Project Plan
Future Aircraft Energy Management Systems

Version Final

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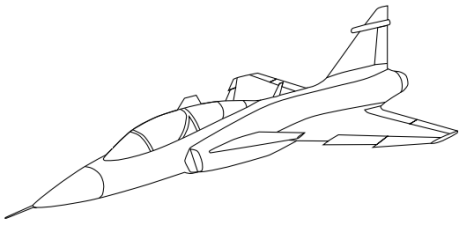

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Document History

Version	Date	Changes made	Sign	Reviewer
0.1	16/9-21	First draft.	Emil Boström	Kristoffer Ekberg
0.2	21/9-21	Final version	Emil Boström	Kristoffer Ekberg

Contents

1 Customer

The customer/order of this project is Alessandro Dell'Amico, working at Saab Aeronautics/IEI. The project is done as a collaboration between Saab and Linköping University.

2 Overview of the Project

In this section a short explanation of the background, purpose and goal will be presented.

2.1 Background

The aircraft industry is the trending towards electrification, also known as More Electric Aircraft, MEA. Electrification is expected to help the industry reach future objectives such as reduced aircraft weight, increased efficiency, lower maintenance and higher safety.In practice this means the development and implementation of a more efficient electric power distribution, more efficient and electric driven components and intelligent control of available power. Energy management will be important when more high power electric consumers, such as actuation system and sensors, are integrated in the aircraft.

The project group will be carried out in two groups, one consisting of 6 students from the ISY department and one group from the IEI department consisting of 3 students. The two groups will work closely together towards mutual goals.

2.2 Purpose and Goal

The scope of this project is to develop a Digital Twin of the power generation system, streamline the energy consumption of the Iron Bird and to ensure that the tactical system gets the desired power, with help of a control system. To reach the objective, the Iron Bird needs to be prepared with the development and implementation of the electric power distribution system, power consumers and control strategies.

Furthermore this will contribute with valuable information for the continued development of electrification of aeroplanes.

2.3 Deliveries

Deliveries from the project group to customer are divided into smaller part deliveries so called decision points (BP).

- BP 2
- BP 3
- BP 4
- BP 5
- BP 6

Table 1 shows what is included in the different BP:s.

Date	BP	Delivery	Version
2021-09-22	BP2	Requirement specification	Final
2021-09-22	BP2	Project plan	Final
2021-09-22	BP2	Time plan	Final
2021-09-22	BP2	Design specification	First draft
-	BP3	Design specification	Final
-	BP3	Interface Control Document	Final
-	BP3	Test Plan	Final
-	BP4	Digital Twin off-line simulation	First draft
-	BP4	Digital Twin on-line simulation	First draft
-	BP4	Test Protocol	First draft
-	BP4	Decide if implement software on hardware	
-	BP5	Test Protocol	Final
-	BP5	User Manual	Final
-	BP5	Presentation of fulfilled requirements	Final
2021-12-03	BP6	Delivery of project	Final
2021-12-06	BP6	After Study	Final
2021-12-13	BP6	Web Page	Final
2021-12-13	BP6	Movie	Final
2021-12-07	BP6	Poster	Final
2021-12-07	BP6	Technical report	Final

Table 1: Mandatory deliveries to be handed in.

2.4 Limitations

The project is a newly started project and therefore is no experience from previous project. This means its hard to predict all limitations that will occur during the project. However an attempt to describe some limitations will be done.

The components that will be used in the system are somewhat set and there will be a limitation in what things could be changed and bought in to the project.

Since part of the project is to develop models for a Digital twin a lot will depend on how accurate these models will be.

2.5 Subsystems

Subsystem 1 – Models for energy supply system

Subsystem 1 will consist of a number of models that will provide real time information to a number of Keysight regenerative power supplies to simulate the power producing components. The output will be used to power the Iron Bird.

Subsystem 2 – Vehicle management system

Vehicle management system (VMS) is the brain behind the system. The VMS control and monitor all components in the system. The VMS includes an energy management part which purpose is to manage the distribution of power for an actual flight mission. The control strategy should be able to distribute the power and handle electric power bursts. Some of the requirements for the VMS will be based on the MIL-STD-704F standard for aircraft electric power characterstics.

Subsystem 3 – Physical components

Subsystem 3, Physical components, consists of hardware in the system related to the power supply and communication between components. This includes, a switch, Ethernet connections, windows computer running the simulation and a real time computer.

Subsystem 4 – Energy consuming components

Subsystem 4 consists of models for the energy consuming components. The purpose is to supply these components with the sufficient power to operate. These components are listed below.

3 Phase Plan

The project management is performed by the model LIPS. The project model is divided into three bigger parts, before, during and after. These parts are in turn then divided into smaller parts. The following section will roughly describe these three different phases of the project.

3.1 Before Project

The work started as a collaboration between SAAB AB and Linköping University. The purpose of the project is to evaluate future electric flight control system and contribute with valuable information for further development.

In the before part of the project planning of the project is done. The planning will be done in collaboration with the IEI group. Requirement specification, project plan and deign specification is constructed and written. This is done to specify the goal of the project, in mind with the limitations that occurs such as money and time but also so that the customer can be satisfied.

3.2 During Project

This part of the project will be dedicated to try to fulfill what was planed in the part 3.1. In other words this means that the project group will work towards the goal of fulling as many requirements as possible. The work will be held in close contact with the customer and in case problems arises this will be closely communicated with customer.

The work of fulfilling the requirement list will be done in accordance with this document (Project plan) and the design specification.

3.3 After Project

When the project is finalised the result will be delivered to the customer. An evaluation between the customer and project group will be done to see how successful the project have been and to conclude if the requirement specification could be completed.

The project will also be presented as a part of the the course TSRT10. A poster shall be made which will be presented at the project conference. Furthermore to summarise the project a project web page will be created and the result of the project will be presented. The project group will also create a movie which shall be used as a commercial movie for upcoming students.

4 Organisation

This sections describes the organisation behind this project. It describes both the internal part as well as the external part of the organisation. It also explains the connection between the two parts.

4.1 Overview of organisation

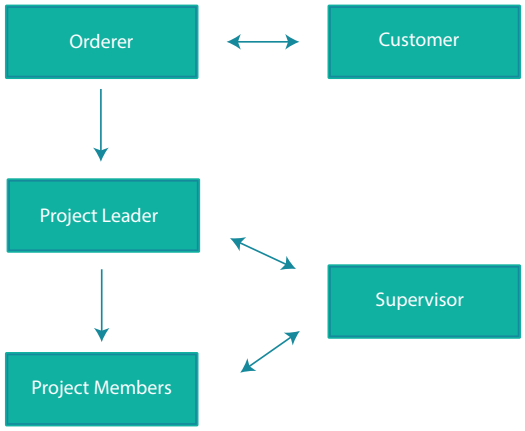

Figure 1: The organisation of the project.

4.2 Project Group

This section explains the different roles inside of the organisation and also brings up what is to be expected from the different roles.

4.2.1 Project Leader

The project leader (PL) is responsible for the long term planing. The PL is responsible for that the project's goals are reached. The PL is responsible for the communication between the project group, order and customer is done in a correct way. The PL is responsible for the group meetings, so that the meetings av an agenda and PL also keep records. Finally the PL tries to be a good leader and motivates the rest of the group.

4.2.2 Document Manager

The document manager (DM) is responsible for all required document in the project. The DM assures that all documents are finished and in place for deadlines. The DM is responsible for that the rest of the group knows where to find documents and that document which have to be shared with customer/order is done in a correct way.

4.2.3 Creative Manager

The creative manager (CM) is responsible for the exterior design of the project. The CM is responsible for web page, poster and a movie that should be made in the project.

4.2.4 Test Engineer

The test engineer (TE) is responsible for all test that should be done in the project. The TE takes care of the communication between the project group and where the test is planned to be done. The TE assures the requirement specification is in line with what test is to be done.

4.2.5 Hardware Engineer

The hardware engineer (HE) is responsible for all hardware connected to the project. The HE is responsible for the power source and the connection between power source and the rest of the system.

4.2.6 Software Engineer

The software engineer (SE) is responsible for all software connected to the project. The SE makes sure all simulation files etc are in place and is well organised.

4.2.7 Integration Manager

The integration manager (IE) is responsible for communication with the IEI group of the project. The IE makes sure the IEI group is informed about what the ISY group is doing and the other way around.

4.3 Terms and Conditions

The group members have each been assigned at least one of the previous mentioned roles. The members shall follow and work after the responsibilities of the respective role. Each member of the group shall meet the required hours of work designated for the project to reach a sufficient solution for the project.

In case conflicts arises in the group this will first be brought up together in the group. The conflicts will be discussed and hopefully a solution to the problem can be found. In case conflicts can't be solved within the project group, the project group will bring in external advice from e.g., supervisor Kristoffer Ekberg.

5 Document plan

Document	**Language**	**Aim**	**Format**
Requirement specification	English	Document with the project's specified requirements.	PDF
Project plan	English	Describes how the construction of the project, with milestones and deliveries.	PDF
Time plan	English	Points out how the time is to be distributed over the various parts of the project.	PDF
ICD	English	Provides all interface information (such as tables, quantities and textual information).	PDF
Design specification	English	An overview of the system and the three subsystems.	PDF
Test plan	English	Documentation containing tests that are to be execute and their requirements from this document, that they shall fulfill.	PDF
Test protocol	English	Documentation of the tests made and whether they were satisfied.	PDF
After study	English	Reflection of the project in large, what went well and what could have be done better?	PDF
Status report	English	Coverage of what team members have done.	PDF
Meeting minutes	English	The agenda and notes of all meetings.	PDF
Technical documentation	English	A documentation with the technical results.	PDF
User Manual	English	Documentation of how the product is to be used.	PDF
Poster	English	A poster that briefly explains the project, primarily results and conclusions.	PDF
Web page	English	A web page presenting the project with all its important documents.	HTML
Movie	English	A movie that summarizes the finished project and how it functions.	Video
Time report	English	A report of how much time each member spent on the activities.	PDF

Table 2: Documentation that is to be delivered during the project.

6 Development Methodology

The project shall work to achieve the requirements with level 1 priority.Thereafter, in mean of time and ability, aim for the requirements with level 2 or lower priority.

With the use of GitLab, the software developed, such as Matlab code or Simulink models, will be managed and each new version of the software will be saved

7 Education plan

The education plan describes what training/information the project group has to acquaint oneself with. It also brings up what training the customer will be in need of to understand the result and find the project useful.

7.1 Education plan - Project group

To be able to work with this project the project group has to acquaint oneself with a lot of new information.

- General information about aircraft's
- Standards, which is used in the development of aircraft's
- Hardware which is used in the project, e.g. Power source.
- The software which is being used today on the iron bird.
- Simulink with library simscape, for the creation of models.

7.2 Education plan - Customer

The customer will have to be educated in what the project group accomplish. In case the project will continue and Linköping University or Saab will further develop the project it is of high importance that the customer gets the correct information so that a transition for further development goes smoothly.

8 Time report

Every week the project manager shall report to the orderer. The time report shall contain all the hours that were spent during the week from each group member and also specify which certain activities the time were spent.

9 Meeting Plan

Each Monday the group of the entire project (including supervisors and the IEI-group) will meet to discuss the work done in the past week as well as the upcoming work the current week. This will also be an opportunity for the ISY-group and IEI-group to make sure both work in tandem towards the goal of the project.

Each Thursday there is also two hours of time assigned to discuss or work with the project.

10 Resources

Below the resources of the group will be presented.

10.1 Human resources

The group consists of six people all studying electrical Engineering, to assist this group a supervisor with some expertise within the area has been assigned. There is also another group consisting of three people studying mechanical engineering who will work with the same project.

Furthermore, one person working on both SAAB and LiU, will act as a customer/ordered and also have some expertise withing the area.

10.2 Material

An Iron bird built by SAAB will be accessible for tests of the developed models. Accompanying the Iron bird is a set of boxes capable of producing/consuming electricity. The group also have full access to Matlab and its accompanying programs.

10.3 Premises

The group has been given acces to the FLUMES laboratory at the campus.

10.4 Economy

Since everything needed to test and develop this project is already available on the campus, this project have not been given a budget to work with.

11 Milestones

Some milestones during the project was set by the group, these are listed in table 3. The number of the milestone, a brief description of it and the date it is to be reached is seen in the table.

Milestone	**Description**	Date
1	Every subsystem should be independently functional and be able to communicate to one another.	2021-11-10
2	A complete functional Digital Twin.	2021-11-17
3	The Digital Twin should manage to complete a mission assigned by the customer.	2021-11-24

Table 3: Milestones.

12 Time Plan

The time plan will have the format shown in table 4. It will have a short description and the approximate amount of hour needed for completion of the activity.

No	**Activity**	**Description**	Hours
1	x	x	x
2	xx	xx	xx
3	xxx	xxx	xxx

Table 4: Template of time plan.

12.1 Time Plan - General

No	**Activity**	**Description**	**Hours**
1	Requirement specification	Provide a requirement specification.	50h
2	Project plan	Provide a project plan.	15h
3	Time plan	Provide a time plan.	4h
4	Design specification	Provide a design specification.	95h
5	Test Plan	Provide a test plan.	25h
6	Test Protocol	Provide a test protocol.	20h
7	User manual	Description of how the product is to be used.	30h
8	Technical Documentation	Provide a technical documentation.	70h
9	After Study	Establish an after study.	30h
10	Web Page	Create a web page.	30h
11	Movie	Create a movie visualizing the project.	20h
12	Deliveries	Meetings with deliveries as agenda.	45h
13	Meetings	Meetings within the project group.	250h

Table 5: General activities.

12.2 Time Plan - Subsystem 1

The following table shows a time plan for subsystem 1 - Models for energy producing components.

No	Activity	Description	Hours
1	Obtain information	Gather information about energy producing components which are suitable in the system.	20h
2	Sketch up	Sketch up and make a possible layout for the system.	95h
3	Create models	Create models for producing components in simulink.	165h
4	Validation of each model	Validate each and one of the models separately.	15h
5	Connect models	Integrate energy producing models with each other for a more complete system.	15h
6	Complete system	Integrate energy producing models with energy consuming components as well as implement in the control system.	15h
7	Validation	Validation of a more complete system of energy producing components.	15h
8	Interface	Create a clear interface where you are able to follow the energy producing components.	15h

Table 6: Subsystem 1 activities.

12.3 Time Plan - Subsystem 2

The following table shows a time plan for subsystem 2 - Vehicle management system (VMS).

No	Activity	Description	Hours
1	Establish knowledge of control strategies	Establish knowledge about control strategies and where they can be implemented.	30h
2	Control strategies for energy management system	Sketch up a possible system layout for the VMS	70h
3	Implement control strategies	Connect each model to the VMS.	25h
3	Validation	Validate the control for each model/component.	25h
4	Combine control system	Combine controllers for a complete system.	25h
5	Validation complete system	Validate the complete control system.	25h
6	Parametrization	Tuning of the control strategies.	25h
7	Optimization	Optimize control strategies	25h

Table 7: Subsystem 2 activities.

12.4 Time Plan - Subsystem 3

The following table shows a time plan for subsystem 3 - Physical components.

No	Activity	Description	Hours
1	Information obtainment.	Obtain information about Ethernet and switches in order to know what to buy.	5h
2	Testing.	Test how long it takes to send and receive a message.	10h
3	Establish connection	Establish connection between computer and power source.	50
4	Distribution of power, iron bird	Being able to distribute the power to components on the Iron bird	10h

Table 8: Subsystem 3 activities.

12.5 Time Plan - Subsystem 4

The following table shows a time plan for subsystem 3 - Models for energy consuming components.

No	Activity	Description	Hours
1	Implementation	Implement the models as part of the complete system.	15h
2	Connect models with complete system	Make sure integration with energy consuming models and rest of the system works	20h

Table 9: Subsystem 4 activities.

13 In Case of Sudden Change

In case of any changes to the project, such as group changes or project directives, the group shall order a meeting to discuss and thereafter act upon the best way to achieve the goal of the project.

14 Quality Plan

Everything that is created during this project, hardware, software or written documents are to be reviewed before publish. This is to ensure highest possible quality is achieved.

14.1 Checkup

All documents created will reviewed before before handed in. External help from supervisor, Kristoffer Ekberg with reviewing documents will be taken. But there will also be an internal control of documents. Preferable this is done by someone in the group which has not been that involved in that specific document.

14.2 Test Plan

A test plan will be established. The test plan will describe what tests are needed to assure the requirement specification will be fulfilled. It will also make sure the there is a high quality in what is created.

15 Priorities

The priorities of the group is to achieve all the goals set up for the project. All work done shall be of a high quality to satisfy the customer.

16 Project ending

This project will be seen as complete when the developed software have been tested and the results are giving satisfactory results compared to the requirements set up for the project. Also the customer needs to be content with the results presented.

Also every document and other media required should be submitted to the course.