WORLD METEOROLOGICAL ORGANIZATION

DATA BUOY COOPERATION PANEL

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ENGLISH ONLY

ARGOS SYSTEM OPERATIONS AND DEVELOPMENTS

(Submitted by Bill Woodward (CLS America))

SUMMARY AND PURPOSE OF DOCUMENT

This document provides for the summary report from CLS/Service Argos on the Argos System operations and improvements for the period 2013 – 2014.

ACTION PROPOSED

The Meeting is invited to note the information contained in this document when discussing how it organises its work and formulates its recommendations.

Appendix: A. Report on 2013 – 2014 Argos Operations and System Improvements

DISCUSSION

-A- DRAFT TEXT FOR INCLUSION IN THE FINAL REPORT

10.3.1 The Panel recalled that Argos is a global satellite-based location and data collection system dedicated to studying and protecting our planet's environment. CLS, is the operator of the Argos system on behalf of NOAA, CNES, EUMETSAT and ISRO, and continues to maintain and improve an operational service for all Argos users, especially for the meteorology and ocean community at a >99% level of availability.

10.3.2 Mr. Bill Woodward (CLS America) and Mr. Michel Guigue (CLS Toulouse) reported on Argos operations and system improvements during 2012-2013. Today the Argos system is composed by a space segment of 6 operational satellites with 3 NOAA POES (15, 18, 19) 2 EUMETSAT spacecrafts (METOP-A & B) and 1 Indian satellite (SARAL). The ground segment has 7 global receiving stations (6 in the northern polar region and 1 in Antarctica) and 65 local real-time stations worldwide.

10.3.3 Operational highlights from the last 12 months include the decommissioning, after 13+ years of service, of NOAA-16 (NOAA-L prior to launch) on June 9, 2014, due to a major spacecraft communications anomaly. The Argos processing centre in Toulouse successfully replaced the Argos processing servers with virtual servers in July 2013 and also successfully upgraded the Oracle archive and real-time databases in December 2013 and January 2014. In 2013-2014, the Argos real-time stations network were quite steady (~66 stations) with 2 new local stations added in Tahiti and in Bali. The 3 stations operated by IRD (Nouméa, Cayenne, La Reunion) were removed in 2013 due to operational maintenance difficulties. These actions combined with substantial progress in implementing the Real-time Antenna Upgrade Project (11stations already upgraded, 6 scheduled for upgrade by the end of 2014 and 3 additional upgrades scheduled for 2015) all continue to improve the global timeliness for data collected using the Argos system.

10.3.4 Improved performances in terms of data mean disposal time observed during the last 12 months have been observed and they are mainly due to the 2 new satellites in the system (METOP-B & SARAL), to more HRPT Stations receiving METOP-A and B (Miami, Monterey, Hawaii, Lannion, Lima, Cape Town, Hatoyama, La Réunion, Libreville, EARS Stations) and the upgraded real-time stations to track SARAL Satellite with the TM_100min capability. SARAL is downloading to compatible Argos real-time stations all datasets acquired in the last 100 minutes which significantly improves the Argos data timeliness. CLS efforts will continue to improve the coverage of the real-time antennas in the regions where it is needed especially with 2 strategic installations: Ascension Island for the South Atlantic and Easter Island for the South Pacific.

10.3.5 Mr Woodward explained that CLS continues to provide the GTS processing for all DBCP Argos equipped drifters and moored buoys in compliance with WMO and DBCP TT-DM recommendations. The CLS GTS processing system as well as the quality of the data and the entire Argos system performance is monitored 24/7.

10.3.6 The Panel noted that an 18 month "Argos chipset" project called SHARC (Satellite High-performance ARGOS-3/-4 Receive/transmit Communication) has been implemented by an European consortium to minimize Argos data communications power requirement. The project objective is to design, build and test a miniature, low-cost ARGOS-3/4 chipset (Asic) that enables two-way data communications and is fully backward compatible with Argos 2. Units are expected to be available for manufacturer test and evaluation by summer 2015.

10.3.7 The Panel also noted that a new Argos hand-held direction finder (called a Goniometer) manufactured by Xerius was now available for sale/lease.

APPENDIX A

Report on Argos 2013 – 2014 Operations and Developments

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1 2013-2014 Argos Highlights

1.1 Operations

- Replacement of the Argos processing servers by Virtual Servers in CLS - July 2013
- Upgrade of the Oracle database version. Migration CLS/CLSA Archive databases to the Oracle 11GR2 version - December 2013
- Upgrade of Oracle database version. Migration CLS/CLSA Realtime database to the Oracle 11GR2 version - January 2014
- Launched in September 2000, NOAA-16 completed over thirteen years of service. NOAA-16 was decommissioned on June 9, 2014 at 14:23 UTC due to a major spacecraft anomaly.

1.2 System developments

- SHARC (Satellite High-performance ARGOS-3/-4 Receive/transmit Communication) chipset development project
- Argos Real-Time Antenna Network Upgrade Project continues
- 2 new ground HRPT Argos stations added in 2013: Tahiti station (French Polynesia) & Bali (Indonesia)
- On-line data extraction from the archive database via ArgosWeb – October 15th 2013
- Access to Argos Data through ArgosWeb and web services extended from last 10 days to last 20 days - February 18th 2014
- A new Android cartography application developed to allow users to access to their PTTs locations through Smartphones – June 2014
- Integration of a new BUFR sequence for drifting buoys in the Argos processing chain
- Improving Argos locations with a new Digital Elevation Model (DEM): as of July 2014, Argos users benefit from a new DEM derived from ACE2.

1.3 Outlook

- **Argos Real-Time Antenna Network optimization**

- **New Argos Orbitography**

  The adaptation of orbitography module (ZOOM) by CNES for Linux environment is done. The integration in Argos processing center is started and will be completed in 3rd quarter of 2014.

- **New earth elevation model**

  For Kalman location only, a new earth elevation model (ACE3) has been integrated to compute more precise locations in some earth areas, and give better altitude accuracy. The integration is completed and it will be put in operation during 3rd quarter of 2014.

- **Improvement of web services for Argos-3**

  The Argos Web Service regularly receives new capabilities. The possibility to send user messages to PMTs will be the next major improvement.

- **BCH (Bose, Ray-Chaudhuri et Hocquenghem) message decoding**

  The study of a BCH message coding to improve Argos message transmission in noisy regions is finished. The development will be realized in 2014. The integration into the processing chain is scheduled beginning 2015.

- **New databank formats**

  On-line data extraction on archive database service will support xml and kml formats

- **Mass production of a low-cost Argos-3/4 chipset** (SHARC project)

- **Argos Doppler location algorithmic improvements**

- **End of Upgrade of the Oracle database version 11GR2**

- **CLS datacenter upgrade**

  New ESX+Lefthand storage dedicated for production (Virtualization of Argos processing servers) - F5 BigIP for Local traffic management – Firewall and Switch upgrade.

- **GTS processing chain refactoring**

2 Argos space segments

2.1 Operational status

During beginning 2013 - 2014, Operational Argos Services where opened for two Argos-3 payload (Metop-B, SARAL) and two Argos-2 payload was decommissioned (NOAA-17, NM and NOAA-16, NL).

Argos instruments are onboard 6 POES's spacecrafts.

The current status information on each spacecraft and its Argos various subsystems is described as follow:

Satellites	Launch date	Status	Real time data (HRPT)	Stored data (STIP)	Data AVHRR
SARAL (SR)	25-Feb-13	N/A	Ok	Inuvik, Kiruna	N/A
METOP-B (MB)	17-Sep-12	AM Primary	Ok	Svalbard, McMurdo	Ok
METOP-A (MA)	19-Oct-06	AM Backup	Ok/Nok*	Svalbard	Ok
NOAA-19 (NP)	06-Feb-09	Prime Services Mission (ADCS,SARSAT) *PM Primary is now Suomi-NPP for other products*	Ok	Gilmore, Wallops, Svalbard	Ok
NOAA-18 (NN)	20-May-05	PM Secondary	Ok	Gilmore, Wallops	Ok
NOAA-17 (NM)	24-Jun-02	DECOMMISSIONED on 10 April, 2013			
NOAA-16 (NL)	21-Sep-00	DECOMMISSIONED on 9 June, 2014			
NOAA-15 (NK)	13-May-98	AM Secondary	Ok	Gilmore, Wallops	Ok

Figure 1 Argos Constellation

* Scheduled activities are defined on Orbit Switch ON and Switch OFF (see below for more details).

2.2 METOP-A HRPT Switch Zone

To minimize the risk of failure to the AHRPT-B unit whilst still offering the user community a service, EUMETSAT has implemented a "partial" AHRPT service in those areas where the risk of damage from heavy ion radiation is reduced.

For southbound passes, AHRPT side B was activated for all orbits over the North Atlantic and European area, starting at around 60°N. The AHRPT will then be switched off before the spacecraft reaches the Southern Atlantic Anomaly region at around 10°N.

In January 2011, EUMETSAT announced the extension of this activation zone while maintaining the same operational restrictions over the polar caps and South Atlantic anomaly. Furthermore, AHRPT operations will also be made in ascending orbits, but with more stringent risk reduction measures

than applied for the descending passes given the availability of data via the Fast Dump Extract System (FDES) to cover the North Hemisphere.

Figure 2 shows the extended activation zone of the AHRPT for both descending and ascending parts of the orbit. The extended AHRPT coverage is effective since 18 January 2011 as a pre-operational service.

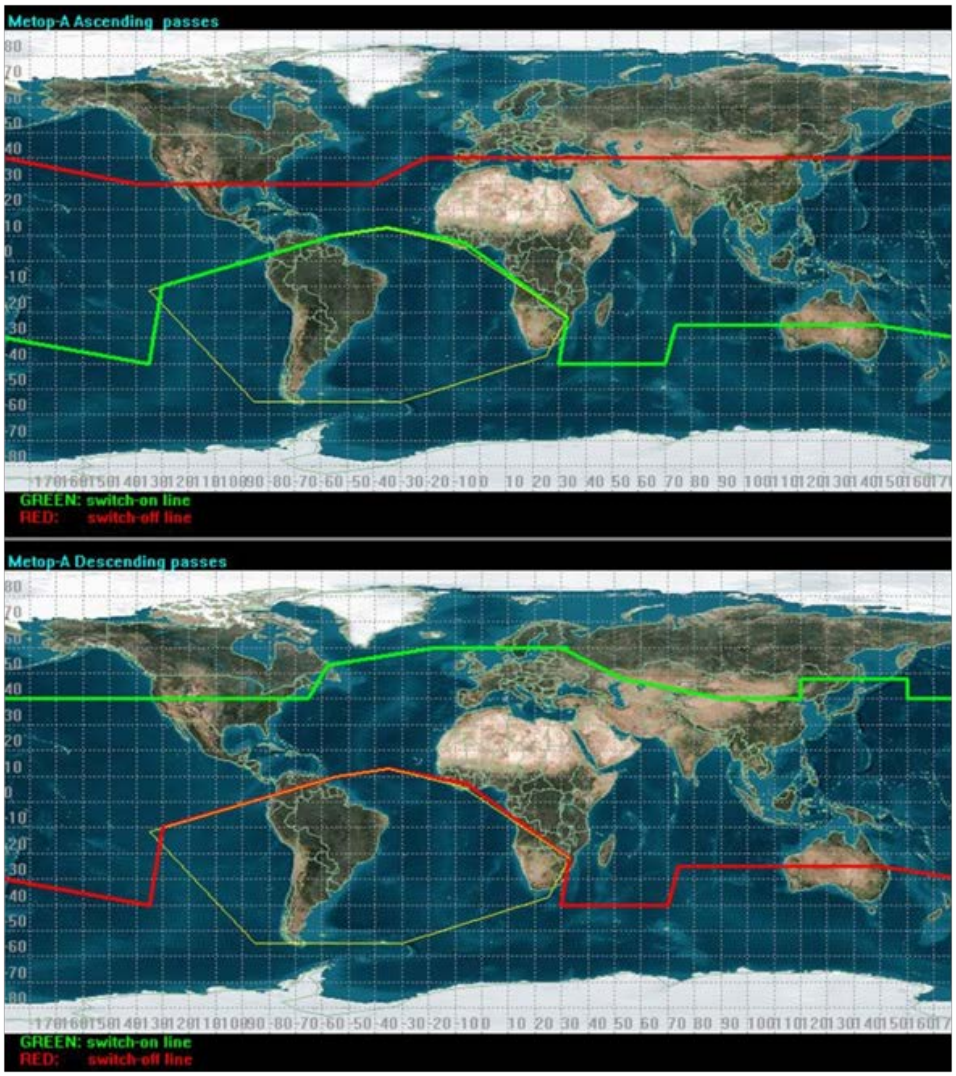

Figure 2 : METOP-A HRPT Extended Switch Zone (Descending and Ascending orbits)

2.3 Ascending Nodes Local hour

The diagram here below presents the local time of ascending notes in June 2014

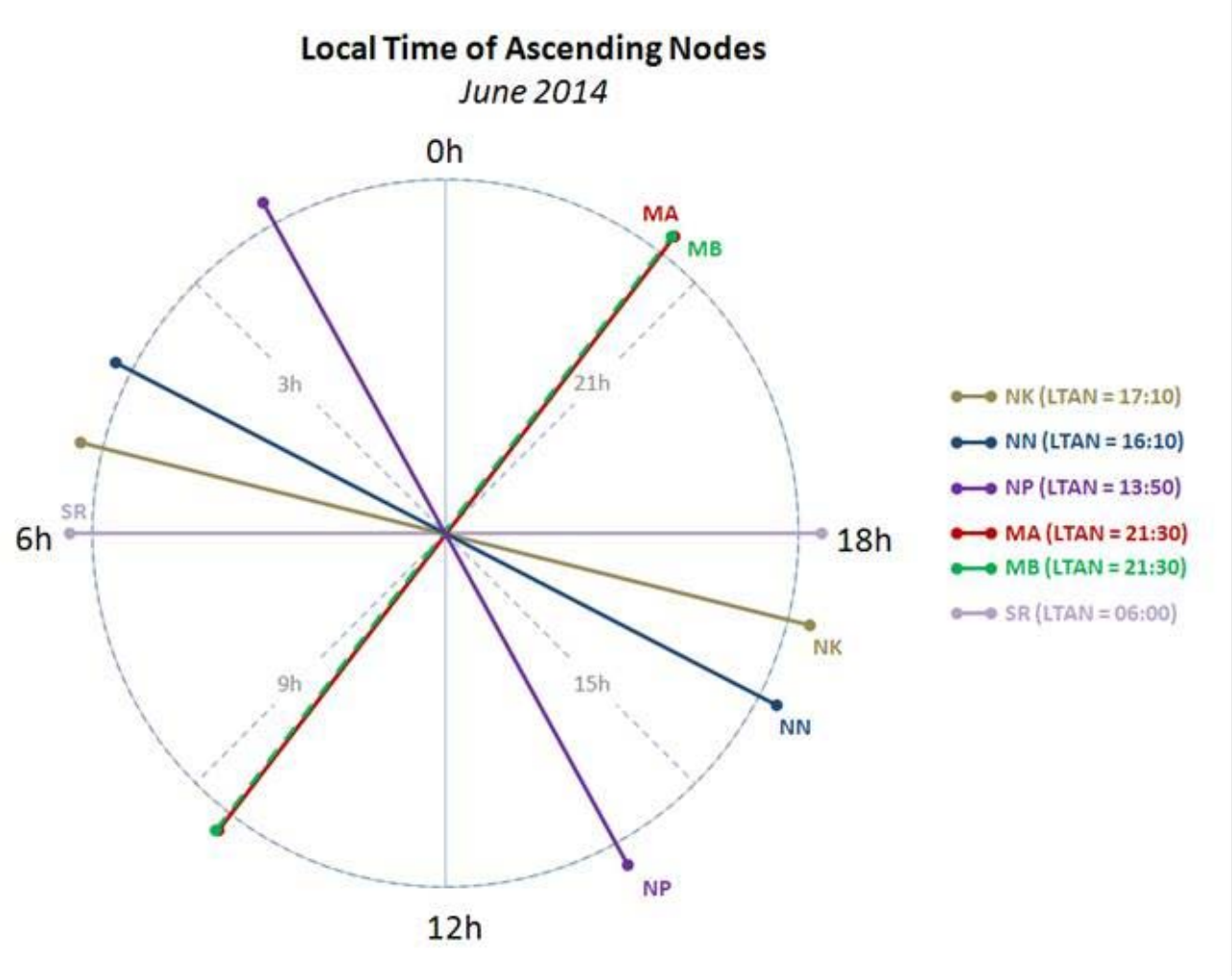

Figure 3: Local Equator crossing time in June 2014

2.4 Argos payloads anomalies in 2013

METOP-A

14/03/2013: None HD message of 8 and 9 blocks. Partial loss of data. Reset of DSP

10/11/2013: Processor failure. No data during 2 minutes

METOP-B

13/04/2013: WatchDog. No data in telemetry. Send of DSP ON

25/04/2013: TX1 OFF In accordance with actions from the ADCS/ARGOS Meeting on 8th April 2013, the Metop-B ADCS ARGOS-3 service was disabled by switching off the transmitter. This decision was taken because of the Metop-B CRA anomaly, which mostly affects the ARGOS-3 service.

01/12/2013: Processor failure. No data during 2 minutes

NOAA-19

08/04/2013: None HD message of 8 and 9 blocks. Partial loss of data. Reset of DSP

NOAA-18

NA

NOAA-17

10/04/2013: Decommissioning.

NOAA-16

NA

NOAA-15

NA

SARAL

25/02/2013: launched

No anomaly since LTX1/RX1/TX1/DSP On

2.5 Maneuvers in 2013

METOP-A

Date	Label	Impacts
20/03/2013	Out Of Plane Manoeuvre 2 bursts of 11 minutes	No ARGOS location for 53 hours.
16/04/2013	In Plane Manoeuvre 1 burst of 3s	Degradation of the ARGOS locations quality for 24 hours
26/06/2013	In Plane Manoeuvre 1 burst of 9s	Degradation of the ARGOS locations quality for 15 hours
04/09/2013	In Plane Manoeuvre 1 burst of 4s	Degradation of the ARGOS locations quality for 15 hours
04/12/2013	In Plane Manoeuvre 1 burst of 10s	Degradation of the ARGOS locations quality for 16 hours

METOP-B

Date	Label	Impacts
23/04/2013	In-Plane Manoeuvre 1 burst of 6s	Services were not already opened
07/08/2013	In-Plane Manoeuvre 1 burst of 5s	Degradation of the ARGOS locations quality for 12 hours
05/11/2013	Out Of Plane Manoeuvre 1 bursts of 8 minutes	No ARGOS location for 165 hours.

SARAL

Date	Label	Impacts	Actions

13/03/2013	Last post-launch manoeuver		CNES instrument validation
23/03/2013	In Plane Manoeuvre (routine) 1 burst of 1.64s		CNES instrument validation
13/04/2013	In Plane Manoeuvre (routine) 1 burst of 1.52s		CNES instrument validation
15/05/2013	In Plane Manoeuvre (routine) 1 burst of 2s real	ARGOS locations quality for 15 hours	
07/06/2013	In Plane Manoeuvre (routine) 1 burst of 1s real	ARGOS locations quality for 15 hours	
24/06/2013	In Plane Manoeuvre (routine) 1 burst of 0.542s	ARGOS locations quality for 15 hours	
14/07/2013	In Plane Manoeuvre (routine) 1 burst of 3s	ARGOS locations quality for 15 hours	
29/07/2013	Out Of Plan Manoeuver (inclinaison) 1 burst of 239s		SARAL ARGOS Location service switched OFF the 28/07/2013 16h30
31/07/2013	In-Plane Manoeuver (complement) 1 burst of 8s	No SARAL ARGOS location for 4 days 19 hours and 30 minutes.	SARAL ARGOS Location service switched ON the 02/08/2013 12h00
07/08/2013	In-Plane Manoeuver 1 burst of 3s	Degradation of the ARGOS locations quality for 15 hours	
26/08/2013	In-Plane Manoeuver 1 burst of 1.6s	Degradation of the ARGOS locations quality for 15 hours	
03/10/2013	Out Of Plan Manoeuver (inclinaison) 1 burst of 98s	No SARAL ARGOS location for 22 hours.	
07/10/2013	Out Of Plan Manoeuver (inclinaison) 1 burst of 100s	No SARAL ARGOS location for 23 hours and 40 minutes.	
09/10/2013	In-Plan Manoeuver 1 burst of 5s	No SARAL ARGOS location for 2 days.	
07/11/2013	In-Plan Manoeuver 1 burst of 1s	Degradation of the ARGOS locations quality for 15 hours	
25/11/2013	In-Plan Manoeuver 1 burst of 1.3s	Degradation of the ARGOS locations quality for 15 hours	
12/12/2013	In-Plan Manoeuver 1 burst of 1.7s	Degradation of the ARGOS locations quality for 15 hours	
27/12/2013	In-Plan Manoeuver 1 burst of 1.4s	Degradation of the ARGOS locations quality for 15 hours	

3 Argos ground segment

3.1 Global antennas (store and forward mode)

The Argos global antennas network is composed by seven stations:

- The two NOAA global stations of Fairbanks and Wallops acquire the global recorded telemetry transmitted by NOAA-15, NOAA-18 and NOAA19.
- The EUMETSAT global receiving station of Svalbard acquires the global recorded telemetry transmitted by Metop-A and Metop-B as well as the 2 daily blind orbits of NOAA-19 for NOAA stations.
- The NOAA Svalbard antenna that delivers NOAA-15 and NOAA-18 blind orbits for Fairbanks and Wallops when not in conflict with NOAA-19.
- Inuvik (Canada) and Kiruna (Sweden) stations for SARAL operated by EUMETSAT.

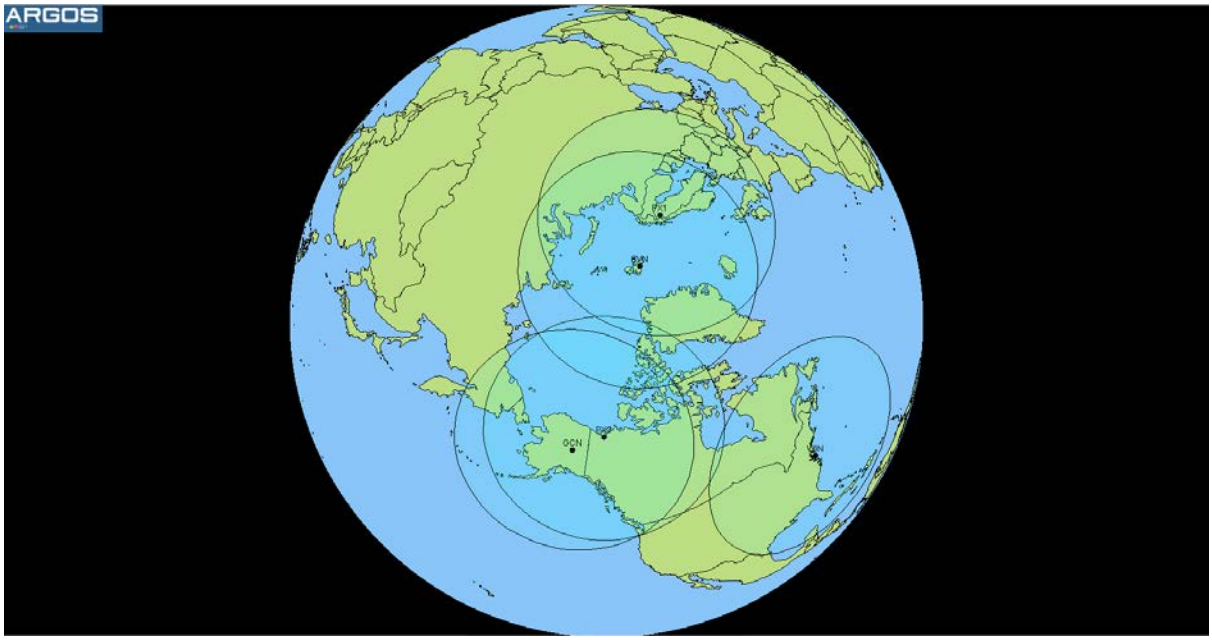

Figure 4 : The Argos Global antenna network (without McMurdo)

- Data recovery from MetOp-B will occur at Svalbard and McMurdo (ADA). Timeliness benefit of McMurdo data recovery is for MetOp-B only. MetOp-A data will continue to NOAA on a best effort basis and without the timeliness benefits of half orbit dumps at McMurdo.

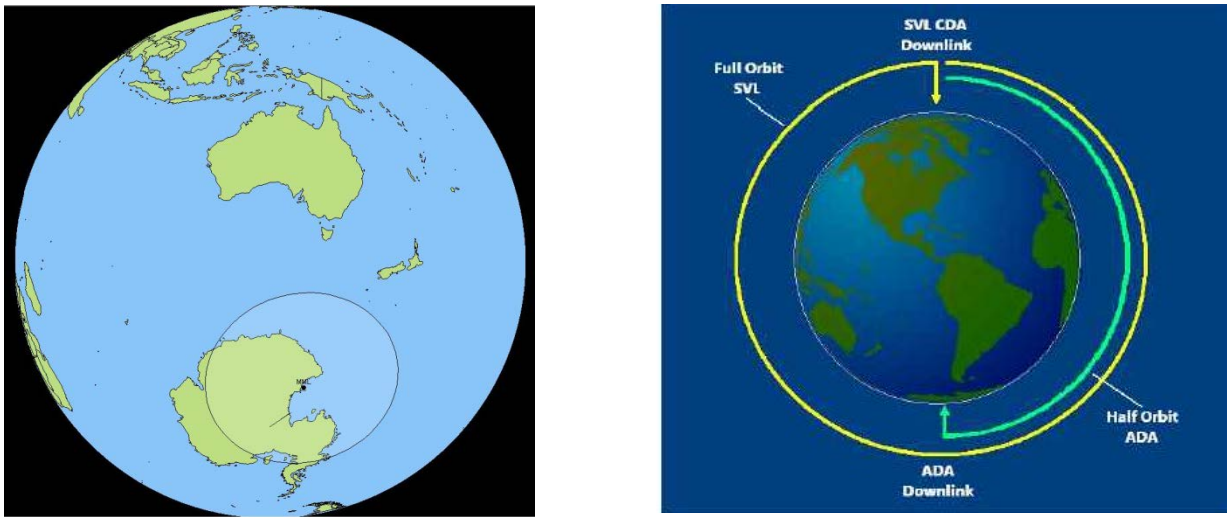

Figure 5 : METOP-B Mc Murdo Global antennas coverage and principle

3.2 Regional antennas (real-time mode)

3.2.1 Operation and improvements

Improvements are still focused on redundancy locations and coverage extension. Today, both Toulouse (France) and Lanham (USA) processing centers receive Argos real-time data from 65 stations located all over the world.

In 2013, the real-time network is quite steady with 2 new ground stations added:
- Tahiti station (French Polynesia) operated by Meteo France
- Bali (Indonesia) station operated by CLS

This two new stations are part of the HRPT-A4 project and are compatible will all Argos satellites: NOAA, METOP and SARAL.

Figure 6 : Argos HRPT Tahiti station

The HRPT ground stations operated by IRD have been removed in 2013 from the network due to operation maintenance difficulties (Noumea, Cayenne, La Réunion…).

The real-time Argos ground station network consists of about 65 antennas. If most of them are capable of receiving NOAA POES satellites data, 22 out of these 65 stations receive METOP satellites data and, for the moment, only 10 receive SARAL data.

In 2013, CNES and CLS efforts were still focused on increasing the number of ground stations capable of receiving POES, METOP and SARAL data. This is what we call the HRPTA4 project consisting in adding new antennas as well as upgrading a set of existing antennas in order to be compatible with all the satellites in orbit. This project also aims at optimizing performances of the real-time receiving stations network with fewer stations for better performances.

Here below are displayed the Argos HRPT coverage world map and the list of the 66 operational stations part of the Argos real-time antennas network in 2014.

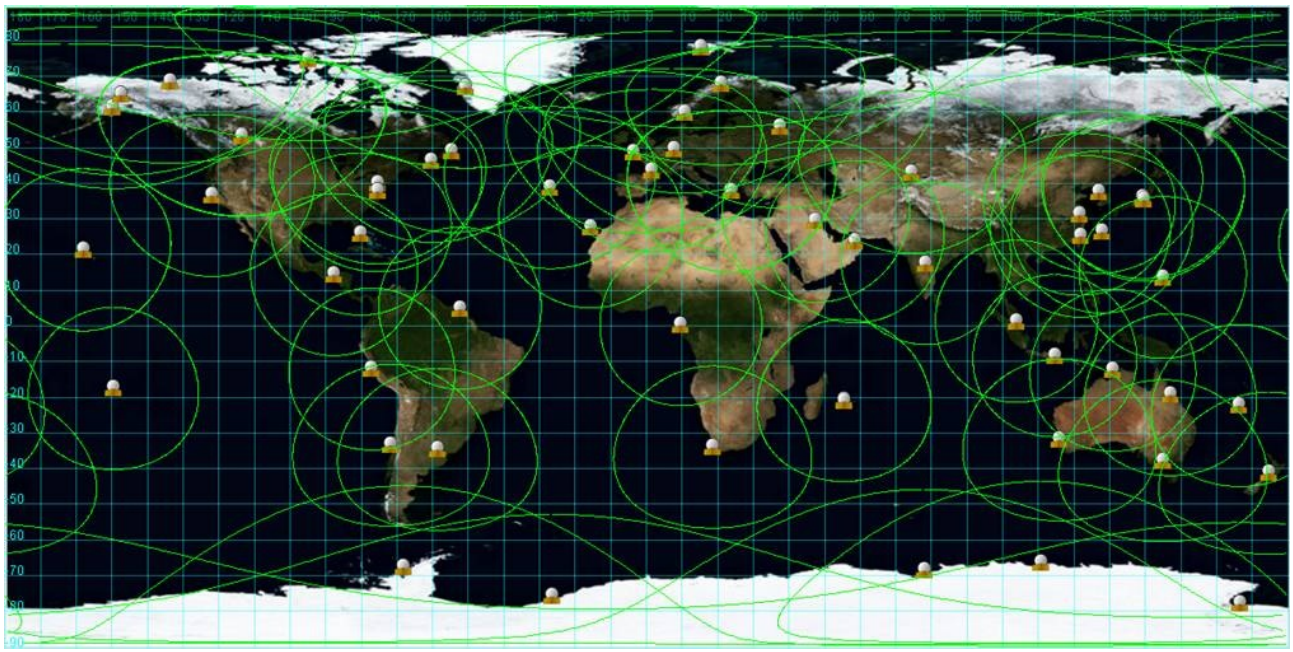

Figure 7 : May 2014 Argos Real-time coverage map

Name	Code	Country	Operator	Possible satellites					
Andersen	AN	GU	US AIR FORCE	NK	NN	NP			
Ali Al Salem	AS	KW	US AIR FORCE	NK	NN	NP			
Athens	AT	GR	CLS			NP			
Buenos Aires	BA	AR	INTA	NK	NN	NP			
Bali	BL	ID	PT CLS INDONESIA	NK	NN	NP	MA	MB	SR
Casey	CA	AU	BOM	NK	NN	NP			
Cape Ferguson	CF	AU	NOAA NESDIS	NK	NN	NP			
Santiago	CH	CL	METEO CHILE		NN	NP			
Darwin	DA	AU	BOM	NK	NN	NP			
Davis	DV	AU	BOM	NK	NN	NP			
Edmonton	ED	CA	ENVIRONNEMENT CANADA	NK	NN	NP		MB	
Elmendorf	EL	US	US AIR FORCE	NK	NN	NP			
Lannion	FL	FR	METEO-FRANCE						SR
Reunion Island	FR	FR	METEO FRANCE	NK	NN	NP	MA	MB	SR
Libreville	GB	GA	CLS	NK	NN	NP	MA	MB	SR
Gilmore Creek	GC	US	NOAA NESDIS	NK	NN	NP		MB	
Sondre	GR	GL	DMI	NK	NN	NP			

Halifax	HF	CA	CANADIAN COAST GUARD	NK	NN				
Honolulu	HI	US	US AIR FORCE	NK	NN	NP			
Halley	HR	GB	British Antarctic Survey		NN	NP			
Hatoyama	HT	JP	Jaxa	NK	NN	NP	MA	MB	SR
Hawaïi	HW	US	NOAA NWS		NN	NP	MA	MB	
Hyderabad	HY	IN	INCOIS	NK	NN	NP			
Tokyo	JM	JP	CUBIC-I	NK	NN				
Okinawa	KA	JP	US AIR FORCE	NK	NN	NP			
Lajes (Acores)	LA	PT	US AIR FORCE	NK	NN	NP			
Lima	LM	PE	CLS PERU	NK	NN	NP	MA	MB	SR
Miami	MA	US	NOAA AOML	NK	NN	NP	MA	MB	
Melbourne	ME	AU	BOM	NK	NN	NP			
Miami Capture	MI	US	CLS FR				MA	MB	SR
Mc Murdo	MM	AQ	NOAA					MB	
Manas	MN	KG	US AIR FORCE		NN	NP			
Montererey	MO	US	NOAA NESDIS	NK	NN	NP	MA	MB	
Wellington	NZ	NZ	NIWA		NN	NP			
Perth	PE	AU	BOM	NK	NN	NP			
Lima	PR	PE	CLS PERU	NK	NN	NP			
Kiruna	PX	SE	Eumetsat						SR
Resolute Bay	RB	CA	Environment Canada	NK	NN	NP			
Reunion Island	RN	FR	METEO FRANCE		NN	NP			
Rothera	RO	GB	British Antarctic Survey	NK	NN	NP			
Lannion	RS	FR	Meteo France				MA	MB	
Ramonville	RV	FR	CLS	NK	NN	NP			
Cape Town	SA	ZA	SAWB		NN	NP	MA	MB	SR
Soto Cano	SC	HN	USAF	NK	NN	NP			
Séoul	SE	KR	KMA		NN	NP			
Singapore	SG	SG	SMM	NK	NN	NP			
Shanghai	SH	CN	EAST CHINA SEA FISHERIES	NK		NP			
Sembach	SM	DE	US AIR FORCE	NK	NN	NP			
Svalbard	SN	NO	NOAA			NP	MA	MB	
Svalbard	SV	NO	EUMETSAT				MA	MB	
Svalbard NOAA	SW	US	NOAA	NK					
Papeete	TA	FR	METEO-FRANCE	NK	NN	NP	MA	MB	SR
Toulouse	TE	FR	CLS		NN	NP			SR
Taïwan	TW	TW	NTOU	NK	NN	NP			
Valley Forge	UA	US	US AIR FORCE	NK	NN	NP			
Lannion	WE	FR	METEO FRANCE		NN	NP			
Wallops Island	WI	US	NOAA NESDIS	NK	NN	NP		MB	
Athens EARS	XA	GR	EUMETSAT		NN	NP	MA	MB	
Edmonton EARS	XE	CA	EUMETSAT	NK	NN	NP			
Gander EARS	XG	CA	EUMETSAT	NK	NN	NP			
Kangerlussuaq EARS	XK	GL	EUMETSAT	NK	NN	NP		MB	
Maspalomas EARS	XM	ES	EUMETSAT	NK	NN	NP	MA	MB	
Muscat EARS	XO	OM	EUMETSAT EARS		NN	NP	MA	MB	SR

Moscou EARS	XR	RU	EUMETSAT	NK	NN	NP	MA	
Svalbard EARS	XS	NO	EUMETSAT		NN	NP	MA	MB

Figure 8 : List for Operational Antennas on July 2014 and tracked satellites

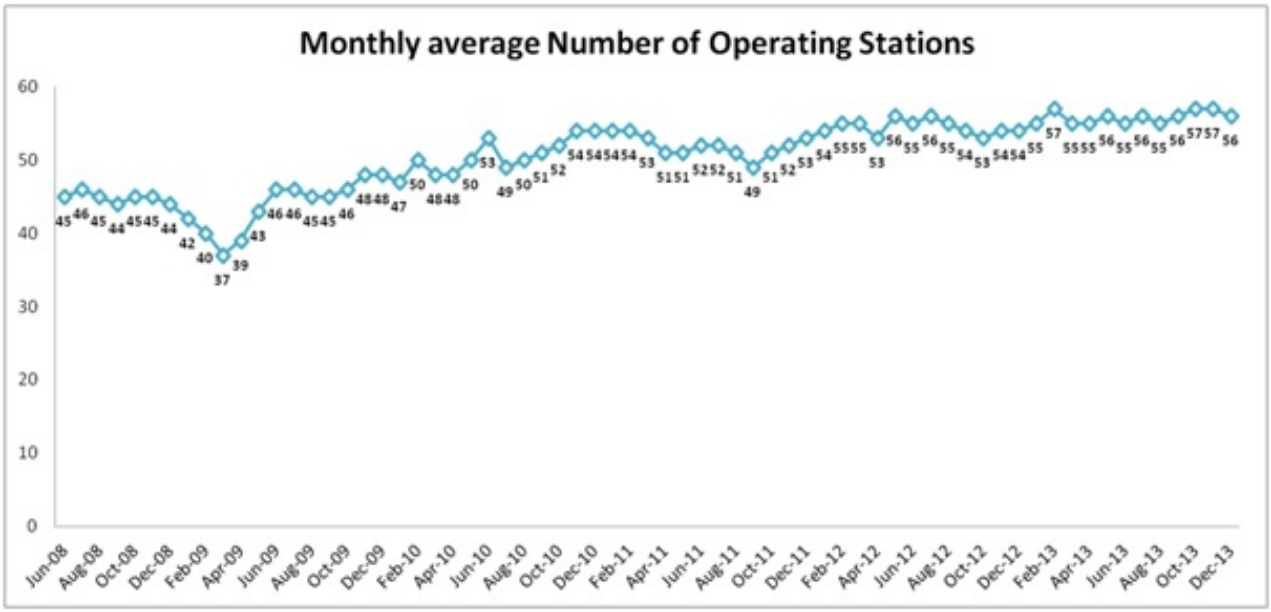

Figure 9 : Operational Argos real-time antennas since January 2008

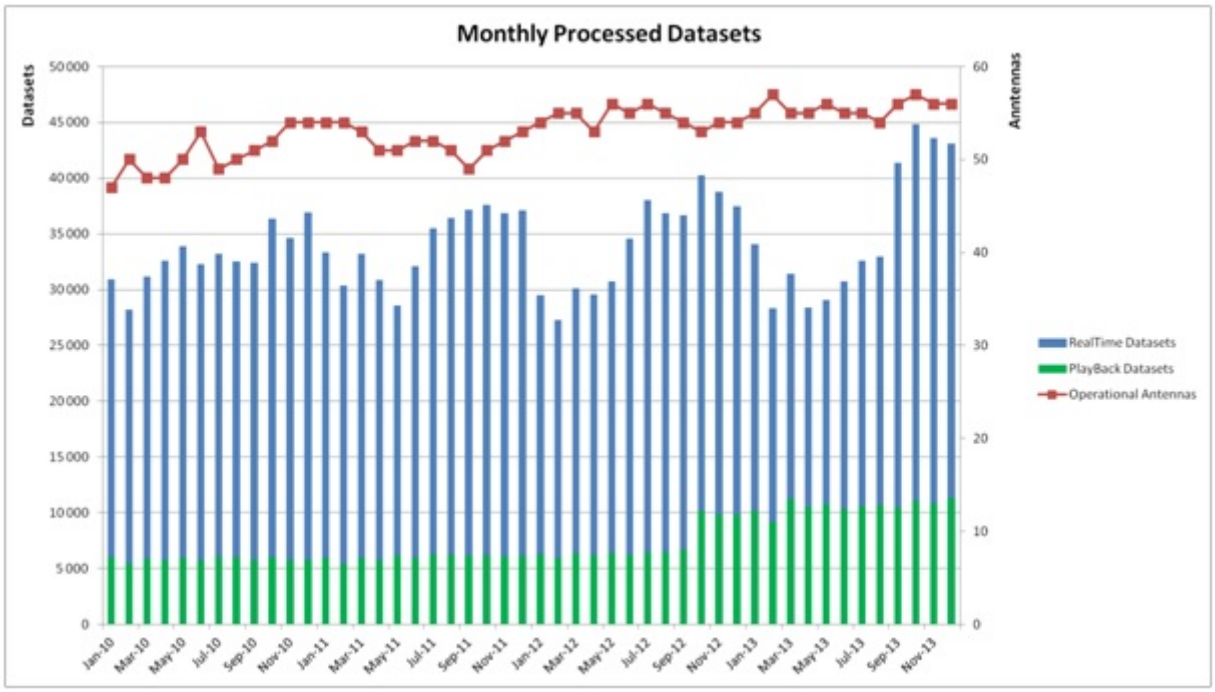

Figure 10 : NOAA/METOP/SARAL Playback and Real-time datasets processed per Month

3.2.2 METOP real-time coverage

All METOP HRPT compatible antennas were configured to track Metop-B except some of the EARS Station network.

- Metop-A by NOAA ESPC: Monterey, Ewa Beach, Miami

- Metop-B by NOAA ESPC: Ewa Beach, Miami, Gilmore Creek, Wallops Island, Monterey
- Metop-A by Eumetsat : EARS network
- Metop-B by Eumetsat : EARS network except Moscow, Edmonton, Gander

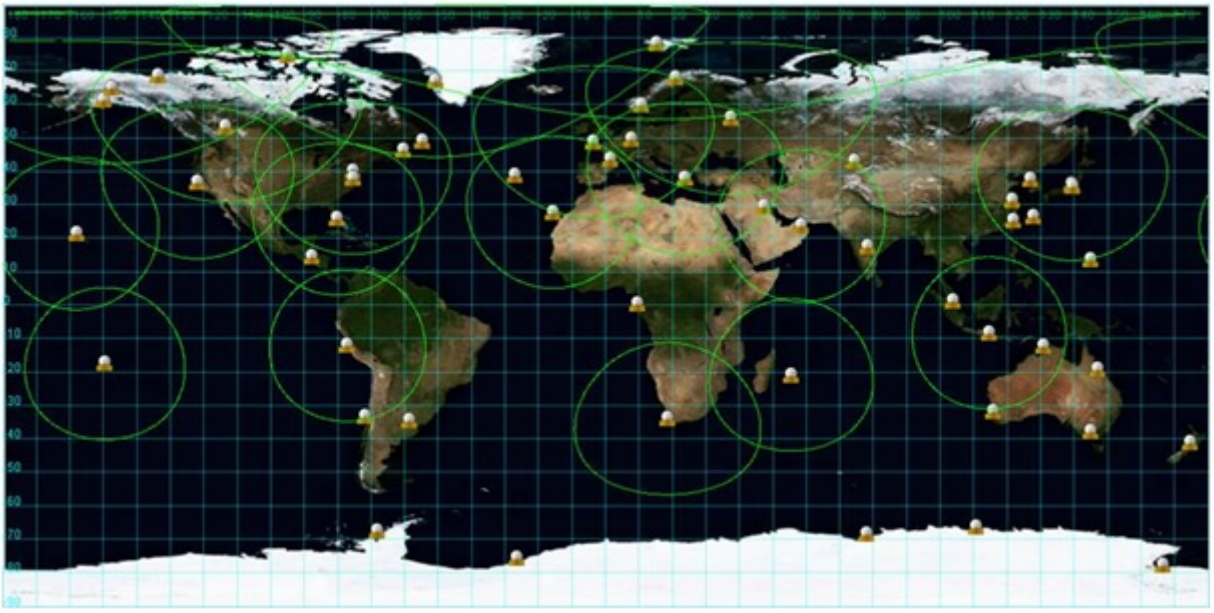

Figure 11 : Current METOP-A (and soon METOP-B) coverage

3.2.3 HRPT-A4 project

This project had been initiated in 2010 and was presented for the first time during the 43rd Operation Committee. It consists in upgrading a significant part of the network so that it is capable of acquiring data from NOAA, METOP and SARAL satellites. The very flexible technology of the receiver should make it compatible with the future satellites which will carry Argos-4 payloads.

On the basis of a system study aiming at selecting the minimal subset of ground stations to be upgraded to get the better overall system performances, a group of 20 stations as shown on the map below have been chosen.

Figure 12 : Argos HRPT-A4 network

From an engineering point of view, all the equipment requested to upgrade an existing station is tested and ready to be deployed.

From a deployment point of view, it has to be noticed that the negotiation with the host organizations is taking much more time than expected at the beginning of the project.

On the date of August 2014, the status of the deployment is as follows:

11 Operational ground stations:

- Lima
- Lannion
- La Réunion
- Hatoyama
- Miami
- Cape Town
- Bali
- Tahiti
- Libreville
- Oman
- Toulouse (spare equipment)

6 Upgrade scheduled end of 2014:

- Mas Palomas (waiting for authorization)
- Athens (waiting for authorization)
- Monterey (waiting for authorization)
- Cape Ferguson (under discussion with the Australian Bureau Of Meteorology waiting for authorization)
- Wellington (under discussion with the Australian Bureau Of Meteorology waiting for authorization)
- Casey (under discussion with the Australian Bureau Of Meteorology waiting for authorization)

3 Upgrade scheduled in 2015:

- Ascension Island (Under discussion with European Space Agency)
- Cayenne – French Guyana
- Easter Island

3.3 Processing centers

The two global processing centers in Toulouse and Lanham were nominal over 2013 and first semester of 2014. Redundancy is used at least once a month (Up to two times on one month). Redundancy means all Argos users rerouted to CLS or CLSA during an anomaly on the nominal global processing center.

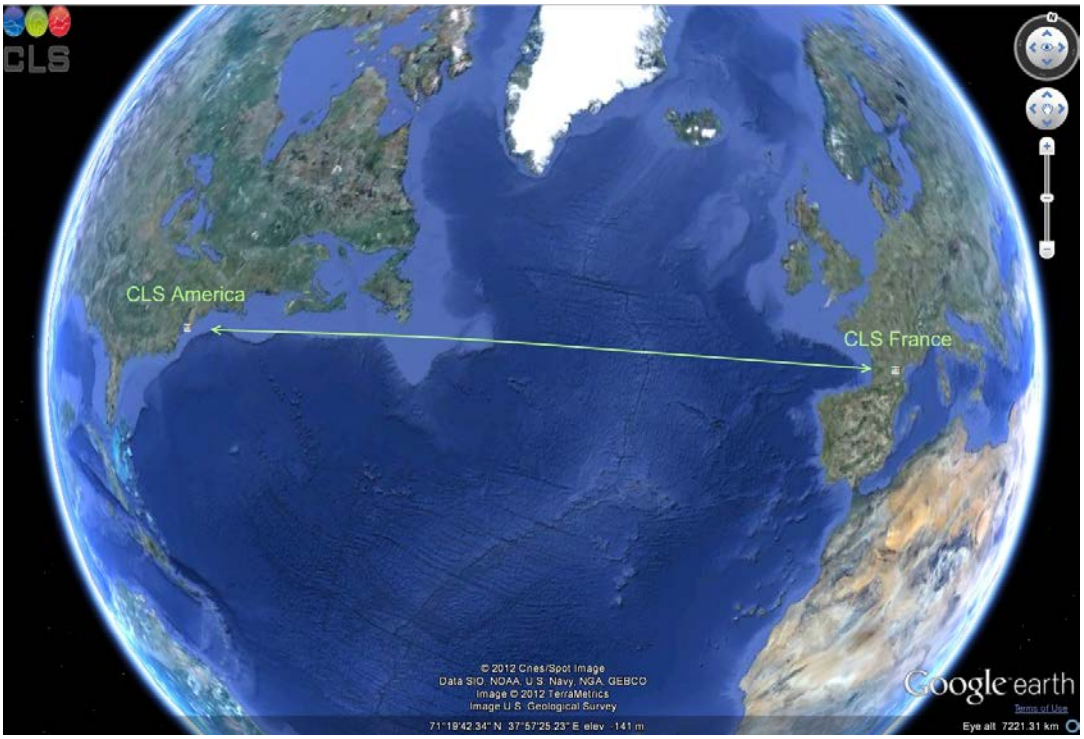

Figure 13 : Global and Regional Processing Centers

Figure 14 : CLS Toulouse new building

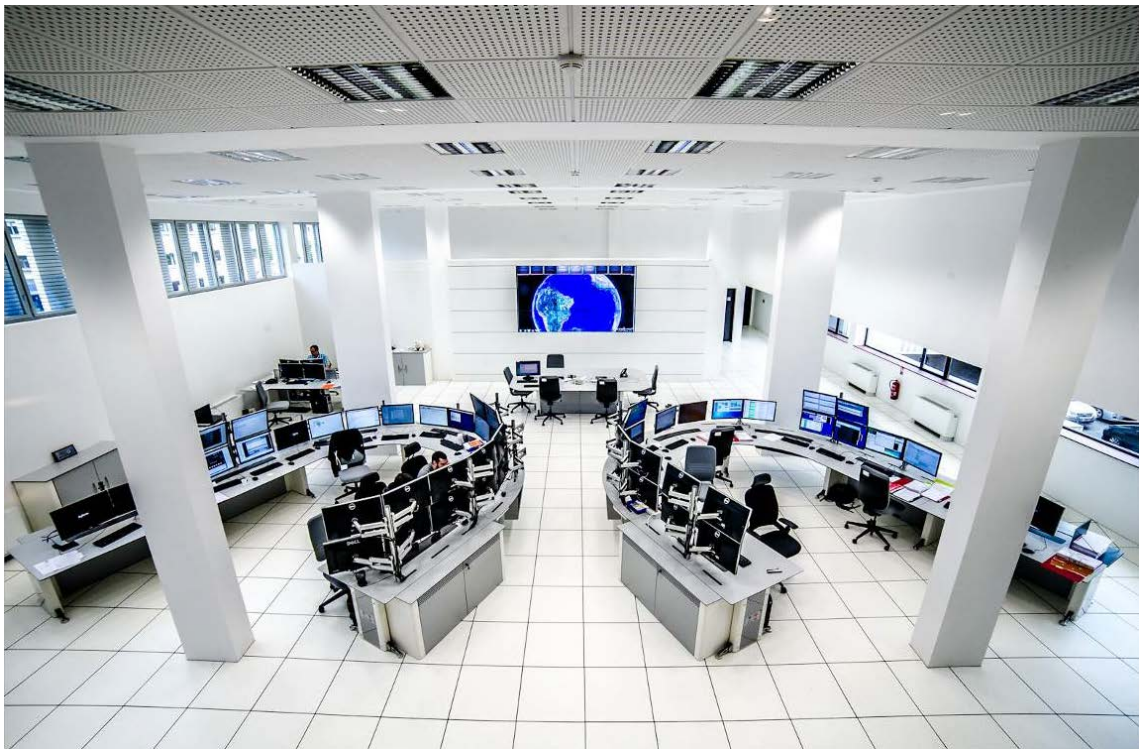

Figure 15 : CLS Toulouse Control Room

Figure 16 : CLS Global Processing Data Center

3.3.1 Argos global processing centres architecture

In 2011, https architecture in CLS France was updated and CLS America firewalls were replaced to get the same hardware and software version as CLS France. We also initiated a rebuilt of ARGOS application servers, in order to prepare the next decade. This process was started on the

development configuration in CLS France. The application server is now based on CentOS Linux release 6.0, 64 bits (rather than RedHat, 32bits).

In 2012, these changes on operating systems have been propagated up to the operational configurations, both in CLS America and CLS France datacenters. In order to address the increase of quantity of data to be processed (due to the launch of METOP-B and SARAL spacecraft), space disk have been increased and few processing servers have been added. The databases backup mechanism has been optimized and updated.

In 2013 and 2014 most of the improvements regarding the Argos processing centers have concerned the performances as well as the scalability:

- the physical servers have been replaced by virtualized servers (Vmware)

- the two physical database servers have been changed by two new powerful servers

- the Argos database has been split into two distinct database : short term database which contains data < 18 months and a long term database for data beyond 18 months.

Each global processing center is autonomous and can work alone. In normal mode, both processing centers receive, process and distribute Argos data to:

- North American users for CLS America
- Users of the rest of the world for CLS France

In case of problem with one of the two centers, the other one stays alive and is capable of receiving, processing and distributing Argos data to ALL users. The switch to the remaining alive center is completely transparent for the users. It means that the users continue to receive or to access to their data, without changing anything on their side, as if nothing has happened.

The figure here below represents the architecture of CLS France and CLS America global processing centers.

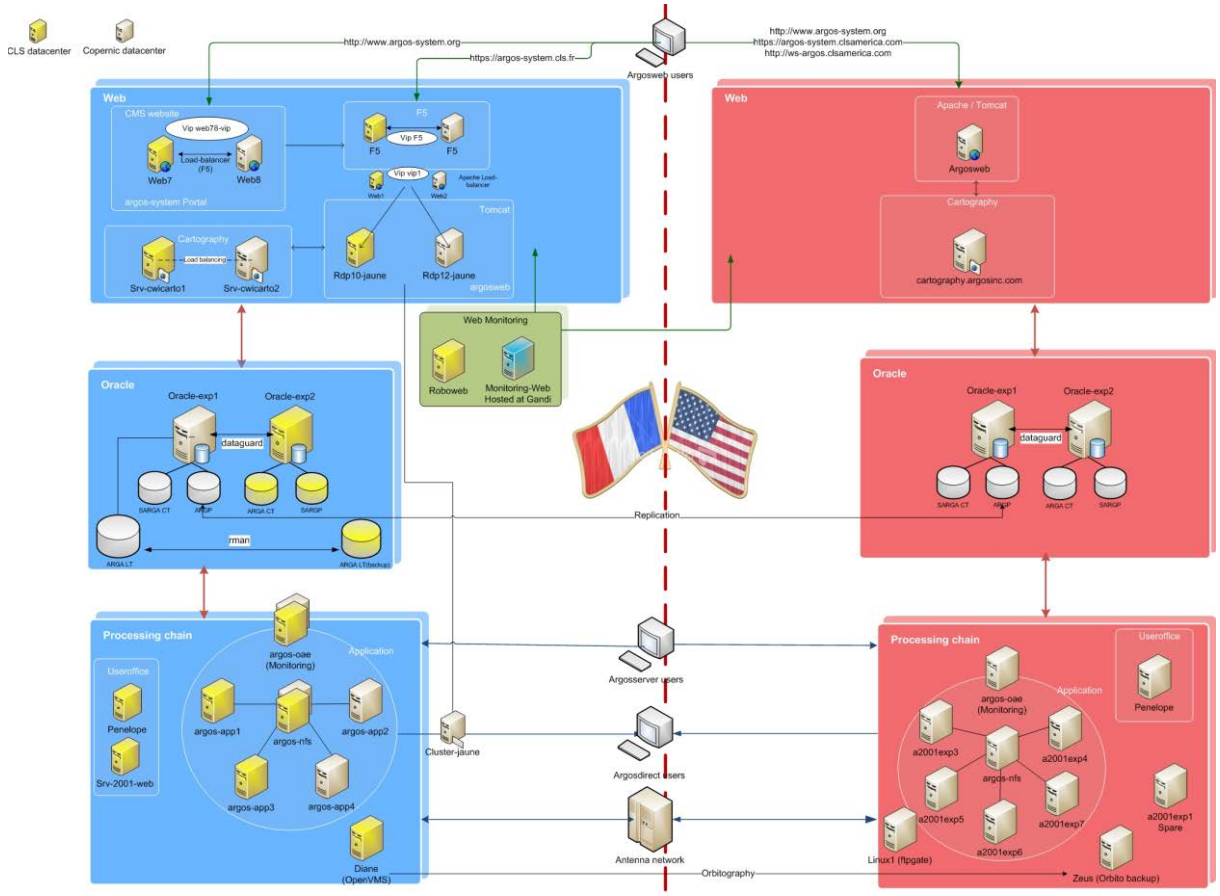

Figure 17 : CLS Toulouse and CLS America IT architecture

The architectures of CLS France and CLS America processing centers are quite similar and based on the same principle. We find three main subsets detailed in the following chapters:

- the processing chain
- the Oracle database service
- the Web distribution

3.3.2 The CLS Argos processing chain

Composed of different software modules, the processing chain is in charge of receiving and processing the Argos data issued from the satellites and acquired by the global and real-time ground stations networks.

Argos data are processed in terms of collect and location, and stored into a database.

The processing chain is also in charge of distributing the data by ADS (Automatic Distribution System) or allowing users to access to their data using Telnet, ArgosWeb or the web services.

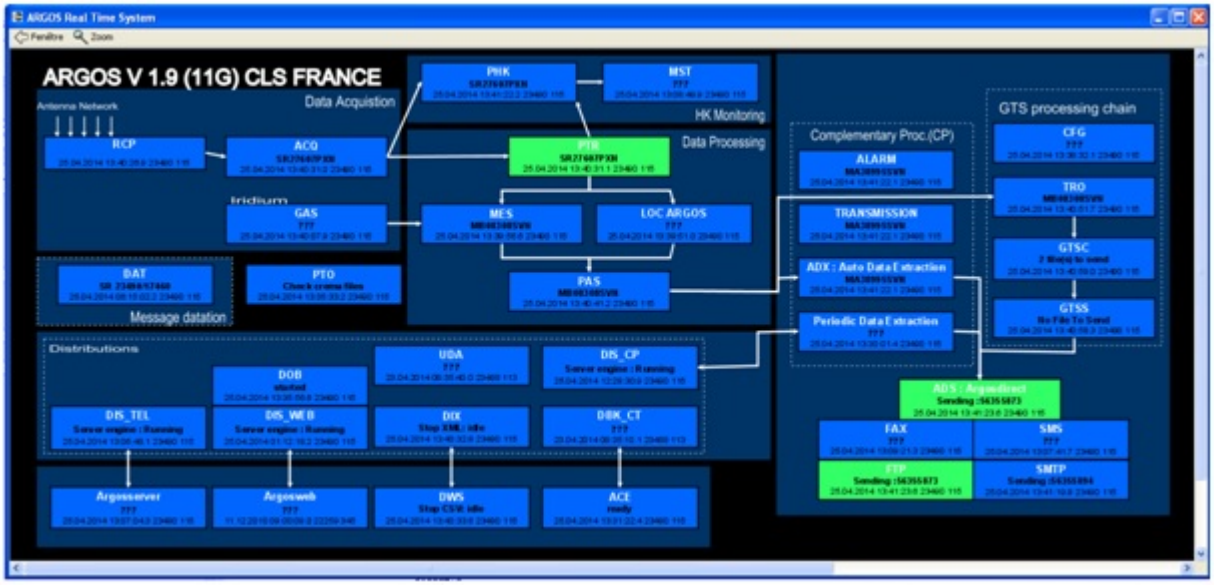

Figure 18: Synoptic of the CLS Argos processing chain

3.3.3 The Oracle database

At the heart of the computing architecture, the Oracle database is used to store the Argos declarative data as well as the processed data.

In order to keep a perfect coherency between CLS France and CLS America centers (mandatory to guarantee the redundancy between both centers), an automatic mechanism of replication is implemented between CLS France and CLS America databases.

3.3.4 The Argos data distribution

3.3.5 ArgosWeb site

Based on a farm of Apache Web servers, the Web distribution allows the users to access their data using a Web cartographic interface. The service of maps is supported by two cartographic servers on which are running the mapping engines C-Map for the marine cartography and MapInfo for the terrestrial one. The application server is supported by Tomcat. ArgosWeb is a free web site for Argos users. They can access their data via the Internet, by logging on to a secure website

(http://www.argos-system.org) with their username and password (assigned to them by User Services).

ArgosWeb gives users secure and easy access to Argos data via an attractive and user-friendly website. With ArgosWeb, users can view platform trajectories on land and marine maps. Users can also personalize data download formats (table or map format). Users have immediate access to information on their Argos account, as well as platform and program settings.

The annual availability of the French ArgosWeb site (FR) in 2013 is 99.74%
The annual availability of the U.S. ArgosWeb site (US) in 2013 is 99.68%

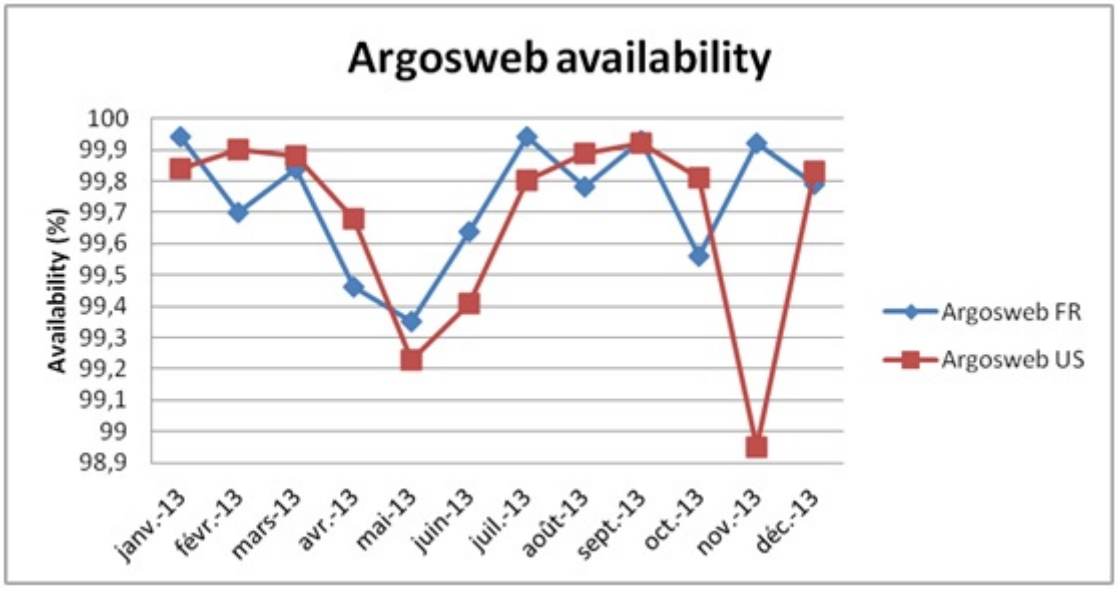

Figure 19 : ArgosWeb availability in 2013

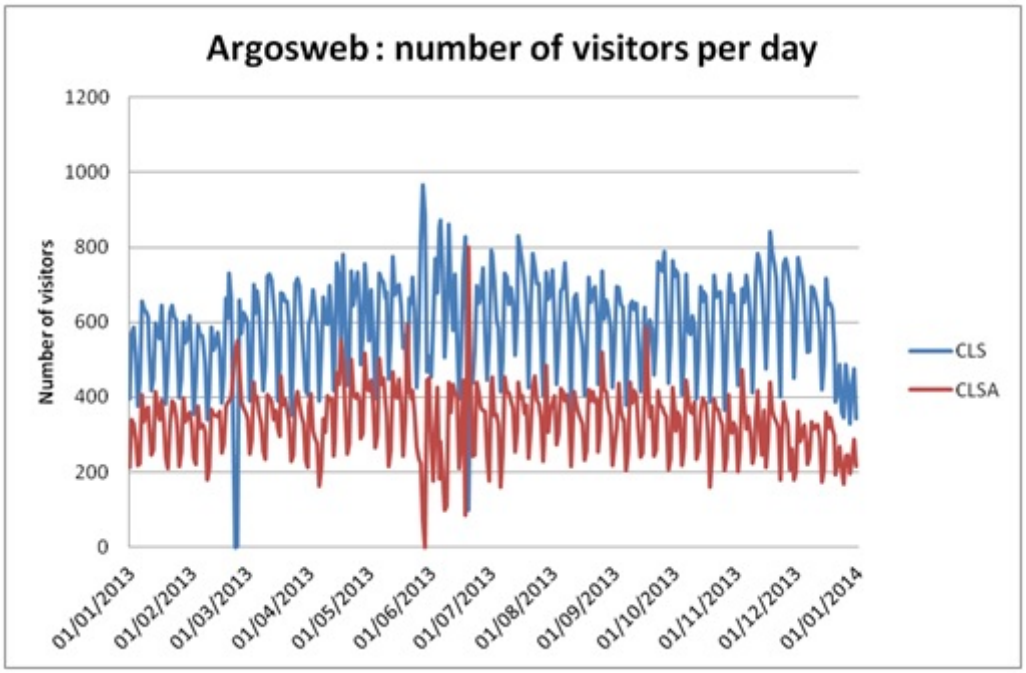

Figure 20 : Number of daily ArgosWeb accesses in 2013

3.3.6 ArgosServer

With ArgosServer, the Argos users can logon to Argos Processing Centers and access their data via TELNET. TELecommunication NETwork is a network protocol used by all TCP/IP compatible

networks. A Telnet session with CLS's servers can be opened by typing the "Telnet" command on most operating systems (Windows, Unix...). Addresses of the both ArgosServers are:

- ArgosServer.cls.fr
- ArgosServer.clsamerica.com

The annual availability of the French ArgosServer site (FR) in 2012 is 99.85%
The annual availability of the U.S. ArgosServer site (US) in 2012 is 99.72%

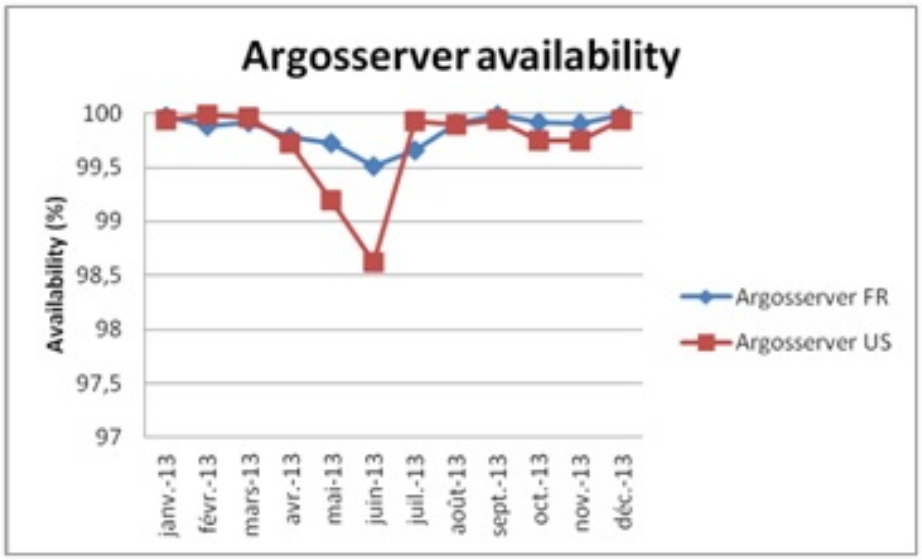

Figure 21 : ArgosServer availability in 2013

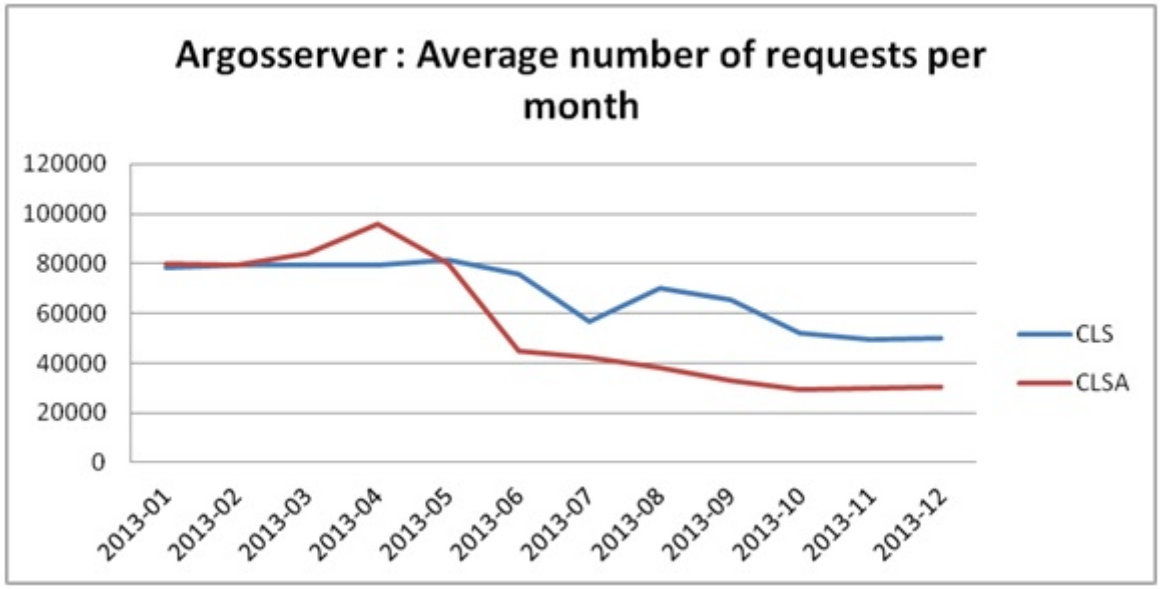

Figure 22 : Number of ArgosServer requests in 2013

3.3.7 ArgosDirect

ArgosDirect automatically sends data to users by e-mail, FTP or CD-ROM. ArgosDirect allows users to receive their data in several available formats (tabular, DS, DIAG…).

Backup periods (One processing centre is sending data of the other processing centre) are clearly identified on the graph below.

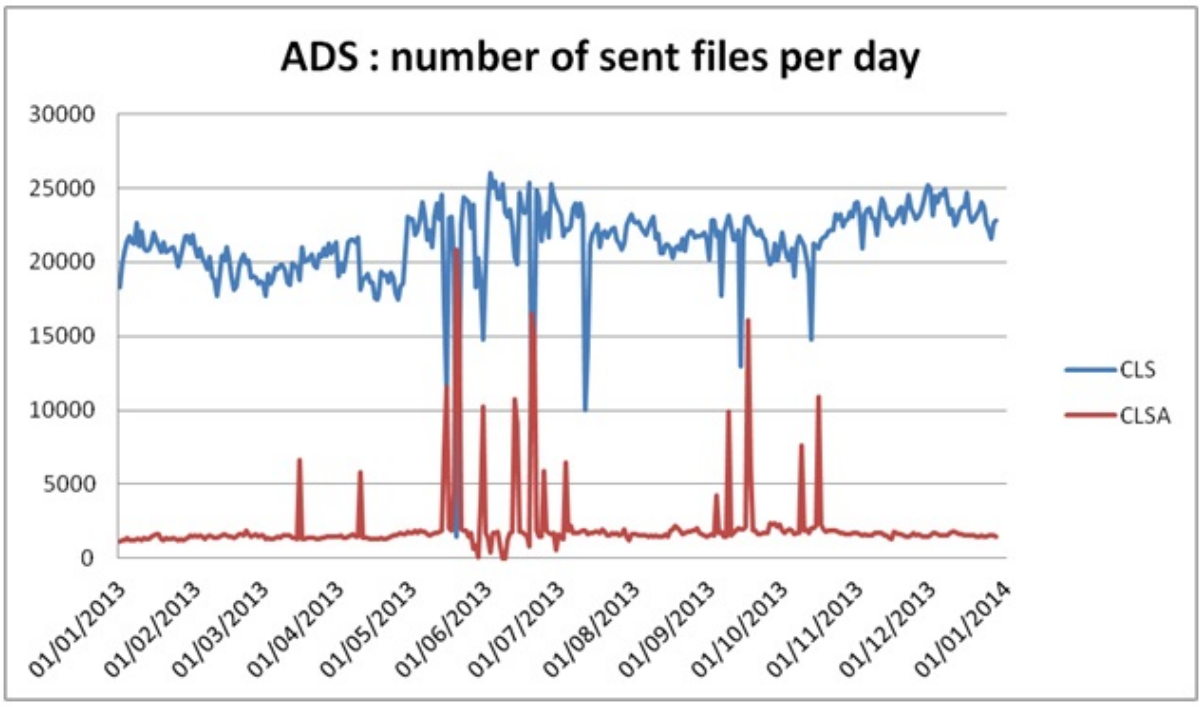

Figure 23 : Daily number of files sent by ArgosDirect in 2013

3.3.8 Argos WebService

Argos WebService is a machine-to-machine/automatic interface for Argos data distribution. This modern alternative to ArgosServer (Telnet) is free of charge and makes it possible for Argos users to contact CLS's database directly, via internet, and receive their data in **CSV, XML and KML (Google Earth) format**. The Argos WebService delivers useful information such as positions, error estimates, diagnostic data, raw messages, sensor data, etc. The user can choose the different types of data to download via filters.

The annual availability of the French WebService (FR) in 2012 is 99.89%
The annual availability of the U.S. WebService (US) in 2012 is 99.91%

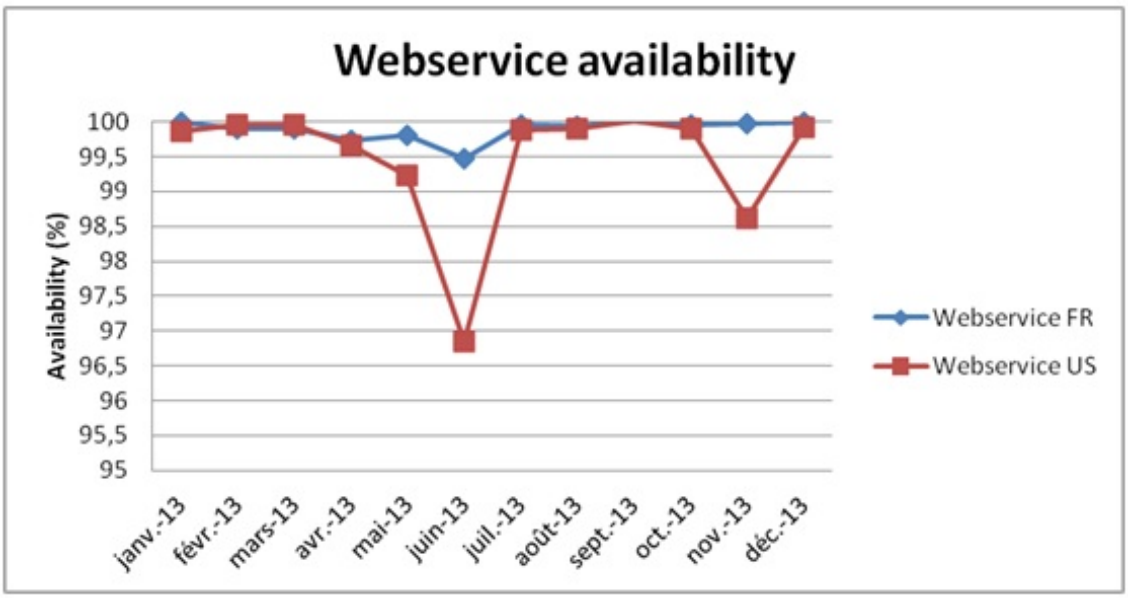

Figure 24 : Argos WebService availability in 2013

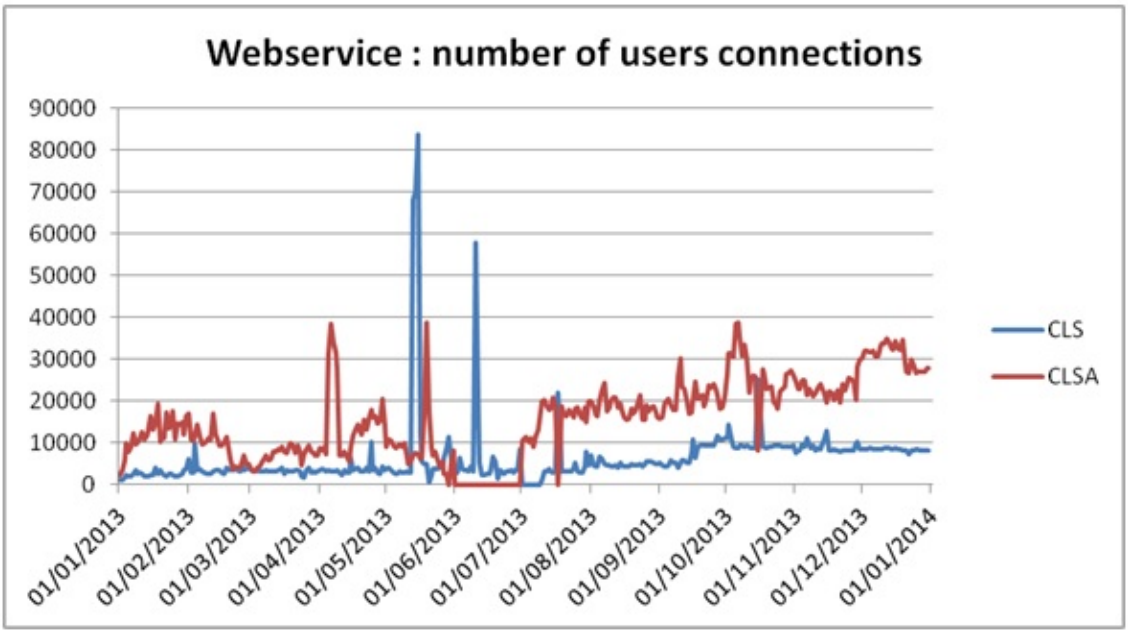

Figure 25 : Number of Argos WebService connections in 2013

3.3.9 Disaster recovery architecture

Disaster recovery architecture implementation is completed since 2012. The computer room is located into CNES Toulouse. Some of the Argos architecture components are DR compliant in order to improve services availability. However, the main backup is based on the 2 global processing centers (Toulouse & Lanham).

Figure 26 : Disaster Recovery Room located in CNES

3.3.10 Data processing statistics

The Argos Operations missions at CLS are:

- Availability and reliability of Argos Products and Services in accordance with the SLAs,
- Support internal or external Argos projects, or proposals,
- Control and reduce operational risks and costs in order to ensure 24h/24, 7 days per week operational services.

In order to monitor the Argos processing centers, statistics are produced in real-time:

- on the availability of Argos data distribution tools,
- on the data delivery time for sample platforms,
- on Argos location delivery time for sample platforms,
- and on the percentage of data available in less than one hour.

In 2013, the processing performance indicator is 97,57%. This indicator corresponds to the percentage of real time datasets processed in less than 10 minutes (Between Pre-Processing component PTR and PAS component in charge of inserting data in database for user requesting). This number does not include periods when French site was in backup mode on the US site.

In this context, decreasing availability could be observed in case of pending datasets inside the processing chain. For example, when several Global datasets are received at the same time, during these periods, other datasets are queued and are waiting to be processed increasing the time they passed between PTR and PAS modules. Priority to Realtime datasets processing was added in July 2013 to avoid this queuing effect

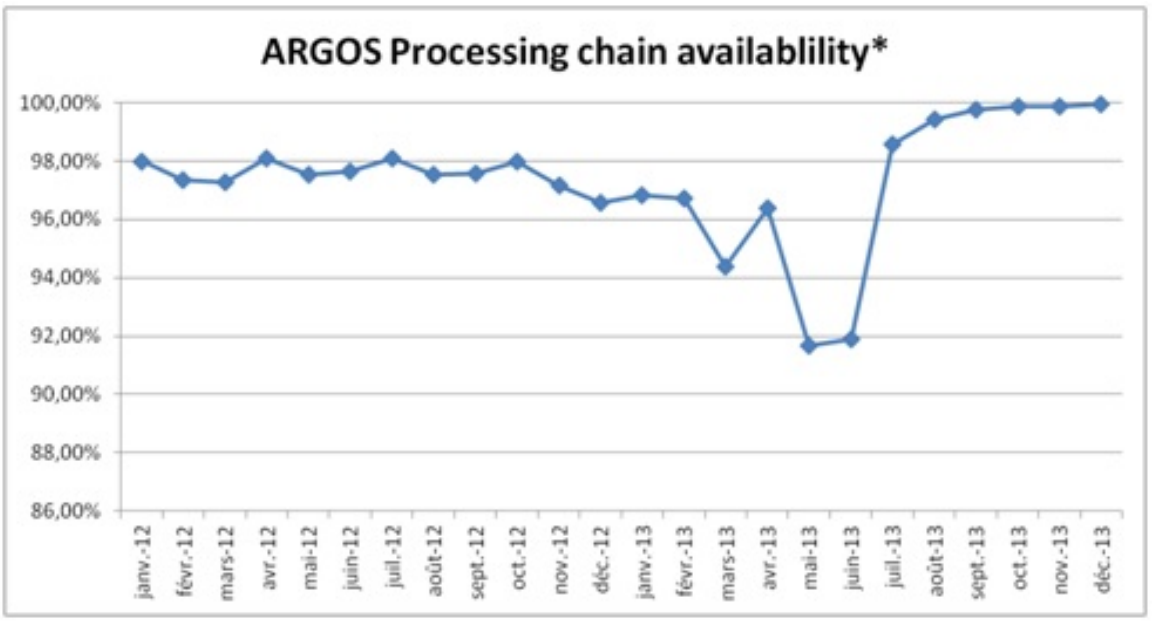

Figure 27 : Argos Processing chain availability in 2013

*(% of Realtime datasets processed in less than 10 minutes)

3.3.11 Number of Argos messages and locations processed

Number of locations and messages computed every day by the Lanham and Toulouse Centers are, in average:

Number Per day	2009	2010	2011	2012	2013
Messages received	2 273 233	2 871 885	2 904 476	2 790 580	3 060 434
Distinct Messages received	1 272 459	1 470 953	1 451 938	1 443 247	1 513 630
Argos Locations	77 837	94 151	92 168	93 343	94 626
GPS Locations	185 496	205 259	212 587	224 857	243 366

Figure 28 : Argos messages and locations per day (table view)

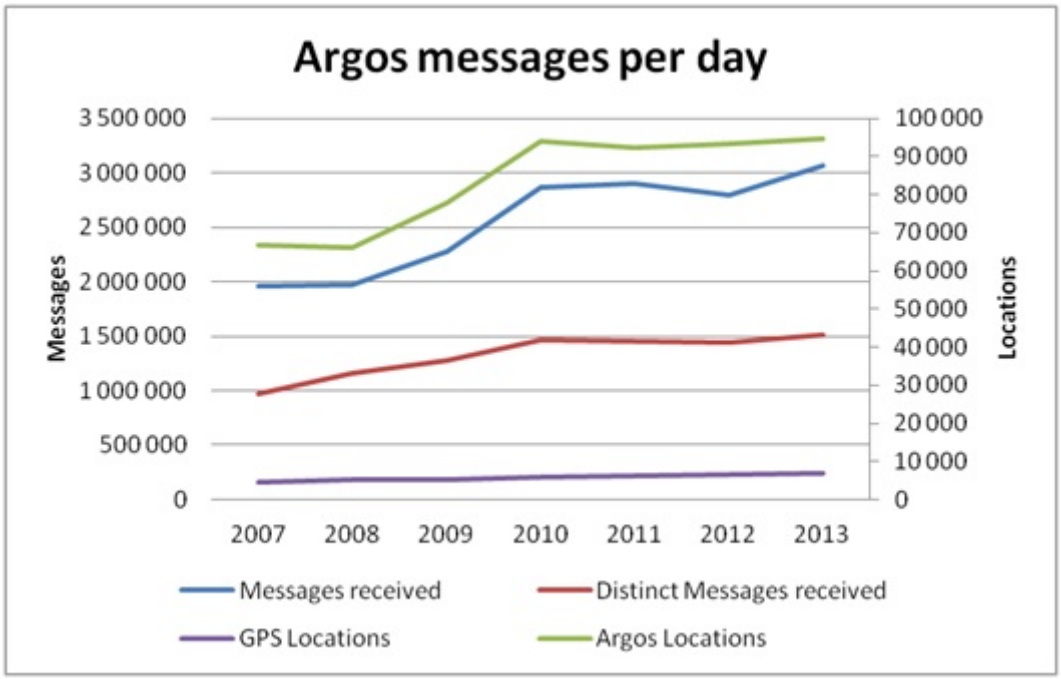

Figure 29 : Argos messages and locations per day (Chart view)

3.3.12 Argos location and data collection latencies

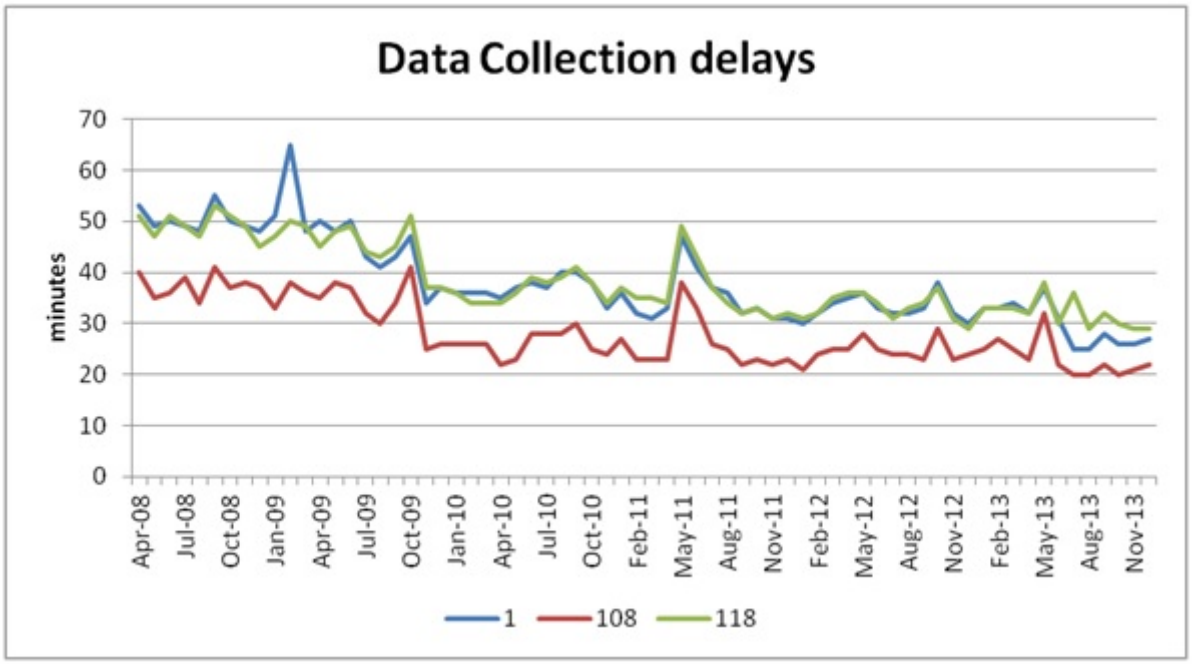

Figure 30 : Average latency on Argos data collection for sample platforms* since 2008

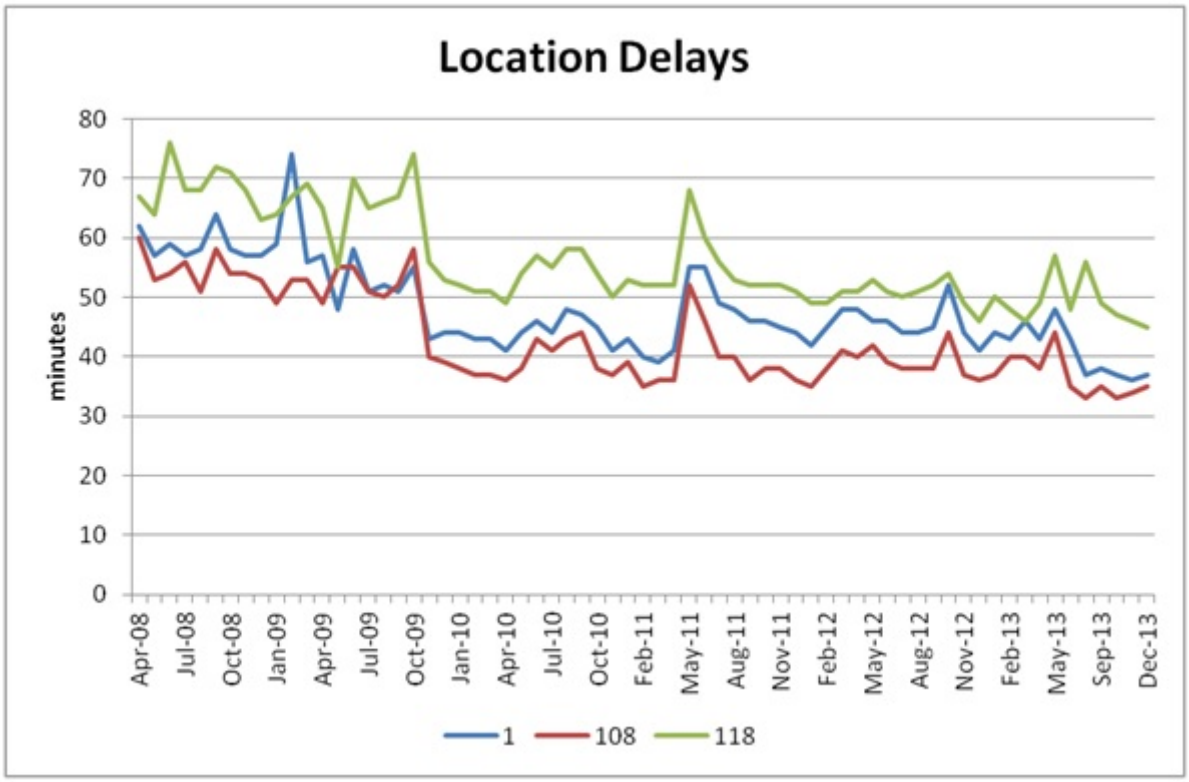

Figure 31 : Average latency on Argos locations for sample platforms* since 2008

* Sample platforms are timing and orbit determination platforms. Every hour, the last data collection and location times for these three platforms are controlled. Collection and location latency on ID 108 (Fairbanks) is under latency of Ids 1(Toulouse) and 118 (Wallops Island) due to the transmitter location and the higher number of passes over this transmitter.

We can see major improvement on data and Argos location delivery time since 2008 due to a better real-time antennas network, new operational Argos satellites (NOAA-19, METOP-B and SARAL) and enhancements of the Argos data processing performance. Increase during May 2011 is due to processing issue (Database insertion driver issue). The average latency on Argos data collection in Northern hemisphere is now less than 30 minutes.

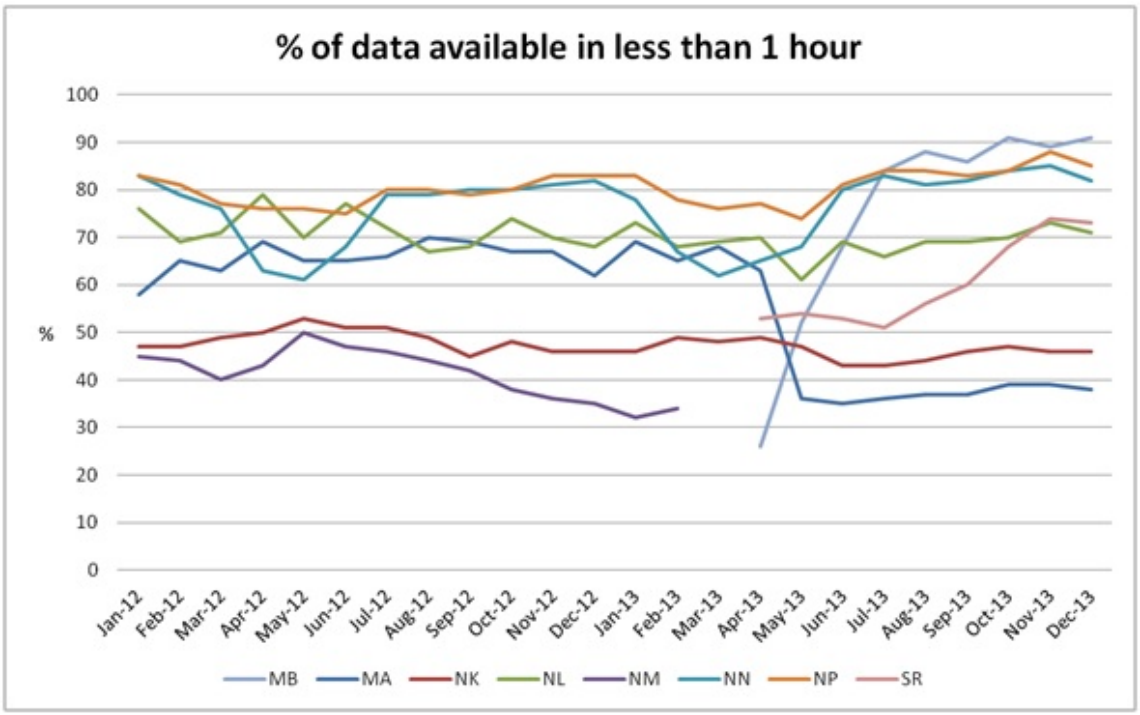

Figure 32 : Data available in 1 hour

Percentage of data available in less than one hour means which percentage of raw data has been processed one hour after its recording on board of the Argos Instrument. NOAA N, M and P operational satellites get a better coverage than NK and NL. For clarification, the Data Timeliness calculations include this metric plus the satellite revisit time.

3.3.13 Monthly active Argos platforms

The number of Argos platforms operating is quite stable in 2013. There is still more activity in Spring/Summer due to the higher number of deployments.

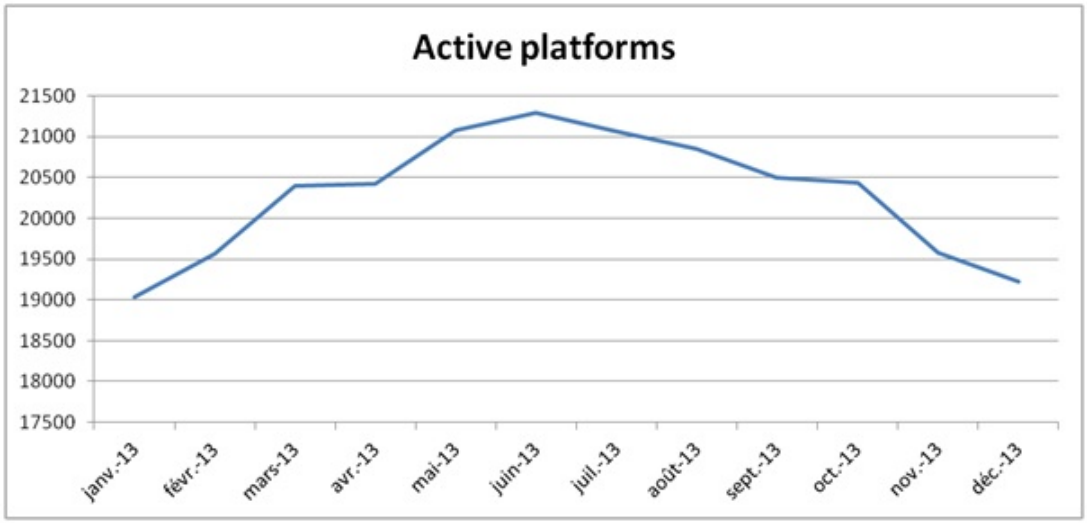

Figure 33: Monthly active Argos platforms in 2013

3.3.14 GTS processing

CLS is monitoring 24/7 a) the GTS processing system with real-time operational surveillance on the processing modules, b) the quality of the data and c) the system performance (time to process the data, number and size of bulletins)

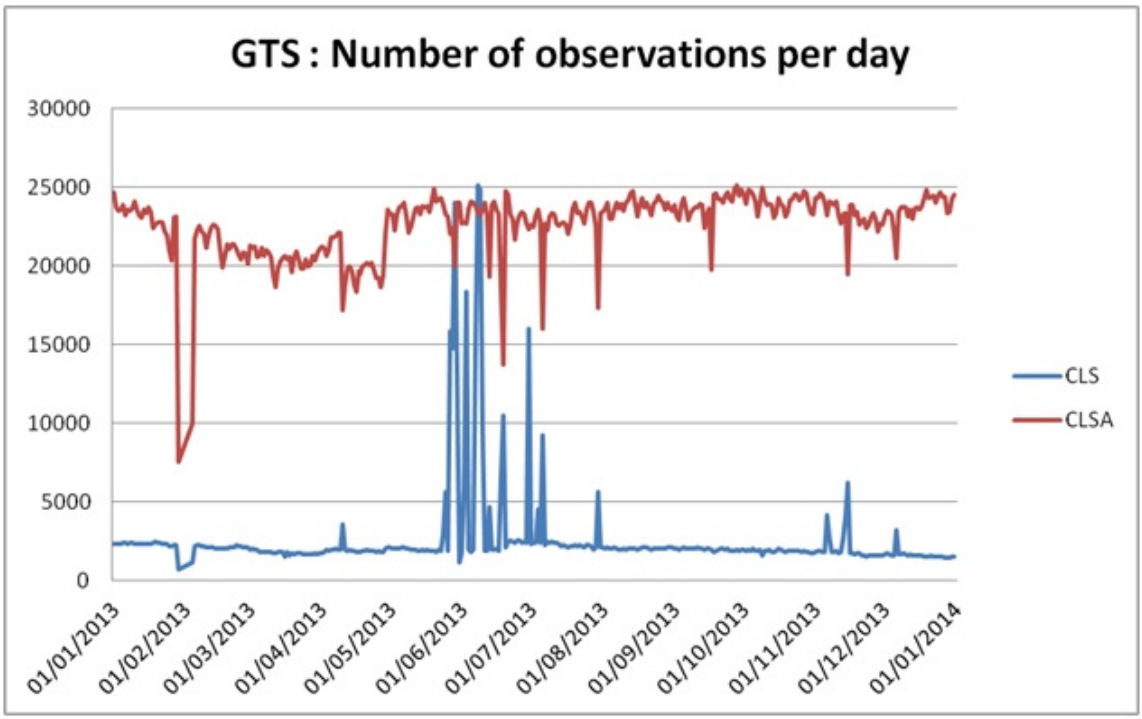

Figure 34: Number of GTS observation processed per day in 2013

Backup periods (One processing centre is sending data of the other processing centre) are clearly identified on the graph above.

CLS has a GTS monitoring tool, with following statistics are computing each day:
- Number of GTS platforms (with a WMO id) processed,
- Number of observations processed,
- Average disposition time (observation time –time inserted onto the GTS)

These 3 statistics are provided for:
- All types of bulletins
- Each type of text bulletins (BUOY, SHIP, TESAC, and SYNOP)
- Each type of buoy (ATLAS, DRIFTERS, ICE, TRITON and OTHERS)
- Each WMO area

The new BUFR sequence for drifting buoys TM 315009 has been qualified. The sequence is ready for deployment, awaiting the official publication of the BUFR table v.19 by the WMO.

Both Alphanumeric (BUOY, TESAC, SYNOP, SHIP) AND BUFR bulletins are produced for each observation reported by ocean & meteorological platforms.

From 900 to almost 1200 active GTS platforms are processed every day at CLS & CLS America including 700 to almost 1100 drifting buoys.

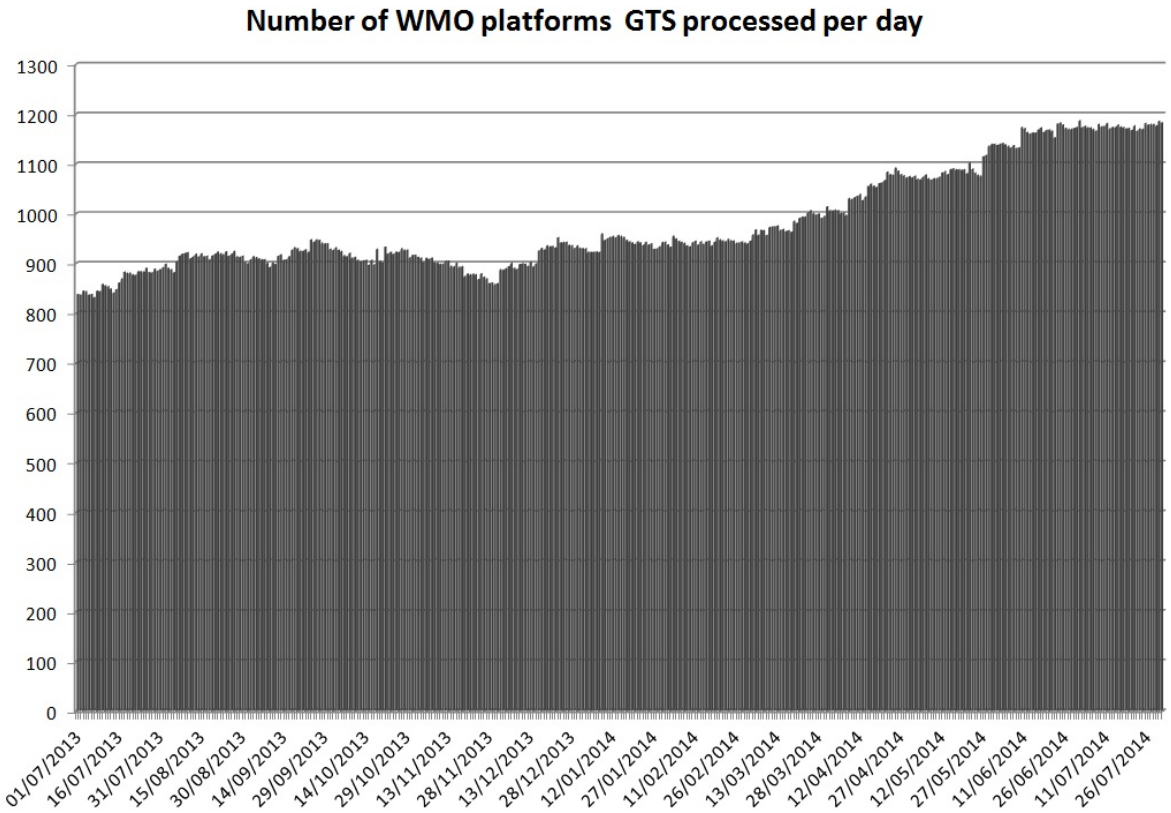

Figure 35: Argos platforms GTS processed per day from July 2013 to July 2014

We can see improvements on the Global Drifter Program network directly on the 2 charts below with increasing numbers of drifting buoys and BUFR bulletins inserted on the GTS since March 2014.

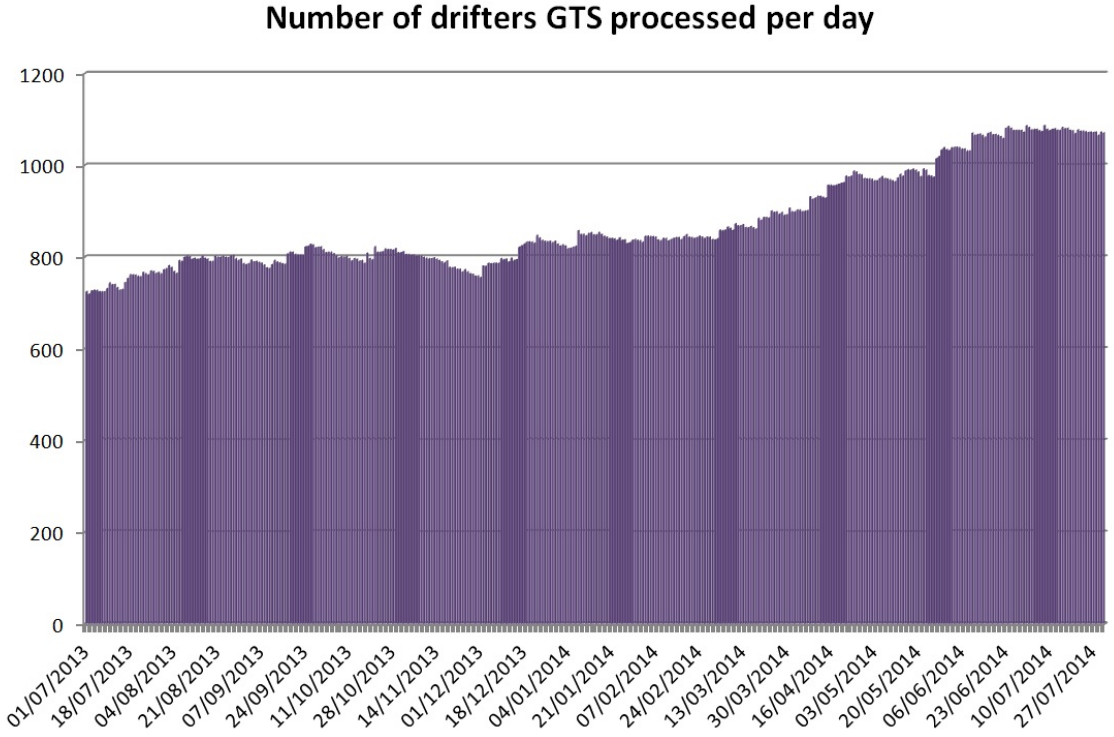

Figure 36: Argos drifters GTS processed per day from July 2013 to July 2014

From 25 000 to more than 30 000 GTS BUFR bulletins have been inserted daily into the GTS between July 2013 and July 2014.

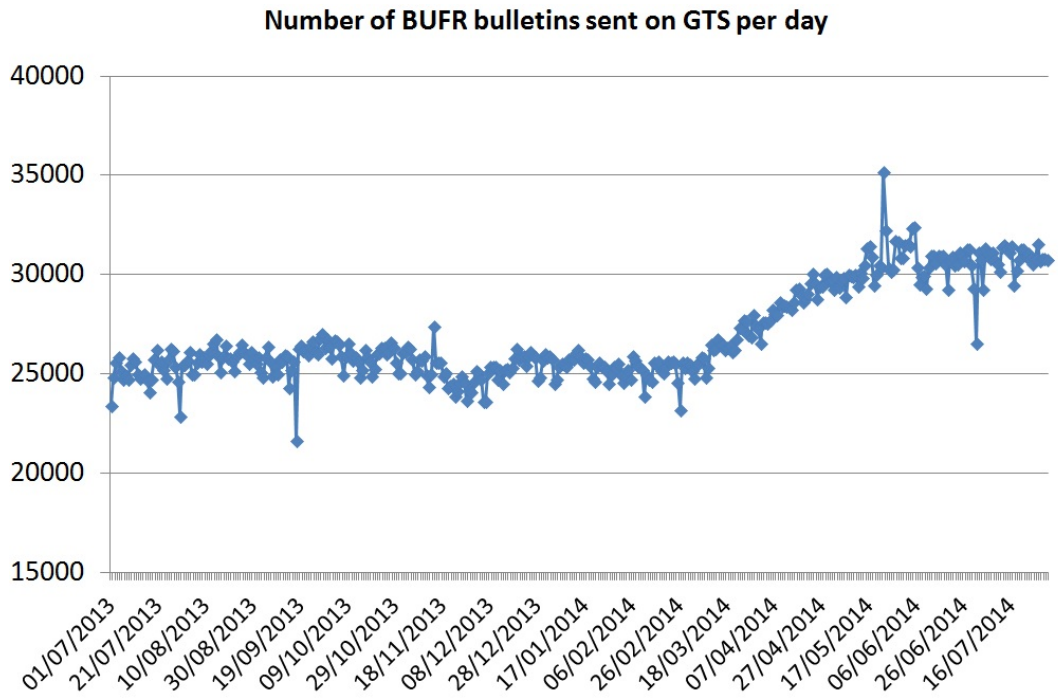

Figure 37: Daily number of GTS BUFR bulletins produced from July 2013 to July 2014

The average delivery time of observation from Argos platforms on the GTS is around 60 minutes.

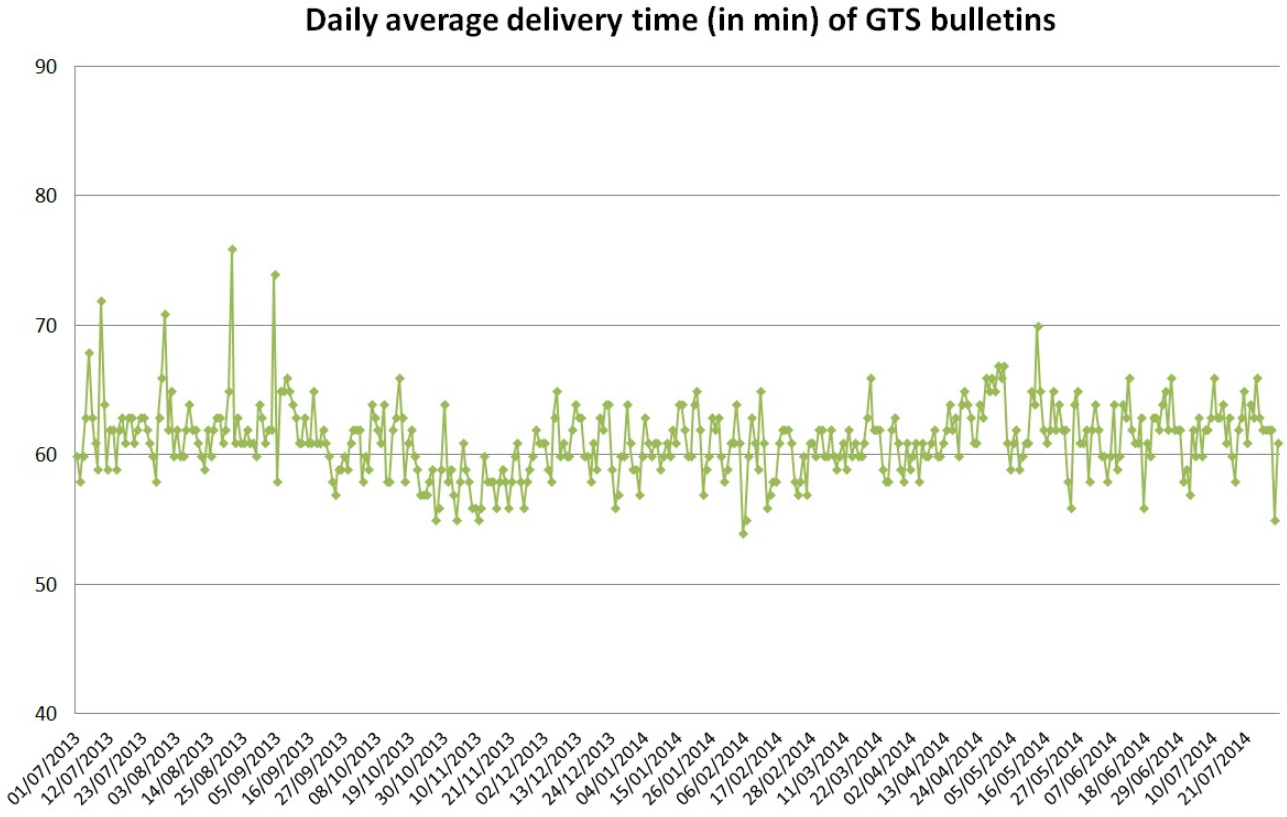

Figure 38: Daily average delivery time for all GTS platforms from July 2013 to July 2014

3.4 System improvements

As every year, several software improvements were implemented in 2013 in order to fit with the user requirements. During this year, 114 anomaly forms have been treated as well as 137 system change proposals. These application improvements have concerned:

- **On-line data extraction on archive database**

Until now there was no possibility for the users to extract its own data on archive database. We have developed a new module allowing the users to extract their own data on archive database (last 12 months of data available). The users create a request using ArgosWeb interface. The data are extracted in less than 30 minutes within 99% of the cases. When the extraction is finished a mail is sent to the user with a link for downloading its data.

- **Migration Oracle 11G plus opening of 20 days on-line data extraction for ArgosWeb and Web service**
  Before giving access to the users to 20 days on-line, we needed to migrate Oracle version to 11G to have better performances on database accesses. The access to 20 days on-line was opened in early 2014.

- **Migration of Argos operating system (OS)**
  The migration of production environments has been done at the end of 2013.

- **Android application**
  A new Android cartography application has been developed to allow users to access to their PTTs locations through Smartphones.

- **Integration of a new BUFR sequence for drifting buoys**
  The new BUFR sequence for drifting buoys has been qualified. The sequence is ready for deployment, awaiting the official publication of the BUFR tables by the WMO.

2014/2015 will see new improvements. Among the ones which are already planned, we can list:

- **New Argos Orbitography**
  The adaptation of orbitography module (ZOOM) by CNES for Linux environment is done. The integration in Argos processing center is started and will be completed in 3rd quarter of 2014.

- **New earth elevation model**
  For Kalman location only, a new earth elevation model (ACE3) has been integrated to compute more precise locations in some earth areas, and give better altitude accuracy. The integration is completed and it will be put in operation during 3rd quarter of 2014.

- **Improvement of web services for Argos-3**
  The Argos Web Service regularly receives new capabilities. The possibility to send user messages to PMTs will be the next major improvement.

- **BCH message decoding**
  The study of a BCH message coding to improve Argos message transmission in noisy regions is finished. The development will be realized in 2014. The integration into the processing chain is scheduled beginning 2015.

- **New databank formats**
  On-line data extraction on archive database service will support xml and kml formats.

3.5 ARGOS-4 ground segment upgrade

This project is aiming at identifying and implementing all the modifications of the existing Argos ground segment to take into account the new generation of Argos-4 instrument as well as a general enhancement of the Argos ground segment. This activity has been delegated to CLS by CNES.

Despite the fact that we do not know when the first Argos-4 payload will fly, the decision of starting the Argos-4 ground segment upgrade has been made, at least the part dedicated to the general enhancement of the Argos ground segment. The project includes the following activities:

Developments:

- Major developments will concern the Argos Processing Center, which will be able to manage all the operational Argos instruments.
- New Master Beacons will be produced. They will have to be compatible with Argos-2, Argos-3 and Argos-4 instruments. They will replace the current Master Beacons.
- New Reference Beacons will be produced. They will be compatible with Argos-2, Argos-3 and Argos-4 instruments.

Qualification on a dedicated Argos Processing Center instance:

- The ground segment technical qualification will follow the development phase. It will include the qualification of technical specifications, the compatibility tests with Argos-2 and Argos-3 processing. In order not to disturb or impact the existing and operational Argos processing centers, all the qualification operations will be performed by using an Argos Processing Center specifically built for the Argos-4 project. This dedicated center will be available for CNES compatibility tests.
- Next step will be the ground segment operational qualification. The processing center performances will be checked; the operational documentation will be upgraded for Argos-4; the operational team will be trained. The dedicated Argos-4 Processing Center will be available for CNES end-to-end tests.
- Final step will concern the system operational qualification which will start after the satellite launch. The system performance will be validated; the operational procedures will be conducted; the operational instrument monitoring will start. During this phase, CNES will use the Argos-4 Processing Center for the instrument in-orbit commissioning.

Operation:

- Before the satellite launch, the new Master Beacons will be deployed, probably at Svalbard, Fairbanks, and Toulouse.
- After the instrument in-orbit commissioning and the system operational qualification, the production Argos Processing Center will be upgraded and configured.
- It will start Argos-4 (and of course Argos-2 and Argos-3) routine processing.
- After the CNES to CLS handover, CLS will operate the instrument and distribute the Argos-4 products.

Status of the project: The project has just started.

4 Argos user's applications

4.1 Monitoring Argos platforms

The number of science Argos platforms (except animals) operating is slightly increasing due primarily to the increasing number of operating drifting buoys in the Global Drifter Program.

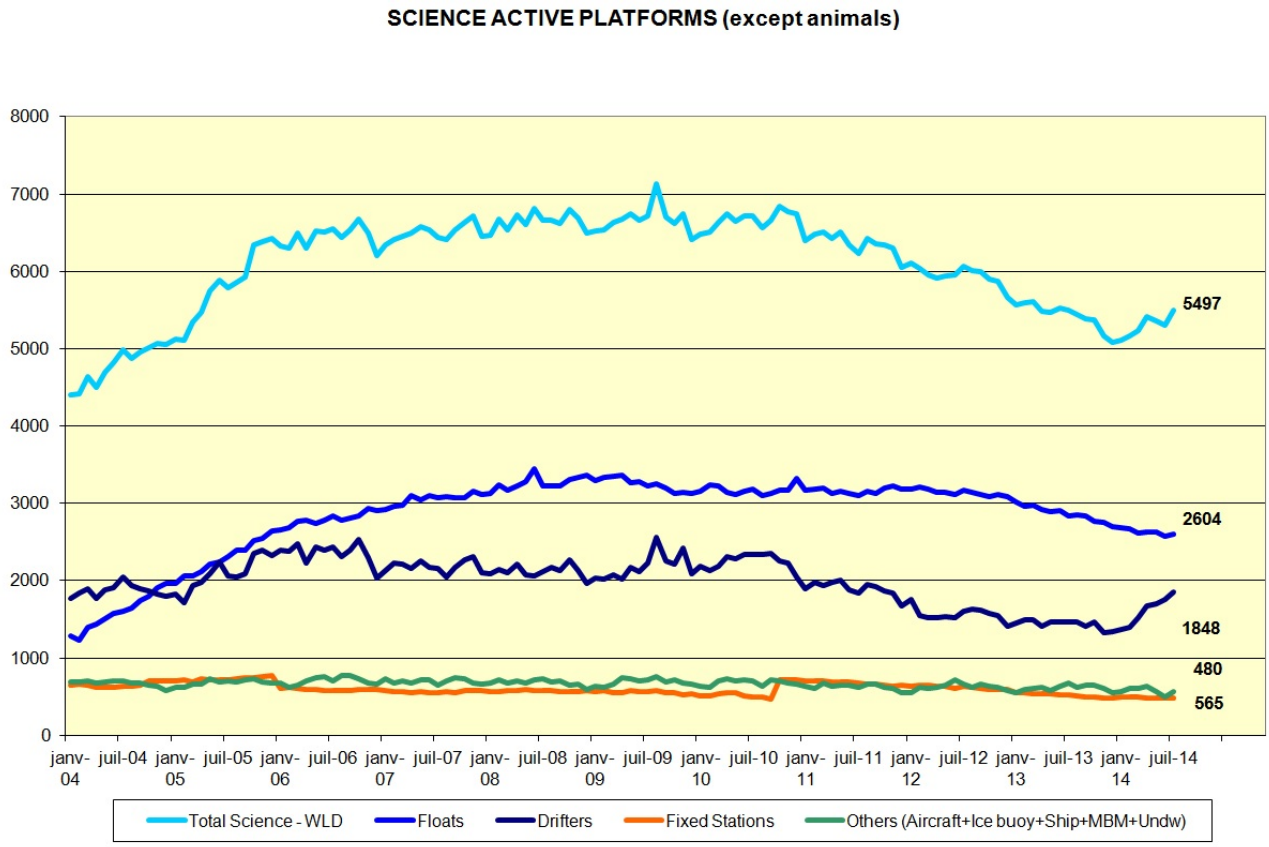

Figure 39: Monthly active ocean Argos platforms statistics

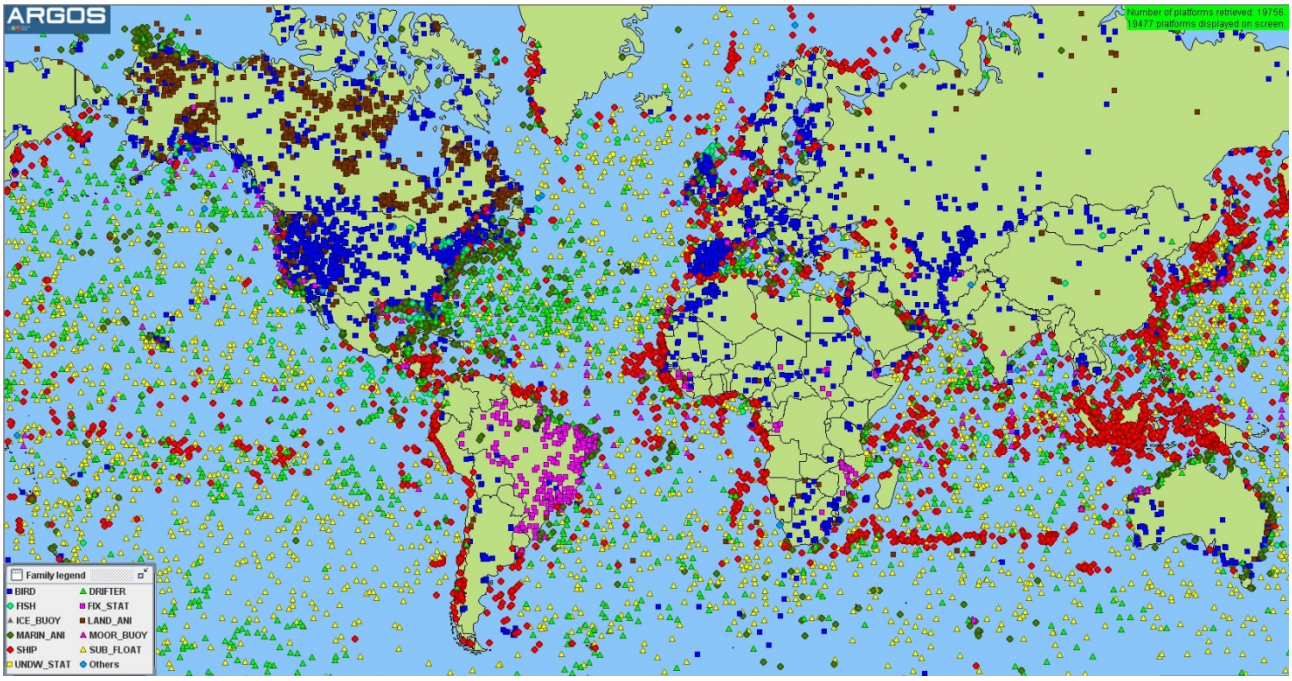

Figure 40 : Active Argos platforms repartition (August 2014)

4.2 CLS Argos report for JCOMMOPS

CLS in close collaboration with JCOMMOPS will begin to submit a report on quarterly basis beginning 09-2012 including the following information:

- All new ocean and meteorological Argos programs created
- All new ocean and meteorological Argos ID numbers created
- Active Argos platforms without WMO ID number allocated
- All Iridium platforms processed at CLS

4.3 Argos data timeliness

The Argos Data disposal time is defined as the elapsed time between when an observation is collected by an Argos platform and is available to the user.

The Argos Data Mean Disposal Time is composed of four typical delays:

- T1 = the revisit time (time for a platform to be seen by one of the Argos satellite),
- T2 = the time for the data to be downloaded to a ground station (it's nearly instantaneous for an HRPT station or it's the time for the satellite to reach a global station),
- T3 = the data retrieval time (average time for the data to be transmitted to the Argos Data Processing Centers),
- T4 = the processing time (requisite time for the data to be processed in the Argos Data Processing Center and to be available for the users).

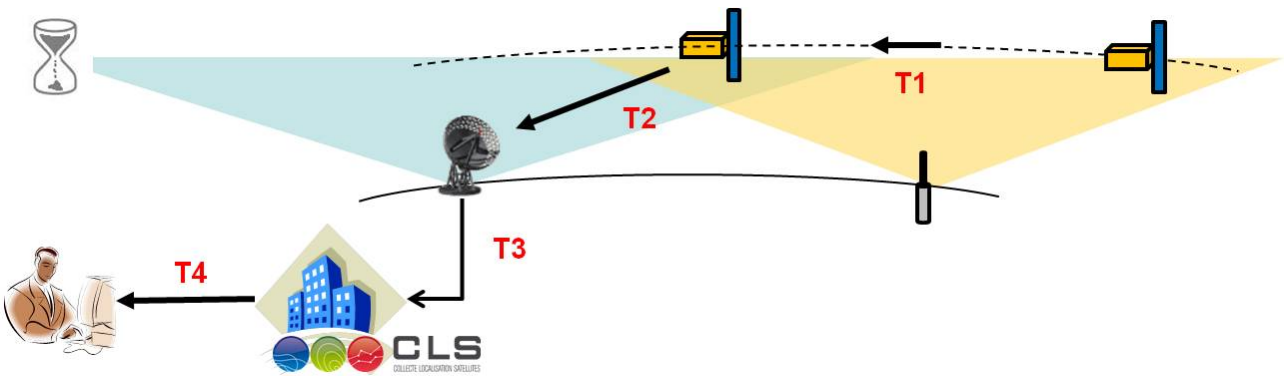

Figure 41 : Argos data mean disposal time diagram

The next figures represent the simulated Argos Data Mean Disposal Time taking into account the Argos satellites constellation, the Argos ground stations and data processing centers' performances in May 2012 and May 2013.

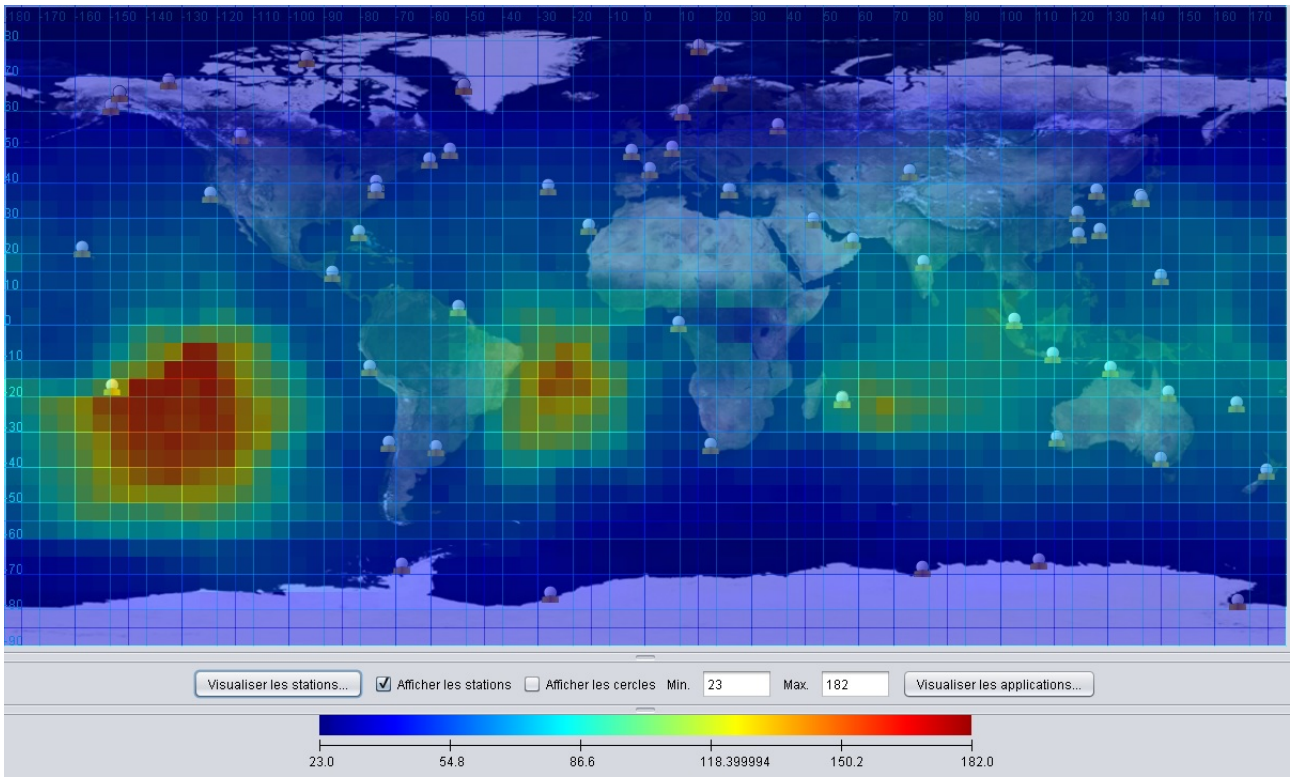

Figure 42 : Argos Data Mean Disposal Time in May 2013 (in minutes)

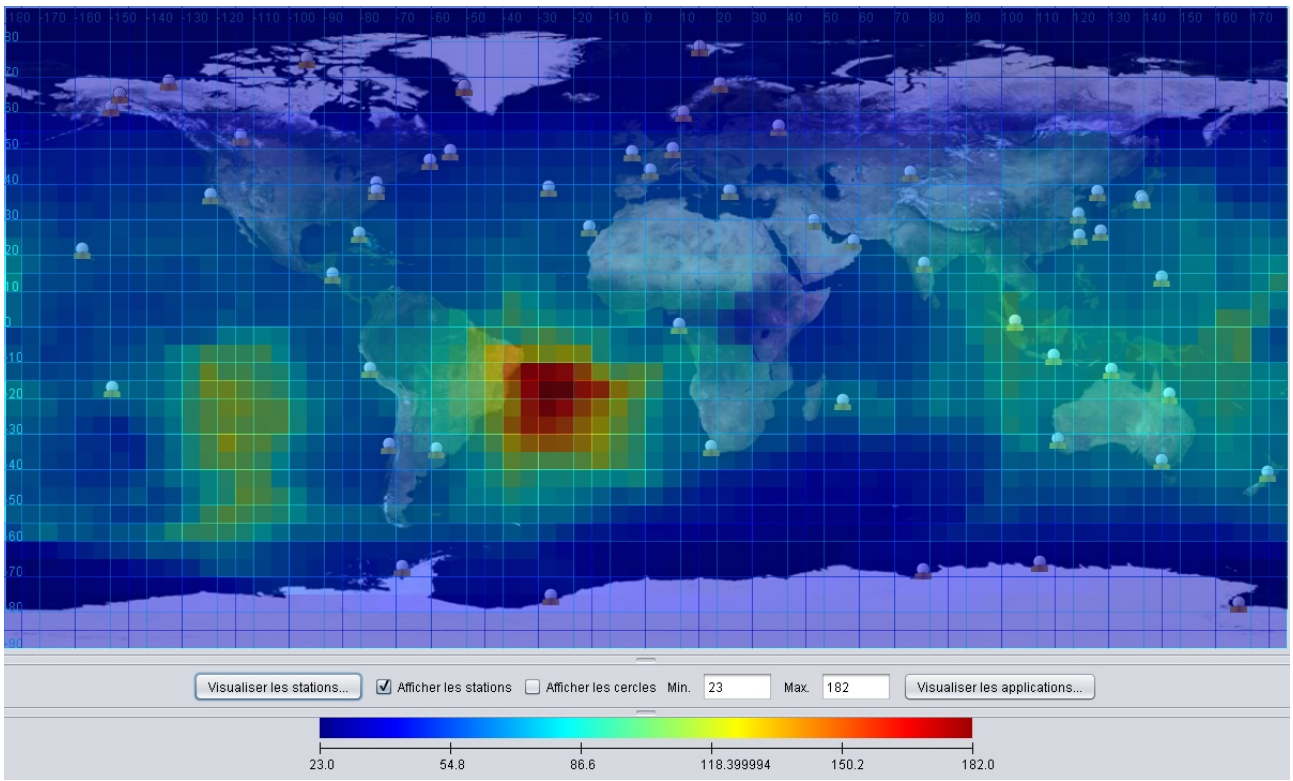

Figure 43 : Argos Data Mean Disposal Time in May 2014 (in minutes)

The improved performances in terms of data mean disposal time are mainly due to:

- The increasing number of upgraded stations in the network receiving all Argos satellites, including Saral satellite (ex: Tahiti, La Réunion, Miami, Hatoyama, Lima, Lannion,…)
- The new installed station at Tahiti in cooperation with Meteo France receives all satellites, including Saral satellite. This station replaces the Tahiti IRD station
- More HRPT Stations receiving MetOp Satellites data (Monterey, Hawaï, Lannion, Lima, Cape Town, Hotayama, EARS Stations,…).

Due to the failure of Libreville and Cayenne Station on the 1st semester 2014, we can observe an important degradation of the Argos mean disposal time in the South and Central part of the Atlantic Ocean.

Another minor degradation can be observed in the South West part of the Pacific Ocean due to the failure of Noumea Station.

Our efforts will continue to improve and maintain the coverage of the real-time antennas in the regions where it is needed. Two areas are concerned: South and Central Atlantic and South Pacific.

Concerning the south and Central Atlantic area

- A HRPT-A4 station receiving all Argos satellites installed at Libreville since June 2014.
- A HRPT-A4 station receiving all Argos satellites, shall be installed at Ascension Island during the 2014 second half.
- A HRPT-A4 station receiving all Argos satellites, shall be installed at Cayenne in the first half of 2015.

These 3 stations will cover the South and Central part of the Atlantic Ocean, including the Caribbean Sea. They will be complemented to the North by Miami and Mas Palomas and to the South by Cape Town and Buenos Aires to provide complete coverage of the Atlantic Ocean

Concerning the South Pacific area, a bi-band X and L station, able to receive all the satellites shall be installed late 2014 at Easter Island in cooperation with Meteo Chile. This station will be relayed to the North West by Tahiti, to the North by Hawaii and to the East and South East by Santiago and Rothera.

Unfortunately, Noumea station (IRD Station) is no more operational. It could be the next area where to install a new updated station.

4.4 Background noise measured in the Argos frequency band

The minimal received power measured by the in-flight Argos payloads permits to determine the geographical areas where background noise is present in the Argos frequency band.

After the one highlighted on Eastern Europe and Mediterranean Sea since the beginning of 2000's, a new large spot appeared and slightly increased for 5 years on Eastern Asia.

Studies at CLS and experiments with our partners are currently in progress in order to understand the origin of these potential interferers and to find applicative solutions to prevent impacts on deployed platforms missions in these areas.

The following maps show the minimal level of reception in dBm measured by METOP-A in May 2013 and May 2014. We can see the strong decrease in the level of the noise over the eastern part of the Mediterranean Sea and China.

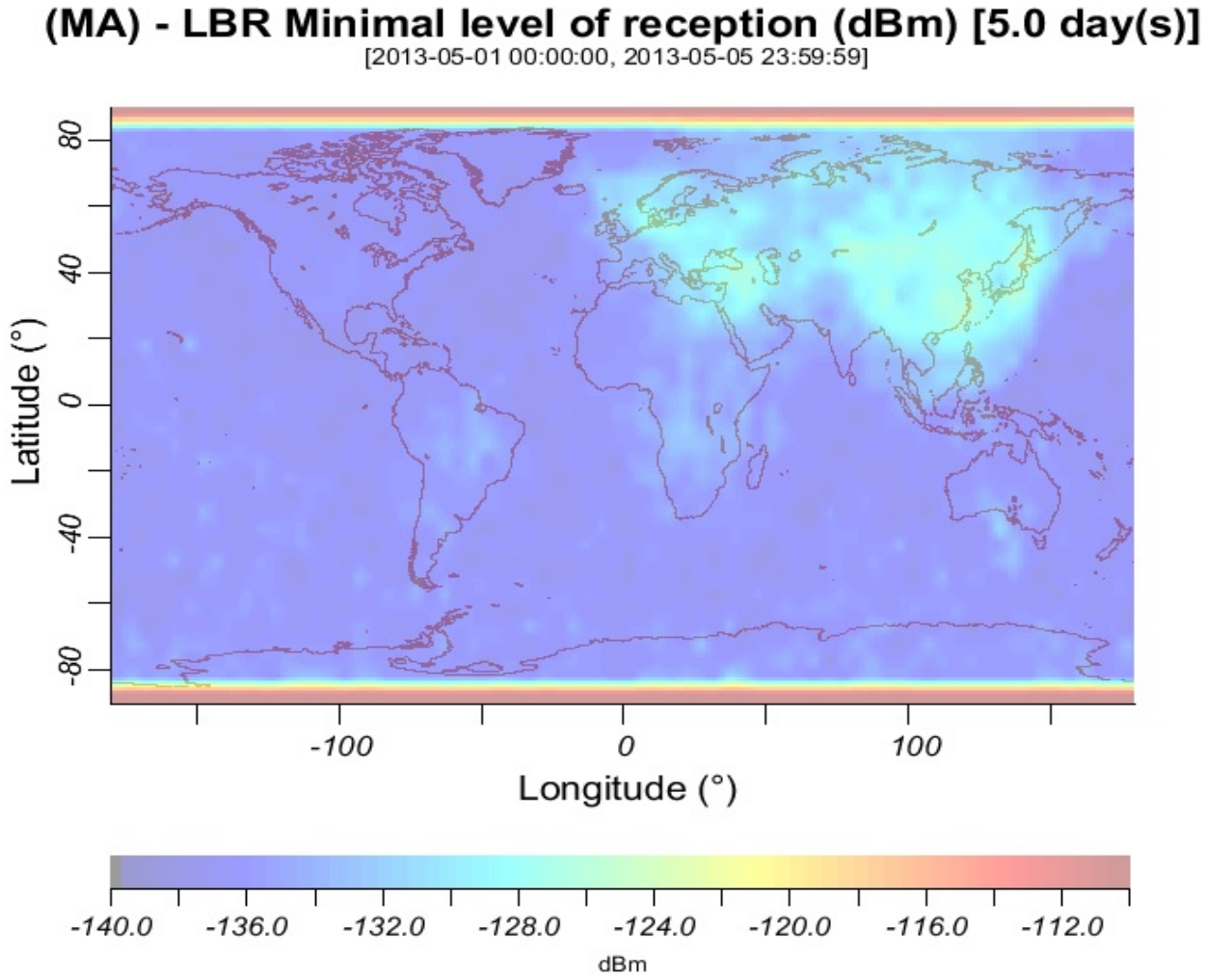

Figure 44 : Minimal level of reception in the Argos frequency band in May 2013

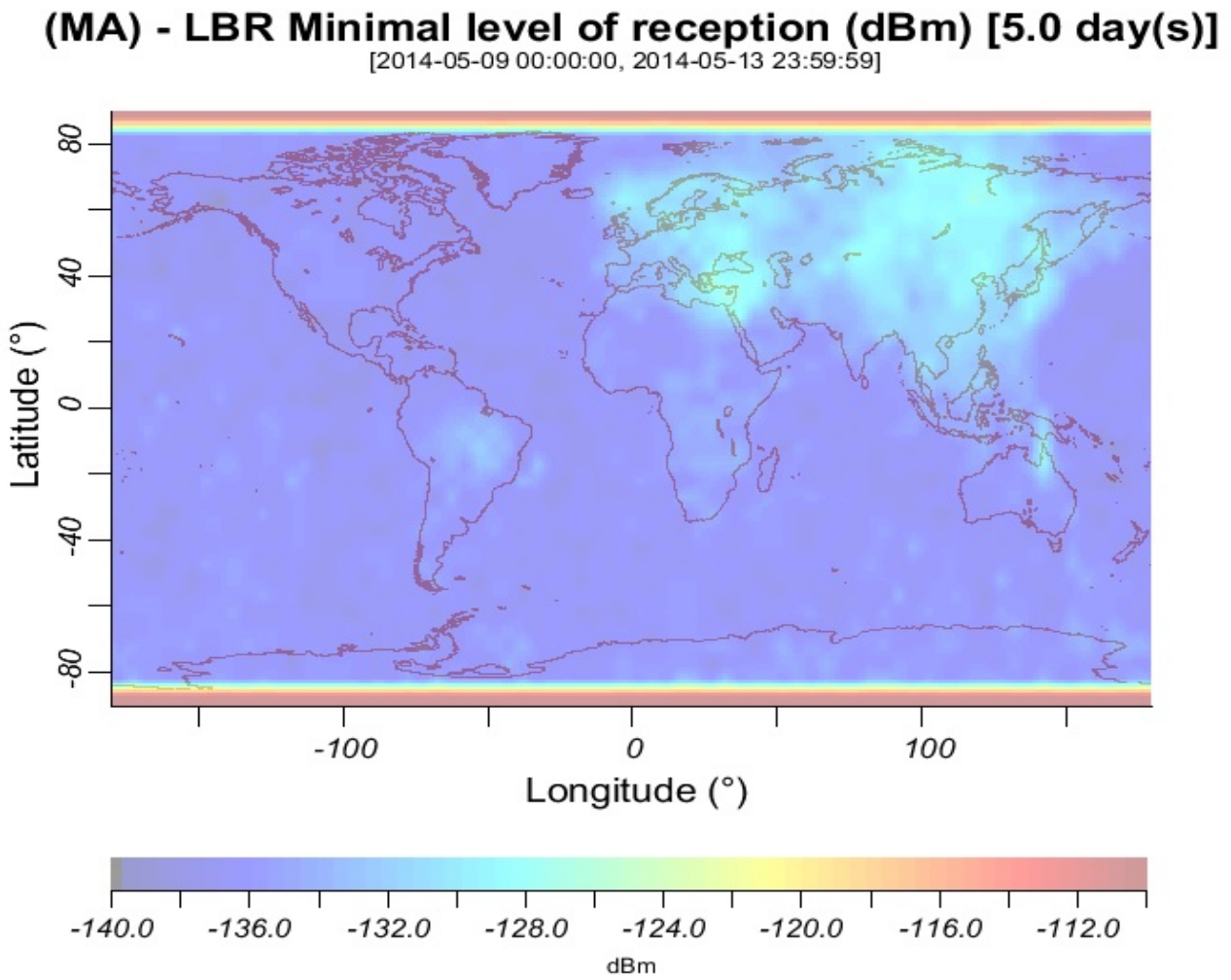

Figure 45 : Minimal level of reception in the Argos frequency band in May 2014

4.5 Argos-3

User applications of Argos-3 in 2013-2014 have been focused on implementing creative xmit/receive strategies using the Argos PMT with the goal of extending drifting buoy lifetimes. The figure below illustrates the dramatic increase in 2014 of the number of active Argos-3 (equipped with a PMT) operating in the Global Drifter Program. The DBCP is watching closely the lifetimes of these buoys in order to quantitatively evaluate the application of Argos-3 for drifting buoy communications.

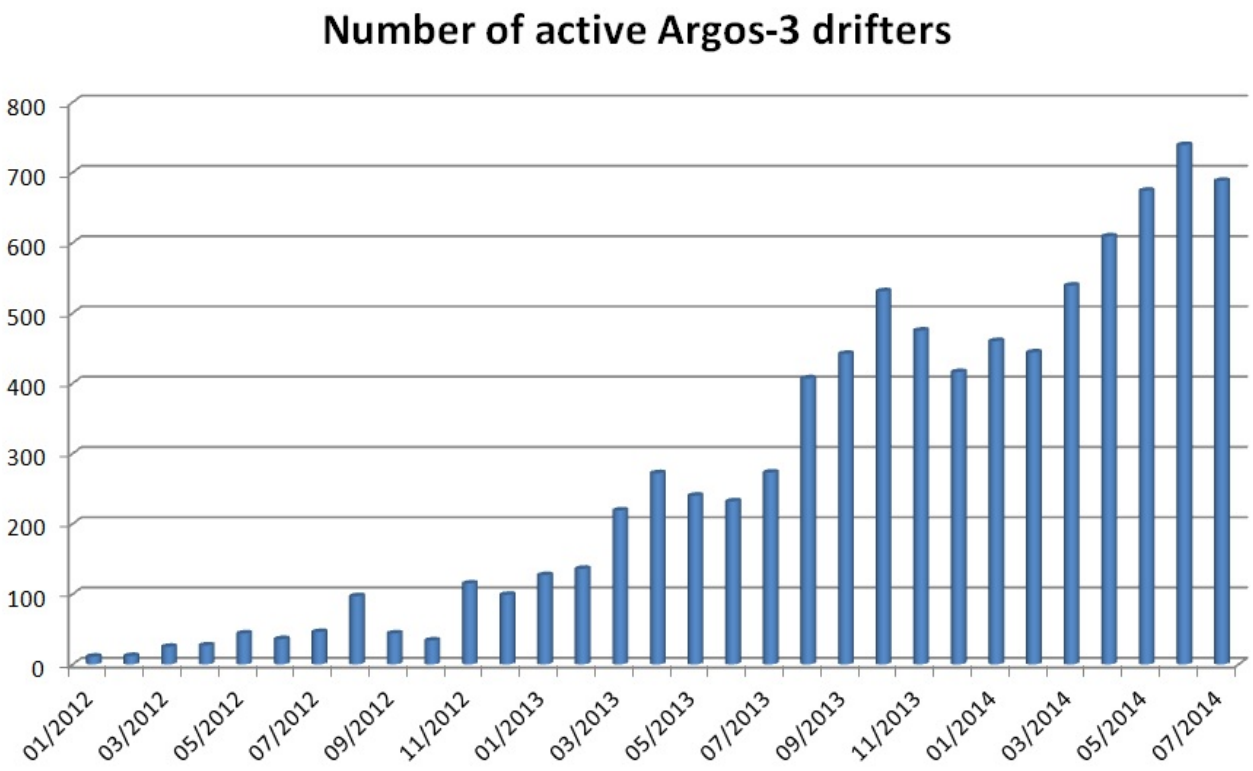

Figure 46 : Number of monthly active Argos-3 drifters in DBCP

4.6 Argos-3/Argos-4 chipset

Thanks to the Argos-3 implementation plan, we learned about the importance of low power consumption PMTs as well as an Argos-3/Argos-4 receiver for the Argos community.

The objective of the "Argos chipset" project is to design, manufacture and test a prototype of a miniaturized and low-cost ARGOS-3/-4 satellite chipset (Asic) that enables two way communications (Argos-3, Argos-4) and provides improved battery lifetime.

The project is called SHARC (**S**atellite **H**igh-performance **A**RGOS-3/-4 **R**eceive/transmit **C**ommunication) and is aimed at:

- Developing a low-cost Argos-3/4 chipset
- Developing a pop-up tag which uses the Argos chipset

In the frame of the European Artes-5 Program, the Belgium Space Agency together with CNES are supporting a 2 M€ contract for developing such solutions.

The project led by ANSEM (manufacturer of chipset) is in good shape:

- the ARGOS-3/4 has been fully defined and the first run of foundry has taken place. Currently, tests are being conducted at ANSEM facility
- The popup tag that will support the field application has been fully defined by StarOddi and will be manufactured at the beginning of this summer
- Finally CLS trough its expertise of the ARGOS system has provided all necessary information to ANSEM as well as to StarOddi to insure a well defined tag/chipset system

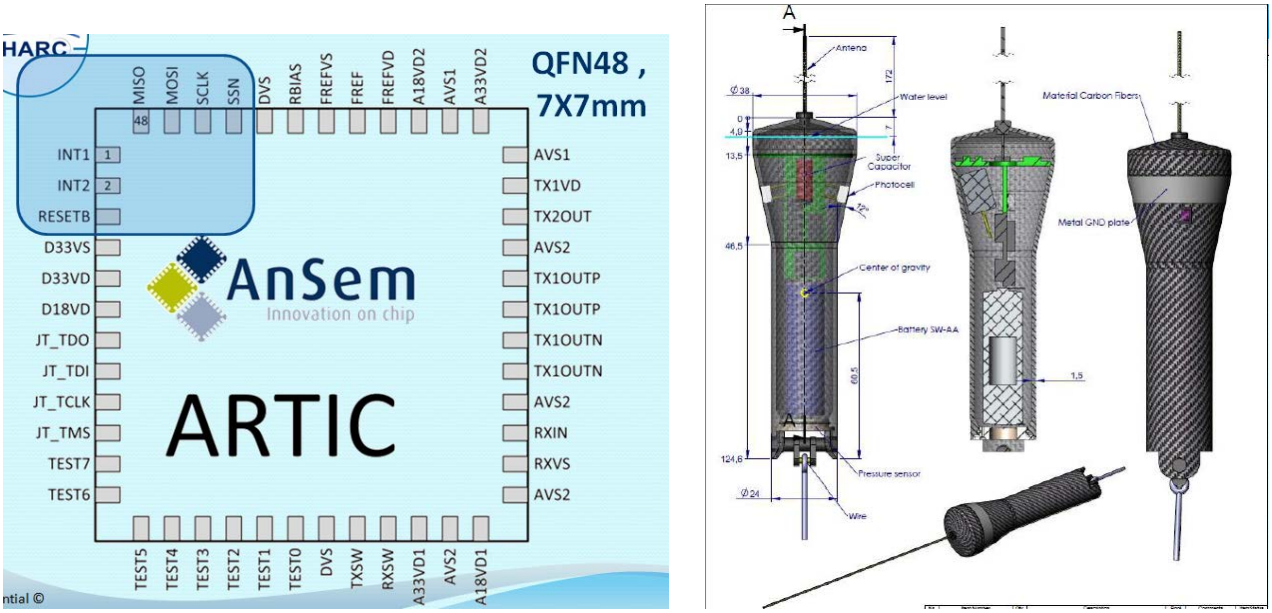

Figure 47 : Argos-3/4 chipset and tag scheme

Next important steps before the end of 2014:

- Tests and certification of the chipset at CNES facilities
- First tests at sea of the popup tag including the chipset

The SHARC project started in October 2012 and will end in March 2015. We expect the chipset to be 5mm X 5mm. It will include the Rx and Tx RF modules that will apply the Argos-3 and Argos-4 capabilities.

A key objective of this project is to offer to all Argos platform manufacturers the capability to integrate Argos-3 and Argos-4 functionalities at very low cost.

4.7 Argos goniometer

Figure 48 : New Argos goniometer

At the request of the Argos users who want to be able to retrieve their Argos transmitters (animal tracking, floats, drifting buoys,…) CLS contracted with the company Xerius, located in Toulouse to develop a new Argos direction finder.

After one year of study and development, the first prototype was delivered to CLS in March 2013. The tests and validation performed since April have been successful. SHOM, the French Navy, has already tested and approved the new Argos goniometer.

Depending to the goniometer antenna altitude, the Argos platform transmission power and the environmental conditions, the Argos signal can be received by the RXG-134 from few meters to more than 100 km.

Received Argos demodulated messages and Argos platform transmitter terminal (PTT) reception angle are displayed on the screen and available on the serial port.

The CLS goniometer is fully compatible with all Argos transmitter generations: from Argos-1 to Argos-3 including the PMT.