

# MEDaCoN: the Mediterranean EGNOS Data Collection Network

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## BIOGRAPHY

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**Antonella Di Fazio.** Graduated in Physics, she is project manager in Telespazio and responsible in the R&D department for projects related with Satellite Navigation applications and services. She is the coordinator various GSA 6<sup>th</sup> FP projects. Since 2000 and 5<sup>th</sup> FP, she is project manager of European projects (for ESA, EC) projects, dedicated to European GNSS. She is also responsible for proposals to European and National Institutions and private companies. She is member of working groups in the frame of National Intelligent Transport Systems (ITS) development initiatives, and member of the technical board for the preparation of the Italian ITS Strategic Plan. Before to join Telespazio, she worked in Alenia Aerospazio in the frame of EGNOS programme. She is the project coordinator of METIS.

**Santiago Soley.** Technical Director of his co-founded company Pildo Labs. Graduated with a MSc in Telecommunication Engineering from the Universitat Politècnica de Catalunya in 1998, he started to work on Satellite Navigation in 1997 with Indra-Espacio S.A. In 1999 he joined the ESA Galileo Team to work on the Definition Phase of Galileo. Since October 2000 he has been providing support to Eurocontrol in all related activities to GNSS-1 Operational Validation, and the introduction of GNSS systems use for Civil Aviation. He is responsible for the coordination of the Eurocontrol EGNOS SIS Validation activities, manager of the EGNOS Data Collection Network, and member of the EGNOS Certification Task Force. In addition, he has been responsible of different flight trials and demonstrations organized by Eurocontrol and some Member Stakeholders in support to the validation and operational testing of the new operations enhanced with the GNSS augmentation systems in the Civil Aviation domain. Among others, he has been leading the Eurocontrol SBAS trials in Nice and Sion, and the first European GBAS tests at Frankfurt and Toulouse Airports. Pildo is also providing the first certifiable SBAS avionics platform in support to the GIANT demonstrations with the Spanish Airline AirNostrum, managed by AENA and under supervision from GSA.

## INTRODUCTION

This paper describes the **Mediterranean EGNOS Data Collection Network (MEDaCoN)** to be performed by the **METIS** project. METIS (MEdiTerranean Introduction of GNSS Services) project has been launched by the Galileo Joint Undertaking (GJU) in July 2006, in the framework of the Euro-MED GNSS I Programme to pave the way for GNSS services in the Mediterranean region. METIS is now entrusted to the European GNSS Supervisory Authority (GSA) and is coordinated by Telespazio. METIS web site is at the URL: <http://www.aui.ma/GNSS/metis>.

METIS main outcome is a GNSS Regional Plan, the roadmap for the GNSS services market development in the MEDA region, covering the next 5-10 years, to facilitate the introduction of the full Galileo services, initially through EGNOS.

To achieve its goal, METIS has put in place a programme of three main activities, running throughout the MEDA region:

- A- Assessing necessary **policies and actions** in favour of a progressive GNSS services market implementation
- B- Running a **training and awareness** programme
- C- Implementing **GNSS service demonstrations**.

These are performed in parallel with the relevant infrastructure preparation for GNSS SIS (Signal In Space)

Provision Activity in the region, undertaken by ESA, the European Space Agency.

METIS includes 10 service demonstrations, distinguished into 6 Local Area Demonstrations, at country level and 4 Wide Area Demonstrations, at regional level (at least 3 countries); one of them is the Mediterranean EGNOS Data Collection Network (MEDaCoN), managed by ESSP (European Satellite Service Provider), and object of this paper.

MEDaCoN is composed by a network of data collection stations in the MEDA Area connected to a data collection server sited in Egypt. MEDaCoN will provide information about the status and the performances of EGNOS over the MEDA area, then including also the EGNOS SiS extension under implementation in the MEDA area.

## **OBJECTIVE AND BACKGROUND**

Objective of MEDaCoN is to provide his local partners with a coordinated tool for the real-time monitoring of the status of the EGNOS service extension in the Mediterranean region, with the following advantages:

- Support the involved local actors in practical learning and understanding of GNSS principles;
- Facilitate local activities, like local demos, academic works and application development and test;
- Increase the confidence about the system and the services, giving a “touch” of actual performances and a precise view of what can be expected in terms of performances in a specific period of time.

MEDaCoN will use the EGNOS signal available over the MEDA region. Signal available in the area belongs to elements deployed as part of the EGNOS basic initial architecture and to elements under deployment within the EGNOS extension programme in the frame of the ESA’s GNSS Support Programme. Such programme regards the installation of 4 additional RIMS to the present EGNOS RIMS ground network, planned to be connected to the network in the 2007-08 and sited in:

- Tel Aviv, Israel
- Abu Simbel, Egypt
- Tamanrasset, Algeria
- Agadir, Morocco

Previous experience made in Europe with the Eurocontrol’s EGNOS Data Collection Network, set-up by Eurocontrol, confirms that continuous GNSS data logging and tests, other than helping the user level assessment of the performances, is one of the best activity to promote gain on knowledge about GNSS, both on technological than functional point of view, as well as to facilitate the application development.

Within a University or Research environment (including Air Navigation Service Providers experimental centers), it offers the potential to promote trials, and development of research activities. In the past years (but also today), such EGNOS Data Collection Network has served to all the actors involved (including main European ANSPs) to learn about the EGNOS system and understand how an SBAS system works and its performances.

From this successful experience, here is the idea to extend these activities in order to provide the means to acquire and develop such knowledge to the MEDA partners. Therefore, it is though than the possible extension of these activities for the MEDA region would provide the means to acquire and develop such knowledge too. Tested and reliable tools and processes, made available from the EDCN to be used in the MEDaCoN, will ease the task to get those stations set up on the region.

Moreover, past experiences in Europe showed that sometimes an incomplete knowledge about the status of the system, missing real status of the provided service in a specific area, made difficult to plan successful demonstration, with the risk to decrease the confidence around the system.

In the next future the Europe-Mediterranean GNSS infrastructure will be characterised by the following phases that impact at different level the provided service performances, especially during the transition periods:

- a) EGNOS qualification and Services start-up, planned mid 2008;
- b) EGNOS infrastructure extension in the South-Mediterranean region, in 2008;
- c) EGNOS infrastructure extension in the Middle-East, in advanced study phase;

Therefore, it is though than the possible extension of such a EGNOS Data Collection Network for the countries inside the Mediterranean Region would provide a precise view of what can be expected in terms of performances in specific period of time.

The geographical extension of the MEDaCoN is in the following figure:



**Figure 1 - MEDaCoN extension and sites**

MEDaCoN then answers to the need to perform data collection over MEDA Area on a regular basis in order to establish a good understanding of the performance of an SBAS Signal-in-Space over a longer time interval and over an area with a good geographical distribution, and to start building up experience on the data processing and analysis techniques to be used in the operational validation process. With this objective in mind, MEDaCoN is going to be established as network of eight data collection stations, to perform weekly ESTB data collections and analysis of the obtained results.

The team participating to MEDaCoN is composed by European and MEDA partners; the European Satellite Services Provider (ESSP), Belgium is the leader, supported by Pildo Labs as main technical partner. Today, MEDaCoN foresees the participation of entities of 8 MEDA Countries (Algeria, Morocco, Tunisia, Egypt, Israel, Jordan, Palestinian Authority, Turkey), promoting technical exchange between the different countries. Such MEDA partners will host one or more of the elements of MEDaCoN. They are mainly National Air Navigation Service Providers, University and Research Institutes. The Galileo Euro-Med Cooperation Office (GEMCO) will also participate to MEDaCoN in supporting related training activities.

MEDA partners will participate to MEDaCoN by:

- Hosting a MEDaCoN Data Collection station or server;
- Supporting the local and global analysis;
- Support to dissemination of the data;

The next figure details the role of the different entities involved in MEDaCoN.

	ESSP Belgium	PILDO Spain	FDC France	GEMCO Egypt	NANSC Egypt	AUI Morocco	TECHINION Israel	TURKSAT Turkey	JUST Jordan	IT.COM Tunisie	ARCE Algeria	ARJI Pal Auth
1 Management	Demo Coordination		Contractual Support									
MEDCoN set-up	Site selection, Demo Plan	Requirements										
2 MEDCoN Server	Procurement, Installation, Configuration, Networking (Mirror Site)	Support, Configuration			Procurement, Installation, Configuration, Networking (Basic Site)							
MEDCoN Stations		Support, Configuration		Procurement, Antenna Site selection, Installation, Configuration, Networking								
3 MEDCoN Maintenance (1 year)	Mirror Maintenance	Network Management, User Support, Transfer of Knowledge			Server/Station Maintenance, Handover	Station Maintenance						
Data Collection Training Course (1 day)	EGNOS System & Service part	Previous Experience, Technical part		Training hosting	Participation							
4 Local activities (training/awareness)	European awareness activity, support			Local Training & awareness								
Web-pages	Provision of technical contents				Arab pages	Hebrew pages	Turkey pages					
5 Data Collection and Presentation	Service Quality	System Performances			Local Assessment							

**Figure 2 - MEDaCoN partners and role**

The flexible architecture of MEDaCoN make easy his extension to cover other EGNOS service extension areas (like

the ACAC zone), as well as to connect it to the EDCN allowing a global analysis of the whole EGNOS coverage.

## **MEDaCoN DESCRIPTION**

It is foreseen to install a **Data Collection Station** in each MEDA Country involved in the MEDaCoN: precise locations for the stations will be chosen in order to obtain a wide representative area, and according to practical and environmental considerations (like interferences).

Due to the educational nature of the MEDaCoN, the preferred option is to install the stations to University and Research Institutes premises: in this way, the environment provides the means to the students and technical people to work and develop further local activities (demos, national pilots, awareness and training) around the MEDaCoN activity. Local LBS Companies (with many contacts with Institutions and Research entities) are also a good opportunities because they can guarantee a basic knowledge of GNSS that facilitate the MEDaCoN set-up and operation. Other options, like ATSP or other institutions have been also interesting possibilities for the site installations, and their link to the first real exploitation of the EGNOS capabilities.

Each Data Collection Station is composed by:

- a GPS/EGNOS antenna, located in a place with free sky view and minimum possible generators of multipath around; antenna location would be precisely surveyed using Phase processing techniques: multipath characterization would be done on the located site to assess whether local effects could mainly contribute to the performance;
- an EGNOS receiver;
- a PC for data storage and communication management;
- an Internet connection for remote monitoring, control and data collection.

The Data Collection Station will receive the EGNOS signals, store the data and perform preliminary analysis. These data will be remotely and periodically read from the Data Collection Server.

A **Data Collection Server** will be deployed in the Area: in principle his location will be in Egypt. Data results will be automatically send and storage from the MEDaCoN Stations to the MEDaCoN Server, as done in the European Data collection network. The installation of a mirror server in ESSP is foreseen for data safety.

The Data Collection Server is composed mainly by:

- a PC for storage and communication management acting as central FTP server;
- an Internet flat connection (always-alive) for data collection.

The **Network Management** of the MEDaCoN will be done remotely by the PILDO Labs server.

In terms of **Tools**, MEDaCoN will reuse at maximum all the tools already developed by Eurocontrol in the frame of the existing Data Collection Network. That has been agreed between Eurocontrol and the partnership of the activity, and coordination would be assured as such to get the latest versions of the tools.

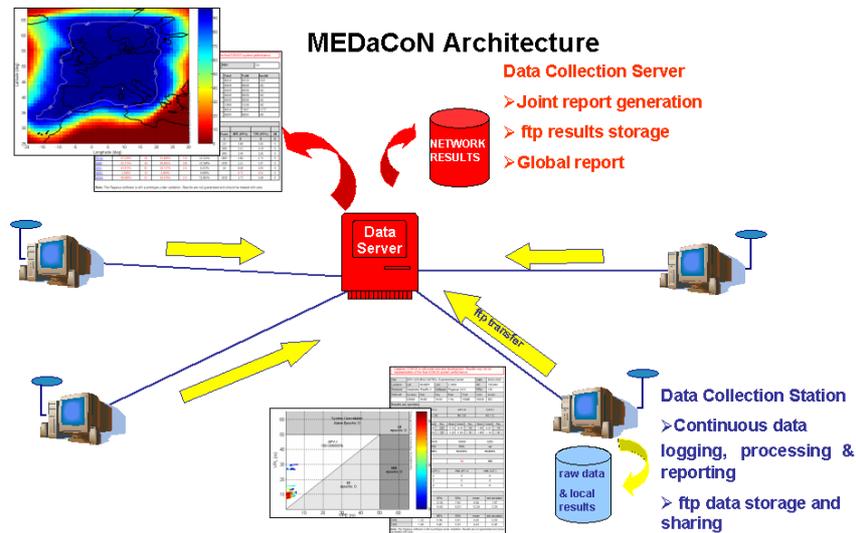
Proprietary Software of the receiver manufacturer would be installed in the computer for raw data logging, while the PEGASUS software will be in used for the raw data processing and performance assessment. PEGASUS is a software able to process receiver-native data from a set of SBAS receivers, and compute the position and integrity solution in accordance with the RTCA MOPS DO229 standards. PEGASUS was designed to facilitate the output data handling and interchange. The tool provides several functionalities such as computation of position and GNSS systems attributes like accuracy, reliability, and availability simulating MOPS-compliant receivers, computation of trajectory errors, prediction of accuracy and availability with the required integrity and simulation of GBAS Ground Station processing algorithms

The tool has been developed in the frame of the SBAS and GBAS Operational Validation activities and is the standard processing and analysing tool to be used in the future EGNOS and GBAS operational validation and in support to the EGNOS Certification processes.

All the software and main tasks would be automated thanks to the installation of the Doit software package also developed under responsibility of Eurocontrol. Doit would automate all the processes without requiring human interface, from data logging to data processing, as well as report generation and mail to the central ftp.

## **DATA ANALYSIS**

The following figure shows the functional architecture of MEDaCoN.



**Figure 3 - MEDaCoN functional architecture**

When computing the achieved performance from measured data, it is necessary to define specific test and clear pass-fail criteria for each of the different system or service parameters. Those methods for evaluating the different parameters from measured data, constitutes one of the three identified main axes in the methodology proposed for the activity to analyse the data collected and correlate it with the system and service performances:

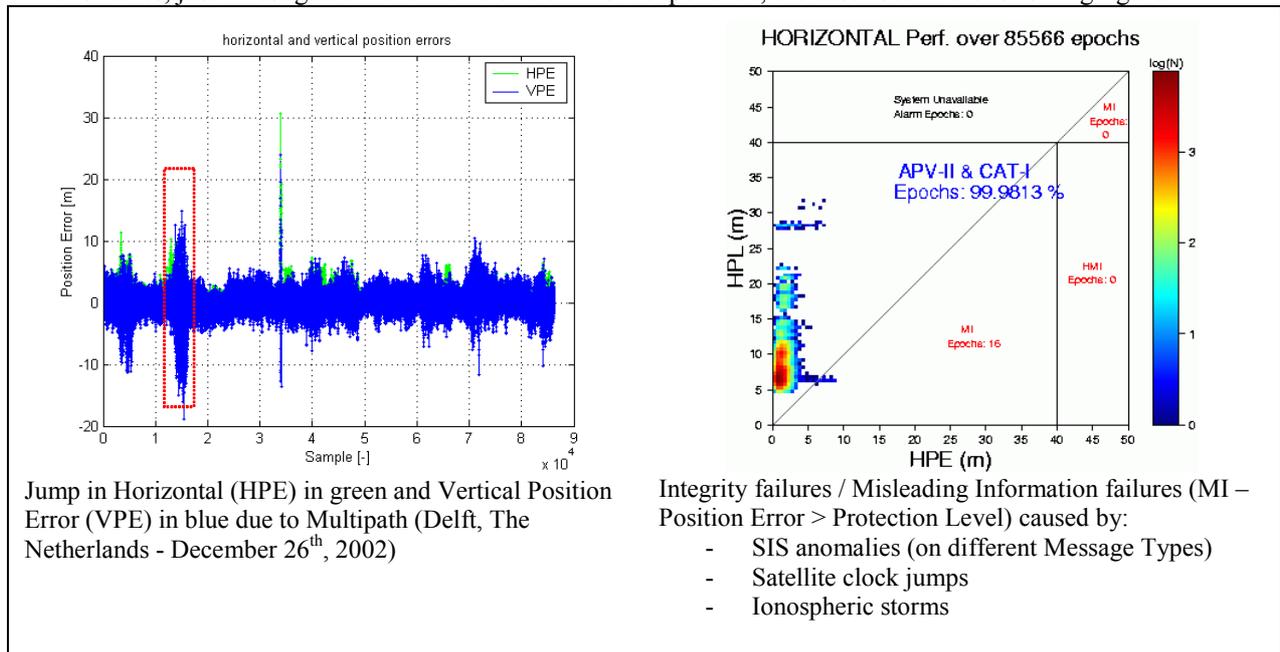
- The system performance achieved at each data collection site will be assessed on a daily basis. These local performances will be checked against the accuracy, integrity, availability and continuity defined requirements. A first glance report on these performances will be generated automatically by the PEGASUS software and send via ftp to the Data Collection Server. An example of a first glance report is in the next figure, taken by the Eurocontrol Experimental Centre station from the EDCN

Caution: EGNOS is still under test and development. Results may not be representative of the final EGNOS system performance.										
Site	[EEC1] EUROCONTROL Experimental Centre						Date	04/05/2007		
Location	Lat:	48.600	Lon:	2.347	Alt:	136.41				
Receiver	Septentrio PolaRx 2		Software	Pegasus 4.2.1 <sup>300131</sup>		PRN	120			
Data set	Duration	Start	Stop	Expected	Total	SBAS Msg	Valid	Valid(%)		
1 Hz	24h00	00:00	23:59	86400	86399	86398	86399	<b>100%</b>		
<b>Results per operation</b>										
	all valid samples	APV-I		APV-II		CAT-I				
HAL / VAL		40 / 50		40 / 20		40 / 12				
<b>Accuracy (m)</b>										
		Meas.	Scaled	Req.	Meas.	Scaled	Req.	Meas.	Scaled	Req.
HNSE(95%)	<b>1.65</b>	1.65	8.41	16	1.65	8.42	16	1.60	8.21	16
VNSE(95%)	<b>1.75</b>	1.75	6.86	20	1.71	2.74	8	1.62	1.88	4
<b>Availability (%)</b>										
samples	86399	86399		85655		50325				
Minimum Required	99%		99%		na					
Availability	<b>100%</b>		<b>99.139%</b>		<b>58.247%</b>					
<b>Continuity</b>										
Events			<b>52</b>		<b>1448</b>					
<b>Integrity</b>										
	MI	HMI APV-I		HMI APV-II		HMI CAT-I				
Total	<b>0</b>	0		0		0				
Horizontal	<b>0</b>	0		0		0				
Vertical	<b>0</b>	0		0		0				
<b>Protection level statistics</b>										
	<b>99%</b>	95%	50%	mean	std deviation					
HPL	<b>17.18</b>	10.69	7.57	7.94	1.84					
VPL	<b>19.61</b>	16.51	11.45	12.04	2.47					
<b>Position error statistics</b>										
	99%	<b>95%</b>	50%	mean	std deviation					
HPE	2.53	<b>1.65</b>	0.98	1.03	0.36					
VPE	2.30	<b>1.75</b>	0.46	0.47	0.67					

*Note: The Pegasus software is still a prototype under validation. Results are not guaranteed and should be treated with care.*

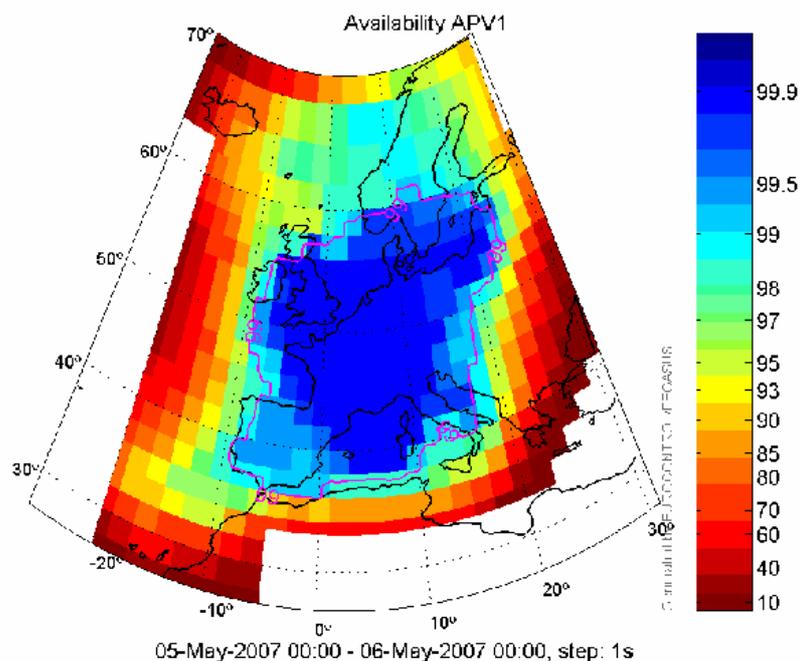
**Figure 4 - Example of First Glance report of EGNOS (EEC May 2007)**

- The anomalies that have been identified in the local performance will be analysed in detail to identify the cause, the probability of re-occurrence and possible mitigation techniques. Local effects such as multipath, antenna/ receiver effects, malfunctions of the signal in space, or other unexpected effects like ionospheric storms, GPS satellite clock malfunctions... etc could be the cause of the encountered anomalies. Some possible anomalies, just investigated in the frame of the EDCN experience, are described in the following figure.



**Figure 5 - Example of EGNOS performances anomalies measurable by MEDaCoN**

- A global assessment will be performed based on the local and daily data sets. The extrapolation method is based on the estimation of the protection levels from the broadcast messages and comparison against the Alarm Limits to the whole EGNOS Service Area providing estimated availability and continuity maps. This estimation method is based on the real SBAS data broadcast collected in one trusted location inside the EGNOS service area and the real GPS ephemeris and almanacs. The method is limited in the assessment of the performance, due to a lack of real measurements of the GPS data. Without this data the assessment on the Accuracy and the Integrity is impossible. This assessment will address the spatial and temporal stability of the performance generating availability maps like the one below.



**Figure 6 – EGNOS Availability (APV-I) on 6th May 2007**

The next figure presents the MEDaCoN set-up and first year operation schedule that will happen in the frame of the METIS project.

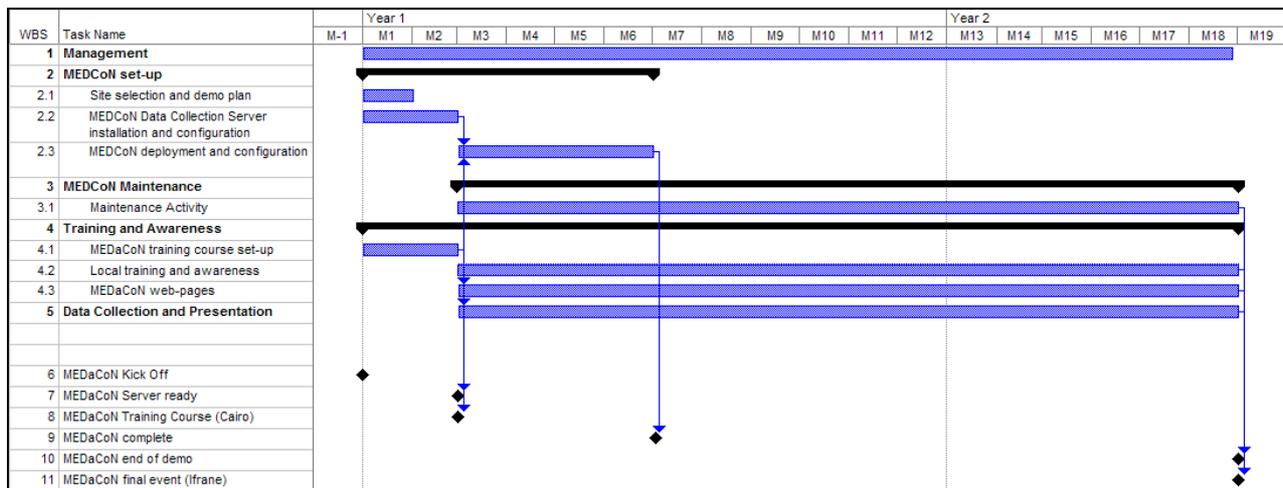


Figure 7 - MEDaCoN first 18 months schedule

## PRESENTATION OF RESULTS

Due to the educational structure of MEDaCoN, communication of results and analysis is one of the main activities of MEDaCoN. It will be performed at different levels:

- **Training** will be provided to the Data Collection Stations responsible; to optimise time allocation and reduce cost, a training course on how to handle the processes required to manage a data collection site, as well as how to process GNSS data with the provided software will be done with the participation of all the different entities part of the activity. Over than Data Collection Stations set-up and operation, the course will also present EGNOS Operation and Service Provision principles, in such a way to create the basis for a further use of the collected data. The course is proposed to be held in the Galileo EuroMED Cooperation Office.
- **Web-site Data Publication.** The METIS web-site <http://www.aui.ma/GNSS/metis> developed for the whole project, will include a specific section dedicated to the publication of collected data in textual and graphical way. The system performances will be mapped on the service requirements, in order to show the applicability of EGNOS to different applications. These pages will be done in English, Arab, Hebrew and Turkey languages.
- **Symposium and Workshop.** As done for the Eurocontrol Data Collection experience, the collected results will be also presented in local and international symposium and workshop, involving the Euro-MED partners.
- **Local activities, like Local training courses or specific Academic activities;** hosting a station of the Data Collection Network will allow the MEDA partners to organise local training and dedicated academic activities (thesis, PHD, seminars) about the use of the equipments, the analysis of the performances, and the development of pilot applications; for this reason, University will have the technical support in performing dedicated academic activities, including the development of pilot applications.
- **Final event.** A final event will be done in Morocco, in order to present the results of the data collection period.

Today MEDaCoN is finalising the technical aspect of the partnership with the local actors; in the same period, a survey on the different receivers available and suitable for the EGNOS data collection and analysis has been performed. The start of the activities is planned for July: it will be announced through the METIS project dissemination channels: METIS Web Site (<http://www.aui.ma/GNSS/metis>) and the METIS project Newsletter.

## ACKNOWLEDGEMENT

The work presented in this paper is part of the METIS project. The team participating to MEDaCoN is composed by European and MEDA partners. The EU partners are:

- European Satellite Services Provider (ESSP), Belgium; Demonstration leader
- Pildo Labs, Spain; Technical partner

Today, MEDaCoN foresees the participation of partners coming from 8 MEDA Countries that will host a MEDaCoN data collection station or the data collection server. They are:

- Association for Research on Climate and Environment (ARCE) – Algeria;
- National Centre of Spatial Techniques (CNTS) – Algeria;
- National Air Navigation Services Company (NANSC) – Egypt;
- Israel Institute of Technology (TECHION) – Israel;

- Jordan University of Science and technology (JUST) – Jordan;
- Alakhawayn University in Ifrane (AUI) – Morocco;
- Applied Research Institute - Jerusalem (ARIJ) – Palestine;
- Elzalacom (EAC) – Tunisia;
- IT.COM – Tunisia;
- Turksat – Turkey;
- The Galileo Euro-Med Cooperation Office (GEMCO) will host the MEDaCoN training course.

The MEDaCoN Team would like to acknowledge **Eurocontrol** for the support to the activity through the provision of tools and procedures developed previously in the frame of the EGNOS Data Collection Network.