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A
Tabelas com as Especificações dos Hardwares

3.2

Tabela A.1: Especificações do IgotU GT–600 (18)

Weight	37g
Dimension	46 x 41.5 x 14 mm
GPS	SiRF Star III Low Power chipset Hot Start: <1 sec Warm Start: <35sec Cold Start: <35sec WASS & EGNOS support
Antena GPS	Built-in GPS patch antenna
Auto record (Motion Detector)	YES
Interface	USB 1.1
Water Resistant	Yes
Battery	Built-in 750mAh rechargeable Li-ion battery
Build-in memory	64Mb
Waypoints	262,000
LED indicator	Blue & Red
Temperature range	-10 +50 Celsius

Tabela A.2: Especificações do fit–PC2 (19)

CPU	Intel Atom Z510 1.1GHz
Chipset	Intel US15W SCH
Memory	1GB DDR2-533 on-board
Storage	Internal bay for 2.5 inches SATA HDD miniSD socket
Display & Graphics	Intel GMA500 graphics acceleration Full hardware video acceleration of H.264, MPEG2, VC1, and WMV9 DVI Digital output up to 1920 x 1200 through HDMI connector
Audio	Line-out, line-in, mic 5.1 Channels S/PDIF
Networking	1000 BaseT Ethernet 802.11g WLAN
USB	6 USB 2.0 High Speed ports
IR	Programmable consumer IR receiver
BIOS	Phoenix BIOS Bootable from HDD, USB thumb drive, USB CDROM, USB hard disk, over network
Operating Systems	Windows 7 Professional Ubuntu Linux 9.10 Other operating systems can be installed by user
Case	100% aluminum Die cast body
Dimensions	101 x 115 x 27 mm
Weight	370 grams / 13 ounces – including hard disk
Operating Temperature	0 – 45 deg C with hard disk 0 – 70 deg C with SSD
Power	12V single supply 8–15V tolerant
Power Consumption	6W at low CPU load <7W at 1080p H.264 playback 8W at full CPU load 0.5W at standby

Tabela A.3: Características do Modem Claro 3G – modelo E–226

Características	HSPDA/UMTS - Tri-Band (850/1900/2100 Mhz) EDGE/GPRS/GSM - Quadri-Band (850/900/1800/1900 Mhz) Tráfego de dados sobre HSDPA/UMTS/EDGE/GPRS, com velocidade de até 7.2 Mbps sobre o HSDPA

Tabela A.4: Especificações da bateria *Tekkeon MP3450 R2* (20)

Weight	15.3 oz / 430g
Size	6.85"(L) x 3.32"(W) x .89"(D)
	17.4cm(L) x 8.4cm (W) x 2.3cm (D)
Battery Cell	Rechargeable Lithium Polymer
Voltage Supported	5V, 6V, 7.5V, 9V, 12V, 14V,
	16V, 19V
Total Energy Capacity	50 Wh
Output Current	Up to 4.0A
Charging Time	4 hrs
Input Charging Voltage	12 - 20VDC
Included Travel Charger Input Charging Voltage	100 - 240VAC
Included Travel Charger Output Voltage/Output Current	19VDC/3.16A
Adapter Tips	9(including mini USB)
USB Output Port	Built-in
Storage Temperature	-20 +35 Celsius
Charge	0 +40 Celsius
Discharge	-20 -60 Celsius
Extra Power	3.5/7 hrs(Laptop computers)

Tabela A.5: Especificações do monitor *MIMO* (21)

Dimensions	When folded: 7"x 5.25"x 1"(thickness),
	When open: 7"x 4.5"(tall) x 5.25"(base)
Display size	7"
Display resolution	800 x 480
Brightness	350 cd/m2
Contrast ratio	400:1
Connections	USB 2.0
Features	Resistive Touchscreen
	Monitor Pivots 90 degrees
	Integrated Stand and Cover
	Ultra-portable, weighs less than 1 pound(< 450g)
	Drivers for Windows XP, Vista, Vista 64-bit included

B
Artigo publicado na Spring Simulation Multiconference 2011

Command and Control:
A low cost framework to remotely
monitor military training

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Abstract. The Command and Control theory of John Boyd, a 20th century military strategist, allow us to introduce computing techniques that are able to speed up the OODA loop (Observe–Orient–Decide–Act), especially on observing and orienteering steps. This paper introduces a low cost framework capable of monitoring people, vehicles, boats, or any other elements of interest, almost in real time. The goal of this design is to gather and present the best possible information for decision makers in a Theater of Operations.

Keywords: Command and Control, OODA Loop, Military Training , Computer Graphics

1 INTRODUCTION

The success of any military operation is related to the ability to observe the battlefield state, decide and act in a minimum time, guided by the current situation. This essentially means having an OODA loop faster than the enemy force. Based on the Boyd's theory [1], we have been working on the development of a framework that speeds up the observing and the orienteering steps by the application of computing techniques and portable electronic devices.

The system to support Command and Control – C2 has the goal of providing, in a unique environment, some relevant information to the high command such as:

- Sketch graphically, in interactive time (near real time), the monitored elements of a force deployed in theater operations as well as the information about speed and direction of travel of these elements;

- Provide information graphically, about the line-of-sight, the weapon range and the radio range of the monitored elements;

- Present thematic layers with various coordination and control measures used in military operations, such as goals, boundaries, landing beaches, among others;

- Record in a database positions occupied by monitored elements allowing the reconstruction of their itinerary;

- Enable virtual positions simulation of monitored elements, allowing the establishment of retransmission stations, fire and visual coverage, in better conditions.

Achieving these goals, we intend to provide to the high command an adequate tool to manage subordinate forces deployed in theater operations during military training. As a result, we still provide to the subordinate forces a useful mechanism to navigate and quickly orient themselves in relation to command and control measures established.

Figure 1: Monitored elements seen from monitor of stateful station (red and blue icons)

2 ARCHITECTURE OF THE SYSTEM

For a better understanding of the proposed system it is essential to explain its pipeline. Looking at the Figure 2 we can identify two main blocks: monitored element(s) and stateful station. The monitored element contains some portable electronics devices such as a small computer, a 3G modem and a GPS logger. We will talk specifically about
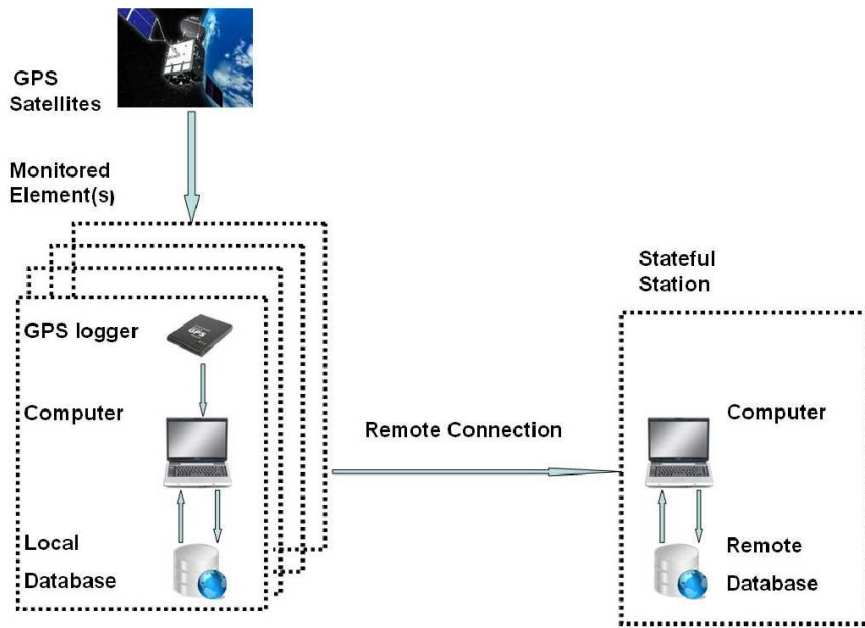
Figure 2: Arquitecture of the system to support C2

the framework's hardwares on the Section 3.

The main idea was to write a script, in our case we use Lua [2], able to do the parsing of the National Marine Electronics Association – NMEA sentence, received by the GPS logger, and transmit/store a record with information such as current speed, latitude, longitude and travel direction. After the parsing we insert all this information in two databases: local (monitored element) and remote (stateful station). The connection with the remote databases is established through a 3G modem. Actually, any remote connection technology can be used (wi–fi, radio, satellite...).

Using a specific application built to handle such data, both members of the system (monitored element and stateful station) can access a display that shows an icon representative of the monitored element georeferenced. We will explain details about the application on the Section 4.

The framework is still able to keep audio and video communication between the monitored element and the stateful station through any communication software such as Skype, MSN, Ekiga...

3 HARDWARE SOLUTIONS

As the proposed framework must be able to monitor from military vehicles or vessels to a soldier, we had to look for hardware that possessed the following characteristics:

- Light
- Small
- Good battery life

So, we found on the market the GPS logger Igot–U GT–600, the computer fit – PC2, the battery Tekkeon MP3450 R2 and the monitor MIMO, with the main features illustrated on the Tables 1, 4, 2 and 3 according to these requirements.

We should note that these characteristics are mainly required by "monitored element", as the "stateful station" could be installed in a room. In this case, the devices used need not to be light or use external batteries.

Figure 3: Vest of monitored element

To solve the problem about how to carry this equipment while keeping the monitored element's hands free, a good approach was to build a vest. The construction of the vest sought to ally materials with the resistance needed to military activities with a design that would promote a good distribution of equipment by the user's body. The compartments that accommodate the devices still provides a satis-

factory water protection. Figure 3 shows the vest and Figure 4 shows the hardwares used by Monitored Element(s).

Figure 4: Hardwares used by Monitored Element(s)

4 APPLICATION DEVELOPMENT

The application that runs both in the monitored element and stateful station was developed using Lua as programming language. A toolkit called Portable User Interface – IUP was used for building graphical interfaces. All elements designed on the canvas of the application were created using a graphic library called Canvas Draw – CD . The images displayed are manipulated through a toolkit for digital image called Image Representation, Storage, Capture and Processing – IM.

The application can be run on several OS such as MAC, Windows and Linux.

In the next subsections we are going to discuss the modeling of the possible simulations on the application.

4.1 Position, Speed and Travel Direction

As explained in the Section 2, the application gets longitude, latitude, speed and direction of a monitored element by a query to the database (data entered into the database coming from the NMEA sentence parsing). To draw the icon that represents the element on the georeferenced position is necessary to follow these steps:

- Through Google Earth or other image provider, we define the limits of the theater of operations using a placemark. This way we obtain the initial and final coordinates of the monitoring area.

- We do a query to the database to find the position of the monitored element (we expect that this element is within the limits of the theater of operations).

- Using a Lua function to convert latitude/longitude coordinates into image coordinates we find the exactly point on the canvas where the application should draw the icon of the element .

The application makes a query to the database to update the information of the monitored elements (position, speed and travel direction) every 5 seconds or other configurable interval.

Data such as speed and travel direction are displayed directly as they are read from database. Figure 5 illustrates this proceeding.
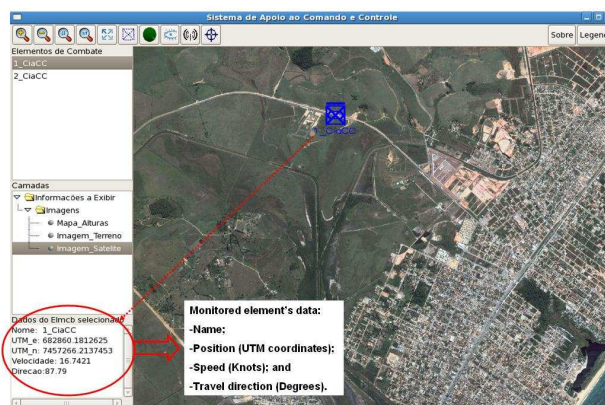

Figure 5: Data from "1_CiaCC" seen on the screen of the system to support C2

4.2 Visual Range

To simulate graphically the terrain area seen by a monitored element from his current position, we use a visual range tool.

The implementation was modeled by a directional cardioid where the range maximum visual considered the naked eye is 4Km. It is worth noting that the choice of cardioid to model the human visual field was due to the fact this is the geometric figure, with defined mathematical formulation, which best approximates the human visual field.

We also considered as input parameters, the altitude of the current position of the monitored element, its direction of travel and terrain to your surroundings.
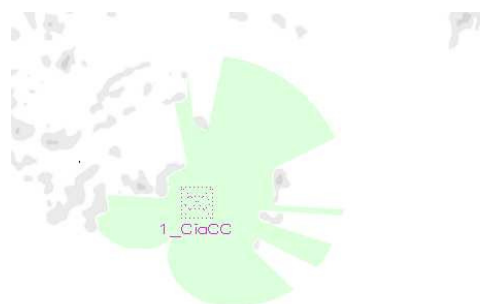

Figure 6: Height map

The applied algorithm [3] needs the altitude attribute of each pixel internal to cardioid. For this reason it was necessary to build a height map of the monitoring area (shown

in Figure 6).

The algorithm compares the altitude of the monitored element position with the altitude of each pixel internal to cardioid (obtained from height map). This comparison is done based on the current position to the edge of the cardioid and 0 to 359 degrees. If the altitude of the monitored element is greater, the pixel is colored green. If the altitude is less, the procedure is stopped and restarted in a new direction until it completes 360 degrees.

Analyzing the example given on the Figure 7, if we had an element positioned in P1, all points belonging to the line that starts from P1 to P2 would be considered visible by the applied algorithm. However, P3 would not be visible from P1.

The result of this tool is shown on the Figure 8. We can notice that all areas colored in green represents visible points by the monitored element "1_CiaCC" from his current position.
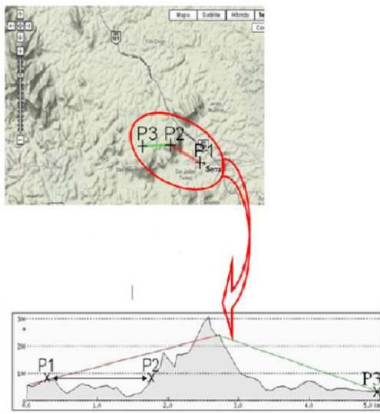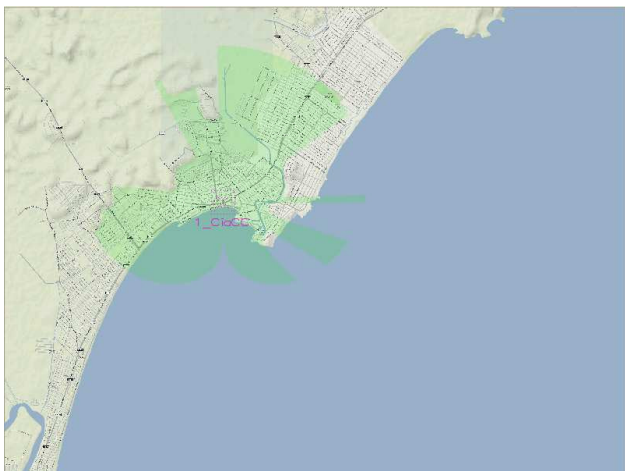

Figure 7: Visualization algorithm

Figure 8: Result of the tool "Visual range"

4.3   Weapon Range

In this tool we simulate graphically the weapon range of a monitored element. It is important to note that the modeling considers just weapons projectiles having roughly straight trajectory (pistol, machine gun or rifle, for example).

The weapon range simulation is quite similar to visual range simulation. The algorithm applied is the same. The only difference is that we replace the cardioid with an ellipse. The current position of the monitored element is one of the ellipse's focus and the maximum weapon range is the major ellipse's axis. When the application makes a database query, the information about what kind of weapon and its maximum range is known. The travel direction of the element provides guidance for the ellipse.

Figure 9 illustrates the result of this tool. All area colored in red could be reached by the weapon of "2_CiaCC" from his current position.

Figure 9: Result of the tool "Weapon range"

4.4   Radio Range

A common problem that usually happens in military trainings is the loss of communications for some fraction of the troops. To try to predict and understand the origin of this type of problem we have developed the tool to simulate the reach of radio equipment associated with specific monitored element.

As input parameters we consider the terrain and the maximum range provided by the manufacturer of the used radio. Again, the algorithm used is very similar to what was used in the tool that outlines the visual range. The differences are as follows:

- The geometric figure used is a circle that is centered in the position of the monitored element. The circle's radius is the maximum range radio provided by the manufacturer.

- To model the influence of terrain on the propagation of electromagnetic waves we consider the following condition:

If there is any point internal to the circle (previously explained) 100 meters of altitude above the position of the monitored element it will block the electromagnetic waves from there.

- All points colored in blue represent the area reached by the radio electromagnetic waves.

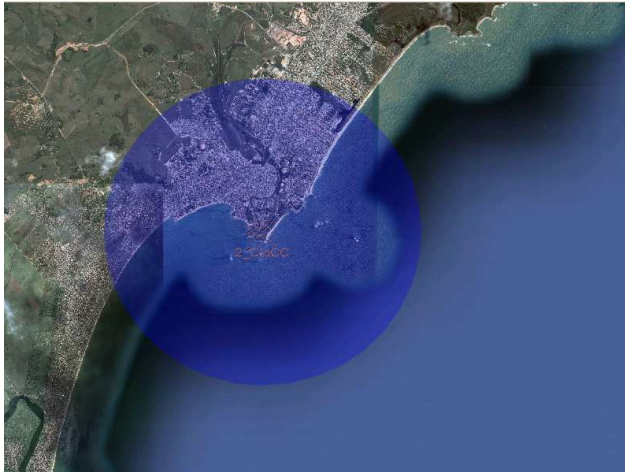Figure 10 shows the result of this tool.

Figure 10: Result of the tool "Radio range"

4.5 Radar Simulation

The movement of approach of various vectors that carry troops from ship to landing beaches, in amphibious operations in military training, is a time that requires great coordination and control of the upper echelon. Depending on the landing beach, the existence of various natural obstacles in this path can easily damage or even prevent the vectors to reach the planned beach .

To assist this approach we have developed a tool that simulates the behavior of a radar providing to the monitored element data such as the distance from its current position to the nearest point above sea level.

We modeled this tool with a circle centered at the current position of monitored element. The radious of the circle (radar range) is configurable. Applying the similar algorithm of visual range tool, a scan is performed inside the circle where all points above sea level are returned. In this case we consider the information brought by the nautical charts in order to discover points above sea level.

We can check the result of this tool in Figure 11.

4.6 Echo Sounder Simulation

Another important information during the transfer of troops from ships to landing beaches is the current depth along the navigation path. Thus to provide this information we have developed the tool "Echo Sounder".

The system requires the construction of a depth map to be able to return the depth of any point. We can see in
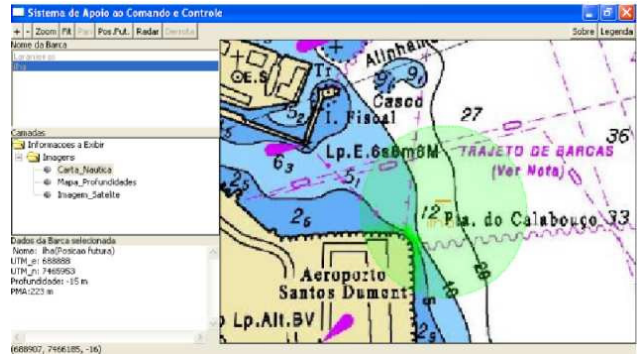

Figure 11: Result of the tool "Radar Simulation"

Figure 12 the depth map from Guanabara Bay. The depth map construction is based on the nautical chart's lines that joins points with the same depth.
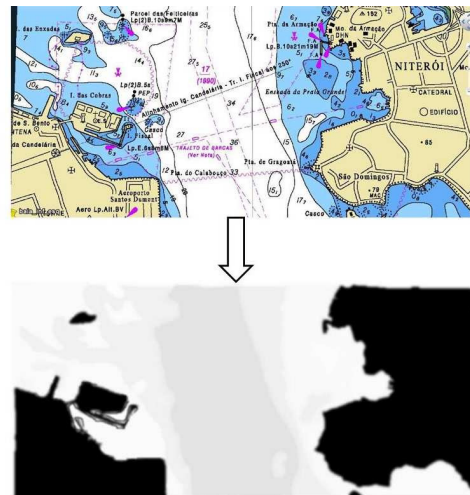

Figure 12: Construction of a Depth Map

4.7 Virtual Position

The problem to be treated by this tool is the adequate establishment of coverage of communication/fire in an area of operations.

The user can simulate the range of the radio of any element, through the radio range tool, and find out all areas not covered by the scope of radio as a function of the limit of its range or the presence of a mountain, for example. In this case, the user can simulate through the tool "Virtual Position" the positioning of a selected element in any point of the theater of operations executing the task of a retransmission post.

This is too a quite useful tool to establish the ideal cover fires of an area. Using the weapon range tool the high command can simulate all area that the arming of a specific monitored element(s) can achieve. Thus, if there is an important area that is not being covered, through the virtual positioning tool, we can check the best position(s)

to be adopted to resolve this issue. It is possible to simulate different main firing direction through a dial control developed in this tool. We can note in Figure 13 a case where the travel direction of the virtual element "2_CiaCC" is not allowing him to fire P1. The user has just turned the dial control to change the virtual element's travel direction and find out that, from the simulated position (facing a different direction), is now possible to fire P1.
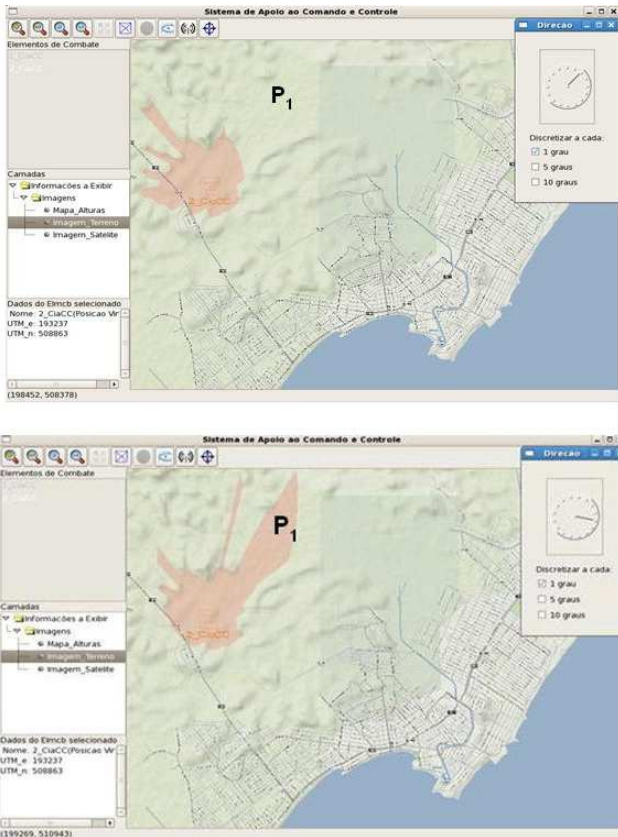

Figure 13: Establishment of the cover fire

4.8   Reconstruction of Itinerary

All positions occupied by a monitored element are stored in a database. This allows us reconstruct all monitored element's path. Thus the high command can find out if any planned maneuver was effectively executed (according to C2 measures) and how it was executed.

Another interesting point is that the system records when the positions were occupied. So this still allows investigating in better conditions any problem that may happen during the training such as an accident, for example.

Figure 14 shows the canvas of the application when the tool is used to reconstruct the path of the "2_CiaCC".

4.9   Thematic Layers

The application allows the user to choose different thematic backgrounds to view the monitored elements. We can see

Figure 14: Result of the tool "Itinerary"

in Figures 8 and 10 images of the same theater of operations obtained from Google Terrain and Google Earth respectively. The user just sets the desired background and the application changes it.

It is still possible to load an image with all C2 measures used in a specific military training as background. In this case is necessary to previously draw such measures, through an image editor. We can see an example of this case in Figure 15 where the monitored element "2_CiaCC" is navigating to the "yellow landing beach".
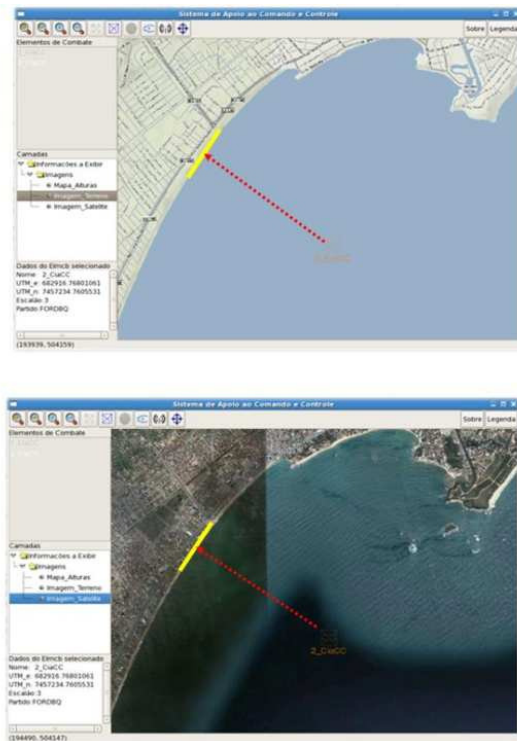

Figure 15: Thematic Layers: the coordination measure "yellow landing beach" seen in two different backgrounds

5 CONCLUSIONS

The implementation of the system to support C2 contributes to an almost immediate observation of all subordinate units of a force deployed on the operations area by high command. The framework still provides to the monitored element an important mechanism to navigate on the theater of operations and, simultaneously, transmit images, in real time, from any deployed element to the high command. This is quite useful to speed up the observation step from OODA loop. However it is important to note that the framework should be integrated with other information systems to obtain data about opposite party in double sided action military training.

The simulation tools developed help decision-makers to orient themselves more quickly. Thus we believe that we have contributed to quicken the step of guidance from OODA loop.

6 FUTURE WORKS

We intend to study mechanisms for integrating information systems to the framework. This integration is an attempt to display both party to decision-makers in a double sided action military training.

An important issue to be improved is the remote connection used by the framework. Nowadays we are keeping the connection between monitored element and the stateful station through a 3G modem. However this kind of connection is not very stable nor secure. So a possible solution is to investigate whether some military radio is able to maintain this connection in better conditions.

We also intend to improve the modeling of the tool "Weapon Range". The idea is to model other kinds of projectiles trajectory. Thus we will be able to simulate the cover fires of other kinds of weapons such as mortars and howitzers, for example.

Table 1: GPS Logger especifications (IgotU GT–600)

Weight	37g
Dimension	46 x 41.5 x 14 mm
GPS	SiRF Star III Low Power chipset Hot Start: <1 sec Warm Start: <35sec Cold Start: <35sec WASS & EGNOS support
Antena GPS	Built-in GPS patch antenna
Water Resistant	Yes
Battery	Built-in 750mAh rechargeable Li-ion battery
Build-in memory	64Mb
Waypoints	262,000

Table 2: Battery specifications (Tekkeon MP3450 R2)

Weight	15.3 oz / 430g
Size	6.85" (L) x 3.32" (W) x .89" (D)
Battery Cell	Rechargeable Lithium Polymer
Voltage Supported	5V, 6V, 7.5V, 9V, 12V, 14V, 16V, 19V
Total Energy Capacity	50 Wh
Output Current	Up to 4.0A
Charging Time	4 hrs
Input Charging Voltage	12 - 20VDC
USB Output Port	Built-in
Extra Power	3.5/7 hrs(Laptop computers)

Tabela 3: Monitor specifications (MIMO)

Dimensions	When folded: 7" x 5.25" x 1" (thickness), When open: 7" x 4.5" (tall) x 5.25" (base)
Display size	7"
Display resolution	800 x 480
Brightness	350 cd/m2
Contrast ratio	400:1
Connections	USB 2.0
Features	Resistive Touchscreen Monitor Pivots 90 degrees Integrated Stand and Cover Ultra-portable, weighs less than 1 pound($<$ 450g) Drivers for Windows XP, Vista, Vista 64-bit included

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Table 4: PC especifications (fit–PC2)

CPU	Intel Atom Z510 1.1GHz
Chipset	Intel US15W SCH
Memory	1GB DDR2-533 on-board
Storage	Internal bay for 2.5 inches SATA HDD miniSD socket
Display & Graphics	Intel GMA500 graphics acceleration Full hardware video acceleration of H.264, MPEG2, VC1, and WMV9 DVI Digital output up to 1920 x 1200 through HDMI connector
Audio	Line-out, line-in, mic 5.1 Channels S/PDIF
Networking	1000 BaseT Ethernet 802.11g WLAN
USB	6 USB 2.0 High Speed ports
IR	Programmable consumer IR receiver
Operating Systems	Windows 7 Professional Ubuntu Linux 9.10 Other operating systems can be installed by user
Case	100% aluminum Die cast body
Dimensions	101 x 115 x 27 mm
Weight	370 grams / 13 ounces – including HD
Power Consumption	6W at low CPU load <7W at 1080p H.264 playback 8W at full CPU load 0.5W at standby

Government, and Aerospace Simulation Symposium, pages 33–39, 2004.

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