The benefits of Lessons Learned from the operations of in-flight satellites to federate the future missions

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CNES has been operating from 15 to 20 spacecrafts belonging to different fleets. Up to now, operational teams involvement in new projects was merely limited to the knowledge acquisition on the new space segment in view of an efficient preparation of the operational phases. The unavoidable consequence is that, most of the time, projects made choices that met their own interests thanks to specific solutions and thus against systematic adherence to recommended standards and genericity between projects. With the emergence of new CNES platforms fleets, CNES wanted to take this opportunity to improve the harmonization of future operational practices and means, with a complete standardization of interfaces and thus a better interoperability. By the end, it is expected to optimize the operational jobs, to facilitate synergies and thus to reduce the operational costs. To do so, the CNES Ops Directorate decided to set-up a specific group of experts with the objectives to collect lessons learned (positive and negative) from existing in-flight spacecrafts operations, then to assess the convergence of ideas to imagine the future operations in order to propose a generic operations concept and finally to inject clear operational requirements at all levels and from the very beginning of definition phases. The objective of this paper is to present this innovative approach, endorsed by the upcoming CNES projects, step by step, to underline the majors drivers that make up the operations concept for CNES future missions from 2015, and to emphasize the awaited benefits.

I. Introduction

CNES Operations Directorate has been operating several satellites in orbit for several decades, allowing to collect a lot of Lessons Learnt at all levels. Thanks to a fruitful collaboration between developments teams and operational entities, helped by the collocation on the Toulouse Space Centre, our space systems have always been improved in order to reach very high levels of service. Now, the tendencies are towards costs reductions, standardization everywhere and, last but not least, strong harmonization whatever the type of mission is. Thus, in order to prepare efficiently our operational future in these ways, the operational community had to deeply rethink the way to operate, the practices and associated tools. The chosen approach was to take benefit of the in-flight missions but at all levels. The aim of this paper is to present this operational involvement in details, from the past to the future operations.

This paper will first quickly present the existing satellites operations performed by CNES on the Toulouse Space Centre, with a kind of critical analysis of the current situation.

Then, we will introduce the next mid-term CNES projects with the associated context of collaboration between operations and developments.

After a detailed description of the specific organization set-up towards these new developments, we will try to analyze the main outputs already achieved. A focus will be presented on the trends for the future operations.

Finally, we will present our point of view regarding the coming years and how we intend to play an active role in these developments in order to achieve our objectives.

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II. Critical analysis of the existing operations

Under the term of operations, we are mainly addressing here the command-control aspects of our satellites, platforms and/or payloads. This concerns the entire in-flight cycle, from the critical phases (LEOP, End of life, etc.) up to the long routine phases. In this area, we are operating several different types of missions, and consequently very heterogeneous space segments. Apart from the transverse supports (such as Ground stations network, collision avoidance service, etc.), we can categorize our operations into five areas :

- *Space Telecommunications from the Geostationary Orbit* (GEO): After TDF, Telecom 1 & 2 fleets, these operations are now reduced to only one remaining satellite (Telecom 2D) up to the end of this year only. These operations are usually rather quiet in routine phase with a permanent space to ground visibility .
- *Earth Observation (EO) from the Low Earth Orbit* (LEO): After the first generation of the SPOT satellites, we are currently operating 5 satellites, the SPOT (for civil purpose) and HELIOS (military) family but also the new generation with the 1st Pléiades. These missions are quite intensive in routine phase with a very high level of expected availability.
- *Scientific missions* (only from LEO): The concerned missions are various, from Earth monitoring, altimetry, astronomy, etc. These are ensured by two satellites fleets, that are called "Mini" for a medium satellite size (500 kg up to 700 kg) – PROTEUS fleet - and "Micro" for a smaller size (100 kg up to 150kg) – MYRIADE fleet. This currently represents 11 satellites (5 mini / 6 micro), all in LEO orbits, but with very different operational scenarios (pointing, calibrations, etc.)
- *Automated Transfer Vehicle* (ATV) in the world of the ISS human spaceflights : After the 1st two missions, we are presently operating the 3rd ATV, while the next are already in final preparation to satisfy one flight / year. These joint operations with international partners are very different from "standard" satellites world.
- *Galileo satellites positioning* : In the continuity of the past where CNES performed more than 50 LEOP, it is now time to deal with the progressive Galileo constellation, the CNES working jointly with ESOC. We are in charge of the LEOP operations.

Inside each category, all is very well in place and efficient to optimize and share resources and knowledge for all the satellites fleet, but also to take benefit from the past to improve the future. This is the case for recurrent missions, such as ATV missions, but not only. For instance, in the world of mini or micros satellites operations, a systematic re-use of the same generic control-command centre is possible thanks to a dedicated customization. It is the same for the operational products for which we are constantly trying to fight any specific part in favour of generic part. Regarding our EO spacecrafts, all the means and resources are efficiently shared in order to spread the induced costs as much as we can.

But from one category to the other, there are so many differences, so many habits over the decades, that in the end, we can consider that there are segregated operational worlds. It is also important to note that the Operations Directorate represents a very large structure of more than 200 people.
A first step to bring it closer together was made several years ago by organizing our large structure in hierarchical transverse entities, such as on-board engineers services, operational flight dynamics services or ground activities service. Despite this, it has always been difficult to establish efficient synergies between these areas in particular when the operational concepts are concerned, the tools and more or less the jobs themselves. Ultimately, it is obvious that this is against the global cost savings. Nevertheless per domain, best efforts are made and shared among several satellites, the final operational costs are still attractive for our customers.

Here are some concrete examples :

- Operations performed on a 24/7 manned base up to nearly fully unmanned concept (one programming per week only)
- From fully manual Control Centre up to nearly fully automatic ground system
- From many routine tasks to be done up to nearly nothing to be done
- From generic tools up to in house tools (very locally)
- From very quiet operations up to very tricky and speedy operations
- From very old means up to modern architectures
- Etc.

Thus, a first idea of improvement would be to see if it would be conceivable to develop operational principles, means and trades to cover all of our current missions.

The other topics to be addressed here are around the relationship between space systems developments and operations.
Thanks to proximity and efficient system engineering loop, both teams are most of the time very close. Thus, exchange of knowledge, cross collaboration, clever sharing of responsibilities during the final preparation, qualification and first in-orbit phase are major assets for the success of our projects and especially in the smooth transition from development teams to operational ones.
However, mainly due to permanent operational workload, the implication of operational representatives has generally been real and effective only through the projects reviews cycle and during the final phases whether it relates to the on-board aspects, the ground-to-space links or even the definitions of ground segments. Therefore, the operational principles were generally already frozen and the involvement of operational experts did not call into question the initials choices made from the beginning, such as the mission concept itself, the trade-off about the sharing between the on-board autonomy and the tasks assigned to the ground teams, etc.
By the end, the system is not systematically fully optimized regarding the relevance of the operations to be done. To illustrate several shortcomings that bother us daily, here are a few typical examples :

- There are regular ground tasks to be done manually by operators during the very long routine phase, without any added value to be required. Sometimes, this is linked to a simple mission function missing on-board or lack of automation of the ground segment. This is not valuable for operators and moreover, this prevents operators to focus on the essential, to analyze in detail the status of their system on a daily basis, or to keep aware of all possible outages for which human aspects and knowledge are mandatory to recover any possible situations.
- Regarding, the ground segment, best efforts are generally made during the development related to the main functions (TM extraction, archive, displays, etc.) but at the expense of all the secondary aspects (TM in depth analysis, Reports generation, collaborative communication inside operational teams, etc.). The consequence leads to the necessity for the operators themselves to develop in-house tools in a very short time and at the last minute. Ultimately, this multitude of tools is difficult to manage, to get at the proper level of quality and sometimes, it can threaten the safety of the operations themselves.
- Another classic domain is about the sharing of monitoring between what can be implemented on-board and what must be defined on ground in complement / coherence in order to get an efficient system monitoring. When this layer is not defined all together, there are unilateral choices that can lead to difficulties at the end. For instance, there are areas where operators must quickly react, such as reaction in less than two minutes not to endanger the on-board devices. The concept is not safe enough for the overall mission.

Finally, a greater involvement of operational staff themselves in projects developments from their genesis should avoid unilateral choices to ultimately optimize the space system in the interest of operational teams but also for overall project costs reduction. This is the second initial idea of improvement for the future but only if the operational representatives have all the cards in their hands to bring the projects towards our desiderata.

The general idea beyond this initiative was to mix the two ways of improvement and this will be detailed in the next paragraphs.

III. Context of future CNES projects

At CNES level, one the major lesson learnt over the last decade would have been the interest of the platforms fleets such as PROTEUS and MYRIADE. This is not the aim of the present paper to go into details about these projects as many presentations were already done in various forums. Because of obsolescence of the existing fleets, CNES decided a few years ago to renovate and to propose a next generation of platforms.
In parallel, CNES, as an agency, invested a lot in the standardization in all parts composing a space segment, from the on-board protocols up to ground links interfaces, etc. This involvement in all the different committees (CCSDS, IOAG, ECSS, etc.) had to be practically applied to a real CNES project. This is the reason why ISIS project was created in order to better federate all the future projects whatever the satellite size, the mission type, etc could be. Instead of imposing detailed concept (like an on-the-shelf platform), the priority of the ISIS approach has always been to freeze and standardize all what is possible in a generic way. This can apply to the on-board interfaces

(platform and payload), the space to ground links, the ground systems, etc. The ISIS initiative, held by CNES, was done commonly with our main primes (Astrium and Thales Alenia Space).
The first targeted applications of the ISIS outputs are :

- The next generation of EO fleet : This project is called CSO and it is about our next EO program for military purpose only. 1st launch is expected by end 2016.
- The renovation of MYRIADE fleet : This project is called "Myriade Evolutions" and the first mission has to do with an application developed commonly with the DLR in charge of the payload for the Earth methane rejections monitoring from space. It is called MERLIN and the launch is expected by the end of 2015.

As the initial intention was to standardize at all levels, it was agreed from the beginning to take the ISIS opportunity to completely redesign a new generation of ground segment including the flight dynamics functions. Thus, all the requirements were rethought in line with CCSDS / Mission Operations standards and with an assigned scope being not only a multi-satellites ground segment but also a multi-missions one. Again, the idea was to limit at the maximum the mission specific parts. This core ground segment is now under development, the first users being CSO and MERLIN.
Of course, the overall intention of these projects is not only to standardize but also to reduce costs at the maximum, to take benefit of existing & innovative products and concepts on the market even outside space domain. This is why all the solutions based on COSTS, Open Sources, etc. are carefully analyzed.

The emergence of these news projects was a golden opportunity for the operational community to get on the train from the departure in order to inject our ideas of improvement detailed previously.

IV. New operational organization specifically set-up for optimization of this future

As mentioned in the previous paragraph, the intention of our Operations Directorate was to play an active role from the emergence of the CNES new projects but with ambitious and clear objectives : to try to imagine a future shared by all the operational entities or in other words, to take benefit of all the lessons learnt, positives and negatives, of the existing operations in order to improve our future by unification of points of view.
Then, it was decided to organize ourselves accordingly by creating two specific entities working in a consistent manner, one in charge of collecting the lessons learnt and sharing points of view and one more in charge of imposing our resulting wishes in the new projects. These entities were clearly defined with clear mandate and by principle, they represent working groups based on recognized experts from all the areas of the Directorate, either in terms of missions memberships or in terms of operational jobs. All the actors are deeply involved in our daily operations. This can be considered as an advantage because they are aware of the exact situation but also, as a disadvantage at the same time because their availability depends on the operational priorities.
These two entities are described hereafter :

A. LESSONS LEARNT / CONCEPT : The OPS Working Group

This OPS WG was created at the beginning of 2009. A group of 15 predefined operational experts was identified and proper dispositions were taken to free at least 10 to 20% of individual time for a good involvement in the WG. The mandate was clearly to collect all the lessons learnt per topic and to try to converge to future solutions in a generic / covering way. The retained approach was to work according to a thematic approach and to capitalize all the outputs in several sets of recommendations assigned to every subject. Of course, when needed, other individual operational representatives could be asked to temporarily join the group for specific topics. Furthermore, for several areas, it was judicious to iterate with our operational partners (agencies or industrial primes) either to benefit from their own experience, or to consolidate our choices in particular when interoperability could be concerned. This WG was managed by the Operations Directorate office exactly in line with the clear objective to cover all the existing domains, even those possibly very far from the future orientations.

The priority assigned to the WG was to deal with the operational practices and the associated tools. Of course, aside these points, that led inevitably to discuss also about the on-board concepts either in terms of autonomy, observability, or commanding capabilities.

The main topics that were addressed were successively :

- Commanding (Telecommands, Flight Control Procedures, Ground Control Procedures, Chronograms, recycling TC issues, On-Board Control Procedures, etc.)
- Operations scheduling / sequencing (Sequence of operations, Reflex rules, etc.)
- Traceability & Real Time management (Events logs, alarms files, communication, shift hand-over, etc.)
- Data management (Operational Data Bases, configuration management, generic / specific arrangement, etc.)
- Telemetry visualization (displays, monitoring, reporting, portability, on-call system, etc.)
- Operational reports (tools, TM computations, collaborative work, etc.)
- Flight dynamics activities (tools, 3D visualizations, protocol exchanges, ground stations interfaces, etc.)

Of course, there are several additional isolated topics that must be dealt by the WG inside these general topics.

For every theme, the base logic was first to set-up a kind of forum where it was asked to each representative from every domain, to present their current practices & tools, to present positive and negative assessments, and to express themselves about what they would like as "and if I had a dream ….". Thus, everyone could be informed of how their neighbours were working and how they imagined their future. In general, during this presentation meeting (even if usually rather long), and thanks to a very interactive spirit from all, there were lots of short term actions that could be taken in terms of possible synergies. We could also begin to underline the drivers and solutions of the addressed topic. Then, the WG leader took the time to try to draft a set of recommendations for the future on the addressed topic, with clear identification of what seemed to be mandatory as is and what must be worked more by the WG. Then, a convergence meeting was organized (one or several pending the difficulty to converge), in order to consolidate the recommendations. When the topic seemed to be sufficiently clear and endorsed by all, then we skipped to the next topic. By the end, this represented roughly one meeting per month for experts and nearly half time workload of the WG leader.

To finish, it is important to underline the level of transparency and freedom of this WG as it was fully open and everyone could express themselves without any taboo, even when it could lead to conflicts or tricky situations. And last but not least, each time we were finalizing an operational concept part with potential strong impacts on future tools (Ground Command-Control Centre, Flight Dynamics subsystem, data model, data bases, on-board concepts, etc.), the colleagues in charge of developments inside projects were systematically invited and could help in the final convergence process. These are the major success keys of this WG.

B. CICEROPS

After the 1st outputs of the Ops WG, the expected changes at all levels appeared so deep and so ambitious that we quickly realized that it would not be easy to get the concurrence of the new projects because for some topics or some people, we were in front of potential revolution of several strong rooted habits and traditions. So, a few months after we set-up the Ops WG, we all acted to create a dedicated entity in order to bring the operational outputs in the projects and if possible to inject concrete requirements reflecting the recommendations in the project referential. The creation was set-up mid-2009 and all the new projects representatives were immediately informed, including the highest level of our management that concurred with the proposed approach.

This entity, called CICEROPS (internal acronym) is more reduced than the OPS WG as it is composed of a core of 6 experts only, 2 representatives per fleet (ISIS and Myriades Evolutions) and 1 in charge of the 1st projects (CSO & Merlin) based on these new fleets. Their attributions were adjusted to free between 10 to 30% workload. In addition, predefined supports are available to help, in particular for the ground segment aspects, the flight dynamics activities, the interface with the GSN and also for the infrastructure aspect. The aim of this entity is clearly :

- To inject the proper requirements in the new projects at all levels : system level, on-board, ground-to-space link, ground segment, etc.
- To build & maintain the associated operational concept via a generic Mission Operations Concept Document, a generic interface in terms of operational inputs required (documentation, data bases, ops manual, etc.) and associated documents such as generic operational qualification plan etc.
- To verify that the 1st missions are in line with the generic concept and if not to fight as much as possible to reduce the specificities.

To do so, they are deeply involved in their assigned projects and there are bi-weekly coordination meetings . The OPS WG leader is also associated to these meetings, in order to recall and inject the proper recommendations when needed and to catch items that would need more transverse brainstorming in order to be clarified by the OPS WG and then propose to the CICEROPS to be injected in the projects.

A weekly reporting of the CICEROPS achievements in the projects is also in place in order to warn the hierarchy when necessary and thus to track all the potential conflicts with our projects colleagues that could require an action at their level.

V. Achieved outputs up to now

Now, after nearly three years of existence of these two entities and a huge work done by all, the results are tangible. Before going into details, it is important to note that the chosen approach has proven efficient as it presents these main advantages :

- Everyone can express themselves, dreams are listened to, natural tendency to believe that we will not reproduce past errors, etc => Natural progressive motivation by all to contribute
- All the outputs are clearly capitalized and shared
- The transverse approach is well endorsed by the new projects teams. They are trying to encourage other jobs to do the same
- This preparation is fully endorsed by the management, who pay a full attention to the process

A. GT OP / REX

Thanks to hours and hours of fruitful brainstorming, we have now produced a consistent set of recommendations that covers at least the major topics to be deeply improved for a better future. This currently represents a document of less than 60 pages and roughly around 300 recommendations for the time being.

It is important to note that sometimes some recommendations address solutions to be implemented and not the needs themselves. This is done to strongly insist on the development teams not to reinvent new solutions, even if formally speaking, we can only inject requirements towards them.

In parallel to the long term, there are many practical outputs from the OPS WG, traced in actions forms, that can be applied to the existing missions thanks to a general increase of the synergies.

Let's now illustrate with a few examples of achieved results :

- *Procedures language* : As far as the on-board commanding is concerned, the current heterogeneity is obviously very important – From basic TC stacks for our old spacecrafts up to very complex procedures with conditional branching, mixing TM checks and TC sending. In parallel, this is a domain where there is a proposed standard (ECSS). Thus, we tried to apply the standard for each application case and by the end, that led us to define a common language that could fit with all our existing platforms. This language is no more than a kind of a customization / simplification of the standard, limited to our interests, regarding the morphology of CNES projects (no deep space missions for instance). But by going-on the brainstorming with all other jobs, we concluded that this language could also fit with Ground Control Procedures, Flight Dynamics Procedures and also the On-Board Control Procedures. So, all future teams will normally work with a common language (so better synergies in terms of editors for instance).
- *Level of automation* : Here also, we currently operate from full manual operations, up to high level of automation. Obviously, if we intend to save operators tasks in the future, it was evidence given that automation must be encouraged while keeping in mind the objective of reliability of the final system. Analyzing this area all together led us to propose new ideas in terms of reactivity of the system and in particular the conjunction of the full automatic operations execution with the specific asynchronous events management. We also define clear recommendations that allow to disengage any automation loop in order to perform manual operations when needed (critical phases, investigations, etc.). Once again, this new logic applies to all kinds of operational activities performed inside the ground segment.
- *Monitoring* : The analysis of the current systems revealed many aberrant situations. For instance, on our EO satellites, the ground monitoring is nearly a recopy of the on-board monitoring. The consequence is that our on-call operators are warned and they must come on site just to acknowledge an on-board alarm without any action to do and there is no added value by the ground monitoring. Another illogical conception is about the required reactivity from the ground. This helped us to define clear rules to be injected at the on-board level in terms of robustness.

- *Architecture principle* : An in-depth brainstorming was done in this area in order to define high level principles about the articulation of all the processes running in parallel but also the need to segregate preparation tasks / execution tasks at all levels with one single logic. Sometimes, diagrams were elaborated to help the understanding. Here is an example :

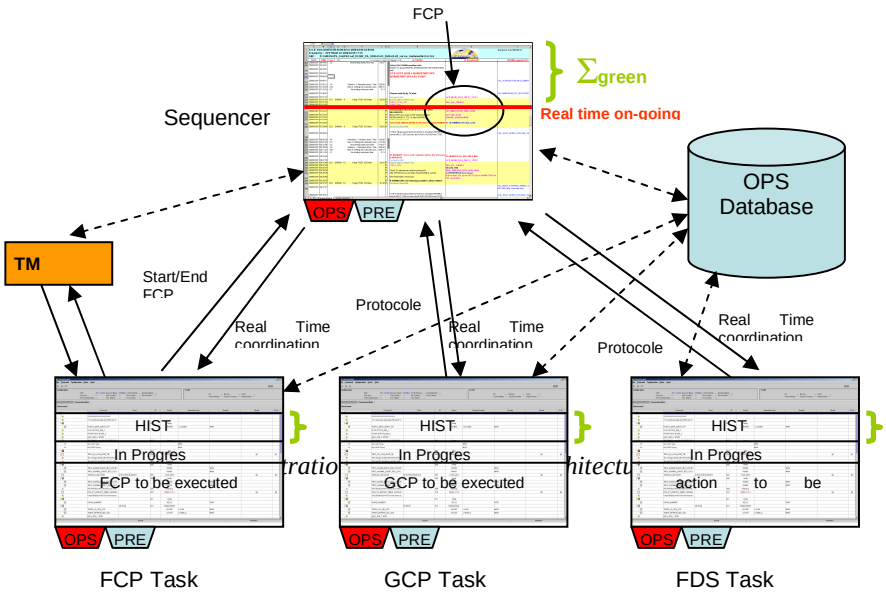

Figure 1. *Illustration of an integrated architecture principle*

Of course, as said before, all this brainstorming phase was done in coherence with the CICEROPS activity, several experts being involved in the two entities.

B. CICEROPS

As said before, from to the recommendations coming from the OPS WG, the CICEROPS translated into clear requirements at all levels in the ISIS project, taken as the generic reference for all projects. Today, all the injected requirements have been integrated / negotiated and accepted by the ISIS project team, including our main industrial primes. They have been submitted with success to all the projects reviews.

Upstream these requirements, the CICEROPS produced a generic Mission Operations Concept Document. This is the most important documents to initiate discussions with every new project, mainly because it represents the stump of our concept. This short document contains the main drivers to be respected from the beginning in terms of organization per mission phase (operational roles, Command-control ground segment / Mission Control Centre interfaces, etc.). These main drivers are normally engraved in the marble and thus not negotiable as opposed to what is relevant to the mission specificities that are clearly to be customized in the document. This notion of generecity via a template is efficient and has already proven its efficiency for more long term projects.

Back to requirements, the CICEROPS also produced dedicated documents for several major areas. These self-content documents have been progressively integrated in the ISIS perimeter. Just two examples :

- *Operability requirements for the ISIS ground segment* : This document contains more than 100 pages of requirements that are presented according to the different activities to be performed by the operational teams all along the mission life cycle. This new initiative led the developers and operational to long but efficient iterations in order to understand each other. These requirements have now been applied in the ground system reference and the traceability will allow to easily verify that the operational expectations will ultimately be met.

- *Procedures language* : As said before, a common language was defined to be used by all the operational activities. To edit a self content document was the only way to address this language to all the involved entities.

Without going into details, let's now provide a few examples of impacting requirements that are essential with regards to our global objectives (costs reduction & operations standardization, that required hard negotiation with the project teams,) :

- Maximum 10 minutes required to download 24 hours of recorded platform telemetry,
- Minimum of 6 months between two successive maintenance operation for any platform piece of equipment, Maximum of 15 days required for the LEOP and assessment phase,
- Maximum of 24 hours required for the transition to NOMINAL satellite mode from the separation or the safe mode,
- Only one TC contact per week required for platform needs,
- Routine operations are performed only during working hours and days,
- All anomalies(board and ground) are categorize in 3 groups : yellow to be treated in the coming week, orange to be treated in next working hours, red to be treated as soon as possible, by on-call teams outside working hours and days. Each red alarm is associated to a recovery procedure,
- The CCC allows full automatic operations execution
- A CCC monitoring service allows to call operators in case of red anomaly,
- Mission operations files including requests from the mission centre can be treated 24/24, to upload mission TC on next booked pass

There are also many requirements to standardize and harmonize all the interfaces at all levels between all the boxes of the space system :

- ECCS PUS and procedure language standard had been tailored for future ISIS missions needs
- Message Abstract Layer (MAL) standard of CCSDS SM&C service concept will be used in ISIS generic CCC,
- CCSDS Space Link Extension services standard will be used for ISIS operations,
- Standard format had been issued for SBD exchange between main contractors and CNES whatever the project,
- A list a standard interfaces within the ground segment (CCC/mission centre, CCC/Station Network Operation Centre,…) had been issued. Missions have to make theirs market in this list prior to develop any interface.

Figure 2 shows the global CCC operations execution concept. The layer 1 could be assimilate to the system level, which schedules all CCC operations from a Sequence Of Operations planned or from reflex rules triggering on specifics conditions (for instance, a red alarm in the recorded telemetry monitoring). Level 2 represents all unitary operations, from a simple message to show to the operator to a FCP or GCP. All this operations are implemented via the ISIS standard language procedure or a script for specifics needs shown at layer 3 level. The layer 4 includes the MMI of the CCC. Layer 3 and 4 call services exposed by the CCC components from layer 5. Exchanges between CCC components is based on the CCSDS MAL standard.

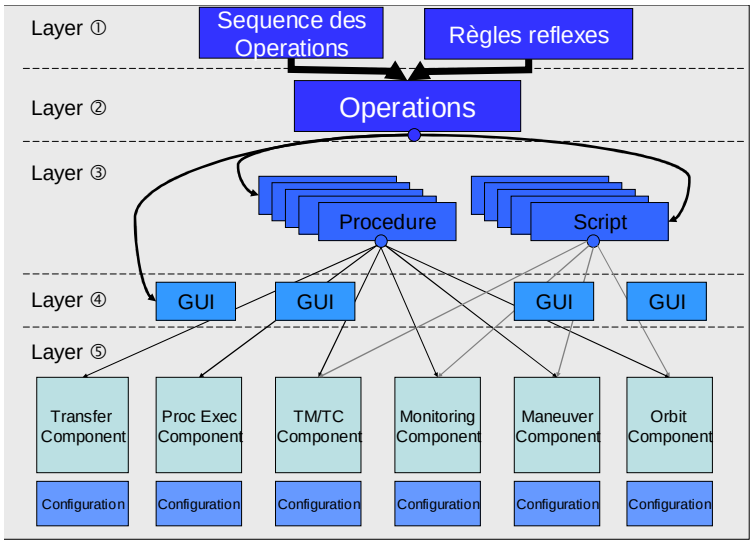

Figure 2. Global CCC operations execution concept.

Apart from the normal work of the CICEROPS deeply involved in the projects, the Operations Directorate required to set up a milestone mid-2011 in order first to be informed of the outputs, the directions and choices taken but also to consolidate the approach via an independent group of experts. The key point meeting was held during one day during which the CICEROPS presented the status, the main outputs and the hypothesis for the future. The board endorsed the CICEROPS point of view to the great satisfaction of all.

VI. What's next now ?

Of course, this initiative is far from being finished. From now on, we will have to face the harsh reality and we are all well aware of that. Our role will be to help all the projects the best we can in order to limit discrepancies. The activities of both entities are on-going with permanent adaptations to priorities and projects progress status.

A. Short & medium term

As the major topics were treated in the past, the OPS WG is now more in a "on demand" mode such as a routine phase. There are already identified subjects that require transverse brainstorming to find efficient solutions. This is mainly around the collaborative work. In general, these are difficult areas to harmonize due to the strong habits, the fear of modern tools, and also because of organizations barriers. Any kind of topics can be asked to the OPS WG on demand. So even if the huge workload is behind us, a permanent activity will always remain, with the major objectives to permanently harmonize and simplify the daily work of our operational community.

The CICEROPS role is far from being over. There are clearly three major mandates assigned to the CICEROPS :

- *"The projects coaching"* : All the requirements are now under implementation down to the lowest levels. This requires to work together with designers to understand ourselves and when possible to make choices together. There are mainly issues to be worked on. When one area is too difficult to converge, there is generally the decision to create a dedicated working group and to capitalize the outputs in a new document that will eventually be a reference. This is the case for instance for the PUS implementation for which we are instructing a "PUS use document" or for the OBCP loop for which it is necessary to freeze all the principles, for on-board implementation and also on-ground, including the validation means, etc. The Ground Segment development represents such a strategic part that we decided to create a specific group of ground experts to jointly assist the developers. We have also required many mock-up, demonstrators all along the developments in order to ease the mutual understanding and convergences. We have also required to play an active role in the validation of the ground segment in order for us to own this new generation of tools as early as possible.
- *"The projects specificities hunting"* : It is essential to escort the projects in order to help them to apply the ISIS referential, to negotiate every specific parts. This is a huge piece of work for the short term projects, in particular the 1st missions and in particular for CSO because the definition phase started before ISIS complete definition and thus changes are have a great impact.
- *" The preparation of future operations"* : As we all hope for many changes in the way to prepare the operations, the customization of the generic ground segment, the automation level to adapt, etc. we have to prepare ourselves far before the beginning of the operations of the mission. In other words, the preparation phase is strategic for the 1st mission and it represents a huge work that has already started. For instance, first deliveries of operational products relative to the flight segment are already under assessment and it is vital to iterate with the provider very quickly in order to converge to what we expected. The sensible part will probably be the preparation of the ground segment because the more it will be generic, the more the layer of customization will be important.

B. Long term

In parallel to the huge work foreseen for the CICEROPS, we have to assess the team building for the 1st missions with of course, the associated organization that should differ from the existing one. The Operations Directorate have already initiated a brainstorming on that sensitive aspect.

Regarding the more long term projects, operational representatives are also assigned to play the same role as what is done today by the CICEROPS team for CSO and MERLIN. There are regular reporting and coordination meetings with the CICEROPS where any discrepancy is carefully analyzed.

There is also an on-going question about the capitalization of all the ISIS requirements injected by the CICEROPS at all levels, in particular for the next initiative after ISIS or possibly for the arrival of a new projects outside the scope of ISIS. The tendency is to thinks of a single document covering all the segments of the space system and all the organizational aspects. In fact, this would mean to implement the same logic as ESOC does with an important and consolidated Operations Interface Requirements Document. The association of OIRD and MOCD could be sufficient providing that they content all the already injected requirements in ISIS referential. We have to think about this in the next years but there is no urgency.

VII. Conclusion

In the frame of the Lessons Learnt process, the CNES Operations Directorate realized that there was an important heterogeneity of operational concepts, practices and tools among the existing in-flight missions. Thanks to a specific organization and dedicated manpower, we managed to collect all the possible Lesson Learnt in order to converge towards unique a point of view for our future operations. By the time and thanks to important efforts, this transverse approach has been very efficient & fruitful at all level. A generic operational concept with associated practices and tools is progressively born from this thematic brainstorming.

After long negotiation, we managed to introduce this concept in the new innovative CNES projects.

Now, the road is still long. We all have in mind that the challenge from now on is to keep focused as much as we can because we are all aware that the harsh reality (mainly costs and schedules) will impact us very soon. Thus the coming years are still challenging for us but we will do our best to meet our expectations.

After the 1st implementation, we will have to assess whether this innovative approach from our operational community will have been profitable.

So let's schedule the next sessions of the SpaceOps to present the progress and efficiency of the final result.

Appendix A
Acronym List

CCSDS	Consultative Committee for Space Data Systems
CNES	Centre National d'Etudes Spatiales
CSO	Composante Spatiale Optique (Optical space component)
ECSS	European Cooperation for Space Standardization
EO	Earth Observation
GSN	Ground Station Network
IOAG	Interagency Operations Advisory Group
ISIS	Initiative for Space Innovative Standards
GEO	Geostationary Orbit
LEO	Low Earth Orbit
LEOP	Launch & Early Orbit Phase
OEL	End Of Life
PUS	Packets Utilization Standard
TC	Tele-Command
TM	Tele-Metry
WG	Working Group

Appendix B

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