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Optical and SAR Ground Segment Integration – An Italian Experience

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INTRODUCTION

In 1994 the Italian Ground Segment for the Treatment of Optical Imaging (Joint Remote Sensing Ground Centre – Centro Interforze Telerilevamento Satellitare) was builded inside the air base of Pratica di Mare near Rome. C.I.T.S. was created to receive, store and analyse the Hélios 1 imagery data .

In 2002 was realized an new antenna beside the principal building with the aim to reduce the information age and to permit the Italian access to Hélios2 satellites. One year later the Chief of Defence decided to realize the new C.O.S.M.O.-SkyMed User Ground Segment inside the Centre., considering the relevant expertise of C.I.T.S.' military staff and the possibility to optimise the integration between optical and SAR systems.

The C.O.S.M.O.-SkyMed dual-use program is composed of the following Ground Segment Elements:

- *CGS: Core GS, devoted to the management of the Space Segment;*
- *CPCM: in charge of planning requests from user community and coordinating the overall mission;*
- *SSE: Support Service Element: containing Remote Station, CalVal facility, GPS fiducial Network and GS Simulator;*
- *UGS: encompassing the data exploitation as well as the user services.*

The complexity of the program is also due to the fact that military needs have been adapted to civilian's ones and vice versa.

Moreover it's necessary to consider the impact of the defence interoperability concept, based on the requirements that the foreign defence partners have the possibility to acquire and process data of C.O.S.M.O.-SkyMed constellation.

The aim of this contribution is not only to underline the difficulties met by the operational users in the integration between two different systems inside the same infrastructure, taking into account limitations deriving from defence environment and related security aspects, but also we want to emphasize military effort to realize a sort of integration of operational Hélios experiences with C.O.S.M.O.'s technical requirements.

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We'll focus our presentation on these three fundamental topics:

- *Infrastructure integration;*
- *Impact of the securities aspects;*
- *Role of Military users inside the engineering cycle together with Italian Space Agency and the industrial pool.*

1.0 OPTICAL AND S.A.R. GROUND SEGMENT INTEGRATION

At the beginning of 80's years Europe was still unprovided of a own remote sensing satellite. In this situation France with Italy decided to start up a military collaboration in this strategic field. It was the first experience in this high technological sector, and we can't forget the industrial involvements that it implied. In 1987 France and Italy signed a Agreement to develop an optical satellite named Hélios. In 1988 Spain joined together with them. We can be proud to have realize the first European system shared between national intelligence and security organizations.

Figure 1: Italian remote sensing ground segment (C.I.T.S.)-An aerial view.

In 1994 began the Italian optical experience with the Hélios 1A launch. Actually C.I.T.S. has made a significant knowledge of remote sensing satellite employment and, as we see after, this aspect was important in the SAR ground segment choice[1].

[1] Hélios1A was launched the 7th July 1995, Hélios1B, nearly twin of Hélios1A, was launched the 3 th December 1999 but it was declared out of service in October 2004. Currently Italy has access to Hélios1A and Hélios2A the new optical sub-metric satellite, realized by France, Spain and Belgium and launched the 18 th December 2004.With COSMO-SkyMed constellation Italy will have an optical and SAR remote sensing capacity.

1.1 C.O.S.M.O.-SkyMed architecture

The C.O.S.M.O.-SkyMed program was born in 1996 when the Italian Space Agency[2] was entrusted to develop a SAR constellation of small satellites flying on polar orbits. In fact C.O.S.M.O.-SkyMed is the acronym of Constellation of Small Satellite for the Mediterranean Basin Observation.

In 1999 A.S.I. and Italian Ministry of Defense signed ad Agreement to combined together their efforts to realize a SAR remote sensing system.

Few years later the Italian and French Prime Ministers subscribed ad Intergovernmental agreement , named Turin Agreement, to share their respective remote sensing systems, C.O.S.M.O. for Italy and Plèiades[3] for France, with the goal to improve national capabilities and reduce the costs.

We can separate C.O.S.M.O.'s architecture[4] into two main segment:

- Space Segment
- Ground Segment

It isn't our purpose to illustrate the characteristics of the Space Segment and we can't go into the details ground segment architecture. What we want to emphasize is the big effort done by the industry, under the supervision of Italian Space Agency and Ministry of Defense, to realize a system able to satisfy military security and performances requirements with respect to institutional civilian, scientific and commercial exigencies.

Figure 2: C.O.S.M.O.-SkyMed ground segment architecture in Italy.

[2] Italian Space Agency was created in 1988. It is under the authority of University and Research Ministry, in coordination with other Governmental Entities. www.asi.it

[3] Very high resolution panchromatic and multispectral Earth observation satellite, with a altitude of 694Km. Sun-synchronous phased and almost circular orbit. More info http:/smsc.cnes.fr/PLEIADES/Fr/

[4] To find more info you can see: www.asi.it/sito/programmi_cosmo.htm ; www.alespazio.it ; www.telespazio.it

We can summarize C.O.S.M.O.'s ground segment architecture naming some fundamental components:

- Mission Planning and Control Center (C.P.C.M.) placed at Fucino, responsible to coordinating the User Ground Segment requests , perform the overall mission control and planning;
- Civilian User Ground Segment (C-U.G.S.), located in the A.S.I.'s Geodetic Center of Matera[5] which is devoted to manage the requests for civilian users to acquire, archive, process and deliver the data received from the satellites by means of co-located and/or remotely located X-band acquisition stations;
- Defense User Ground Segment (D-U.G.S.) with the same assignments of civilian one, guarantee data integrity, serves defense customers through the distant cells.

Both have the capabilities to manage up to five international partners each.

Moreover the system is composed by some remote up-link/download stations and a dedicated communication network with the aim to guarantee the daily data exchange between Defense User Ground Segment , the civilian one and the Planning and Control Center.

1.1.1 Requirements' integration - C.I.T.S. in front line

The Italian Space Agency has performed, in accordance with Ministry of Defense availability, a selection of the candidate sites for the installation of the D-U.G.S. and, at the end of survey campaigns, has indicated the C.I.T.S. of Pratica di Mare as the best one.

The C.I.T.S.' choice was determined taking into account the follows aspects:

- The opportunity to use the existing infrastructure conceived for a remote sensing ground segment, the Hélios one;
- The higher security levels guarantee by C.I.T.S. infrastructure and air base environment;
- The possibility to reduce the staffing increase until 25-35 operators and the opportunity to exploit C.I.T.S.' experience.

But we can't forget that C.I.T.S.' infrastructure, together with the availability of electric power, air conditioning systems, an existent anti-fire alarm system and access control one, have been conceived to manage only one remote sensing system and not two. For this reason C.O.S.M.O.'s requirements have stressed the reuse concept. In fact the equipment selected has been chosen considering, as much as possible, the integration with the existing environment without major changes in the infrastructure and, overall, to avoid a power budget increase.

Last but not the least, the SAR X-band antenna had to be placed taking into account the maximum distance with respect to Hèlios' one but also as close as possible to C.O.S.M.O.'s operative room.

Fortunately we had a recent experience regarding a X-band antenna accomplishment thanks to Hélios CSU4 up-grade that foresaw a receiving device closely to the optical remote sensing center. Despite this, we have had not few problems to coordinate the various needs coming form Italian Space Agency, responsible for the C.O.S.M.O.' contract, industrial team, Airbase authority, responsible for the local security flying, and other military organization proper in flying coordination, building authorization, contract management.

[5] With a total surface of 100.000 m^2, almost half of it is A.S.I.'s property, Matera is the most important remote sensing ground segment in Italy. Since 2001 Telespazio S.p.A. has moved there all its remote sensing activity.

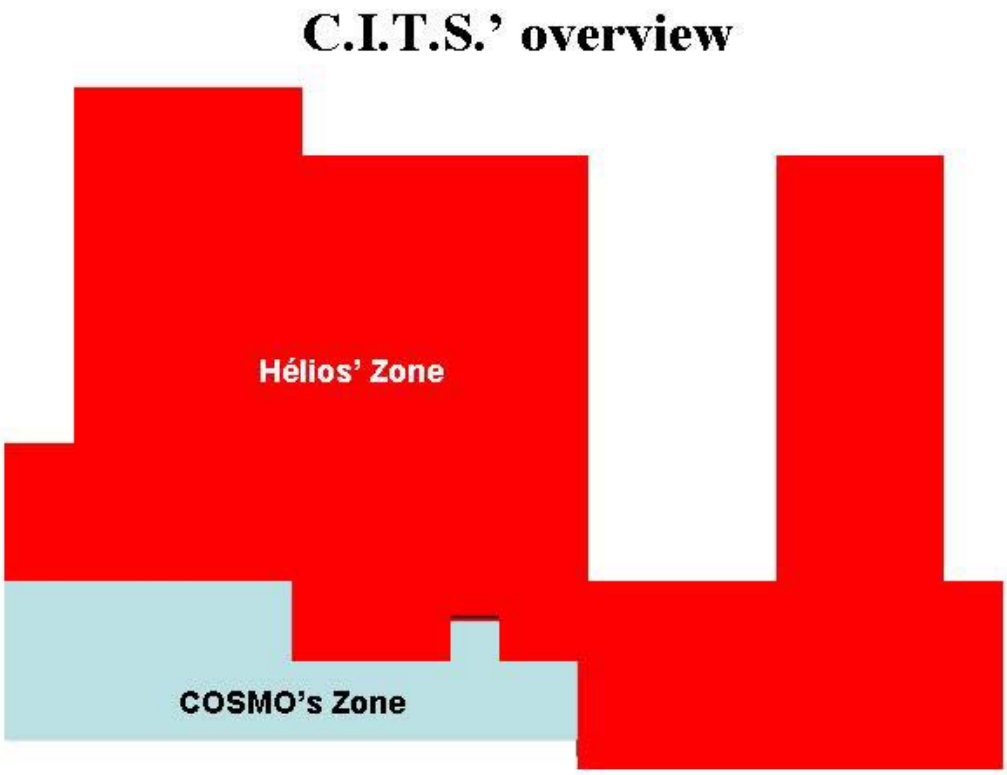


Figure 3: Infrastructural integration between Hélios and C.O.S.M.O. segments.

When the D-U.G.S. design was approved and the industry was ready to start up its work , C.I.T.S. was, in the meantime, interested by an Hélios software and hardware reconfiguration due to the new CSU4 (User Ground Component) developed in France.

It was difficult to choose which was the priority considering the international consequences of a possible Hélios Italian Center upgrade delay, on one side, and the C.O.S.M.O.'s timeline, on the other side.

In fact the integration of another ground segment emphasized the following problems:

- the area interested by C.O.S.M.O.' works had to give to the industrial hands through Italian Space Agency due to the fact that C.O.S.M.O. is a dual-use program in which civilian is the majority part.
- some areas, chosen for C.O.S.M.O., were still used both by the new and by the older Hélios computer equipment and have to be "sanitized" from Hèlios' network, not by C.O.S.M.O.'s team but by a joint military and Hélios' industrial one, which had to be quickly created.
- C.I.T.S.' anti-fire detection and control access systems had to be "cut" to permit to be reconfigured. At the works end two systems should be integrated with C.I.T.S.' ones without any interruption and security gap.
- electric power, air-conditioning system and telephones lines had to be re-used without any risk of service interruption.

Regarding the first aspect we want to highlight that it was the first time in which a military entity reduces its responsibility and authority on its infrastructure giving it to a civilian agency.

This problem was particularly evident when the C.O.S.M.O.'s antenna building start up. In that case C.I.T.S. had have to play a fundamental role to disentangle the bureaucratic net.

When we delivered to A.S.I., prime customer, all the areas dedicated to C.O.S.M.O. we were involved into a critical situation from a security point of view. We accepted to live and work side by side with civilian personnel not under our responsibility by under the A.S.I.'s one.

Formally the military personnel can't have access into C.O.S.M.O.'s area, without industrial authorisation, seeing that we are still customers and not owners of the system!

Moreover the military part has to speak to the industry only through Italian Space Agency .It's evident the complex situation in which C.I.T.S.' team works everyday. We are the householder by we can't discuss directly with the C.O.S.M.O. industrial team presents in Pratica di Mare because the Italian Defence is the minority customer.

And we can't forget that Pratica di Mare is one of the most important Italian military air base , frequently involved in political events, as the NATO-Russia summit held in may 2002, and it was not easy to coordinate local authority with Italian Space Agency exigencies and the industrial ones.

Moreover it is important to recall the security problems linked to the industrial exigency to move without any restriction, and overall, to manage the laborer's team completely disengaged with respect to defense's rules. For example, one of the most important effort was to sensitize the firms to maintain their duty to provide, many days in advance, all the generality of their personnel involved in D-U.G.S. ' works.

Taking into account the international scenario in which Italy is, and has been, involved it's evident the distance between military and the industrial approach respects to this delicate aspect.

It would be incorrect to say that the Italian Space Agency hadn't the sensibility to understand our nuisance for this situation and sincerely I can confirm that thanks to A.S.I.'s C.O.S.M.O. team and overall thanks to A.S.I. defence's delegates, it has been possible to go beyond the difficulties.

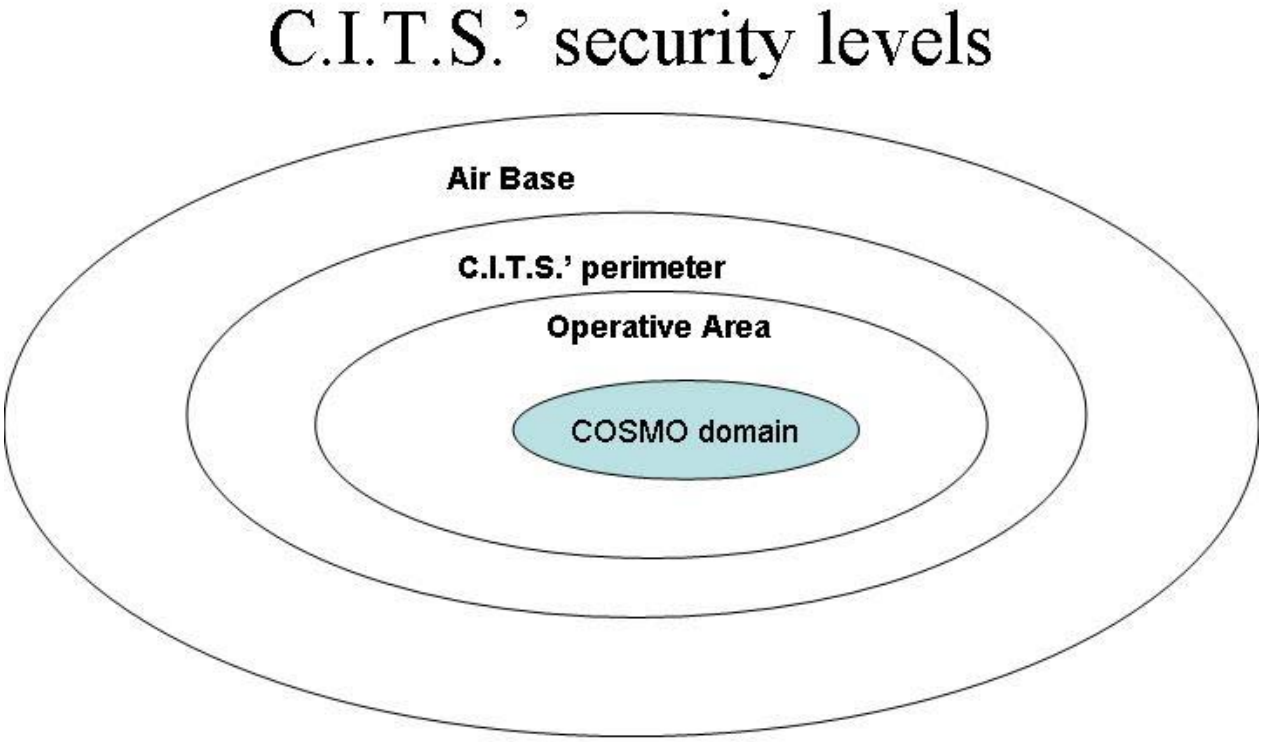
1.1.1.1 Security Requirements

From a security point of view, we have to consider the particular architecture of C.O.S.M.O.- SkyMed dual use program. In fact, as we have seen before, there are three different worlds: the military user ground segment, the civilian one and the Mission Control and Planning Center which has to be connected with both sites.

Besides the C.O.S.M.O.'s architecture has foreseen a data flow from civilian UGS to military one, in particular: GPS and additional data for precision processing, data from external stations, High priority Civilian Programming request to be inserted into the HP military mission plan.

The link between Matera, the civilian site, and Pratica di Mare will use a public network , for this reason at D-U.G.S. will be foreseen a security, but not certificated, area where will be realized a "data cleaning-room".

These security requirements have determined a particular effort to locate different security levels areas, as required by the National Security Agency, in which realize the un-classified and classified C.O.S.M.O.'s domain inside C.I.T.S.' operative area.



We can't describe the particular technical solution adopted to carry out these requirements. However we want to underline once more the absolute necessity to write technical requirements taking into account not only the perfect theory but the operative needs too.

As said before, C.O.S.M.O. and Hélios systems must be absolutely separated not only from a architectural point of view but also for what concerned the data network. To realize this requirement it was necessary to avoid any sort of LAN's "cohabitation".

To clear old optical platform from the designed C.O.S.M.O. area, we have chosen a progressive policy, also forcing to respect Hélios' up-grade schedule.

In fact, taking into account the security exigency to realize two different worlds inside the same infrastructure, it was necessary to create, in the remainder Hélios' area, a new space where it were possible to set up the CSU4's development platform without any risk for the Helios approved architecture.

To do so we were involved, together with A.S.I. and industrial and security consultant teams, to analyze any possible architectural solution. Fortunately our work has been helped by new technology employed which allows to reduce the necessary space and the power budget required.

This phase has engaged both Hélios and C.O.S.M.O. 's industrial support teams under C.I.T.S. support with the aim of synchronize the work of two teams without any risk of data loss. Thanks to ASI coordinating Alenia Spazio, now Alcatel Alenia Space, and its subcontractor Telespazio it was possible to respect the Hélios' schedule with no delay for C.O.S.M.O.

But we can't hide our effort to follow these works, creating a military support team and reducing Hélios' operative team.

1.1.1.2 Staffing implementation

The C.O.S.M.O.'s requirement defines precisely the new staff sizing as "*The Defense Users GS shall be designed in order to be operated with a staff of 25-35 operators maximum*".

The process to define the roles and the functions for C.O.S.M.O.'s staff was initially carried out exclusively by the industry. This process had determined a distance between military exigencies and industrial project. In 2004 the Italian Space Agency in accordance with Defense Users, proposed to create a Joint Operational Team , named G.O.D. (Gruppo Operatore Difesa), in which it was possible for Defense's operators to have a round table with industry together with an A.S.I.'s representative. Thanks to this working group it was possible to reduce the distance between industrial and military teams and to create the positive attitude to work together.

For what pertain to staffing plan, our goal was to reduce at minimum the operative figure's redundancy and to put our knowledge to good use regarding the number and the operator's workload. In fact with Hélios upgrade (CSU4) it was evident the difference between industrial prevision and the real operative life. For example the number of figures with workload on shift (24 hours 7days on 7) was foreseen extremely reduced (only 1 role) but during the operative life it appeared evident the exigency to augment them up to 4. Therefore this difference had determined a lot of problems for us to quickly improve the C.I.T.S. staff (for each role on shift we have 4/5 operators) .

To avoid the same mistakes we have stressed the importance to align the C.O.S.M.O.'s industrial staffing plan to real military exigencies. Besides we have clearly asked to participate to the HMI (Human Machine Interface) definition.

Considering that we will probably enforced to employ the operators both on Hélios and on C.O.S.M.O. because of Italian international engagements, we are trying to tune the HMI definition by means of G.O.D. group interaction with Industry, obviously through A.S.I., trying to maximize our experience in Hélios reusing suitable Hélios solutions which have been demonstrated by use to be effective.

To obtain this , we are going to dedicate some operators to the definition and implementation of C.O.S.M.O.'s interfaces. It is evident that this effort has a cost both from an operational point of view, with the operators on shift team reduction, and for what concern the payment of overtime, but we are confident to obtain good results.

The Hélios experience has been useful also for training definition. In fact we have cooperate, through the authorized round-table, with Telespazio to define the operative exigencies to reach an high level of theoretical preparation together with well structured training on the job. We have obtained to perform a preliminary verification and review of the training courses structure and material and that the training courses will be executed only after our agreed on their completeness.

2.0 CONCLUSIONS

At the end of this brief presentation we would like to underline some very important aspects regarding our experience in the integration of a new program into a pre-existent reality.

First of all we have to consider that C.O.S.M.O.-SkyMed is the first remote sensing program completely conceived and realized in Italy and besides it is the first dual-use in Europe.

This last element has to be considered as the most innovative but also critical because has involved a big effort for two clients, military and civilian, to try to work together with same mentality.

We can register good results in this direction, even if we can't hide the initial difficulty for us to interact with Italian Space Agency.

Regarding the problems linked to the C.O.S.M.O. and Hélios integration we can emphasize the follows main points:

- even if C.I.T.S.' personnel has been involved in the requirements definition phase, we had met a lot of problems when the requirements have been endorsed into system documentation. This has determined a growing our involvement in the C/D Phase in accordance with E.C.S.S. standards.[6] In fact C.I.T.S. has participated at almost all C.O.S.M.O.'s workgroups. This has forced the C.I.T.S.' chief to create a Study Section exclusively dedicated to C.O.S.M.O.;
- As said before, the physical integration between two systems is incurred to many difficulties linked to the simultaneous Hélios up-grade. This situation has involved a significant effort for C.I.T.S.' operative personnel to realize a good synchronisation between two industrial teams. This circumstances should been avoided with a scheduling more close to operatives' real exigencies;
- For what concerns security requirements, we can only point out the good results obtained until now. We are confident that IDUGS will be certificated without any problem thanks to modular C.I.T.S.' architecture for example the floating floor which has permitted to integrate C.O.S.M.O.' L.A.N. without any risk for Hélios' data protection;
- The staffing definition has been possible thanks to A.S.I.'s open mind and industrial availability to follow our indications.

Last but not least, we must emphasize the important rule had by Joint Operative team (named G.O.D.) without this fundamental round-table any operatives' effort should not been efficacious. But we would like to suggest:

- to all Program Office team: to take into account a significant operators involvement in the delicate phase of technical requirements writing and to not underestimate the Ground segment manger 's difficulties to satisfy, in the meantime, the current operative exigencies and the new program ones;
- to site manager we suggest to create immediately a small cell dedicated to follow the new program with the goal to customize it to real operative exigencies.

[6] European Cooperation for Space Standardization previews a requirements definitions phase (named "A" Phase), a feasibility analysis (B Phase), a development, engineering and validation phase (C/D Phase) and the E Phase regarding the deployment of the system.