17th ICCRTS

"Operationalizing C^2 Agility"

SYSTEMIC APPROACH AND TECHNICAL SOLUTION FOR LEGACY SYSTEMS INTEGRATION

Topic 8: Networks and Networking

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17th ICCRTS: Operationalizing C^2 Agility

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Abstract

This work provides an overview of the Brazilian experience regarding the integration and interoperability among Command and Control systems. The issues and capabilities related to the physical and link integration are presented for a range of technologies covering several types of radio frequencies, satellites and networks. The use of the Service Oriented Architectures for systems interoperability is also presented along with the future for Tactical Data Link (TDL) integration and evolution, under the System of Systems engineering. The Service Oriented Architecture discussed in this work is developed under a Cortex-Synapse framework concept. The proposed methodology was proved in a Close Air Support (CAS) experiment involving the integration of two legacy Command and Control systems. This integration was finally verified in a operational flight test involving a ground troop from Brazilian Army and a fighter from Brazilian Air Force.

Keywords: Interoperability, systems integration, Cortex.

1. Introduction

The development of any kind of military system must be driven by the operational need attendance, aiming to the deployment scenario. The need for agility that Brazil foresees is translated in a multi endeavors environment the armed forces will be deployed within few years.

Such environments include events of short duration that we know when will occur, like the Football World Cup in 2014 and the Olympic Games in 2016, as well as support to peacekeeping operations and natural disasters as examples of unpredictable and unknown duration ones. They also include the permanent protection against threats to Brazilian resources, as for instance the pre-salt oil reserves and the Amazon rainforest biodiversity.

In order to be capable to act in such broad pleiad of scenarios, the military force should be able to adapt itself to a mutable scenario. But that capability does not just happen from night to day. It resides upon many domains, like doctrine, training, material and technological development.

The main goal of this work is to reveal how the systems of systems approach is improving the Brazilian armed forces capability to deal with those broad scenarios of employment.

The remainder of this paper is organized as follows. Section 2 presents the six agility aspects in order to allow their mapping context to the topics described herein. Section 3 presents the Brazilian command and control System of Systems (SoS), positioning the Tactical Data Link System (SISTED - *Sistema Tático de Enlace de Dados*, in Portuguese) within it. Section 4 describes the SoS-based methodology adopted to develop the SISTED. Sections 5 and 6 describe some considerations about the solution of technical and cultural issues, aiming to improve development and combat power. Section 7 describes a Close Air Support experiment conducted under the concept of SoS, which involved the integration of two different tactical data links of different armed forces. Section 8 closes this article showing how the content presented definitively improves agility.

2. Agility

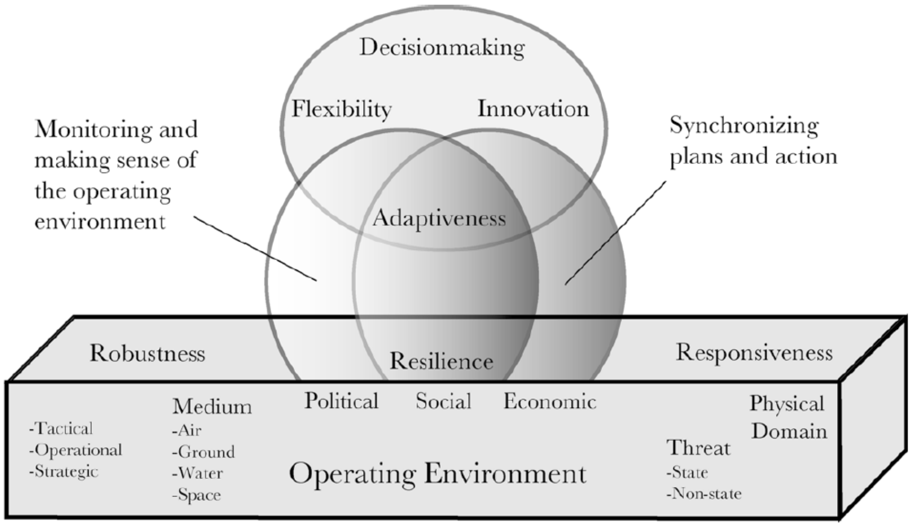

Figure 1 - The Six Aspects of Agility in the Domains of Warfare [03]

Agility is the synergistic combination of robustness, resilience, responsiveness, flexibility, innovation, and adaptation (see Figure 1). Each of these attributes of agility contributes to the ability of an entity (a person, an organization, a coalition, an approach to command and control, a system, or a process) to be effective in the face of a dynamic situation, unexpected circumstances, or sustaining damage.

Robustness

Robustness is the ability to maintain effectiveness across a range of tasks, situations, and conditions, spanning the spectrum of conflict, operating environments, and/or circumstances. Usually it is the first ability that an entity lost when operational concepts, C^2 systems or military forces are strictly optimized to face a particular threat. The reason why the entity loses its ability of robustness in such an optimized scenario is very straightforward: if the threaten scenario changes, what normally happens very often and quickly, the whole set presents high probability of failure.

Resilience

Resilience is the ability to recover from or adjust to misfortune, damage, or a destabilizing perturbation in the environment. Under the Information Age approach, the command centers become less suitable to risk of failure. Nowadays they are distributed, senior commanders present more mobility, the communication systems are networked offering multiple paths for information flow, and the collaborative decision-making improves both the quality of the decisions and the understanding of the reasons behind specific command intentions. We also highlight that a more deep information system where messages are shared broadly has the capability of reducing the casualties and platform losses, even dropping the fratricide losses.

Resilience also contributes to better performance for commanders under pressure and stress. Many aspects contribute in such cases: the availability of deep field information allow the commanders to recognize cause and effect as arising from local conditions. It also allow them to have more control over events and see problems more as temporary issue than a permanent one. For such kinds of commanders, the C^2 systems must adjust quickly in the event of a misfortune or damage, providing conditions for fast decisions.

Bottom line, the more resilient C^2 system will be the one that can withstand greater pressure and larger shocks and is disrupted for a shorter period of time.

Responsiveness

Responsiveness is the ability to react to a change in the environment in a timely manner. While resilience deals with the ability to recover from a crash, for C^2 systems, responsiveness deals with the speed in which this recovery happens.

Responsiveness of forces is further increased because of their ability to conduct simultaneous and continuous operations– not just hitting harder, but also allowing the adversary less time to build situation awareness and develop countermeasures. Then, C^2 systems must provide means to see more opportunities earlier and allow the forces to exploit them more quickly, more efficiently, and more effectively.

Flexibility

Flexibility is defined as the ability to employ multiple ways to succeed and the capacity to move among them. This concept is related to the capability of employing a variety of synergistic efforts to accomplish a mission efficiently.

It is composed by two main parts. The first one is the planning phase, where all possible evolutions of a given scenario must be considered and analyzed. This phase is responsible for helping decision-maker to choose an action if an unexpected fact occurs. The second part is the monitoring phase, where the goal is to provide to the decision-maker the information regarding the deviation of the planned action. As soon the C^2 systems are alerted by the monitoring phase, the commander can adapt the plan to the new scenario.

For instance, let us consider a Special Forces infiltration operation. The team can be transported to the operation area by car, helicopter or by boat or launched by aircraft. All possibilities for each option must be considered during the planning phase, considering both the positive and negative aspects. Let's consider that the planning phase points out the best option been to transport the team by aircraft and launch them by parachute. Once this action is chosen and the operation is launched, the monitoring phase starts. If, for instance, the airspace becomes hostile and it becomes necessary to change from aircraft to car transportation, such information must arrive to the decision-maker sooner and precisely, even under electronic interference. That example illustrates the C^2 system flexibility attribute.

The commander that considers a unique course of action and decides solely for air transportation would not accomplish the mission, even if the C^2 system is flexible to provide information under adverse conditions.

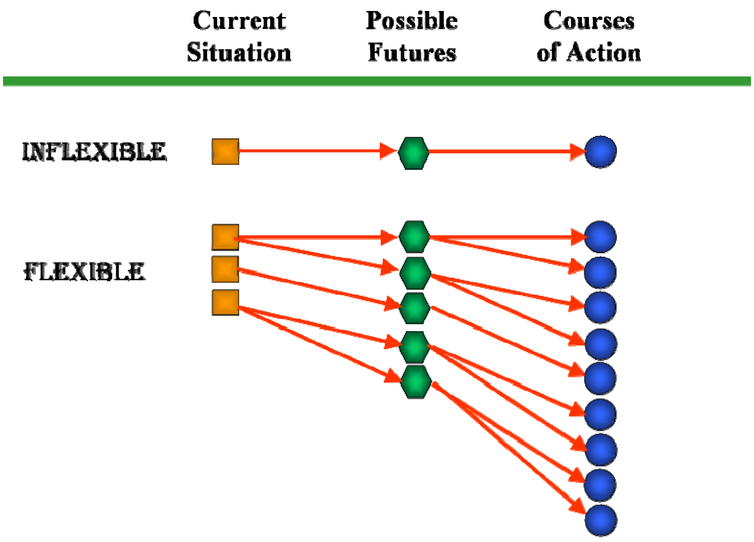

Figure 2 - Flexibility creates more options in a given situation [03]

Innovation

The innovation concept invokes both the ability to do new things and the ability to do old things in a new way, both abilities aiming to achieve the desired ends. It also involves the ability to take lesson from past missions and operational environments, using them to create and maintain competitive advantages.

That is the point where war games and combat simulation meet C^2 systems. By storing data gathered during campaigns as well as decisions made by commanders and playing them back on simulation platforms, possible alternatives can be analyzed and taught to the new commanders.

Adaptation

Adaptation is the ability to alter force organization and work processes when necessary as the situation and/or environment changes.

The capacity to change our organization and business rules can make us more effective and efficient when dealing with different types of missions.

To become more effective and efficient when dealing with different types of missions an agile force must be able to change its organization and business rules.

Under this concern, C^2 systems must be capable to attend many types of needs, military and non-military, and adapt themselves fast from one scenario to another.

3. Brazilian C^2 System of Systems

The Military Command and Control System (SISMC^2 - *Sistema Militar de Comando e Controle*, in Portuguese) covers all levels of command, from the highest strategic Supreme Command Armed Forces to the lowest tactical levels of each Force. Since each Armed Force has its own C^2 system, according to their operating environments, weapon systems, platforms and other specifics, the Ministry of Defense promotes interoperability between these systems, and supports the Joint Operational Command and Peacekeeping Forces, contained in Defense Military Structure, when activated.

The SISMC^2 is a good example of System of Systems concept, since it is composed of Armed Forces C^2 systems, both operational and tactical, and Ministry of Defense (MoD) C^2 systems, strategic and operational.

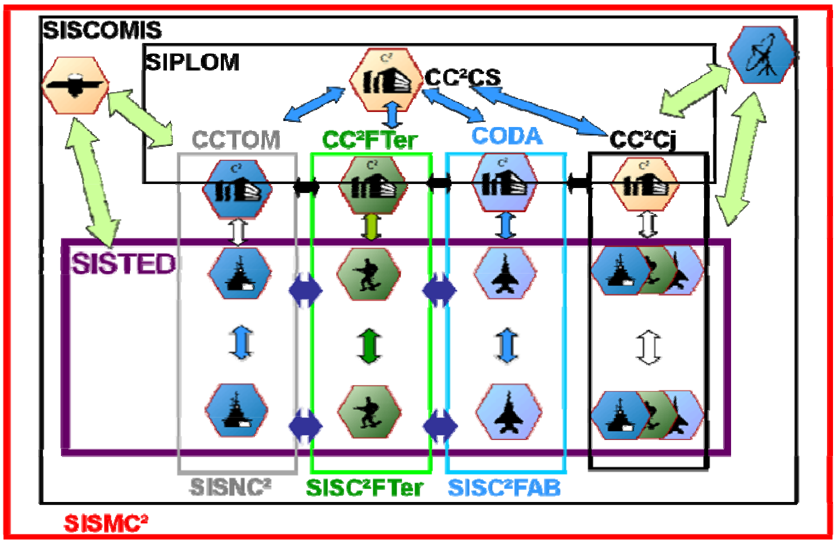

Figure 3 – Brazilian Military C^2 System

The main MoD C^2 systems are the Military Operational Planning System (SIPLOM - *Sistema de Planejamento Operacional Militar*, in Portuguese), the Military Satellite Communication System (SISCOMIS - *Sistema de Comunicações Militares por Satélite*, in Portuguese) and the joint Tactical Data Link System (SISTED). The interaction of those systems with services C^2 systems constitutes the SISMC^2. The first successful approach to interoperability has emerged from a Service-Oriented Architecture (SOA) [01][02][04] solution proposed by the Army and Air Force. The success of using this architecture comes mainly because there were lots of capabilities spread across the services legacy systems that other users might like to exploit and access.

The architecture logical model for this solution is presented on Figure 4. This figure presents Ministry of Defense, Navy, Air Force and Army C^2 systems providing and consuming services via intermediary servers cluster through an Enterprise Service Bus (ESB).

The integration to the tactical level will be performed by adding an intermediary server to the component named Telematic Module (MT - *Módulo de Telemática*, in portuguese) which will be described later, and developing web services where possible to supply the systems with services from/to the tactical level.

This SOA concept was developed by Stefanini IT Solutions using Cortex [09] framework, which will be explained later on section 5, and JC3IEDM to the MoD.

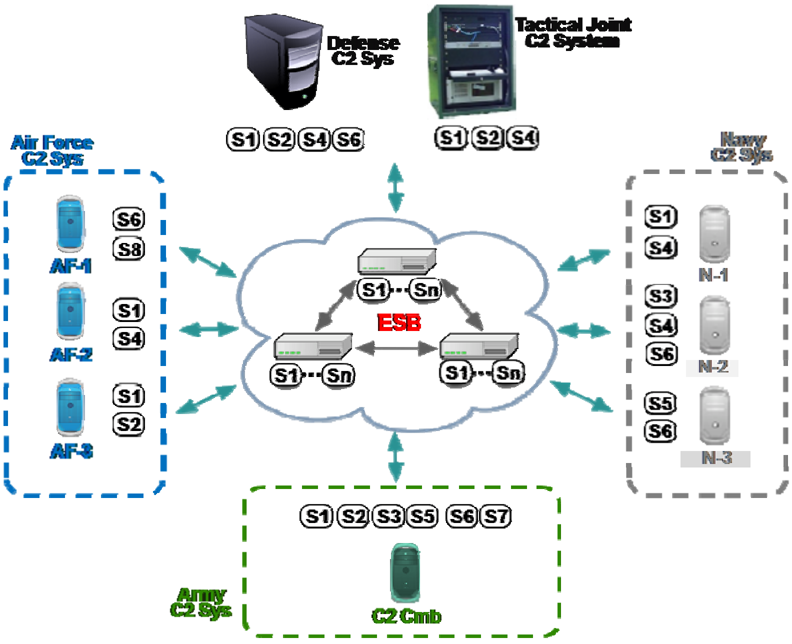

Figure 4 - SOA Logical Model [05]

Joint Tactical Data Link System

This is the so called SISTED and its objective is stated following:

"*To exchange tactical messages among Services, in a standardized and parameterized way throughout the processing, in order to ensure that the actions in interservice tactical scenarios are conducted with efficiency, effectiveness, safety and without mutual interference.*"

Besides the objective, the systemic solution must take into account the following premises:

- Services have autonomy to conceive, develop, operate and maintain their own tactical C^2 systems;
- Services have different organizational cultures;
- Services have different technological generations;
- Services have different methodologies for systems engineering.

As there was no option to purchase a complete "ready to use" system, the task was to develop a solution that fits to all these requirements, as will be explained straight on the next section.

4. Methodology

The discussed methodology is based on the initial assumption that all legacy systems eventually will become obsolete and a new system would be prepared to replace it. The new system must keep at least the functional requirements performed by the retired one. If new capabilities are provided by the new system, these shall be available for the entire system, including those subordinated subsystems. This methodology deals with the creation of new System of Systems (SoS), using a System of Systems Engineering approach, aiming the replacement of the obsolete legacy systems.

System of Systems Engineering

The requirements stated above points to a very complex system. In order to develop such system, a proper methodology must be used. The references chosen to guide this task are the ISO/IEC 15288 - Systems Engineering - System Life Cycle Processes [06] and the INCOSE Systems Engineering Handbook v3 [07]. Both documents establish a life cycle process splitted in the following phases: *Concept*, *Development*, *Production*, *Utilization*, *Support* and *Retirement*. The purpose of each phase is described on Table 1.

A system life cycle must be defined aiming the establishment of a framework which has the task of fulfill the stakeholders' needs in an orderly and efficient manner. This is usually done by defining life cycle stages or phases, and using decision gates to determine readiness to move from one stage to the next.

Lyfe Cycle Phase	***Purpose***
Concept	*It is executed to assess new business opportunities and to develop preliminary system requirements and a feasible design solution.*
Development	*It is executed to develop a system-of-interest that meets acquirer requirements and can be produced, tested [verified], evaluated, operated, supported, and retired.*
Production	*It is executed to produce or manufacture the product, to test [verify] the product, and to produce related supporting and enabling systems as needed.*
Utilization	*It is executed to operate the product, to deliver services within intended environments and to ensure continued operational effectiveness.*
Support	*It is executed to provide logistics, maintenance, and support services that enable continued system-of-interest operation and a sustainable service.*
Retirement	*It is executed to provide for the removal of a system-of- interest and related operational and support services, and to operate and support the retirement system itself.*

Table 1 – Life Cycle Phases Purposes

The whole life cycle process is conducted under eleven technical processes presented on Table 2, which are: *Stakeholder Requirements Definitions*, *Requirements Analysis*, *Architectural Design*, *Implementation*, *Integration*, *Verification*, *Transition*, *Validation*, *Operation*, *Maintenance* and *Disposal*. The purpose of each technical process is described on Table 2.

Technical processes are used to establish requirements for the system as the basis for the efforts to create an effective product or service; to sustain the system through its useful life; and to support retirement of the system.

Technical Process	***Purpose***
Stakeholder Requirements Definitions	*It is to elicit, negotiate, document, and maintain stakeholders' requirements for the system-of-interest within a defined environment.*
Requirements Analysis	*It is to review, assess, prioritize, and balance all stakeholder and derived requirements (including constraints) and to transform those requirements into a functional and technical view of a system description capable of meeting the stakeholders' needs.*
Architectural Design	*It is to synthesize a system solution that satisfies the requirements.*
Implementation	*It is to design, create or fabricate a system element conforming to that element's detailed description. The element is constructed employing appropriate technology and industry practices.*
Integration	*It is to realize the system-of-interest by progressively combining system elements in accordance with the architectural design requirements and the integration strategy.*
Verification	*It is to confirm that all requirements are fulfilled by the system elements and eventual system-of-interest, i.e. that the system has been built right. This process establishes the procedure for taking remedial actions in the event of non-conformance.*
Transition	*It is to transfer custody of the system and responsibility for system support from one organizational entity to another. This includes (but is not limited to) transfer of custody from the development team to the organizations that will subsequently operate and support the system.*
Validation	*It is to confirm that the realized system complies with the stakeholder requirements.*
Operation	*It is to use the system to deliver its services.*
Maintenance	*It is to sustain the system through its useful life.*
Disposal	*It is to remove a system element from the operational environment with the intent of permanently terminating its use.*

Table 2 – Technical Process Purposes

In SISTED Concept Phase, twenty-nine scenarios were identified as those where the Services exchange tactical data. However, during the initial analysis, it was noted that those scenarios share some degree of commonality regarding the *mission threads* and the *operational effects* involved, as for instance the demand for intelligence and the close air support.

These lead to move one step further from transforming the scenarios into capabilities, in order to respond to the complex and sometimes unpredictable operational environments. Therefore, a scenario is served or defined by a set of capabilities. Thanks to the changing from scenario to the capability concept, still considering a through-life perspective, Services can now easily meet their corresponding operational needs, driving to a better understood and balanced acquisition process, reducing the operational and support costs.

This focus on the capability requires some different engineering approaches, which go beyond the traditional System Engineering, including all project delivery functions and their the integration.

SISTED is a system of systems which interact to perform the desired operational capability. Both the integration and collective performance (or emergent properties) of their components becomes a key factor for evolving the equipment-centric approach to a system-centric one more suitable to this new way of thinking.

In order to manage the capabilities evolution as well as the competencies and the lines of development that influence it, some models are under study. One of them is the proposed by Hardin in "*A structured approach to planning and managing systems engineering capability evolution in a complex through-life business space*" [08].

This model is presented on Figure 5. It has a 3D representation where each cell within the model handles the competencies under some lines of development. It deals with three levels:

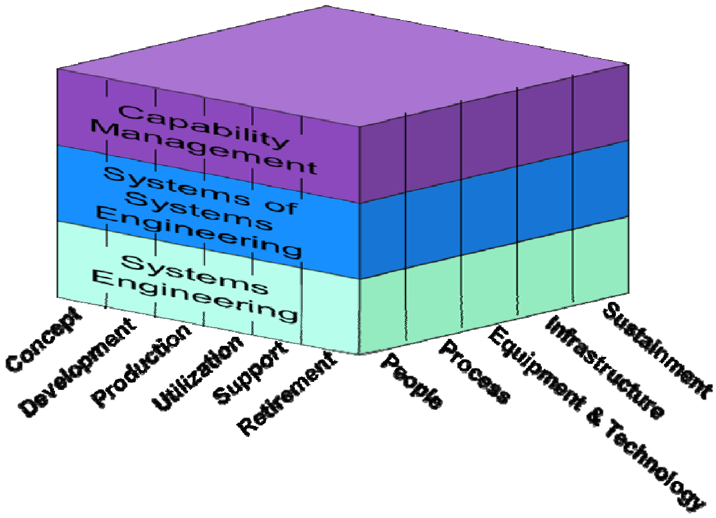

Figure 5 – *Capability Management* model

Their proposed model handles the task under three levels, listed below:

- *Capability Management* – – responsible for planning the delivery of operational capability.
- *System of Systems Engineering* – responsible for managing consistently across the system components that underpin the capability, based on an architectural approach.
- *Project Systems Engineering* – where the focus is on project delivery of a new/modified system or service that delivers operational benefit.

SISTED Operational Capabilities

Once the Stakeholder Requirements were defined, the identified capabilities were grouped into five main sets of capabilities shown on Figure 6: Joint Logistics, Intelligence-Surveillance-Reconnaissance (ISR), Joint Command and Control, Joint Maneuver and Electronic Warfare.

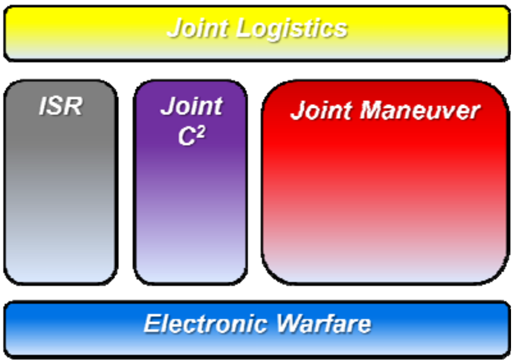

Figure 6 - Operational Capabilities

The scheme show on Figure 6 fits well under the NCW (Network Center Warfare) and OODA (Observe-Orient-Decide-Act) loop concepts, which are organize as following: first it is necessary to sensor the threat, then it is decided what actions should be accomplish and finally it is chosen who will act. These 3 steps are supported by logistics and by electronic warfare. The TDL system shall be able to support all these capabilities and in accordance with the conditions stated in section 3 above.

This entire job closed the technical process *Stakeholder Requirements Definitions*, handling the CONOPS (Concept of Operations) and Joint Tactical Scenarios.

SISTED Functional Model

As shown by the Requirements Analysis process, it was necessary to add some management capabilities to the scheme of figure 6. These management capabilities help a system to fulfill both the requirements stated in previous process as well as the main system objective. It is a useful toll to avoid some data link problems like: data looping, spectrum allocation, performance guarantee, security assurance, and technical addressing. It also helps the evolution of the system without jeopardizing its operation. There are six management macro functions, named *Operational Network*, *Data*, *Spectrum*, *Addressing and Routing*, *Performance* and *Security*.

Those macro functions should be performed by entities within the Services and the MoD, during the deployment or during the preparedness. The final structure that handles this whole task is presented on Figure 7.

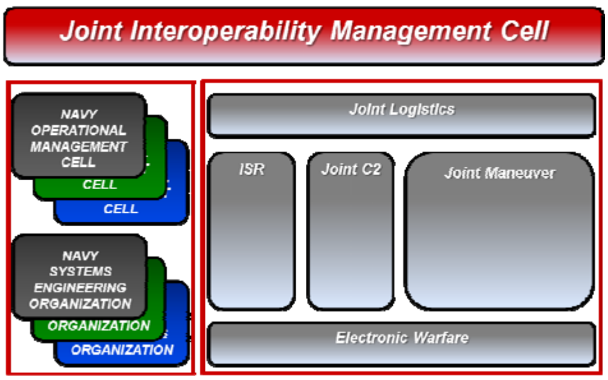

Figure 7 - SISTED Architecture

5. Challenging Technical Issues

The update or replacement of legacy systems may become a very expensive endeavor. It can lead to an inefficient interoperability solution if a systemic approach was not applied on these processes. The main goal regarding the update or replacement of legacy systems is the minimization of efficiency losses. As consequence, the new system must keep the capacity of the old one as a minimum level until its substitution.

Telematic Module

One form to solve the replacement of legacy systems problem is the use of gateways with multiple layers capabilities. Only a systemic approach can surely reveal where this solution is suitable and feasible.

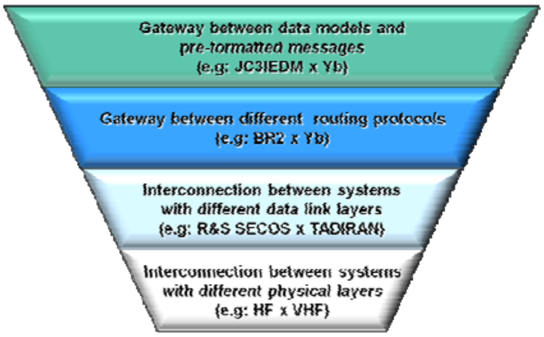

Figure 8 - Levels of interconnection interoperability

A solution to perform such approach is the Brazilian Army connectivity solution called *Telematic Module* (MT). It was conceived under the C^2 in Combat (C^2Cmb) project to distribute data as well voice communications over the tactical field.

The MT is the first integration project within the Army that successfully allow different and separated networks to exchange information transparently. As for example, it enables a wireless networks based on radio solutions radios (HF, VHF and UHF) to send data a and wired network serving another user.

The MT is a set of integrated telecommunication and computer equipment providing data and voice communications among combat elements in the field. It aggregates a large number of the common available technologies; most of them coming from the civilian segment. It allows multiples routes to be automatically chosen to connect different user. Figure 9 illustrates the MT components.

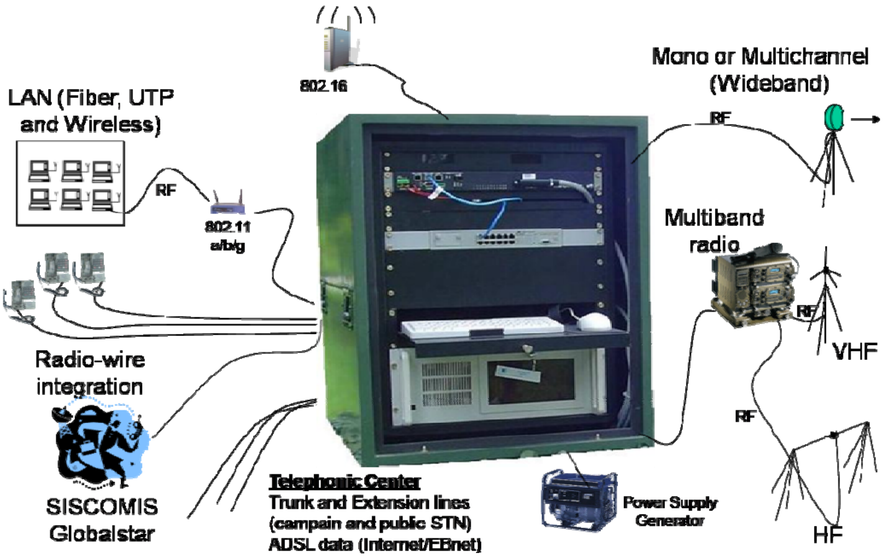

Figure 9 - C^2Cmb Telematic Module

There are three types of MT, called MT type "A", "B" and "C". The type of a MT is defined by the technologies and equipment employed within each set. The "A" MT type is the most complete one, used at the Brigade level. It is a fully integrated system employing technologies like WIFI, WIMAX, H/V/UHF radios, SISCOMIS, Globalstar, ADSL, PSTN and trunk campaign lines. The "B" MT type is used at the Battalion level and the "C" type is employed at the Company and lower levels.

When a group of MTs are connected, they form a physical and logical network able to share data, images and voice among the combat elements disperse on the field campaign, even through external networks such as internet, PSTN and cellular network. The MT interconnections are construct in order to allow alternatives paths or routes between two system points on the terrain. When one route becomes unavailable, the system automatically adapts itself to find another operational route in order to reach the required destination. Alternative routes use distinct technologies, making the system independent of transmission conditions that could affect a specific technology.

CORTEX Framework

Another suitable solution to integrate legacy systems is the use of a software framework named CORTEX. [09]

Cortex is a solution for developing cross-platform desktop applications using C^{++} language. It is based on the composition of *synapses* (dynamic libraries) at runtime and strongly suggests its modeling in a Service Oriented Architecture. It is based on SOA principles, but not necessarily implying web services. Cortex was developed by the Brazilian Army as a solution of modularity to facilitate reuse and extensibility in the context of developing a family of applications geared towards the defense segment. It has been successfully used for about two years.

One example of successful application of the Cortex solution was an integration test performed between two C^2 legacy systems from the Brazilian Army (EB - *Exército Brasileiro*, in Portuguese) and the Brazilian Air Force (FAB - *Força Aérea Brasileira*, in Portuguese). This test was supported by EMBRAER company, under a Closed Air Support scenario belonging to SISTED. It will be described in details on section 7.

6. Challenging Cultural Issues

Probably cultural issues are the hardest and complex aspect to be overcome under a TDL development. One of the main reasons is because non-technical people usually tend to believe that a interoperability problem in a battle field can uniquely be solved by using a standard telecommunication solution: buying the same radio transceiver for all personal instead of working on the system level. It is more like a small piece of the platform-centric thinking problem instead net-centric thinking.

We believe that the best way to challenge cultural issues is the experimentation. It is easy to see the advantage of conducting an operation when it is developed under a systemic approach: the interoperability problems can be addressed with lower cost solutions, a contrast against the application of a platform-centric approach.

The cultural change is not only a problem to be solved on the customer point of view, but also on the vendor side. The Brazilian National Strategy of Defense (END - *Estratégia Nacional de Desefa*, in Portuguese) document states that any partnerships between Brazil and other countries must be construct seeking the national technology independence when it drives the defense industry. Companies interested solely in selling their equipment instead of providing a solution that fits the END recommendation most probably will fail in their intentions. The END recommends long term partnerships where both sides can fulfill their objectives.

The END aims not only the national strengthening against a remote hypothesis: the Brazil involvement in a large-scale armed conflict. It also aims the country strengthening for achieving flexibility and elasticity against conventional and non-conventional actions. The asymmetrical war, in the context of a national resistance war, represents an effective possibility of the national doctrine seek by the END.

For this reason, this doctrine refuses the temptation of seeing high technology as an alternative to combat. It assumes the technology just as an element to reinforce the operational capacity. It insists in the role of surprise, transforming uncertainty into solution, instead of facing it as a problem. It combines meditated defenses with devastating attacks.

7. Close Air Support Capability Test

Current Scenario

Nowadays, the CAS missions are conducted in an old fashioned way, in which the surface forward air guide starts the assignment via voice authentication, followed by sending the target´s coordinate, the aircraft attack profile maneuver and the ammunition to be employed. After the will comply message, the pilot heads the aircraft to the target position. Once he is ready to attack, the surface forward air guide sends the target´s detailed descriptions.

Preliminary

The first well succeeded attempt to increase the combat power under the SISTED system of systems approach was conducted within the SISTED Joint Fire Support capability, specifically the Close Air Support scenario. The Army legacy C^{2}Cmb software was used to assign targets to the Air Force A-29 aircraft, equipped with a legacy Data Link developed by the company EMBRAER for FAB.

Following the non-intrusive concept behind the SISTED system of systems approach, EMBRAER was selected to develop the synapse to integrate the A-29 to C^{2}Cmb since this company has prior experience developing the A-29 DL. It was imposed to the company the following restriction: it would not receive any technical information regarding the C^{2}Cmb software beyond the synapse construction rules. By the other side, symmetrically, no DL technical information should be passed to the C^{2}Cmb development team.

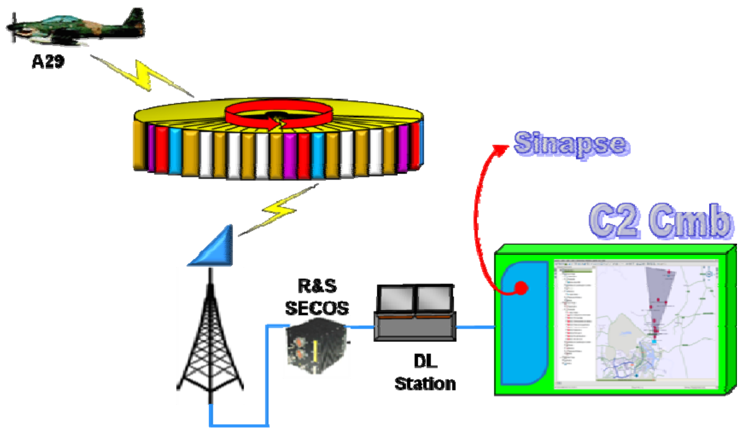

Figure 10 - General Test Concept

Technical Development

It was defined three goals to guide the development of this experiment:

1. Send target coordinates from C^{2}Cmb to the A-29 aircraft;
2. Receive the A-29 aircraft position in the C^{2}Cmb software;
3. Exchange text messages between C^{2}Cmb and A-29.

EMBRAER had prior knowledge of the A-29 DL interface, thus the first step towards integration was to wrap it around some higher-level Application Programming Interface (API). Because it was the C^{2}Cmb's architectural framework and open-source software (available at Brazilian Government's Public Software Portal [09]), Cortex was the natural choice for accomplishing this task, due to its generic approach to designing compatible software components with no prior knowledge one from another.

Then a synapse was developed by EMBRAER in order to expose the DL interface in a service-oriented fashion. This synapse (DL Service) was designed to be executed in a workstation with UDP/IP connection to a computer with physical connection to the DL ground-station (DL Gateway). This computer had the appropriate device driver for serial communication with the hardware: a R&S V/UHF radio transceiver equipped with a SECOS 2/12 security protocol.

The key success factor that allows the parallel development by both the EMBRAER and Brazilian Army teams was the project decision of not embedding the device driver directly in the synapse. After the service interface exposed by the DL Service was established, the work followed three concurrent threads:

1. EMBRAER: the application protocol for UDP communication with the DL Gateway was specified and two teams were spawned:

    a. Team 1: developed and tested the DL Service with the aid of a simulator implemented as a dummy UDP server;

    b. Team 2: developed the DL Gateway;

2. Brazilian Army: a dummy synapse providing the established DL Service was rapidly developed and integrated to C^{2}Cmb, including the Graphical User Interface (GUI) for user operation.

The whole work spanned a week, and the integration test of the three pieces of software passed with a day-long effort. Once again we highlight that no modifications was performed on the A-29 embedded legacy data link due to project constrains imposed by the SISTED methodology here tested.

The next phase included testing with real data and was expected to work with no further modifications to software, as both C^{2}Cmb and the A-29 DL are well-proved systems.

Ground Test

After the synapse integration to C^{2}Cmb, it was performed a ground pre-flight test with the aircraft parked. The main goal of this test was to verify that the developed solution was working properly.

The communication between A-29 and C^{2}Cmb was established and message exchange was performed successfully, proving that the system was ready to take off.

Figure 11 – Ground Test Set Up

Figure 12 – Pilot Display Arrived Message

Flight Test

Following the ground test, a flight test was the first real challenge, where the whole technical concept should work.

It was previously selected a set of ten targets whose coordinates should be sent from the C2Cmb to the A-29 DL system. The targets were assigned randomly to the aircraft without previous knowledge from the pilots.

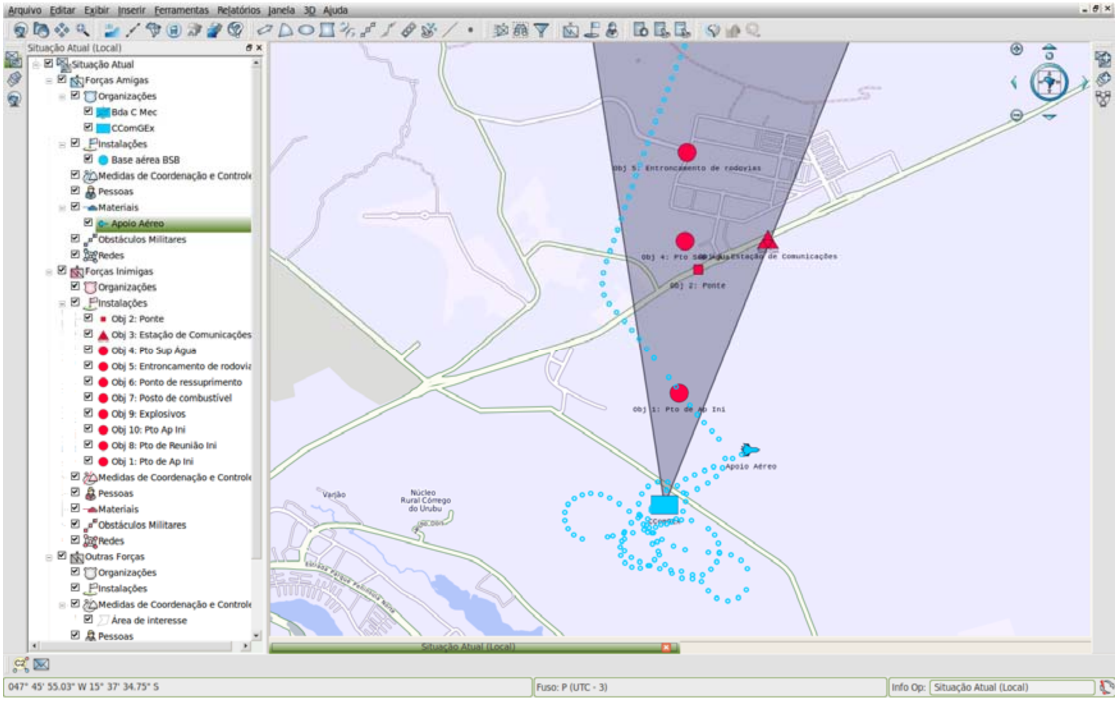

Figure 13 - Flight Test Screen Capture

As expected, as soon as a surface target was assigned to the A-29, the aircraft started to move to shoot the target. It was possible to follow its maneuver in C^2Cmb screen. The target description, the WILCO message and the final strike result were also exhibited in C^2Cmb screen.

Operational Test

Following the three phases laboratory test, an operational test was performed within the Amazon operation conducted by the Ministry of Defense on June 2011.

A set of air to ground attack was conducted in a traditional way: the ground guide coordinates the attack of the aircraft only by voice commands. On a next step, the same set of targets were assigned via data link from the C^2Cmb interface to an A-29 aircraft manned by another pilot.

The integration of these two C^2 legacy systems provided operational gain, as confirmed by statistical evaluation described in following.

Test Results

The experimental data link conduction of the CAS flight test reduced operating time by more than 4 times compared to the time normally spent on a mission coordinated only by voice commands.

The A-29 aircraft also gained the capability “to see” the ground troops´ position, reducing the fratricide risk. Once the A-29 position was also available within the Army C^2 software via data link, it can be forwarded to the anti-aircraft artillery, also reducing the fratricide risk.

The current doctrine was also benefited by the data link integration. It states that an aircraft must be able to support more than one CAS request. This task was strongly facilitated by using the data link integration solution: the pilot can store the targets received by two or more ground CAS guides, attacking then in the most convenient order.

The proposed solution was able to integrate two legacy C^2 systems, which were developed in a standalone manner, without the requirement to exchange data between them. It was proved that they can share data in an efficient manner, applying a systematic solution with low cost, which demands a minimal time to be implemented. This systematic solution is much better than a platform-centric solution which would imply, for example, developing new software for targets exchanging and visualization.

As a consequence of the operational gain obtained, the Brazilian Air Force (FAB) is discussing with EMBRAER a project to develop a prototype solution based upon the results obtained within this test.

The Cortex-Synapse concept has proved its remarkable value to increase the combat power, not only within the Army, but also on the Ministry of Defense and the Air Force.

The presented solution also allows companies to develop their products integrated to the Cortex framework, like Stefanini, Elbit and Mectron companies, which also contributes to increase the combat power as well to improve agility by reducing the development and integration time.

This development tool has proven to be very suitable as a solution to realize the SISTED System of Systems approach tied together to the physical gateway approach represented by the Telematic Module (MT).

8. Conclusion

In this work, we presented the Brazilian C^2 SoS. We also discussed how the Tactical Data Link System (SISTED) is being developed under this SoS concept.

We defended that the SISTED architecture can improve the agility by allowing the legacy systems evolution without losing consolidated features, unlike adding and making available new features possibly added to other systems.

We also presented some considerations regarding how technical and cultural issues can be handled and, as an example, we described that under the Close Air Support test which had integrated in a non-intrusive fashion the Army C^2 software and the Air Force aircraft A-29, demonstrating that the agility aspects of Innovation and Flexibility are well supported by this approach.

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10. Glossary

ADSL	Asymmetric Digital Subscriber Line
API	Application Programming Interface
C^2	Command and Control
C^2Cmb	Command and Control in Combat
CAS	Close Air Support
CONOPS	Concept of Operations
DL	Data Link
EB	Portuguese acronym for Brazilian Army
END	Portuguese acronym for Brazilian National Strategy of Defense
FAB	Portuguese acronym for Brazilian Air Force
GUI	Graphical User Interface
INCOSE	International Council on Systems Engineering
ISR	Intelligence-Surveillance-Reconnaissance
MoD	Ministry of Defense
MT	Portuguese acronym for Telematic Module.
PSTN	Public Switched Telephone Network
SIPLOM	Portuguese acronym for Military Operational Planning System

SISCOMIS	Portuguese acronym for Military Satellite Communication System.
$SISMC^2$	Portuguese acronym for Military Command and Control System
SISTED	Portuguese acronym for Tactical Data Link System
SOA	Service Oriented Architecture
SoS	Systems of Systems
TDL	Tactical Data Link
UDP	User Datagram Protocol
WIFI	Wireless Fidelity
WILCO	Will Comply
WIMAX	Worldwide Interoperability for Microwave Access

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COMGAR (General Air Command – Brazilian Air Force)
CCOMGEX (Army Communications and Electronic Warfare Center – Brazilian Army)
CIGE (Electronic Warfare Instruction Center – Brazilian Army)