Detailed Design Description (DDD)

Terma case

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1 Revision history

Date	Ver. No	Author	Contact	Description
22-Feb-2014	1.0	-	-	Initial version
22-Feb-2014	1.1	Fatemeh	201210732@iha.dk	Added req. ID file into Detailed component
25-Feb-2014	2.0	Lars L	-	Changes in accordance to F-MoMDDR-2014-V1
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2 Stakeholders

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3 Subcontractor Information

A subcontractor will be used to develop and manufacture the pod and any additional climate control protection as described in Requirement 29 and 41 in the document F-SRS-2014-V1 . The subcontractor will be Group G.

4 Scope

The origin of this section is the section "Scope" in the F-SRS-2014-V1 document.

4.1 Identification

This document applies to the self protection suite to be developed by Terma A/S for the Royal Danish Airforce.
The solution will incorporate a pod and an intelligent cockpit control unit for the F-16 Combat Aircraft. The pod will be able to dispense payloads consisting of chaffs and flares and also host the Missile Warning System (MWS). The solutions will provide warning upon detection of missile threats and be able to automatically dispense payloads in response.

4.2 System-overview

The goal of the system is to protect the aircraft from enemy incoming missiles by deploying flares and chaffs. It also provides threat information to the information computer, which interacts with the pilot. It is possible for a technician to load the system with chaffs and flares. During the preparation phase before the missions, the system informs the technicians about the current amount of chaffs and flares present on the aircraft.

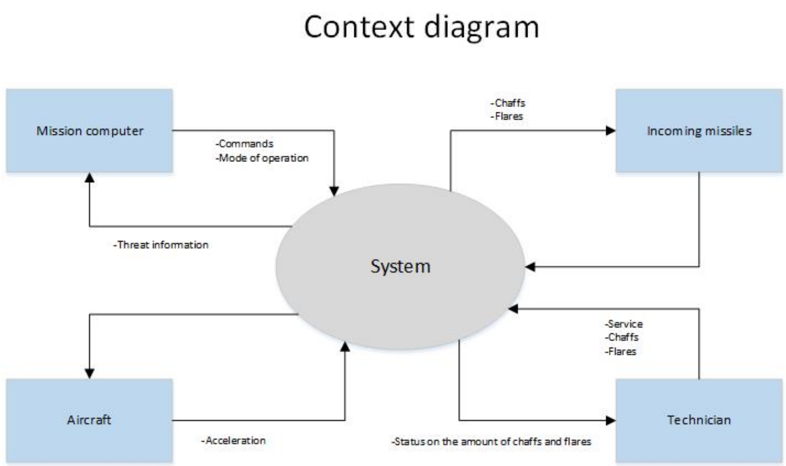

Figure 1: Context diagram

5 System-wide design decisions

System-wide design decisions for the system were made as part of the preliminary design effort. The team evaluated potential system-wide design issues and conducted analysis on how the system and its components would behave under different environmental conditions. The design focuses on the different states the systems has, the hardware and software that will be a part of the aircraft.

States of the system
The system will have different states depending on what is set as input to the cockpit unit by the mission computer. The system has three distinct states:

- Automatic: The system automatically detects and deploys the payload without the pilots interaction
- Semi-automatic: The system detects the enemy missile but it asks for the pilots consent before deploying the payload
- Manual: The pilot has to select the desired payload and deploy it himself.

Safety lock to prevent dispensing on ground
The system has a built in safety feature which will prevent deployment of the payload when the plane is not airborne. This will be possible by an independent hardware device that detects when the landing gear is on the ground. This hardware device cannot be circumvented.

Detection and action upon incoming threats
We are using the missile warning system (MWS) to detect incoming missiles. Incoming missiles are considered an input in this design where the payload deployment system will respond to this input by deploying the payload upon detection of a missile. The payload is located in the pod that is mounted on the aircraft.

Communicating with the pilot
The cockpit unit is responsible for the communication between the pilot and the system. This communication uses the mission computer as a link and the communication will therefore be purely digital.

Loading chaffs and flares
The payloads or more specific: chaffs and flares, has to be loaded manually to the magazines of the pod before take-off. A flap is present on the pod through which the chaffs and flares can be loaded by a technician.

Physical characteristics of relevant components:

Cockpit unit
The cockpit control unit will be located in the cockpit of the aircraft. The device will be as compact as possible by the current technology in order to allow more space for other devices. The role of the cockpit control unit is to be the bridge between the mission computer and the missile warning system.

Pod
The physical dimensions of the pod cannot exceed $0.5\times0.5\times5$ meter. The pod will have the same color as the rest of the aircraft in order to blend in with the environment. The pod will have a correct aerodynamic shape in such a way that it will create as little drag as possible so it will have minimum

effect on the aircrafts speed. Moreover, the weight of the pod cannot exceed 270 kg. The pod contains three different components:

- Dispenser
- Magazines
- MWS

This means that the total size of those three components cannot exceed neither the inner dimensions nor the total weight of the pod.

Cost
Cost has a significant impact on delivering a solution that will meet the requirements. The hardware components will be made out of more expensive but high quality materials and craftsmanship in order to ensure a reliable and high quality product. The parts made by the subcontractor are expected to be the same level of high quality.

Installation
The CCU will be installed in the cockpit. The POD will be installed under the left wing with standard T-hooks.

6 System architectural design

6.1 System components

6.1.1 Component overview

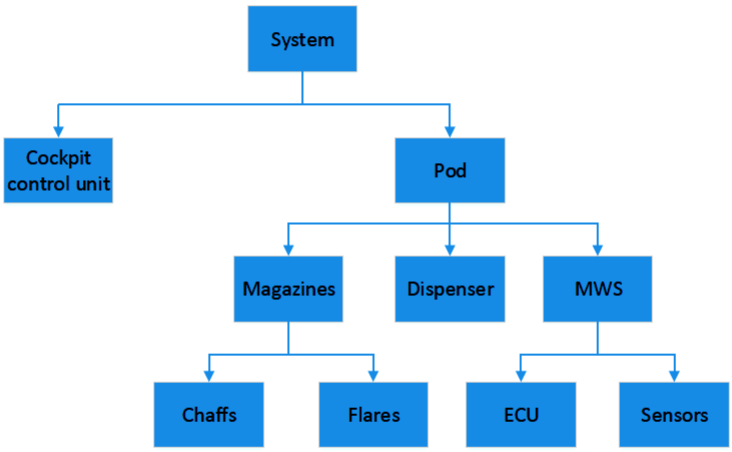

Figure 2: Overview of components

- Cockpit Control Unit (ID: CCU)
- Pod (ID: POD)
  - Dispenser (ID: DIS)
  - Magazines (ID: MAG)

- MWS (ID: MWS)
  - ECU (ID: ECU)
  - Sensors (ID: SEN)

6.1.2 Detailed component description

This section describes all system components and their connection to the requirements.

Cockpit Control Unit
The Cockpit Control Unit (CCU) shall provide all necessary data to the aircraft mission computer.

- The CCU is responsible for switching between the three defined modes when receiving the respective signal from the aircraft mission computer (Req. No. 1-4 in F-SRS-2014-V1).
- The CCU shall be able to turn power ON and OFF for the dispensing system and the MWS (Req. No. 7 in F-SRS-2014-V1).
- The system shall be able to erase sensitive data upon input from a discrete zeroize signal from aircraft and the zeroize signal shall be received by the CCU (Req. No. 25-26 in F-SRS-2014-V1).
- The system shall provide the aircraft mission computer with status information and built-in test results (Req. No. 15 in F-SRS-2014-V1).
- The system status on individual LRU level shall be provided by cockpit unit (Req. No. 17 in F-SRS-2014-V1).

POD
The pod is a detachable compartment on an aircraft for carrying chaffs and flares. The pod also holds the dispenser, magazines and the MWS.

- The pod structure must be functional when exposed to steady state acceleration levels of 4g forward, 2.5g backward, 22g upward or 10g downward.
- The weight of the pod cannot exceed 270 kg (Req. No. 28 in F-SRS-2014-V1).
- The pod shall be operational at temperatures of maximum 134 degree Celcius on outer skin and 152 degree Celcius on leading edge for maximum 3 minutes (Req. No. 29 in F-SRS-2014-V1).
- The pod shall be operational at temperatures of maximum 95 degrees Celcius on outer skin and 152 degrees Celcius on leading egde for a maximum of 25 minutes (Req. No. 41 in F-SRS-2014-V1).
- The physical dimensions of the pod cannot exceed $0.5\times0.5\times5$ meter (Req. No. 35 in F-SRS-2014-V1).

Dispenser
The dispenser is the mechanism in which the magazines are installed.

- The dispenser shall be able to dispense forwards, downwards and sideways (Req. No. 6 in F-SRS-2014-V1).
- The system shall be able to dispense a minimum of two payloads within 0.1 sec (Req. No. 8 in F-SRS-2014-V1).
- The system shall be able to dispense a pattern of payloads programmable by the customer (Req. No. 9 in F-SRS-2014-V1).

Magazines
The magazines contain the chaffs and flares.

- The pod shall include eight standard magazines (Req. No. 5 in F-SRS-2014-V1).
- The magasines shall be stored at no lower than -10 degrees Celcius and no higher than 70 degrees Celcius (Req. No. 26 in F-SRS-2014-V1).

Chaffs and flares
The chaffs and flares are the payload of the system. They are to be dispensed from the magazines.

- The aircraft has to be loaded with the payloads before takeoff (Req. No. 36 in F-SRS-2014-V1).

Missile Warning System
The missile warning system (MWS) consists of an Electronic Control Unit and six sensors.

- The aircraft has to be loaded with the payloads before takeoff (Req. No. 36 in F-SRS-2014-V1).

Electronic Control Unit

- The Electronic Control Unit (ECU) provides threat information in inertial format and the direction of the threat is relative to north (Req. No. 14 in F-SRS-2014-V1).

Sensors
The sensors are responsible for detecting incoming missiles (threats).

6.2 Concept of execution

This paragraph describes the concept of execution among the system components, which are shown in Figure. 2. Since the relations between system components do not change dynamically, this section will describe the execution of a threat being detected.

Threat detected scenario
This scenario unfolds when the sensors detect a missile threat. The sequence diagram shown in figure. 3 describes the automatic mode where the system responds without pilot interaction.

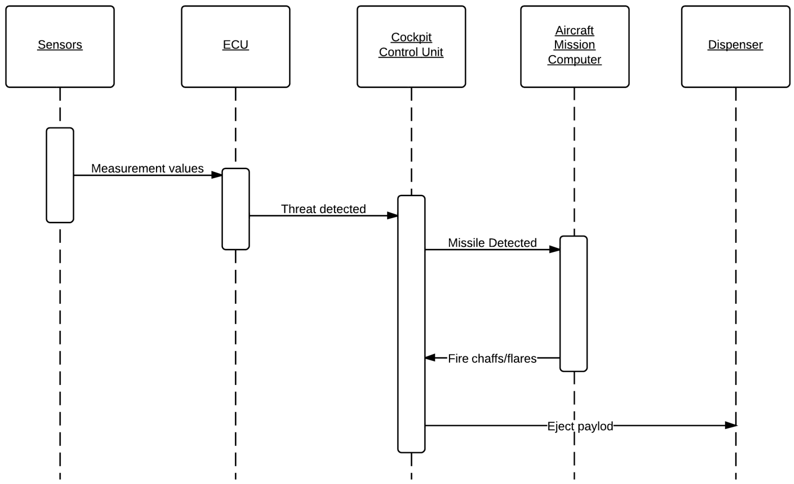

Figure 3: Threat detected sequence diagram

6.3 Interface design

There are different ways in which a system interact with its environment and the other systems. The interaction happening at the various boundaries are called the system's external interfaces. The boundaries between individual components inside the system are called system's internal interfaces.
The external and internal identification can fall into different types such as: electrical, mechanical, real-time data transfer and storage-and-retrieval of data. All the interfaces illustrated in figure. 4.

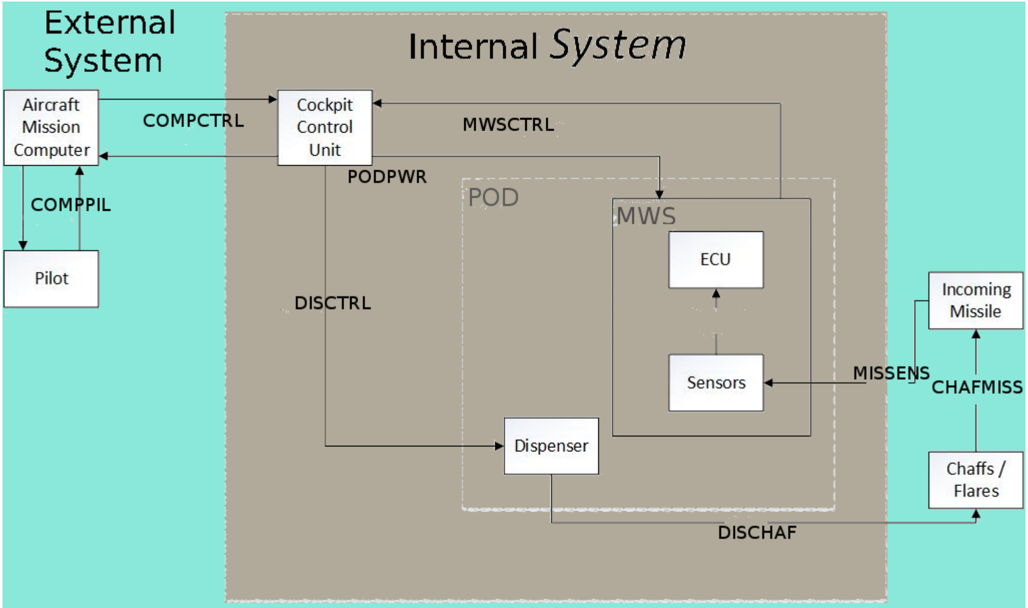

Figure 4: Signal Identification Diagram

6.3.1 External interfaces

External interfaces are the interaction between the missile and the sensors, chaffs/flares and the dispensers, cockpit control unit and the aircraft computer, and lastly the pilot an the computer.
The system interfaces listed and identified on table. 1.

Table 1: External interface units

Interface name	**Identification**	**Endpoint A**	**Endpoint B**
Computer Pilot interaction	E-IF-COMPPIL	Mission computer/ Pilot	Pilot/Mission computer
Computer control	E-IF-COMPCTRL	Cockpit unit/ Mission computer	Mission computer/Cockpit unit
Missile sensor input	E-IF-MISSENS	Cockpit unit	MWS
Chaffs/flares missile disturbance	E-IF-CHAFMISS	Chaffs and flares	Incoming missile
Dispenser Chaffs control	E-IF-DISCHAF	Dispenser	Chaffs and flares

The unique identification listed under table. 2.

Table 2: External Interface Elements

	E-IF-COMPPIL	E-IF-COMPCTRL	E-IF-MISSENS	E-IF-CHAFMISS	E-IF-DISCHAF
Type	Software, Hardware	Software	Environment	Environment	Mechanical
Commun. methods	Visual, Audio	Wired	Radar	Physical	Physical
Physical compatibility	Large keyboard and Screen	FPGA	High sensitivity and fast	Fast reaction	Easily disposable

6.3.2 Internal interfaces

This section describes the internal interfaces. The system interfaces can be seen on figure 4. The internal interfaces are listed in Table 3.

Table 3: Internal interfaces

Interface name	**Identification**	**Endpoint A**	**Endpoint B**	**Standard**
MWS Control	I-IF-MWSCTRL	Cockpit control unit	MWS	MIL-STD-1553-B
Dispenser Control	I-IF-DISCTRL	Cockpit control unit	Dispenser assembly	MIL-STD-1553-B
Pod power control	I-IF-PODPWR	Cockpit control unit	Dispenser assembly and MWS	N/A (electrical)

I-IF-MWSCTRL
This real-time data transfer interface connects the cockpit control unit and missile warning system (MWS) in the pod. The interface is used to extract threat information from the MWS. The interface also provides the MWS with aircraft navigation data. Communication on this interface is formatted as specified by MIL-STD-1553-B.
The data exchanged through this interface can be seen below:

- Threat data (MWS → Cockpit control unit)
  - Direction relative to north
  - Size
  - Velocity
- Aircraft navigation data (Cockpit control unit → MWS)

The physical layer is defined by the MIL-STD-1553-B standard.

I-IF-DISCTRL
This real-time data transfer interface connects the cockpit control unit and the dispenser assembly in the pod. The interface is used to control payload dispensing. The data on this connection flows only from the cockpit control unit to the dispenser assembly. Communication on this interface is formatted as specified by MIL-STD-1553-B. Any data transaction on this interface is command to fire containing the following data:

- Direction to dispense (forwards, downwards, left, right) relative to aircraft heading.
- Payload selection (chaffs/flares)
- Pattern to fire

I-IF-PODPWR
This electrical signal connects from the cockpit unit to the dispenser assembly and the MWS in the pod. When asserted, this signal enables power to the dispenser assembly and MWS. When not asserted, the power is off.

7 Requirements traceability

In this section the traceability matrix for the system is presented. From this it is possible to make the connection from the system requirements to the system design components.

	Hierarchy level								
	1		2			3			
Components / Requirement No.	Cockpit unit	Pod	Dispenser	MWS	Magazines	Chaffs	Flares	ECU	Sensors
1	x								
2	x		x		x	x	x		
3	x		x		x	x	x		
4	x		x		x	x	x		
5		x							
6		x							
7	x		x	x				x	
8			x						
9	x		x		x	x	x		
11	x								
12	x			x				x	
13	x			x				x	x
14	x								
15	x								
16	x								
17	x								
18	x			x				x	
20	x								
21	x	x							
22	x								
23	x		x						
24	x								
25	x								
26					x				
27		x							
28		x							
29		x							
30	x		x						
31				x				x	
35		x							
36		x			x	x	x		
37	x								
38	x	x	x	x	x	x	x	x	x
39						x	x		
40						x	x		
41		x							

Figure 5: Traceability matrix