17th International Conference on Space Operations, Dubai, United Arab Emirates, 6 - 10 March 2023.

SpaceOps-2023, ID # 229

CNES Ground Station Networks for Science - SciNet

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Abstract

As a National Space Agency involved in launchers and satellites design and operations, the CNES (Centre National d'Etudes Spatiales) has developed since the beginning of its activities significant ground station networks to acquire telemetry and send telecommand to space vehicles. These large and bulky antennas are the first picture in mind when talking about Ground Station Networks. However, a more discreet activity exists and is essential for many space applications: Small Antenna Ground Station Networks. These networks are most of the time the answer to specific needs for space applications, especially in science. This paper will present four projects at CNES pooled under the Ground Station Networks for Science Cluster (CNES SciNet). It will address the organization set up to increase synergy and efficiency in the deployment, operation and maintenance of these different networks by taking advantages of the commonalities whatever the project purpose. Beyond organization aspects, the fundamental importance of hosting sites contribution and excellent working relationships with them will be emphasized.

Keywords: station, network, science, GNSS, CNES, SciNet

Acronyms/Abbreviations

CNES	Centre national d'études spatiales	(fr)
	National Centre for Space Studies	(en)
IGN	Institut national de l'information géographique et forestière	(fr)
	National Institute of Geographic and Forest Information	(en)
TSA	CNES Telecom, Stations and Alerts Department	
GNSS	Global Navigation Satellite Systems	
REGINA	Réseau GNSS pour l'IGS et la Navigation	(fr)
	GNSS Network for IGS and Navigation	(en)
SAGAIE	Stations ASECNA GNSS pour l'Analyse de la Ionosphère Equatoriale	(fr)
	GNSS ASECNA Stations for the Analysis of the Equatorial Ionosphere	(en)
DORIS	Doppler Orbitography and Radiopositioning Integrated by Satellite	
SVOM	Space-based multi-band astronomical Variable Objects Monitor	
CNES SciNet	CNES Ground Station Networks for Science	
ASECNA	Agence pour la Sécurité de la Navigation Aérienne en Afrique et à Madagascar	(fr)
	Agency for the Safety of Air Navigation in Africa and Madagascar	(en)

1. Introduction

When a project starts, most of the time the Project Management develop a system component from scratch if the appropriate skill does not exist or is not well-identified in the company. This component is then so deeply integrated to the project that there is almost no exchange with other projects sharing close requirements. It was the case at CNES for the ground stations networks dedicated to science application for many years. Lessons learnt with time lead as a first step to separate two aspects: infrastructures to get the data and data applications. Through a major CNES reorganization, a Networks, Stations and Alert Department was created in 2016 at CNES regrouping all skills to develop, deploy, maintain and sometimes operate all kind of stations. An overview of this Department, named now Telecom, Stations and Alerts Department (TSA), will be given this paper with a focus on activities concerning small station networks dedicated to scientific projects. Today four projects of this kind exist at CNES with different histories and they are pooled as CNES Ground Station Networks for Science (CNES SciNet) since 2022. In the next chapter, descriptions of the different projects will be given before addressing the organization aspects.

The purpose of this paper is to describe the different projects forming the CNES Ground Station Networks for Science with their specificities and commonalities and then explain how synergies are developed on many topics like operations, logistics and maintenance through a new organization. Lessons learnt from DORIS and REGINA projects for the benefit of newborn SVOM project will be addressed. These topics could be of interest for any existing or future stations operator on distant hosting sites.

2. Description of the different projects

2.1 REGINA

The last decade has seen the accelerated development of Global Navigation Satellite Systems (GNSS) and data-processing techniques, assisted by land-based augmentations aiming to provide a significant improvement of the associated positioning and navigation services.

In this context, and following their respective missions, CNES and IGN have agreed in 2012 to collaborate to the deployment, operation and maintenance of a real time GNSS observation infrastructure, including an equipment enhancement to meet scientific or operational needs related to the GNSS positioning and navigation. Named REGINA (GNSS Network for IGS and Navigation), the project results in the acquisition of multi-GNSS data, in controlled configurations, and the dissemination for the benefit of the scientific community on a long-term approach.

By now, REGINA is a worldwide network of GNSS stations for IGS and navigation with 39 stations providing a global geographic coverage. It provides Real-Time NTRIP streams to IGN and CNES casters with 1 Hz data and consolidated data files (15mn, 1h and 1 day). REGINA has a multi constellations capability including GPS, GLONASS, GALILEO, BEIDOU and also SBAS.

REGINA provides an important amount of GNSS data to scientific community through its contribution to the International GNSS Service (IGS) and contributes to the International Terrestrial Reference Frame (ITRF) with few major sites including GNSS, DORIS, Very Long Baseline Interferometry (VLBI) and Satellite Laser Ranging (SLR) technologies. REGINA also contributes to the survey and calibration of GNSS systems and services by providing appropriate data to the CNES navigation experts.

Beside GNSS core activities, REGINA is also used for other applications like Search and Rescue (SAR) GALILEO Return Link Monitoring described in [2]. More information on REGINA could be found in [1] and dedicated website (cf. Appendix B).

Fig. 1. REGINA Gamak station – KASI - South Korea

2.2 SAGAIE

SAGAIE is a French acronym for GNSS ASECNA Stations for the Analysis of the Equatorial Ionosphere. The stations cover the Western Africa Region and are all installed at major airports of this region. This area is subject to high ionosphere activity and SAGAIE network provide useful information to assess scintillation phenomenon and assess impact on GNSS. A long term agreement exists between ASECNA and CNES since 2013 to operate SAGAIE network. This task was done by a CNES contractor for many years but in order to get synergy, operation and

maintenance of SAGAIE network was entrusted to REGINA Team in September 2021. CNES and ASECNA also signed an agreement in June 2022 for providing management assistance in systems engineering for the ground segment, the space segment and system performance of a Satellite-based Augmentation System (SBAS) in Africa. The ground station operational network will be different from SAGAIE which is dedicated to science and technologic demonstration.

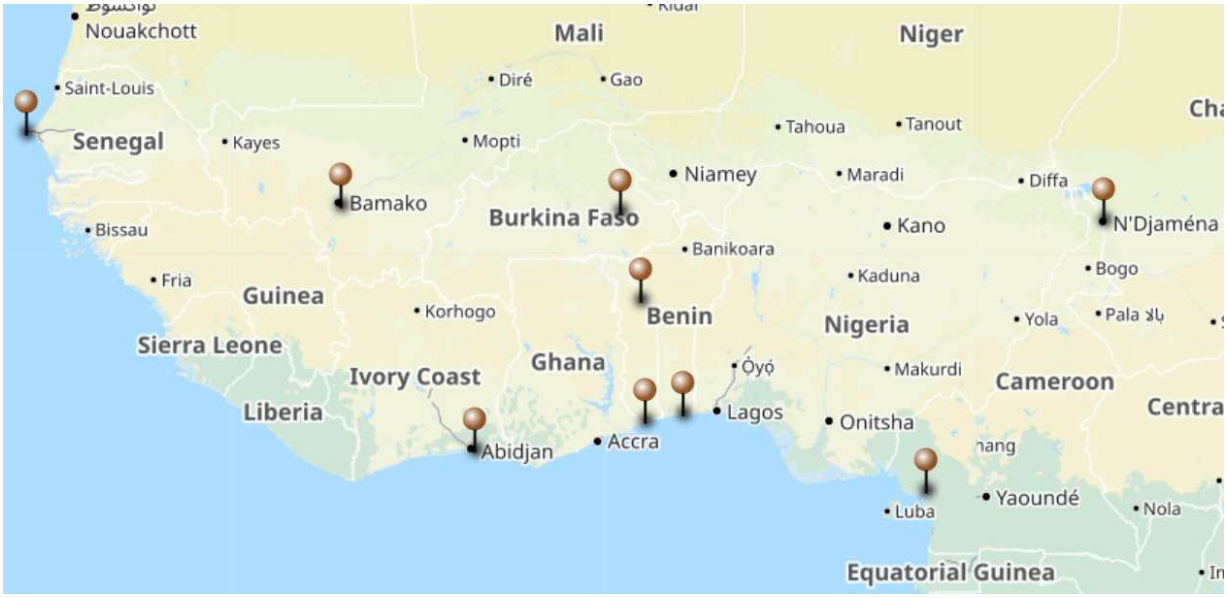

Fig. 2. SAGAIE Network

2.3 DORIS

The Doris system (Doppler Orbitography and Radiopositionning Integrated by Satellite) is a French civil precise orbit determination and positioning system based on the principle of the Doppler effect with onboard instruments on the satellite's payload (antenna, radio receiver and ultra-stable oscillator) and a transmitting terrestrial beacons network.

The Doris system was designed by CNES in partnership with IGN and the space geodesy research group GRGS. The first test onboard was with Spot 2 mission in the 90's. The successive altimetry missions TOPEX/Poseidon, Jason-1, Jason-2, Jason-3, ENVISAT, Cryosat-2, HY-2A, SARAL/Altika and Sentinelle-3 as well as others survey SPOT missions have demonstrated the performance of this system. Since 2003, International DORIS Service (IDS) provides Doris data and products.

Now, the ground segment includes about 50-60 ground stations, equally distributed over the earth and ensure a good coverage for orbit determination. For the installation of a beacon only electricity is required because the station only emits a signal but does not receive any information except for the station management through an Iridium link. DORIS beacons transmit to the satellites on two UHF frequencies, 401.25 MHz and 2036.25 MHz.

More information on DORIS could be found on International Doris Service website (cf. Appendix B).

Fig. 3. DORIS Wettzell station - Germany

2.4 SVOM

SVOM is the acronym for Space-based multiband astronomical Variable Objects Monitor. SVOM is a Chinese-French space mission dedicated to the detection and study of Gamma Ray Burst (GRB) and their use for astrophysics and cosmology. Launch is planned end of 2023 for a 3-year nominal mission and is expected to detect more than 200 Gamma-ray bursts (GRB) over this period.

A network of 45+ VHF stations located in the inter-tropical region will be used to maintain a reliable and permanent contact with the satellite. It is dedicated to receive at any time an alert message delivered by SVOM satellite after any GRB detection. This message will be forwarded to Ground Telescopes and Cameras through the mission center for their pointing. The VHF ground network is under CNES responsibility, on behalf of French Government.

Fig. 4. SVOM Arequipa station – UNSA – Peru. Misti volcano in the background

More information on SVOM could be found on SVOM website (cf. Appendix B).

DORIS and REGINA projects started many years ago as written before and are now on a cruising pace and are fully operational. They acted as a backbone to start the deployment of the SVOM Network in April 2019 with the ambitious objective to have a network of 45 stations ready mid of 2023. This topic will be addressed further down.

3. Telecom, Stations and Alerts Department

Reorganized in 2022, the Telecom, Stations and Alerts Department (TSA) is responsible in particular for:

- Conducting Telemetry/Telecommand station operations and data reception from orbital systems payloads for the benefit of CNES projects or external partners,
- Conducting development and maintenance in operational conditions of mission ground segment (mission centers, production, expertise, calibration/validation and associated software products) related to Telecom, Radiofrequencies and Space Survey,
- Operating the networks, the mission ground segments related to Telecom, Radiofrequencies and CNES monitoring and alert systems.

Two of the four TSA divisions are essential to SciNet: Station Engineering Division and Software & Central Resources Division.

- Station Engineering Division is responsible for maintenance in operational condition and the development of CNES satellite ground stations,
- Software and Central Resources Division is responsible for maintenance in operational condition and the development of software components of CNES mission centers.

Role of these two divisions for SciNet will be explained further in organization chapter.

At the beginning of 2023, TSA has about 170 operation stations in charge and this high number is obtained with small stations for science which represent around 150 stations. A global map for TSA stations is given in Fig. 5 hereafter.

Fig. 5. Overview of TSA stations around the world, pins colour is specific per project. It can be seen the global world coverage. TSA is present on all continents.

4. A first step towards SciNet: the deployment of SVOM VHF network

DORIS (started in the 90's) and REGINA (started in 2010's) were the first Ground Station Networks for Science and they are both managed jointly with IGN. DORIS through the precise orbit determination and REGINA with GNSS are two of the four main technics for geodesy. The two other technics being the Satellite Laser Ranging (SLR) and the Very Large Band Interferometry (VLBI) which are much more complex and costly. A site with the four technics are of prior importance for geodesy and for the establishment of the International Terrestrial Reference

Frame (ITRF). In any case it is interesting to have both Doris and Regina at the same site and "linked" together by geodetic measurements. This explains why DORIS and REGINA stations are often deployed on the same site.

Therefore, a hundred of REGINA and DORIS stations are hosted by around 70 hosting sites around the world with whom CNES and IGN have a long history of good working relationship. As SVOM project required a global network of VHF stations around the world, it has turned naturally to TSA to look for some support. Deployment of VHF stations was given to TSA in 2018 with REGINA project manager entrusted as coordinator for the deployment.

The first station of SVOM Network was deployed in 2019 before the COVID-19 pandemic. It must be pointed out that there is no shared scientific interest with REGINA and DORIS projects, the final application being very different: SVOM stations have to receive VHF alert signal from satellite only for Astrophysics purpose. Nevertheless, TSA experience and very good relationship with hosting sites allowed us to deploy a lot of stations even with hosting sites not concerned by Astrophysics.

Fig. 6 shows the dynamic of stations deployment for REGINA and SVOM. REGINA had a number of 10 stations from a previous project at the beginning, SVOM had no station at the beginning. The benefit of TSA experience appears clearly on this graph with a faster deployment for SVOM. Moreover, the context was very unfavorable for SVOM due to the COVID 19 pandemic and lockdown on many sites between years of reference 2 and 4. SVOM reached 38 stations deployed in October 2022.

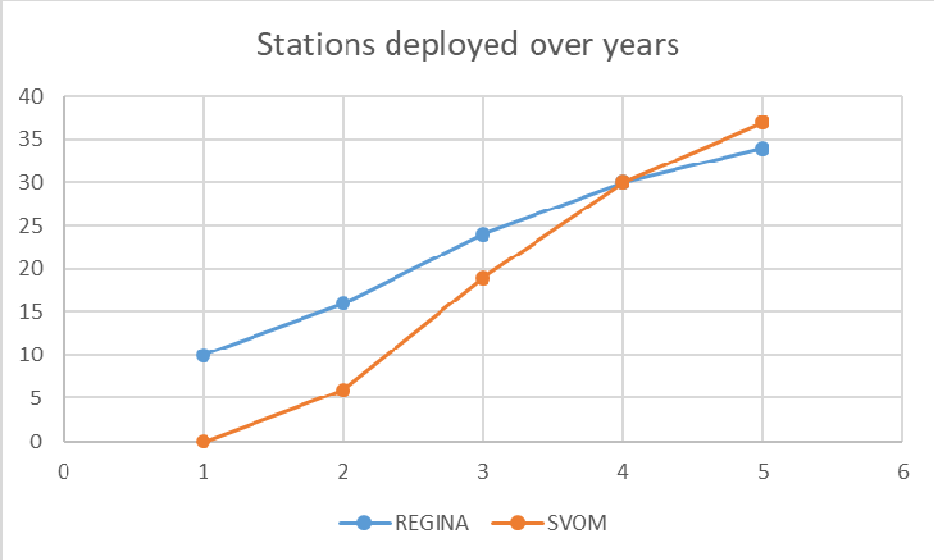

Fig. 6. Comparison between REGINA and SVOM number of stations deployed per year. Year 1 being a reference for the starting of the deployment. Slope is the main parameter to look as REGINA started with 10 stations already installed.

5. The turning point: contractors' synergies

In our roadmap the first opportunity to highly increase synergy between the projects was given by an invitation to tender to renew the Operations Support and Application Maintenance contracts in 2021 at the same time. Before 2021, there were one contractor for Operations Support and one for Application Maintenance and contracts were specific per project. The synergy at contract level was done in two steps:

- On CNES side, Operations Support activities (Operation / Contacts Management / Shipping / Inventory Management) for all projects were regrouped in a common package. In the same way, Application Maintenance activities (for project having one) were regrouped in another package.
- On industrial side, a consortium regrouping two companies joined their skills and proposed an industrial organization to increase synergy even between packages Operations Support and Application

maintenance. For example, by proposing a position in the Operation Team with skills in application development (Fig. 7).

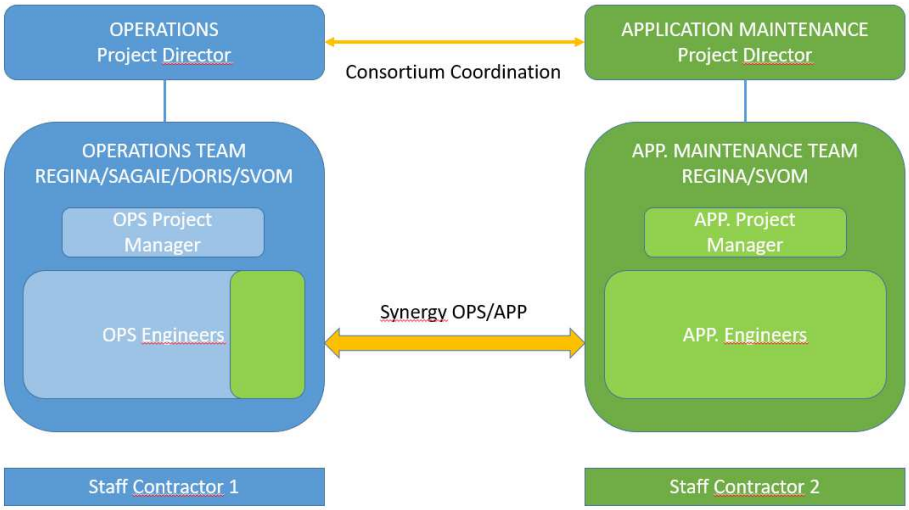

Fig. 7. Contractors Organization for SciNet

This major step was the keystone of CNES SciNet creation described hereafter. It was also the opportunity to incorporate SAGAIE GNSS network operations. This network was deployed in Africa jointly with ASECNA in 2013 but was operated by a CNES contractor with no link with REGINA Team. By regrouping SAGAIE mid-2021 with DORIS, SVOM and REGINA in the frame of the same contract for operations, the synergy obtained was immediate and impressive due to the high experience of REGINA Operations Team on GNSS networks.

6. CNES SciNet (Ground Station Networks for Science Cluster)

6.1 SciNet purpose

In coherence with industrial organization, the activities of the REGINA/SAGAIE/SVOM/DORIS station networks were regrouped at TSA under a cluster “Ground Station Networks for Science" or SciNet as short title. SciNet aims to develop synergies between the various networks of stations managed at CNES TSA with common characteristics such hosting sites resources, operation and maintenance processes, tools… These networks can be fully internal TSA projects (REGINA project) or be linked to projects from external structures (SAGAIE/SVOM/DORIS).

The guiding principles are:

- Increase synergies in deployment, operation, maintenance and management between all projects,
- To have both CNES and contractors’ organization consistent,
- Maintain the accountability of CNES actors with clear perimeters
    - Technical Management by Software and Central Resources Division
    - Operation and stations Management by Station Engineering Division,
- Guarantee simple interfaces for contractors and hosting sites,
- Improve information sharing between all projects to avoid confusion,
- Maintain specific identity for each project (projects have different budgets, downstream applications and final users).

6.2 *SciNet organization*

6.2.1. Industrial Organization

As mentioned before, the major part of operation activities on REGINA/SAGAIE/DORIS/SVOM are done by contractors:

- One contractor in charge of Station Network operations
- One contractor in charge of Application management

As shown in Fig. 7, each of these activities has a Project Director and a Project Manager

NB: Another contractor provides Quality support for the projects

Cnes Organization is almost a mirror of this industrial organization to be the most efficient and it is described in the next chapter.

6.2.2. CNES Organization

Cnes organization is built with following key staff.

Cluster Coordinator

Belonging to the Cell of the TSA Department Head, he is Coordinator of Ground Stations Networks for Science (SciNet) for shared activities, he is also REGINA Project Manager and Deployment Team Leader in the deployment phase of SVOM network.

With the implementation of the new industrial contracts covering REGINA, SAGAIE, SVOM and DORIS, he is Contract Technical Manager in tandem with the Purchasing Manager. He manages SciNet with its recurring activities, in particular:

- Budgets management and reporting to hierarchy,
- Supervision of the Operation and Maintenance activities. If necessary, he prioritizes with the contractors the activities between the different projects after consultation of the Operation Manager and Technical Manager,
- Communication and maintenance of internal and external relations.

To conduct the activities of SciNet, he works closely with the Operation Managers and the Technical Managers as well as with the Quality Manager(s).

Operation Manager

Belonging to the Station Engineering Division, the Operation Manager is also Station Technical Manager (to be differentiated from the Technical Manager described in the next chapter). For allocated networks, the Operation Manager is the CNES responsible for:

- Operation of the Mission Center (when relevant),
- Maintenance of the Stations in Operational Conditions.

He relies on an Industrial Team which has delegation for the Operation activities.

Due to the volume of activities, there are currently two Operation Managers in SciNet:

- REGINA/SAGAIE Operation Manager
- DORIS/SVOM Operation Manager

Technical Manager

Belonging to Software and Central Resources Division, the Technical Manager is responsible for the maintenance and evolution of technical means for networks operated by Station Engineering Division. The CNES Technical Manager is responsible for:

- Mission Center software maintenance and evolution,

- Supporting Technical Systems at CNES.

He relies on an Industrial Team in charge to maintain the Mission Center Sofware and he is the main interface between TSA SciNet Team and CNES IT services.

Due to the Software and Central Resources Division organization, there are currently two Technical Managers in SciNet:

- REGINA/SAGAIE Technical Manager
- SVOM Technical Manager (no need for DORIS)

Specific position could also be added for specific need like the coordination of TSA activities with SVOM Project.

TSA SVOM Coordinator

With regard to the involvement of Station Engineering Division in the design of SVOM stations and the development phase of the project, a specific role exists for SVOM. Within the division, TSA SVOM coordinator ensures the coordination of SVOM activities delegated to the TSA Department with those of the global project. He is the main TSA interface with the SVOM System Manager.

He is the design and qualification authority for the VHF stations used by SVOM as well as an expert Radio frequency. It ensures that activities related to:

- the development of VHF stations,
- the deployment and operation of the network of VHF stations,
- the development of the SVOM Network Manager software,

meet the expectations of the SVOM project.

6.2.3. SciNet global interface

The global CNES and contractors' organizations allow simplification of the interfaces between them and a better information sharing. The table hereafter shows the different packages and their leaders both for CNES and contractors' activities.

Table 1. CNES SciNet matrix with activities and key staff

PACKAGE	ACTIVITY	SUB-PACKAGE	PROJECT	CNES SciNet	CONTRACTOR	CNES Division
1	OPERATIONS	1-1	REGINA	Cluster Coordinator	OPS Project Manager	REGINA/SAGAIE OPS Manager
		1-2	SAGAIE			
		1-3	SVOM			DORIS/SVOM OPS Manager
		1-4	DORIS			
2	APPLICATION MANAGEMENT	2-1	REGINA		Application Project Manager	REGINA Technical Manager
		2-2	SVOM			SVOM Technical Manager

To summarize, there is one Operations Team on REGINA/SAGAIE/SVOM/DORIS and a Maintenance team on REGINA and SVOM (no DORIS need, SAGAIE still under study). The contractors have one Project Manager for each of the Operation and Maintenance activities. CNES has two Operation Managers for the Exploitation activity and two Technical Managers for maintenance activity. Each CNES Manager can therefore interface easily with the Contractor Project Manager of its corresponding activity.

The SciNet Coordinator is in charge for all contracts and insure the overall communication between projects and activities to promote cross-functional processes/tools to avoid any silo effects in the Cluster Organization. As he is the only cross-functional CNES staff on the 4 projects and 2 activities (Operations/Application), his role is essential to keep consistency between them.

7. About synergies

At this step, projects, organization and guidelines to get synergies have been described. This chapter will discuss about concrete situations to highlight achieved or potential synergies.

7.1 Cost reduction

Through the pooling of projects and activities combined with the overall simplification of process and interfaces, costs are significantly reduced. This is true for contracts but also for maintenance station. Indeed, it is now easy to

- Group equipment from different projects before shipping on a shared site,
- Share hosting site resources (network equipment, storage area, internet access...),
- Share technical gear at CNES.

7.2 Meetings

One another improvement was the reduction of the number of meetings. Meetings by activity or by project coupled with inter-activities or inter-project meetings allows a better information sharing and an increased global efficiency.

7.3 Reporting

The Cluster Organization allows clear, quick and consistent reporting at every level of the hierarchy: Operation Managers and Technical Managers report at their own division level. The Cluster Coordinator reports at Department Head but also to external projects. Through this organization, the Department is able to provide a point of contact and a backbone for any new ground station network request from any kind of project.

7.4 Missions

Missions are necessary to install or maintain a station and the total number of SciNet stations is very high (around 150). By regrouping stations and sharing information between projects, a multi-projects installation and maintenance schedule plan could be done and reduce the number of missions required. This is both cost-effective and with a positive environmental impact.

7.5 Agreements

For the four projects, agreements have been made between CNES and the hosting sites. We see today that for the same host site, there are unjustified differences in the agreements due to the absence of cross-check between projects. In order to maintain consistency between the agreements of the various projects established, the Cluster Coordinator jointly with the Legal Department could ensure the consistency of the agreements.

7.6 Operation Project quality

Operating lifetime for a ground station network for scientific applications is few years to few decades. A quality management plan is obviously of primary importance in order to assess the good handling of the operations and of the maintenance in operational conditions over time. Such a plan implies to trace anomalies impacting the system behavior and system or process evolutions. The number of anomalies per year is very high due to the fact that most of the time anomalies are not on project technical equipment but external. Around three-quarters of anomalies are linked to internet service providers or station hosting sites. For instance, around 300 anomalies per year was tracked for REGINA project in 2022. Given this context and the multiplicity of projects, it is of course fundamental to have the same quality processes and tools to optimize the time spent by the Operation Team. It is also of interest to share lessons learnt on these anomalies between projects.

In the past each project had its own tool to track anomalies or evolution with its own Quality Manager. The goal is to optimize practices by maximizing the sharing of tools, process and human resources between projects. This may seem obvious but for instance migrating a 10-year database with thousands of anomalies from a software to another

could have impacts and pro and cons have to be assessed carefully. This is why it is highly recommended to have the best practices from the beginning. In our case, the last two projects SAGAIE and SVOM will use the same tool.

7.7 Project Management

In CNES organization, each project provides the financial resources for its activities. They are therefore specific to REGINA, SAGAIE, SVOM and DORIS. Nevertheless, types of expenses are the same for each project:

- Management (missions, communication, …)
- Stations (equipment, shipping, internet access, hosting fee...)
- Mission Center (equipment, maintenance contracts…)
- Operations (operations contracts…)

To operate Ground Station Networks for Science and optimize budgets, TSA Department has internal budgets or budgets delegated by the projects, the Cluster Coordinator is most of the time in charge of global management of these budgets. He works with the controllers of the various projects to ensure better control costs, overall consistency and can provide a summary report to hierarchy and projects.

Delegation to TSA Department allows greater responsiveness (geographical proximity and frequent meetings) and better synergies with other projects by avoiding the creation of silos. This mode of operation is strongly recommanded. It should be noted that this *modus operandi* also allows better expertise for costs forecast for new projects (e.g. for SVOM project).

Concerning the human resources, the Cluster Coordinator summarize the needs in human resources for the activities and can provide a synthetic overview to Department and Divisions Heads.

7.8 Cartography

As written before, TSA Department is in charge of around 170 stations around the world. It was essential for communication but also for management to create a global cartography. The cartography was done at Cluster Coordinator as SciNet represent the greatest number of stations. TSA Department has now a tool able to show stations location on maps for every project it has in charge.

7.9 Lessons Learnt sharing

Lessons learnt can now be easily be shared across projects to improve processes. For example, lessons learnt about local customs and impact on time to delivery with shipping can be mutualized and are of interest for maintenance of existing projects or to provide forecasts for a project in the deployment phase.

7.10 Others

As the work is recent and still in progress, we are confident that new synergy possibility could occur in the future. For instance, Operations Managers and Technical Managers could be a mutual backup when required but it will require some training and pros and cons have still to be assessed.

8. A concrete case: communications with external entities

In the past, each project had its own way to exchange information with the hosting site. Most of the time it was through an email address e.g. operation.regina@cnes.fr for REGINA project. This unique email address was used both for communications with the hosting sites but also for final users of the network. At the time being it was well suited but with the increasing of activity and projects by site it seems more efficient to review this *modus operandi*. As site could host many projects with mutual resources (power, internet, modem, UPS...) we choose to use an address common to the projects science.ground.stations.networks@cnes.fr. Obviously, long established habits are not easy to change and specificities could exist for each project. A possible recommendation for a new born project:

1) Use generic email address as soon as possible in operation. During the network development it is more practical to use professional personal email address and it creates a friendlier connection between people but once in operation the generic email has to be used.
2) Since the beginning, use one email address for the technical maintenance (e.g. in our case science.ground.stations.networks@cnes.fr) with the hosting sites and one for the operational contact with the final users (e.g. in our case operation.regina@cnes.fr).

Other communication canal as the social networks very used in day life are more and more used in professional situation. These networks are very dependent on the people/country but they have to been take into account. It is more convenient for people in the field to provide quick situation analysis with picture from smartphones through social network application than computer with email. One thing to avoid is the personalization of this way of communication and a shared solution should be preferred.

9. Results and Discussion

Organization and concrete cases of synergies have been given in this paper. It must be pointed out that despites obviousness of synergies added value, it takes time to change well established and old processes as well as human habits. The energy to provide to get back on the track of good practices will increase with time and this paper could be especially of interest for entity looking to deploy a new ground station network.

10. Conclusions

This paper presents the CNES organization set up over the last three years to regroup and optimize activities of ground station networks for science applications. Belonging to the Telecom, Stations and Alerts Department and supporting mainly by two divisions, the SciNet Cluster regrouping REGINA/SAGAIE/DORIS and SVOM networks of stations is in charge of the deployment, operation and maintenance of the networks. The number of stations is currently around 150 with a worldwide coverage. This paper contains lessons-learnt over decades and advices about organization concept and good practices to get, especially when starting to deploy a network of the same type. Besides that, the most important thing to keep in mind is that such networks for science is possible only through to incredible support provided by hosting entities and it is fully appropriate to conclude this paper by a special thanks to them.

Acknowledgements

Author is thankful to colleagues from IGN who provided their high expertise and greatly assisted the evolution of REGINA and DORIS projects since the beginning of our partnership decades ago.

CNES thanks European Union Agency for the Space Programme (EUSPA) for its financial support through GRC-MS Grants facilitating access to Galileo Data for the GNSS community with REGINA.

CNES thanks ASECNA for its longstanding relationship allowing to provide important GNSS data in Africa and Madagascar area.

And of course we would also like to acknowledge all station hosting sites for their very much appreciated involvement which allows to support all these activities for science.

Appendix A: Hosting Sites

As written before, all our daily work would not be possible without the continued support of the hosting sites which is the key factor to get efficient station networks. It would be too long to name all of them in this paper but to show how various can be their activities, hosting sites are given hereafter for one project, REGINA.

Table 2. Hosting organizations cooperating to the REGINA network, January 2023.

Hosting Organization	Acronym
Badan Informasi Geospatial	BIG
Centre d'études et de recherche de Djibouti	CERD
Conseil Général de Mayotte	CG - Mayotte
Centre national de la recherche scientifique	CNRS
Direction des Territoires, de l'Alimentation et de la Mer de Saint-Pierre et Miquelon	DTAM St Pierre et Miquelon
European Space Agency	ESA
Finnish Geodetic Institute	FGI
Institut de Physique du Globe de Paris	IPGP
Institut polaire français Paul-Emile Victor	IPEV
Institute of Geodesy and Geophysics	IGG
Instituto Nacional de Meteologia y Geofisica	INMG
Instituto Nacional de Pesquisas Espaciais	INPE
Korea Astronomy and Space Science Institute	KASI
La Direction des Infrastructures, de la Topographie et des Transports Terrestres de Nouvelle Calédonie	DITTT
Land Information New Zeland	LINZ
Météo France	MF
National Mapping and Resource Information Authority	NAMRIA
National Meteological Services	NMS
National Technical University of Athens	NTUA
Natural Resources Canada	NRCan
Observatoire de la Côte d'Azur	OCA
Service hydrographique et océanographique de la Marine	SHOM
Ulugh Beg Astronomical Institute	UBAI
Universidad Nacional de La Plata	UNLP
Universidad nacional de San Agostin	UNSA
Université de la Polynésie Française	UPF

Appendix B: Websites

More information about REGINA: **https://regina.cnes.fr/en**
More information about DORIS: **https://ids-doris.org/**
More information about SVOM: **http://www.svom.fr/en**

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