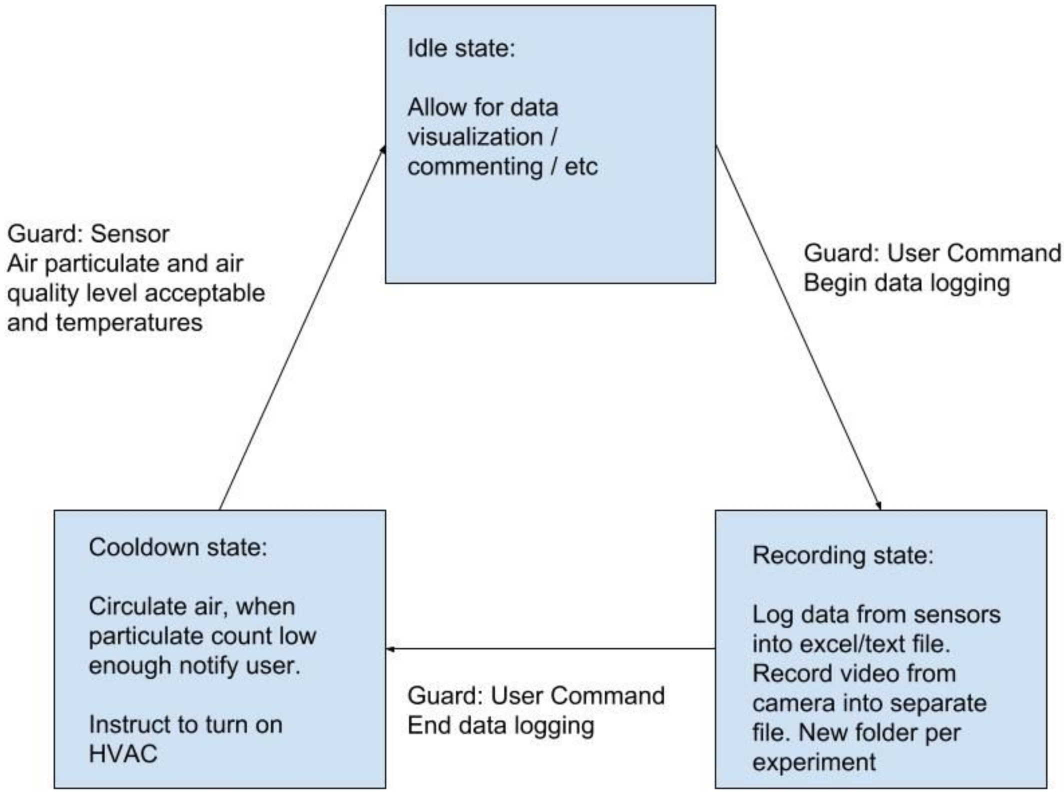
The code running on the raspberry pi can be tested both by simply taking readings as well as by using a virtual sensor in order to verify that the code functions. In addition to simple calculations related to converting the thermocouple and temperature sensor readings into the corresponding temperature, the raspberry pi is used to transmit the readings to the connected computer. This means that in theory the code for the raspberry pi should not be very complex and quite simple to test. On the other hand the data logging software and user interface will likely be a fair deal more complex. The data logging and visualization functionality can be tested with simulated data while the user interface can only really be tested by having people use it and report on if they considered it good or not.

In-progress version testing can be tested in the workshop by members of the team and assistants. In addition to this, milestone versions of the prototype can be taken to Safera in order to demonstrate the state of the project. This will allow them to actively give feedback and suggestions for improvement while also reducing the chance that the end product is not what they expected. It will also help with transparency especially if there're unexpected issues during the course of the project.

In addition to the prototype itself, another aspect of the course is the process of creating the prototype and what was learned during course of the project. The first part of evaluating what each member of the team learned and how the project contributed to their learning is by having each member of the team giving their personal learning goals. After this, during the mid project and end of project report each member of the team gives a rundown of how they feel about the project and what it taught them. In addition to this, once the team members have given their learning goals the tasks they handle during the project can be tailored towards what they wish to learn.



Addendum 1: Structural model for the concept for the system.



Addendum 2: Abstract state machine representation of the process of the data logging system.