

# **COP Dismounted**

## **System Design Description**

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## History

Date	Description	Name	Version
05/10 2010	Document created	AHP	1
06/10 2010	Adding drawings and section 1 - 4	AHP	2
07/10 2010	Adding interface description and requirements	AHP	3
07/10 2010	Adding dynamic behaviour	AHP	4
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# **1. Scope**

## **1.1 Identification**

This document describes the system design of the dismounted version of the Common Operations Picture (COP) situational awareness platform. The a Dismounted COP is achieved by scaling the full COP, as defined by the SiteWare Tracking Server system (see COPvA and STSSvA4) to fit a portable device and adding required security, communication and location measures.

## **1.2 System overview**

The system is a Dismounted COP, enabling military, disaster and other required personal to gain an overview of the battlefield, crises or other situation.

The system allows for integration with other military and disaster systems as defined by the Systematic SiteWare Track Server system (see COPvA and STSSvA4).

The Dismounted COP must be able to transmit its current location to the tracking server, as well as receive tracking and other information from the server about units and activities in the area.

The system must be battery powered, mobile and operational under extreme conditions and while wearing gloves.

An overall system drawing may be seen in Figure 1.

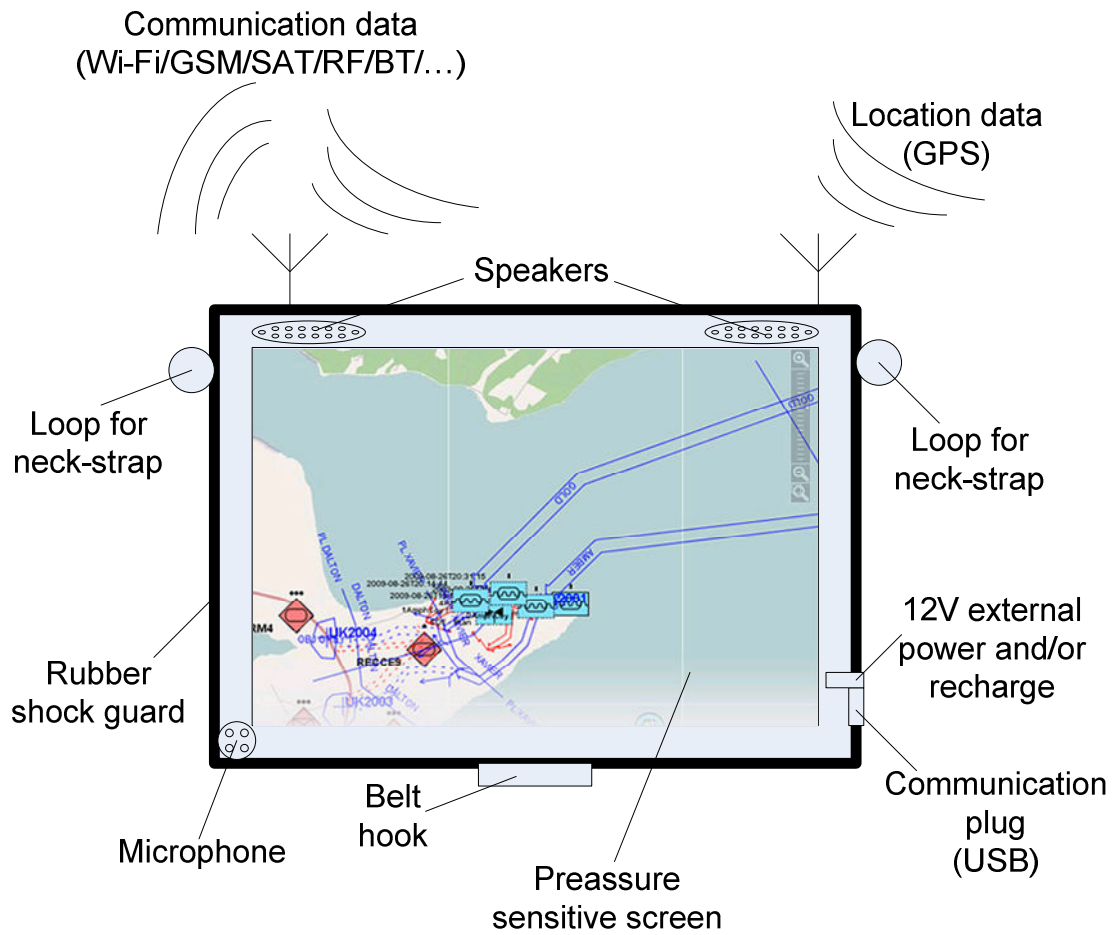


Figure 1: System drawing of the Dismounted COP.

### 1.3 Document overview

This document details the overall system design and its purpose is to guide the detailed design of the dismounted COP to achieve the optimal solution while keeping the overall goal abreast as well as document any rationales of rejected technologies or designs and pinpoint risks and areas with tight requirement traceability (areas where extra care must be taken to meet requirements).

## 2. Referenced documents

Doc. ID	Name	Description
COPvA	COP main project	The requirements, design and documentation for the main COP project which this project is a sub element of.
STSSvA4	SiteWare Tracking server system	The complete documentation of the SiteWare Tracking server system which this Dismounted COP is a portable version of.
SOW		Statement of work from main contractor.
		Q&A regarding SOW from main contractor.
CLi-ionvB	Cobolt Li-ion specification	Details about the performance, weight and handling of the Cobolt Li-ion power cell.
GSMv5	GSM specification	
SATv6	SAT communication	

	specification	
WLANv7	Wireless LAN specification	
RFv8	ISM and general RF specification	
BTv2	Bluetooth specification.	

### 3. System-wide design decisions

In order to best understand the design decisions, risks and challenges it is beneficial to have a comparable device to measure against. For that purpose the Apple iPad is well suited, as it is similar in physical dimensions and capabilities. In the table below may be seen the design specifications for the Apple iPad.

Weight excl. battery	480g
Battery weight	250g
Battery power	25Wh
Battery type	Phosphate Li-ion = 100Wh/kg
Battery durability	Up to 10 hours (9 hours using GSM)
Display	9,7" touch screen
Communication	Wi-Fi, USB, GSM, Bluetooth

#### 3.1 General considerations

Due to the wide spread use of much of the technology employed in this project in civilian industry (GSM modules, GPS modules, touch screens, Wi-Fi, etc.) it is a general design choice that COTS is used whenever possible and as little custom design as possible. As an example of this there is the GSM capability. It is naturally possible to design a Quad-band antenna amplifier and LNA, design the print-board with oscillator, antenna, microcontroller, etc., and write the code to control modulation and protocol. Test and approve EMC and ensure that the noise, both internal and external do not interfere with system. Or a complete High-end module where all this has already been done and all tests has been performed and which has already proven its worth in real life. The latter solution is preferable when the unit count is not very high, for GSM modules in the order of 1 million.

#### 3.2 Weight and power consideration

At present the Cobolt Li-ion batteries support the highest energy concentration of 160Wh/kg, and the design will therefore use this as a basis for creating the power architecture – this is not a design constraint, and should better technology emerge naturally it should be considered.

The safety aspect of using anything with this high a energy density will not be considered, as it is not a requirement and any problems regarding transportation and storage of the batteries falls to the main contractor.

As the requirements for the Dismounted POD's critical operation time is 12 hours and it has a 10-12" display this means it requires more power and for a longer time than the comparable device. It also

requires more back-light and communication. To accommodate these requirements it is estimated that a minimum of 400g of Cobolt Li-ion is required, i.e. 64Wh of power.

As the battery already consume half the permitted weight much consideration must be taken into the design of the frame and screen, as comparable device weighs 480g without battery, leaving only 120g extra for the added durability (rubber protection, harness, ...) and communication. It is believed that this will be a major design risk and must be reduced early in the implementation process.

### 3.3 Battery life and usage considerations

Even with 64Wh it is not realistic to run the backlight at 1000 candela per square meter for 12 hours, and also the communication is a limitation (see communication considerations). Therefore a definition of critical operations will be set up to guide the design:

Usage	Description	Time
Backlight at 1000cd/m2*1	Maximum backlight – should be used under very bright light to see while temporarily in direct sunlight.	3 hours
Backlight at 500cd/m2*1	Normal backlight – should be used under normal lighting conditions.	12 hours
Backlight at 100cd/m2	Low backlight – should be used in poor lighting conditions.	>12hours
Active data transmission*2	By active data transmission is meant the actual transmission of the data by the physical layer (magnetic waves in one form or other). If new is received every minute and transmission takes 5 seconds (depending on amount and signal strength (retransmissions)) then the system can be operational for $60/5 * 2 = 60$ hours. Naturally any duration above 12 hours is not guaranteed. Active data transmission includes speech.	2 hours

\*1 for numbers between 500 and 1000 cd/m2 please refer to the operational time chart for details.

### 3.4 User interfacing consideration

Due to the requirement that the Dismounted COP must be used with gloves there are limitations on the accuracy of the touch, especially if moving about or in a volatile situation. The design focus must therefore be on simplicity and the system must be able to cope with incorrect or double presses. Furthermore, due to the very limited interfacing capabilities of a gloved hand, an administration mode may be beneficial, e.g. using the USB interface to attach a keyboard and then simply supplying the administrator with a command prompt. The administration mode is only for setup and utility functions, never for normal or critical operations.

The glove is considered to be a fingered glove and not a mitten.

### **3.5 Communication considerations**

As the main SiteWare trace server is designed to be a command center and be hosted in a large van or trailer it is not feasible to support the same forms of communication. For example the use of low frequency RF to communicate over long distances requires a large antenna and high power output, which is simply not possible. The SAT communication generally requires a larger antenna and has a higher power requirement than e.g. GSM, but it is a feasible communication media to build into the system.

The system will automatically choose the “best” communication media available based on bandwidth and power consumption.

### **3.6 Security considerations**

The system will use the communication media as-is, and not additional security (encryption) will be added.

### **3.7 Non-critical design decisions**

There are many parts of this project that has successfully been implemented in both civilian and government projects, and these parts may simply be reused, and they are subject to very low risk and will therefore not be considered in this overall design. These elements are considerations regarding:

- Choosing a touch display module
- Choosing a GSM/SAT/BT/Wi-Fi/ISM/GPS module
- Choosing a communication bus for module to CPU communication (e.g. i2c, RS232, ...)
- Choosing a specific microcontroller, RAM circuit, Flash drive, etc.
- Choosing a specific charge circuit and transformer.

## **4. System architectural design**

### **4.1 System components**

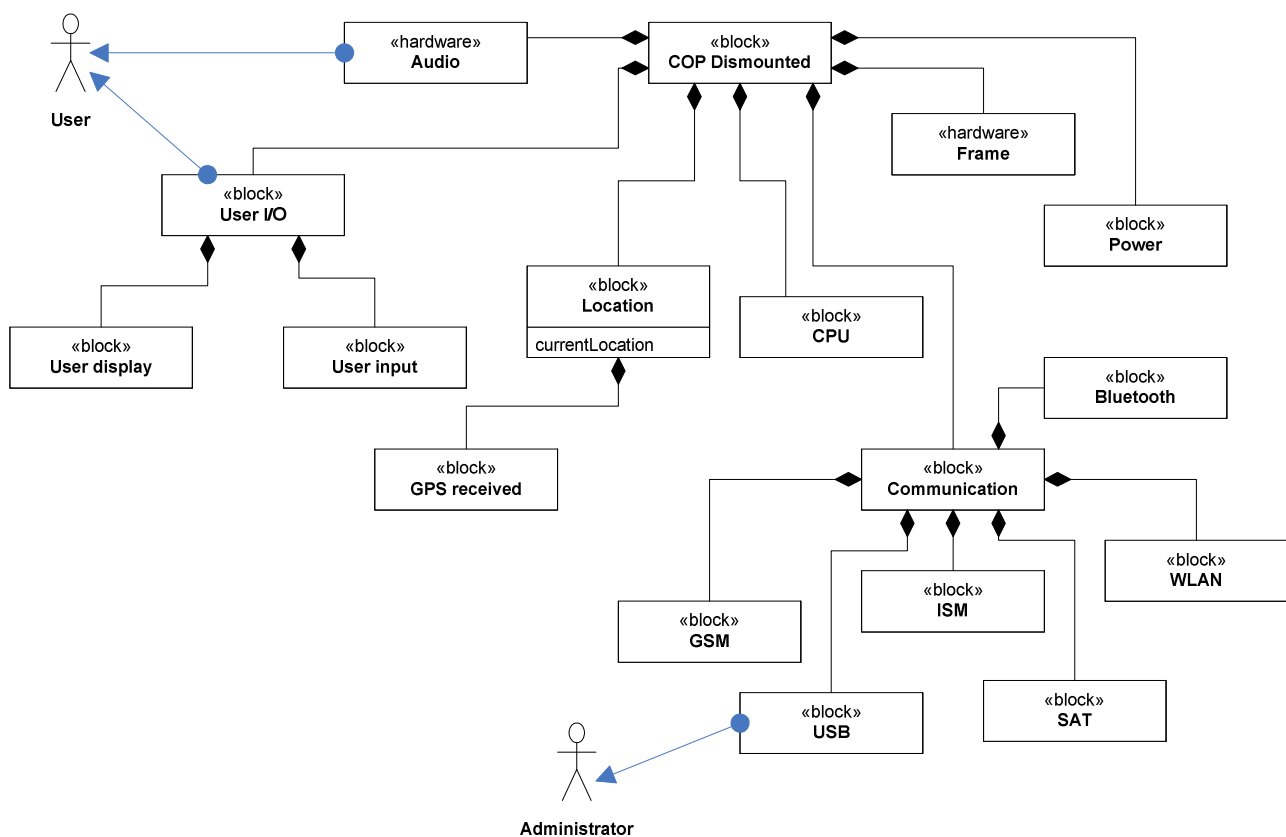
In Figure 2 may be seen the overall elements that comprise the system. These elements are displayed using the SysML notation for a block diagram.

The elements are further broken down in the following sections until a level sufficient for detailed design is achieved. The interfaces are identified and will be described under the section about interfaces.

The individual elements will be described as is required to gain an understanding of the system in the sections following.

Some specific design constraints are transferred from the requirements directly into the design and apply to all elements:

- The handheld device shall be fully operational in the temperature range of: -25 – 80°C.



**Figure 2: Element overview**

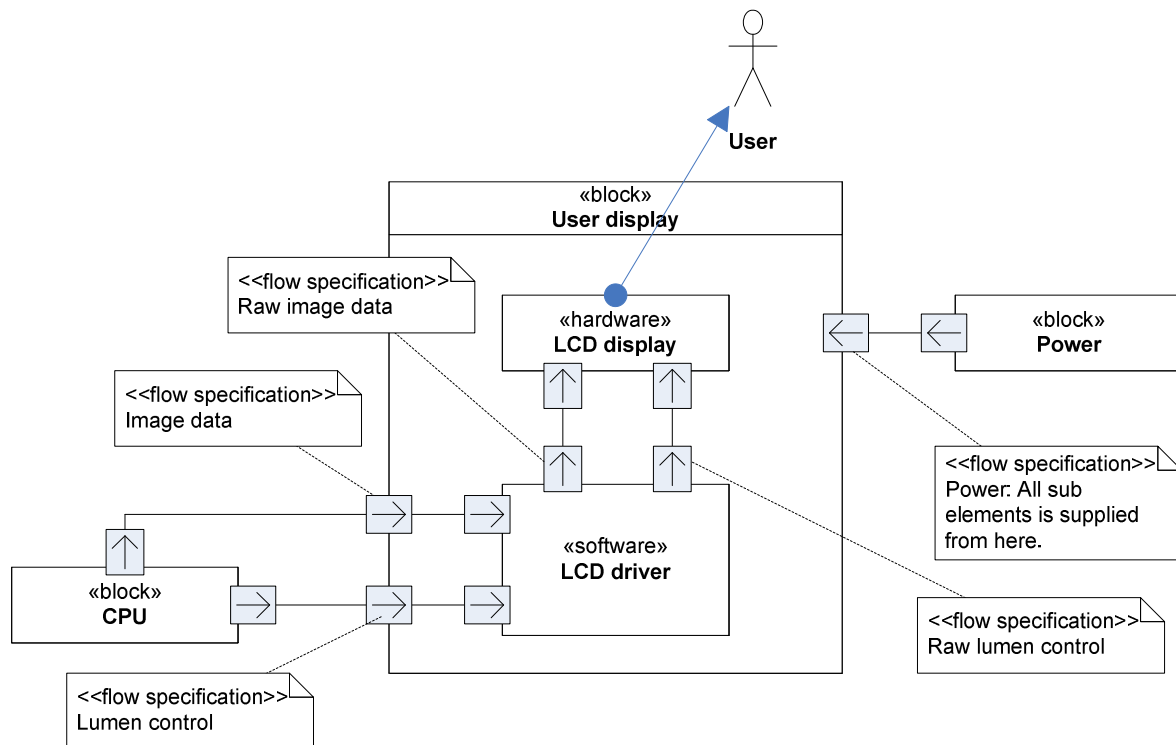
### 4.1.1 User display

The User display element encompasses the part of the display that is responsible for conveying information to the user. This includes any required HW acceleration, SW codices and lumen control.

Even though the LCD driver is depicted in the user display block this is a logic placement only, and it is expected that all driver code is executed by the CPU, with the exception of possible FPGA code required for optimization of encoding/decoding or other raw math processing relating to image processing.

See Figure 3 for a depiction of the inner block diagram for the user display element.





**Figure 3: User display inner block diagram**

Some specific design constraints are transferred from the requirements directly into the design:

- LCD display size 10-12"
- LCD backlight up to 1000cd/m2

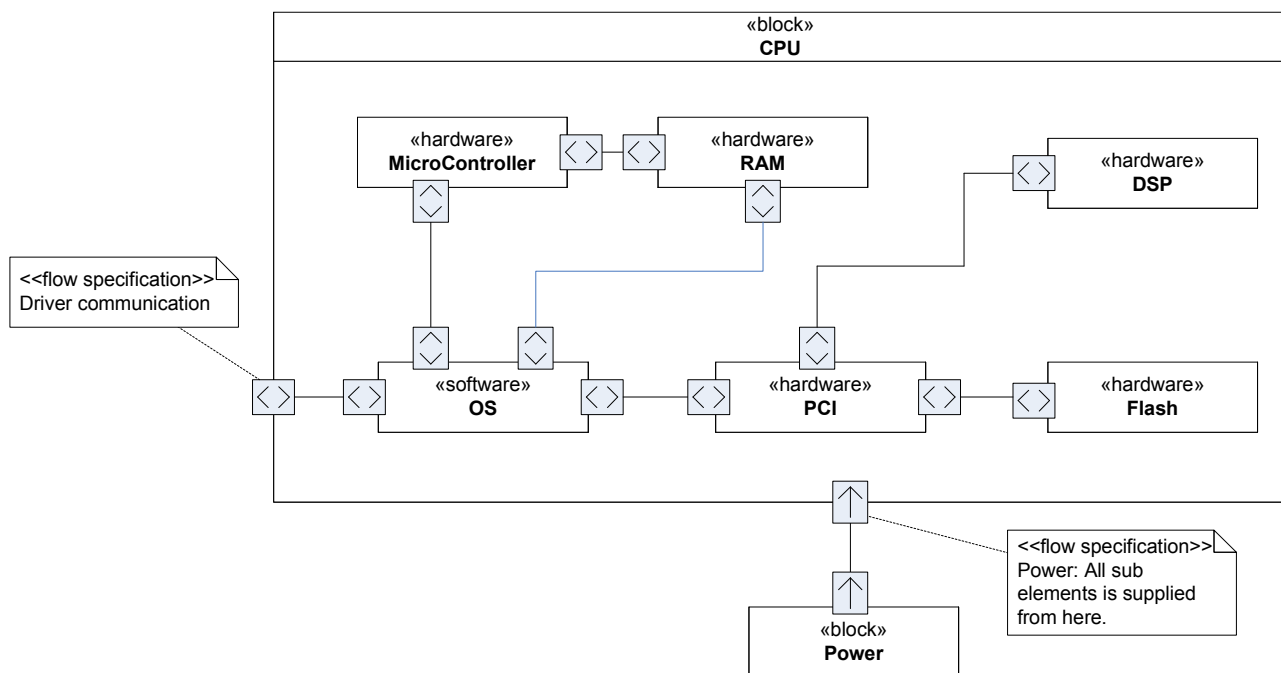
#### 4.1.2 CPU

The CPU element encompasses the microcontroller and supporting bus and peripherals.

In order to avoid cluttering the diagram a single driver I/O interface is shown. This I/O interface represents all drivers to CPU relationships in the other elements. It is shown communicating with the OS, but also have a hardware side to it. In the inner block diagrams of the drivers is shown the wiring between the driver and the hardware. In practice this wiring naturally goes to the CPU block, or more specifically to the Microcontroller or DSP. An example of this could be the Audio I/O – the raw amplified audio input and output may be wired directly to the microcontroller's ADC and DAC pins, where the driver simply control the levels on these pins and whether they are active. Also the display element has this construct where the raw image data is the actual wiring and data bus carrying the data from the microcontroller/DSP to the LCD display and the image data is the SW graphics interface for generating the raw image data.

Also the inner wiring of the CPU/DSP is shown as an example and detailed design may update this.

See Figure 3 for a depiction of the inner block diagram for the CPU element.



**Figure 4: CPU inner block diagram**

Some specific design constraints are transferred from the requirements directly into the design:

- The handheld device shall as minimum contain a general purpose 1GHz processor and 512MB Ram and 420MHz dedicated DSP processor.
- The firmware must be replaceable on site (FOTA).

### 4.1.3 User input

The User input element encompasses the part of the display that responds to touch and thereby is responsible for receiving input from the user. This includes any required HW debouncing, SW drivers and initialization control.

Even though the Touch driver is depicted in the user display block this is a logic placement only, and it is expected that all driver code is executed by the CPU, with the exception of possible FPGA code required for optimization of touch debounce or other raw math processing relating to touch input processing.

See Figure 5 for a depiction of the inner block diagram for the user input element.

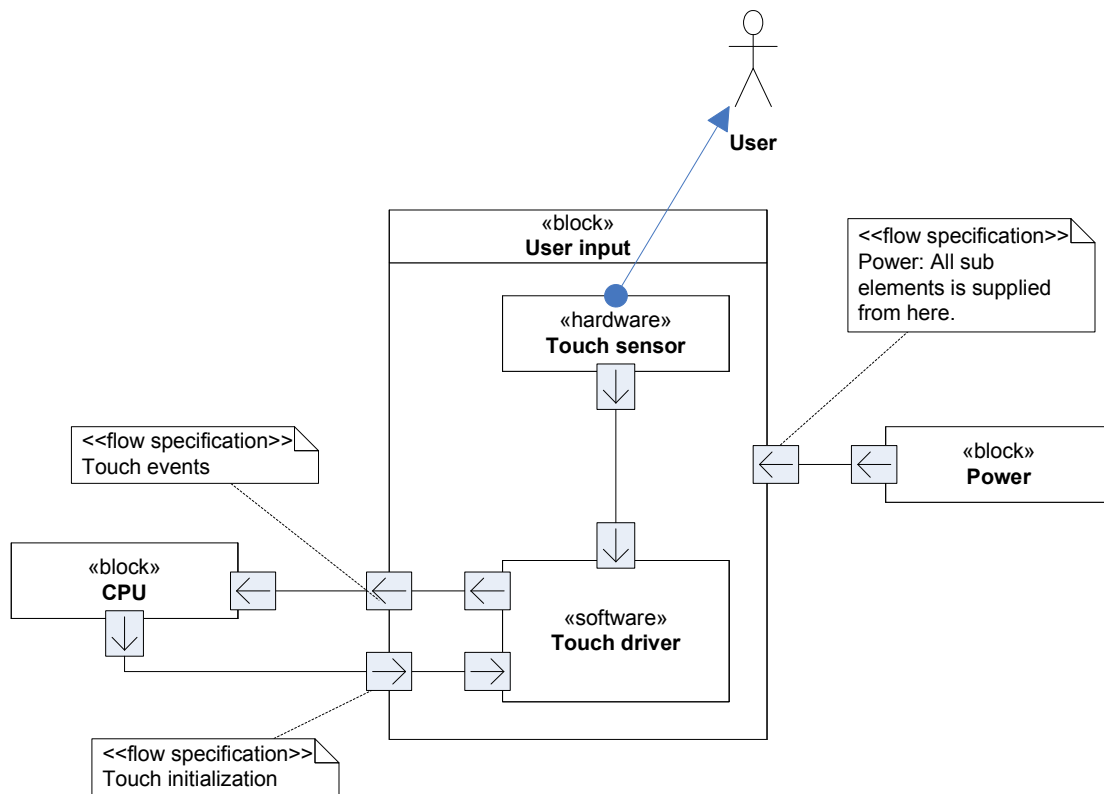


Figure 5: User input inner block diagram

#### 4.1.4 Location

The Location element encompasses the software and dedicated hardware responsible for maintaining the unit's current location.

Even though the Location driver is depicted in the Location block this is a logic placement only, and it is expected that all driver code is executed by the CPU. This includes the Bluetooth driver code, with the exception of code executing directly on the Bluetooth module.

The Location capability has a high priority for the customer, and as getting a GPS location fix is not always possible alternatives must be considered. The following may readily be employed, yet this should not be considered a complete list.

- GSM BTS fix

Each Base station (BTS) indirectly sends out its location, as the base station's location is known and do not change readily. Based on this information and the signal strength it is possible to achieve an approximate location. If multiple BTS's are within range this fix may be greatly improved.

- SAT fix

The Satellite phone network has a built in GPS capability, yet if SAT phone is functioning then GPS is most likely also, and this is therefore of little value.

- Other units

The Dismounted COP is meant to work in conjunction with other units, and if one or more units are within range (e.g. using ISM), and they are aware of their location a similar fix as was achieved with the GSM BTS can be achieved.

Naturally these techniques and others that are discovered during detailed design may be combined to achieve better accuracy, though if GPS is achievable no further location calculations need be performed – the GPS fix will always take precedence.

See Figure 6 for a depiction of the inner block diagram for the Location element.

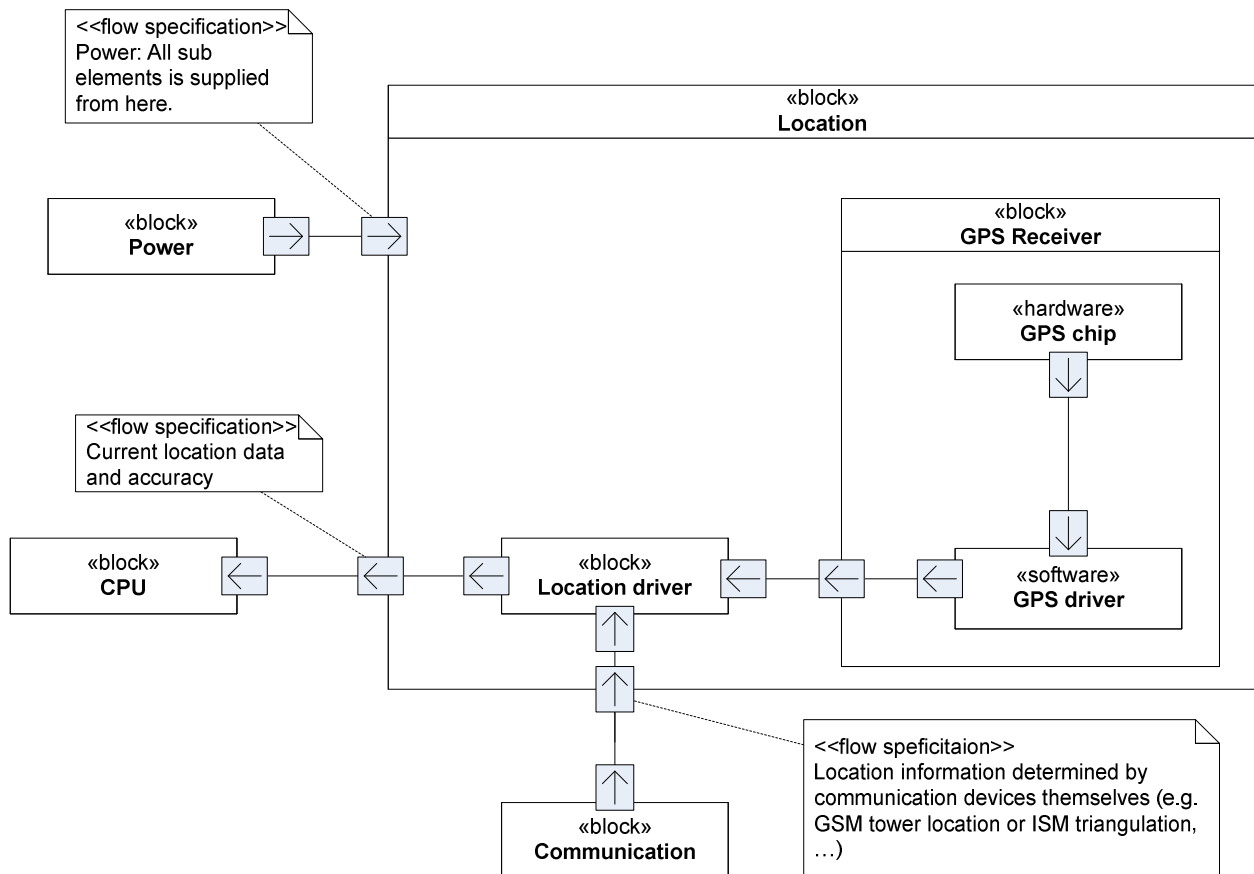


Figure 6: Location inner block diagram

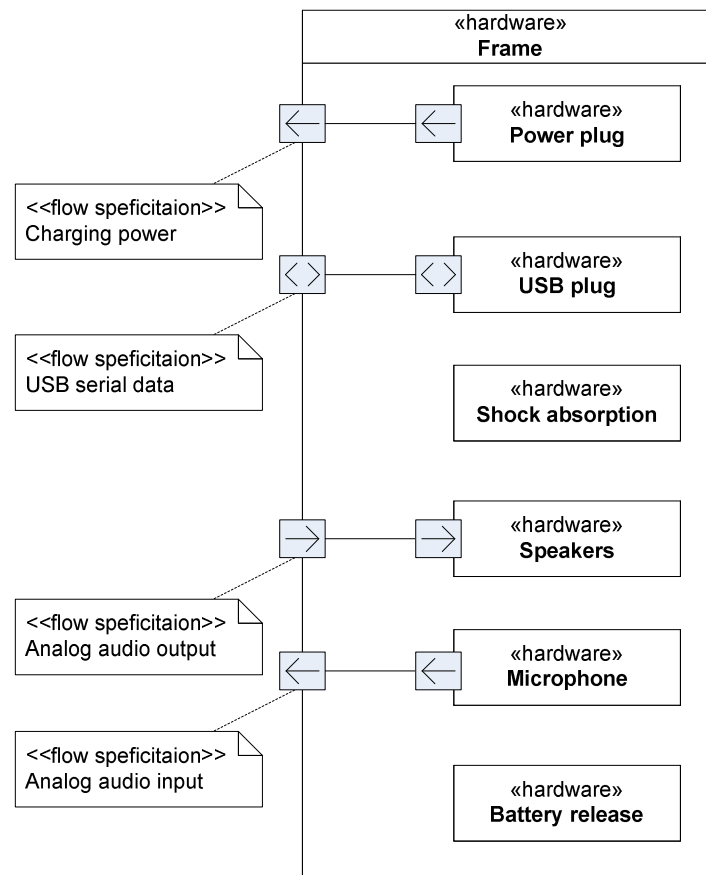
#### 4.1.5 Power

The Power element encompasses the software and hardware responsible for charging the units battery and ensuring that the power is transformed to a suitable level and to report battery status to the CPU.

Even though the Power driver is depicted in the Power block this is a logic placement only, and it is expected that all driver code is executed by the CPU.

See Figure 7 for a depiction of the inner block diagram for the Location element.





**Figure 8: Frame inner block diagram**

Some specific design constraints are transferred from the requirements directly into the design:

- The handheld device shall perform according to IP-67 classification.
- The battery in the handheld device shall be replaceable on sight.

### 4.1.7 Communication

The Communication element encompasses all the external data interfaces of the unit, including hardware, software and modules. It furthermore has the responsibility of making any location determining information that it gains through or because of its data interfaces available to the Location element.

Even though the Communication driver is depicted in the Communication block this is a logic placement only, and it is expected that all driver code is executed by the CPU, with the exception of any code executing on the individual modules.

Due to strict power needs the Communication element will power down any modules currently not in use, e.g. if no Bluetooth headset is in use the Bluetooth headset is shut down. If the ISM communication channel is employed all other data communication modules is shut down (GSM, SAT, WLAN).

The Communication driver will, based on a prioritised list attempt to establish contact with less power consuming communication channels at a regular interval to ensure that the lowers power consumption is achieved, e.g. if the SAT communication channel is employed then the GSM and ISM bands are polled to

see if one or the other can take over. Naturally as this polling also consumes power it should be done at an optimal interval relating to power consumption for poll, power consumption for active communication channel, probability of success.

See Figure 9 for a depiction of the inner block diagram for the Communication element.

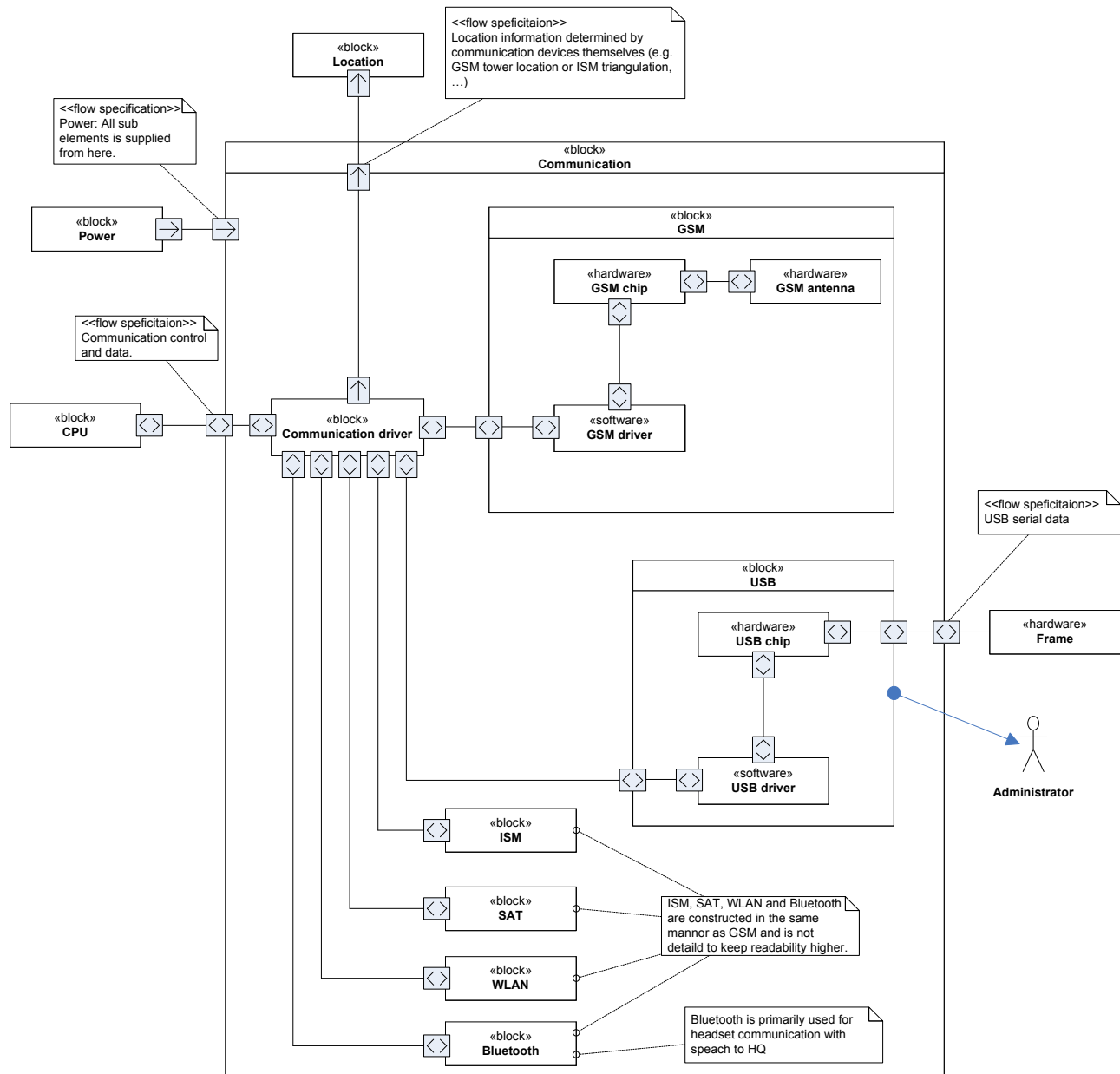


Figure 9: Communication inner block diagram

## 4.1.8 Audio

The Audio element encompasses functionality required to play audio on the unit's speakers and receive audio input from the microphone, as well as software to control this (volume, on/off, ...).

Even though the Audio driver is depicted in the Audio block this is a logic placement only, and it is expected that all driver code is executed by the CPU.

The audio element is expected to be used only with respect to conference calls, where the unit is used by a group of people, or to allow the central server to hear what is going on. For person-to-person communication it is recommended that a Bluetooth headset is employed.

It is therefore not a design consideration that the Audio amplifiers has to be very power efficient, as the 12 hours running time to not include them (2 hours active data transmission also greatly reduced this number).

See Figure 10 for a depiction of the inner block diagram for the Audio element.

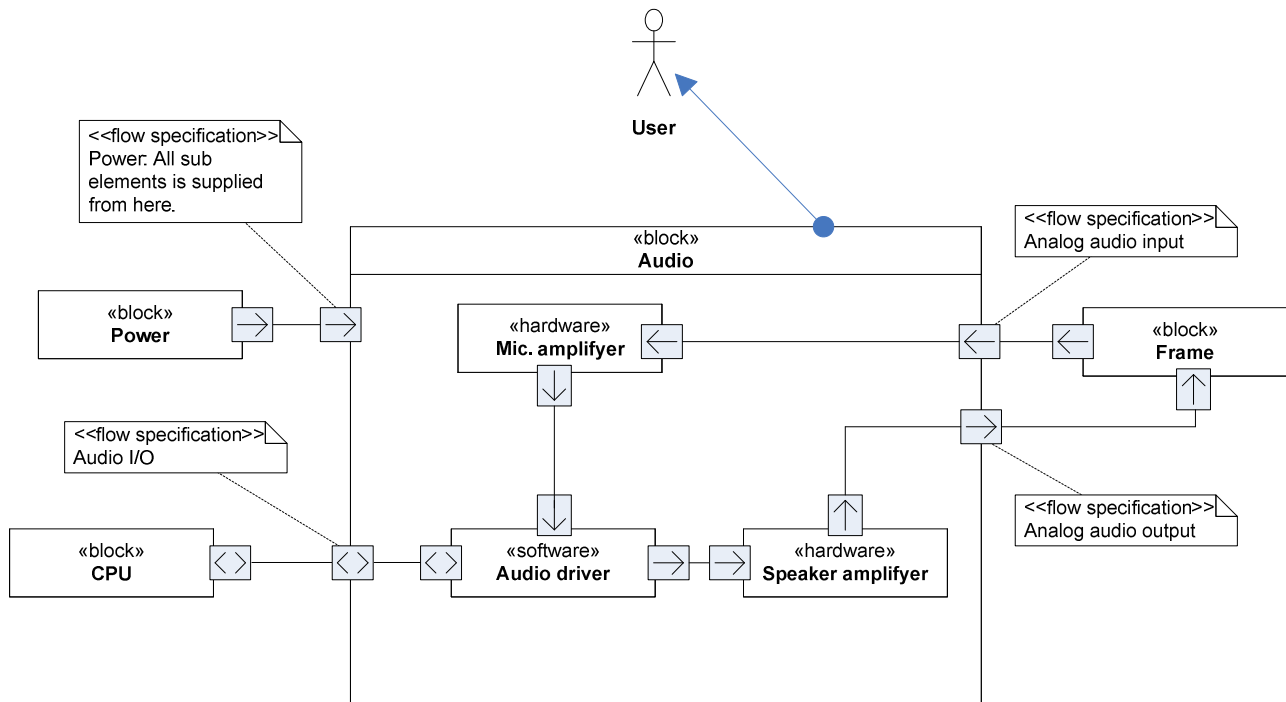


Figure 10: Audio inner block diagram

## 4.2 Concept of execution

As most of the overall execution and data flow is intuitive from the block diagrams and the detailed from of operations within a given element is left up to detailed design, illustrating dynamic behaviour will have a very limited benefit on the understanding of the overall design.

Most of the elements only have two states: ON and OFF, which is the case for the Audio element, the User display, the User input, etc. yet the Communication and Location elements has a slightly more interesting inner state, yet as the Location element has already been described, and the determination of location from triangulation or other means is a very detailed and implementation specific matter, and this one will be left for detailed design.

Finally an overall activity diagram for the system will be drawn up to show the overall path through the system architecture.



### 4.2.1 Communication states

The Communication element as a whole has three overall states; OFF, LOOKING FOR CONNECTION, CONNECTED. Each sub-element has the same states. Only two sub-elements will be shown in the diagram; GSM and SAT, however the other data communication elements (i.e. not Bluetooth and USB) behave in similar fashion.

As it may be seen from Figure 11 the connection lookup is repeated at a predetermined interval, even though a connection is established. This is so it is possible to choose the best possible connection. It may be furthermore be seen that in LOOKING FOR CONNECTION in the Communication element there is a prioritization of the connections, as the SAT connection is disconnected if the GSM connection is achieved, and the same would be true for the other data communication channels.

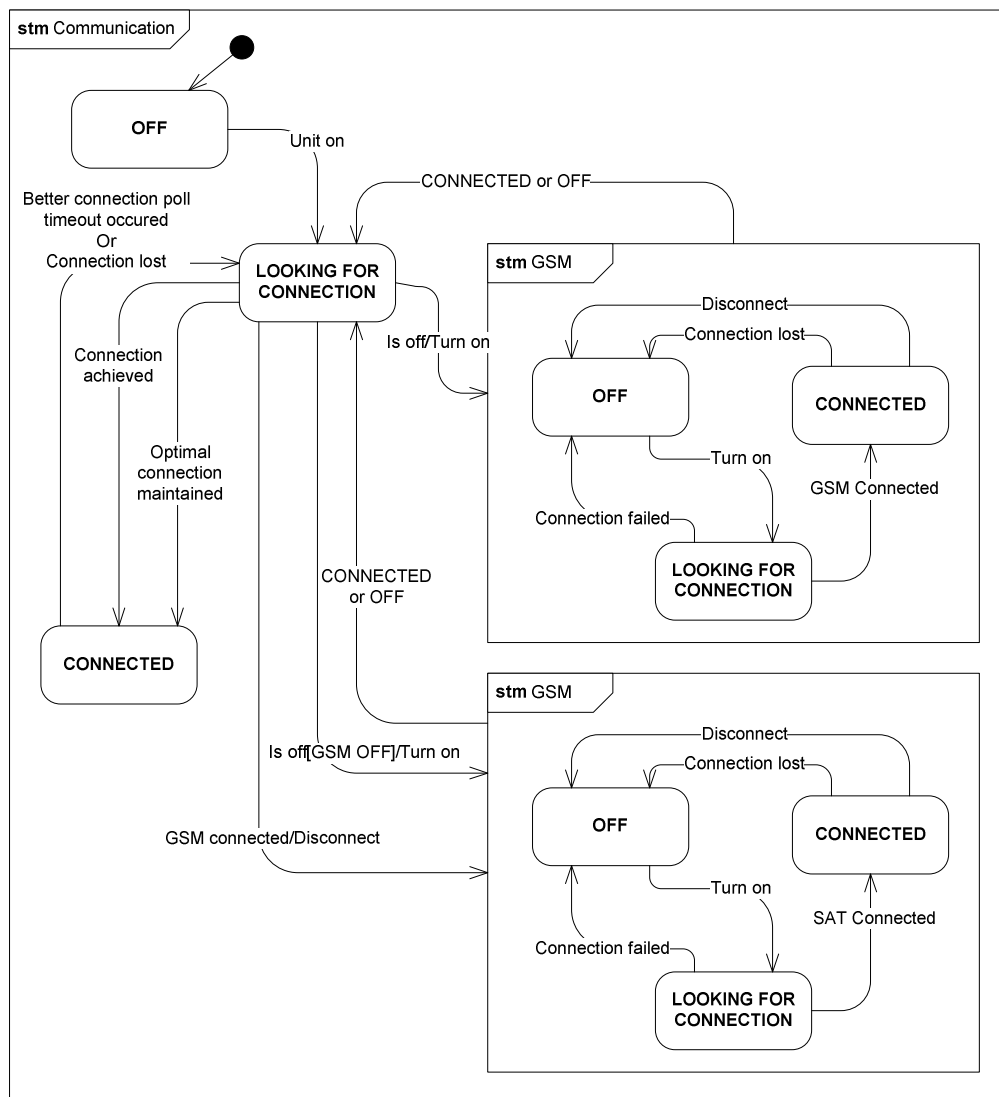


Figure 11: Communication element state diagram

### 4.2.2 Overall activity diagram

The overall activity diagram in Figure 12 merely shows some of the activities the different elements undergo during a subsection of a normal operational run. All activities are naturally cut short to

accommodate space and readability, and it is also important to remember that this is an example of an activity, and not the path always taken. Also note that the different activities take different time, and it is therefore not possible to compare the time of two forked activity lines, as no time indicators are shown.

There are many aspects not touched by the activity diagram, like recharging the battery, using the Bluetooth headset, etc. and naturally these must be considered during detailed design, yet they are not required to gain an architectural understanding of the system.

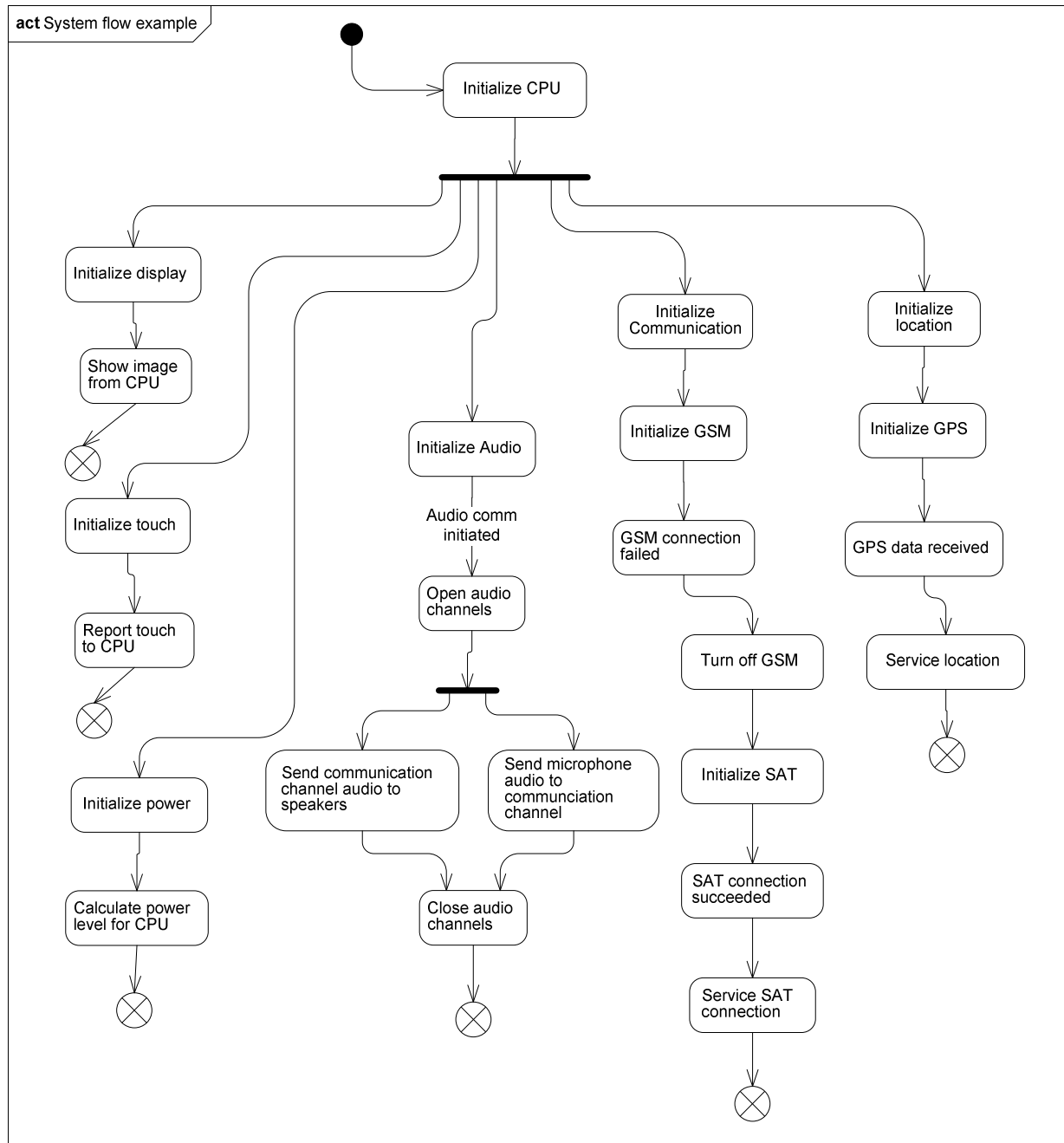


Figure 12: Activity diagram of assorted element activities

## 4.3 Interface design

### 4.3.1 Interface identification and diagrams

This is not an in-depth list, and only the interfaces with any special considerations, as well as an example of the driver to CPU interface, is included. For a detailed description as well as the interface diagrams please refer to the IDD.

Interface	Type	Description
Image data	SW	This interface is used by the application code to generate images on the display; it could e.g. be the OpenGL API.
Raw image data	HW	This is the wiring, protocol and data bus to the actual LCD display and optional dedicated circuits, e.g. FPGA with video codec.
lumen control	SW	This interface is used by the application code to control the backlight of the LCD display.
Raw lumen control	HW	This is the actual wiring, protocol and data bus to control the LCD backlight; e.g. a serial bus with a vendor specific protocol or an analog pin.

## 5. Requirements traceability

Element	Requirement	Description
Communication	TPOD-0001	By including “all” communication channels supported by the main project the Dismounted COP should be able to interface the same way as the main project, given that the relevant protocols are implemented.
User input	TPOD-0002	The user input is a touch screen
Location	TPOD-0003	This element is dedicated to determining the unit’s current location by any means necessary.
Audio, Communication	TPOD-0004	The data communication channels can be used to transmit and receive audio data to/from the Audio element (speakers/microphone) or the Bluetooth sub-element
Communication, CPU	TPOD-0005	The communication channels can be used to transmit new firmware and the CPU element will ensure its persistence and execution.
General	TPOD-0006	Monitored by project manager as module selection and unit design progress.
Power, General	TPOD-0007	By selecting high batteries it is possible to gain the required power at a lower weight, and the project manager will monitor the unit’s weight as module selection and unit design progress.
User display	TPOD-0008	The user display is a 10-12” LCD display.
Frame	TPOD-0009	The rubber shock guard and general unit design will ensure this.
Frame	TPOD-0010	The unit design will ensure this.
Frame, Power	TPOD-0011	The Frame ensures that the battery can be replaced and the Power element contains a charge circuit to charge the batteries from a 12VDC source.
User input, User display	TPOD-0012	The touch screen is calibrated and the display software written for use with gloved hands.
General	TPOD-0013	Monitored by project manager as module selection and unit design progress.

General, Power	TPOD-0014	Battery selection and communication channel optimization ensures this under normal operating conditions.
User display	TPOD-0015	Ensured by LCD display choice.
CPU	TPOD-0016	Ensured by design.