Centre of Space Techniques

Feasibility study and site choice for an EGNOS station in Algeria

S. KAHLOUCHE, L.TABTI
Space Geodesy Department
Email : kahlouche@asal.dz

INTRODUCTION

GNSS (GPS, GLONASS, GALILEO, BNSS) :
Positioning (position, speed, acceleration) in a terrestrial reference system

NEEDS: GNSS applications developed in Algeria :

- Standard Localisation (accuracy: dm < σ < dam)
- Geodesy (National network, Cadastral Networks, Urban Networks, ..): $\sigma < 10^{-6}$ D
- Industrial Risks: Auscultation of Dams, bridges, GNL tank storage,.....
- Public Works (Roads, Rail Infrastructure. ...)
- Scientific applications: crustal, tectonic movements, atmospheric modelling (TEC), Climate Change (IVW) ..(10^{-6} D< σ < 10^{-8} D)
- **Navigation**: Terrestrial, Maritime, **Aerial**, ..) : positioning and navigation in real time (Position, Cap, Speed,...)

PROBLEMS : Accuracy in Real Time insufficient + **Integrity** $\Rightarrow$ EGNOS

EGNOS, it's there. Use it.

SBAS (EGNOS ?)

EGNOS (European Geostationary Navigation Overlay Service) responds to the needs of civil aviation by providing **accurate** positioning and **integrity,** that is means providing the user information on the reliability of the GPS (Galileo) in the form of confidence levels and alarms in case of anomalies.

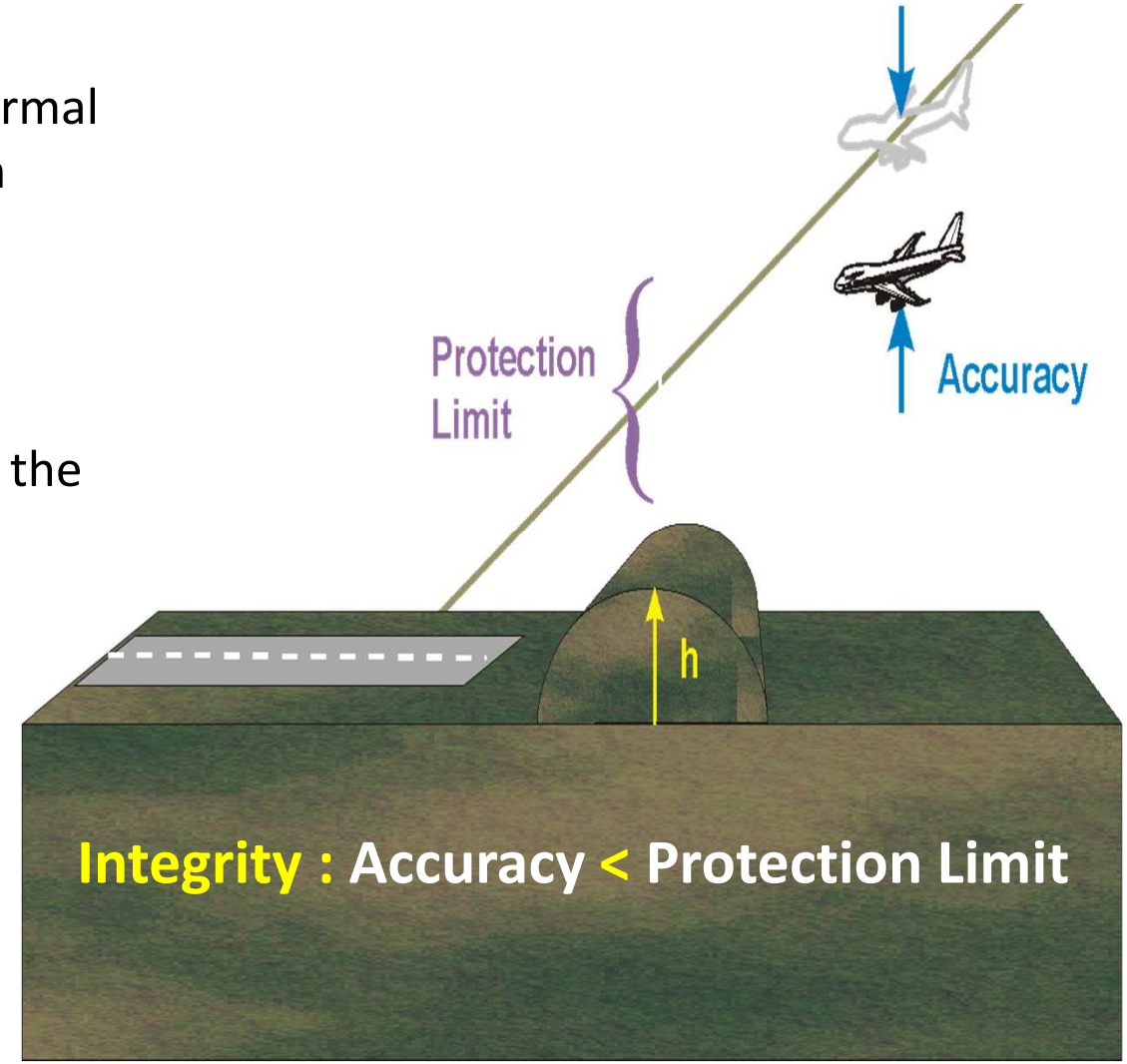
Performances: ICAO Requirements

1. Accuracy : Characterise typical behaviour of the system in presence of nominal errors

2. Integrity : Limit risk from abnormal behaviour affecting the system
- Integrity risk
- Maximum tolerable error
- Time to alert

3. Continuity : Limit risk of losing the service unexpectedly

4. Availability : Fraction of time that one has accuracy + integrity + continuity



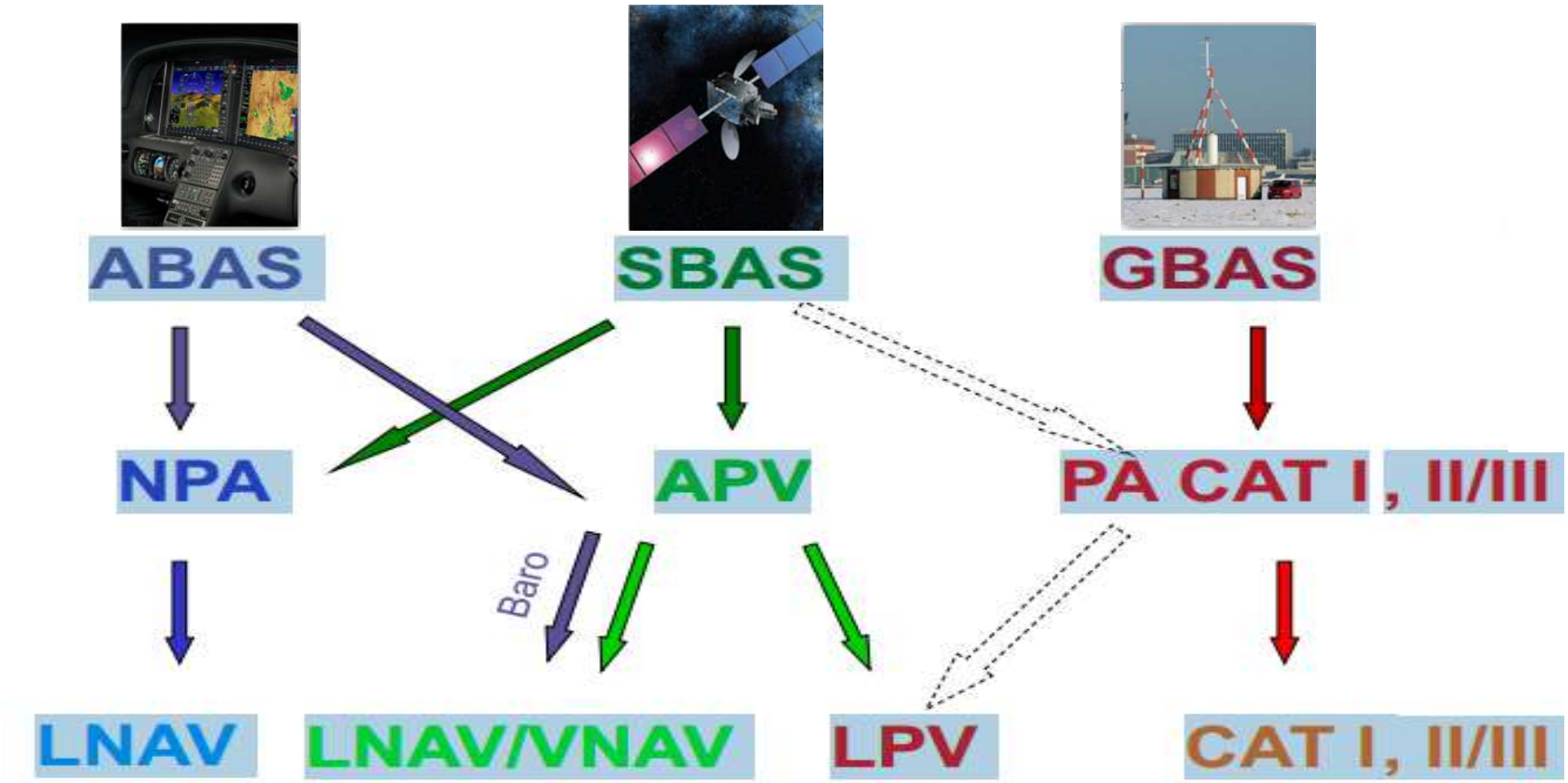
***HPE** : Horizontal Position Error, **VPE** : Vertical Position Error, **HAL** : Horizontal Alarm Limit*

Satellite Based Augmentation System : SBAS

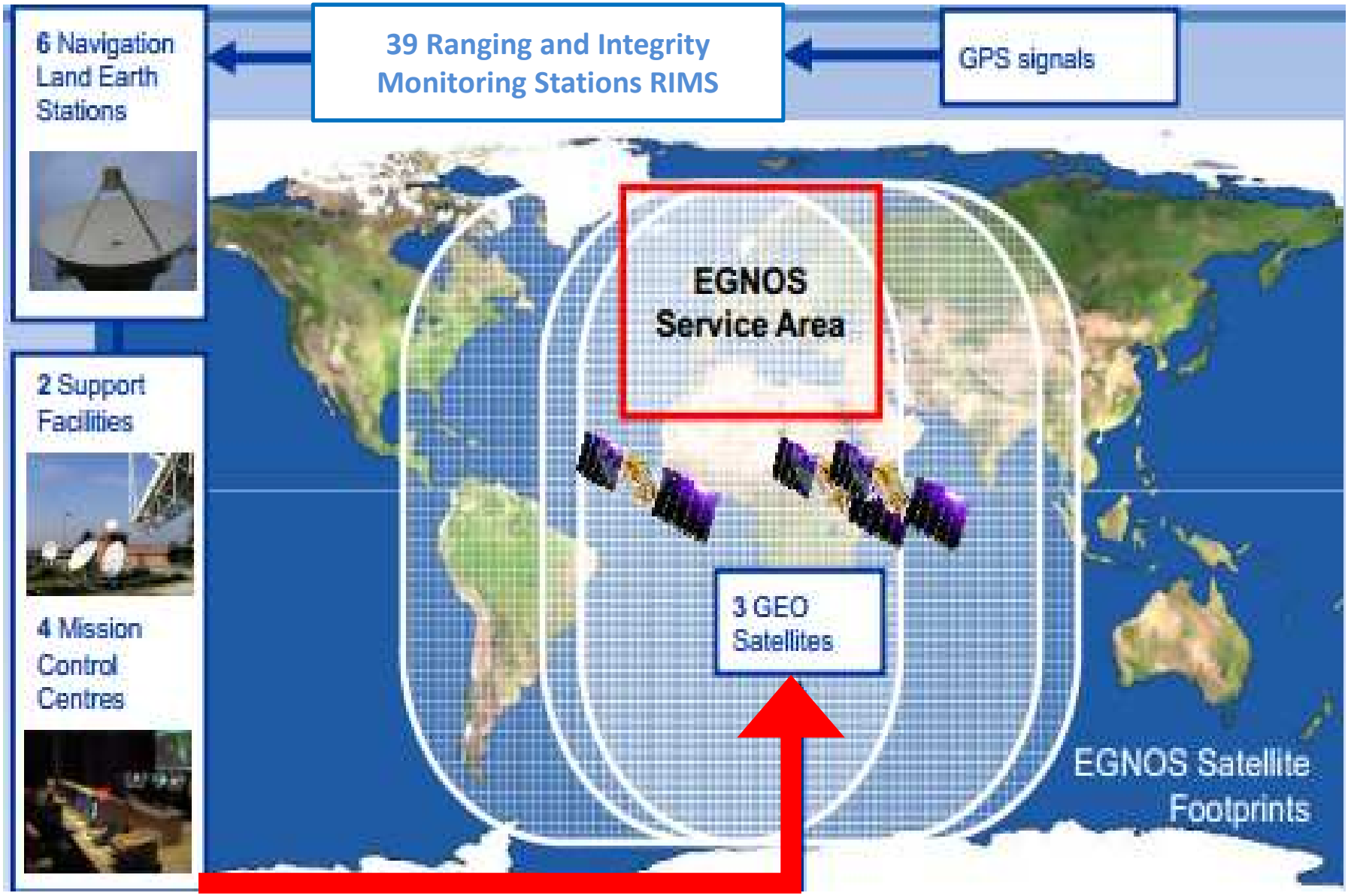
SBAS is a navigation system that **supplements** Global Navigation Satellite Systems providing a **more accurate and reliable navigation service than GNSS alone**.

SBAS Benefits

SBAS provides a more **accurate** navigation service than GNSS and also provides the high level of **integrity** required for most aviation navigation operations.



EGNOS System Architecture and Service Area

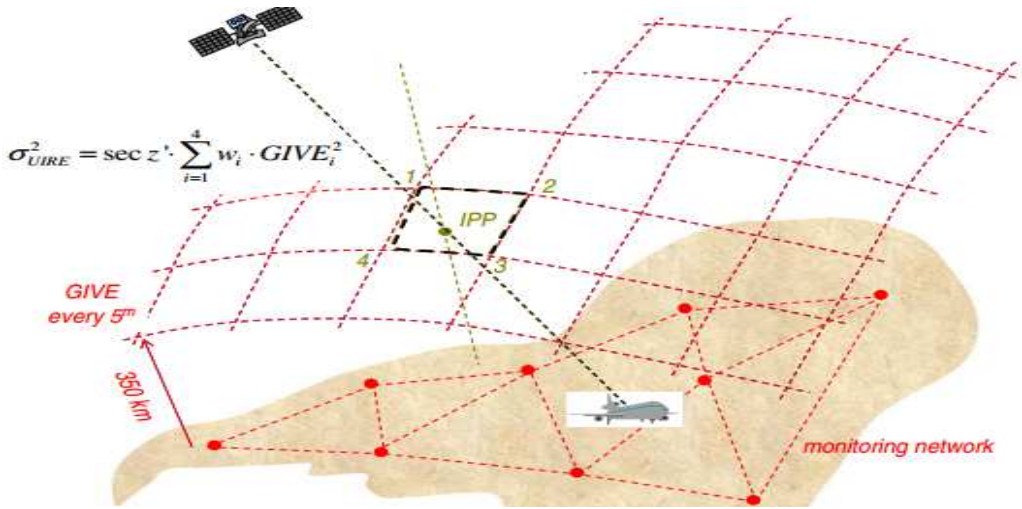


EGNOS Correction

The broadcast EGNOS messages, generated at the EGNOS Master Station using the observation from the EGNOS reference stations, include [EGNOS MOPS] :

- **Differential corrections:** Fast and long-term satellite clock-ephemeris error corrections and ionospheric delay error correction;
- **Accuracy of the differential corrections:** User Differential Range Error Indicator (UDREI) and Grid Ionospheric Vertical Error Indicator (GIVEI);
- **Masks:** A mask is used to designate which slot is assigned to a specific satellite for a correction message;
- **Geostationary navigation messages:** This message updates the location of EGNOS geostationary satellites;

Type	Description
1	Masque des PRN
2-5	Corrections rapides
6	Information sur l'intégrité(EDREI)
7	Facteur de dégradation pour les corrections rapides
9	Paramètres de position du satellite GEO (éphéméride), (X, Y, Z, time, etc.)
10	Paramètres de dégradations
12	Temps UTC SBAS
17	Paramètres de position des satellites GEO (Almanach)
18	Masque de la grille ionosphérique
24	Corrections rapides/corrections lentes
25	Corrections lentes
26	Délais ionosphériques



RIMS stations

- **RIMS site will itself comprise 2 to 3 independent RIMS channels (called "A/B" or "A/B/C").** Basically the EGNOS RIMS subsystem performs the following key functions :

  - **Signal Quality Monitoring** : local interference and local multipath mitigation, detection of excessive interference or multipath levels and, for RIMS channel C, detection of satellite failure events capable to degrade the signal

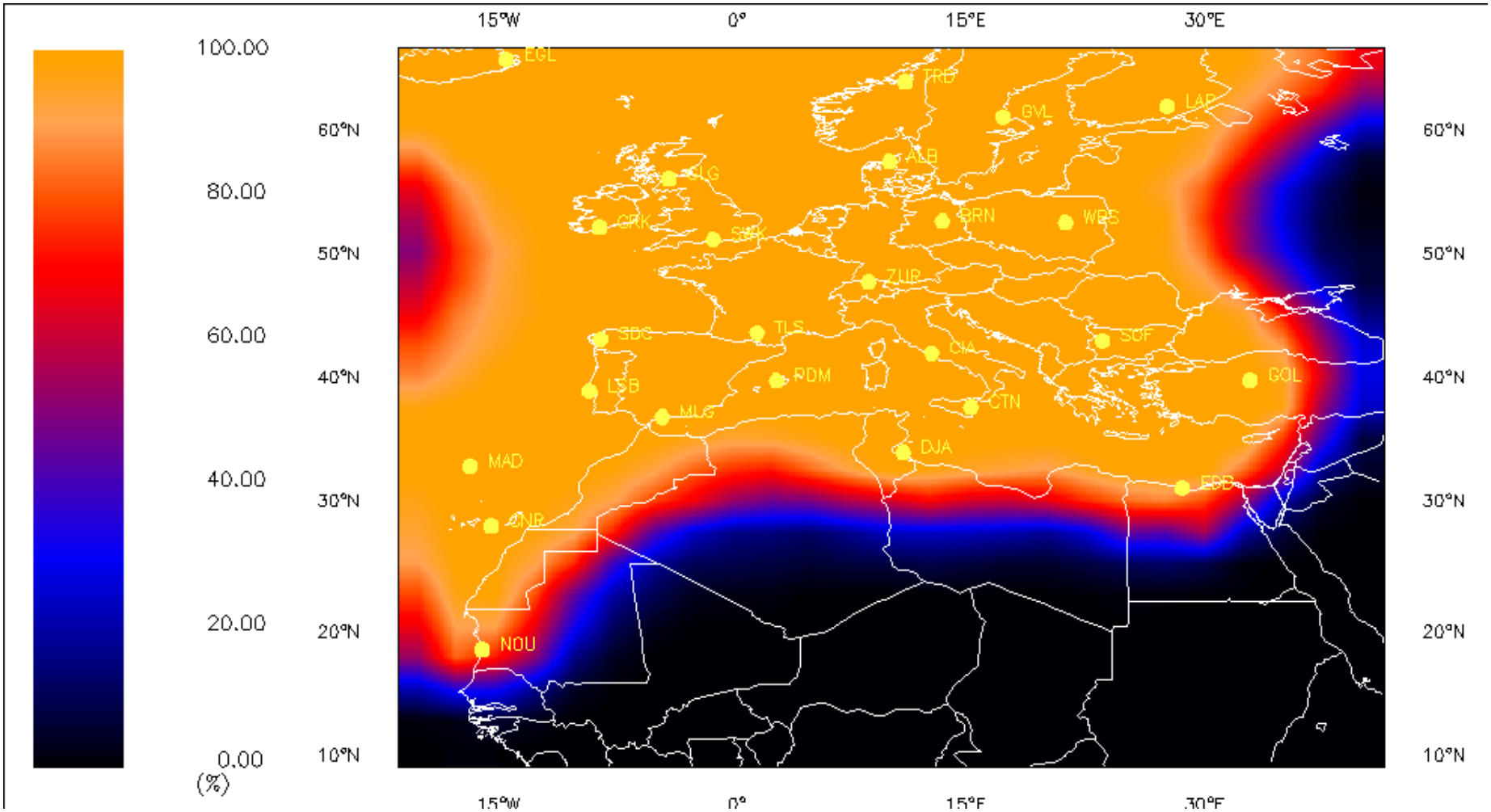
  - **Satellite pseudo ranges measurements** (code + phase) on GPS/GLONASS and SBAS Geostationary satellites signals ,

  -

  - **Messages formatting and transmission** towards EGNOS Master Control Centers (MCC's)
  - **Measurement of the time** offset between a reference UTC clock and the EGNOS Network time (ENT)

  -

EGNOS coverage before extension



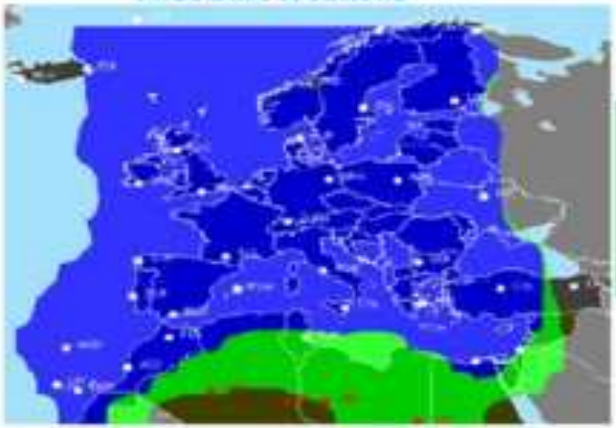
Service availability simulation

EGNOS SoL extension ENP South: infrastructure required to cover priority areas

ENI South
APV-I Availability, 27 GPS SVs

APV-I 99% Availability 27 SVs

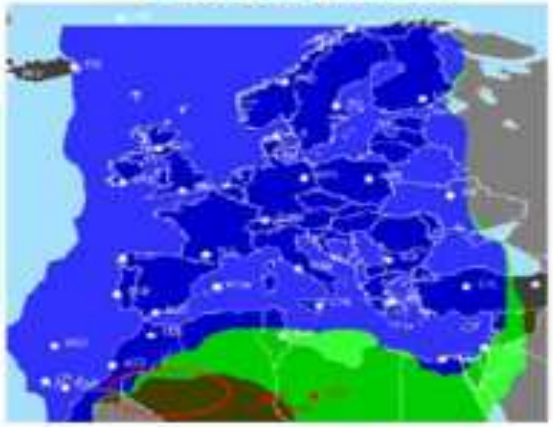
First best locations



RIMS network: v2.4.2B + **5 RIMS**

PRIORITY ZONE 1 AIRPORTS IS COVERED

Second best locations



RIMS network: v2.4.2B + **5 RIMS**

5 more RIMS needed

Source: ESA, 2015

RIMS sites in North Africa

RIMS station In Algeria

The implementation of the **RIMS station** in Algeria (**Tamanrasset**) allow to receive the corrections transmitted by the EGNOS system and will certainly benefit from the advantages offered by this system in particular in the center and south of Algeria, in terms of **accuracy, availability, integrity and reliability.**

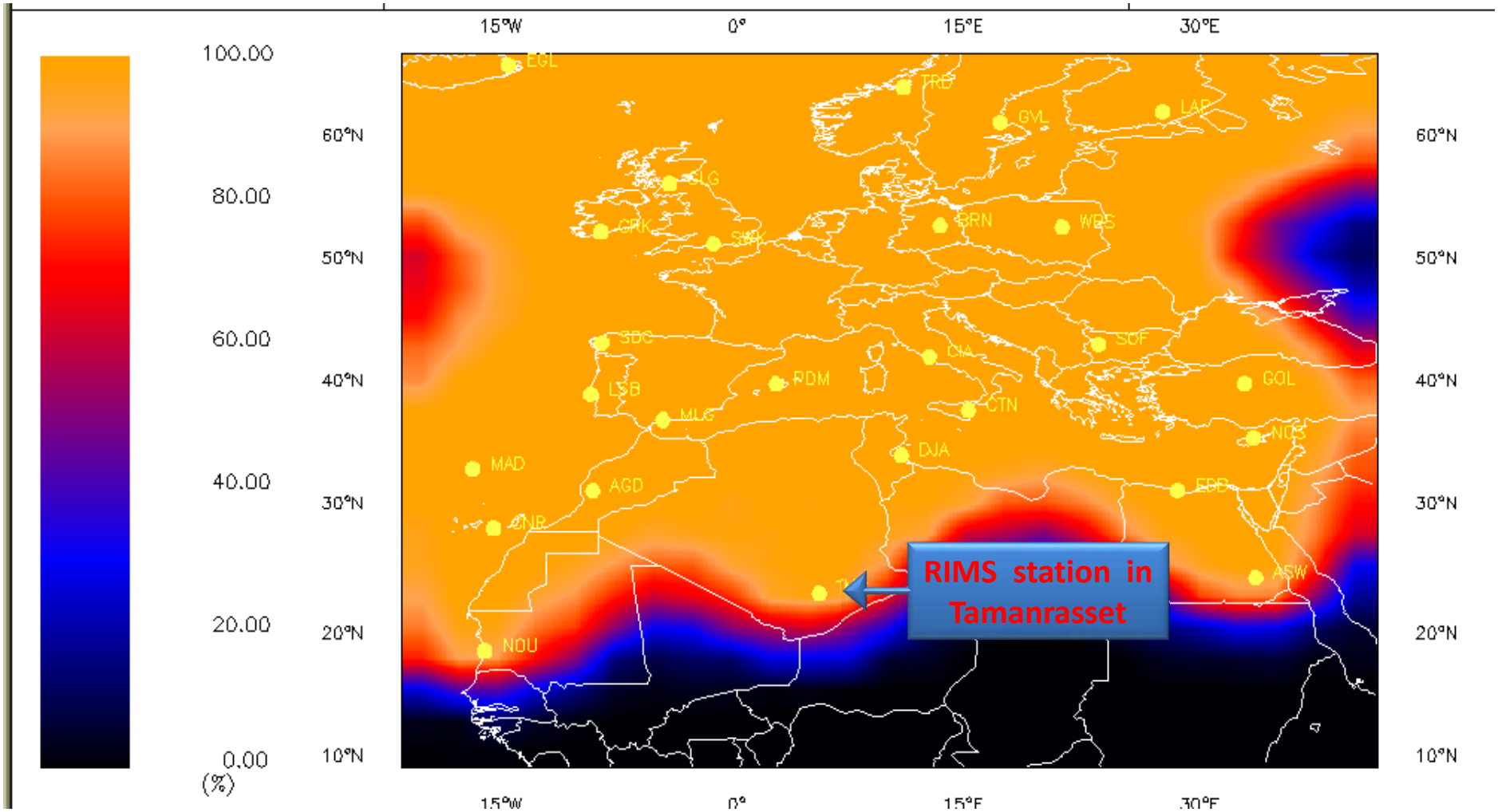
Ensure :

- **that EGNOS is used optimaly in Algeria**
- **the continuity of the services in Algeria**

RIMS Antenna Aalborg

2 new RIMS in Abu Simbel and Agadir entered in operation in November 2013

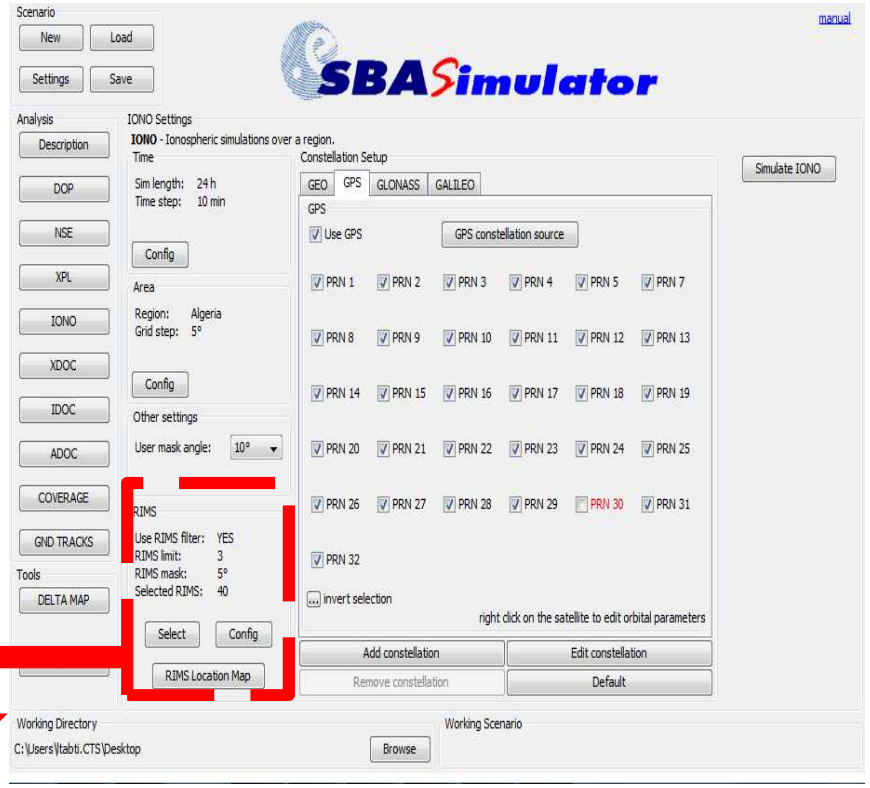
Coverage after extension : Tamanrasset site



Service availability simulation

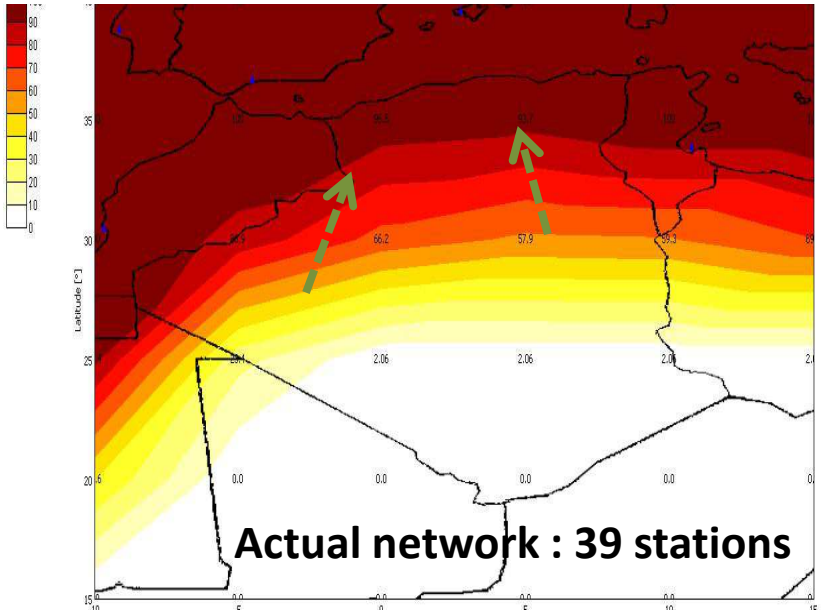
General parameters used in the simulation

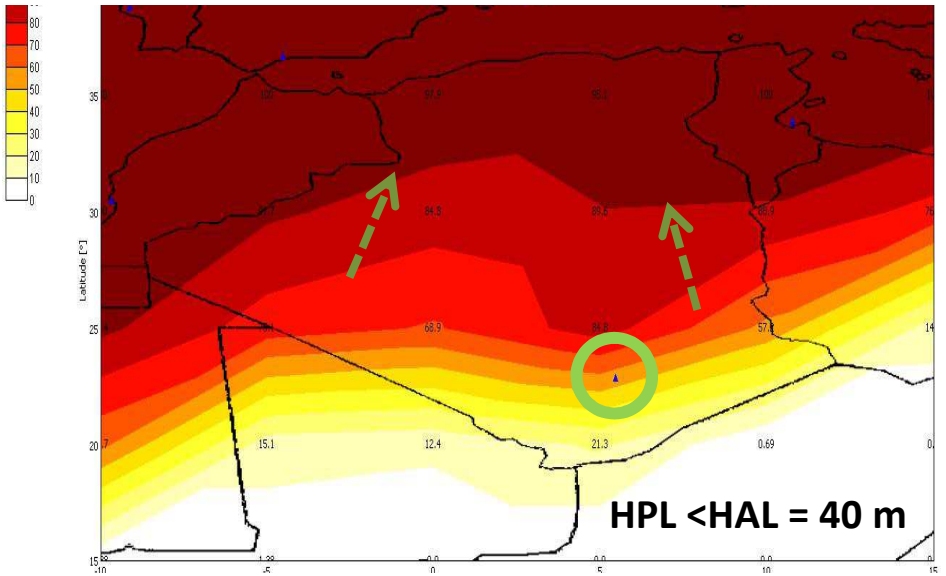
- Date: day 49 (2015), the GPS constellation contains **30 satellites**;
- Study area chosen : λ (longitude) ∈ **[-10 °, 15 °]**; ϕ (latitude) ∈ **[15 °, 40 °]**;
- The model used to calculate the satellite orbit and clock errors (**UDRE**) depends on each satellite;
- The model used to calculate the ionospheric error (**GIVE**) is based on an interpolation which depends on current RIMS stations;
- **APproach with Vertical guidance (APV I):**
  HPL < HAL = **40m** and VPL < VAL = **50 m**.



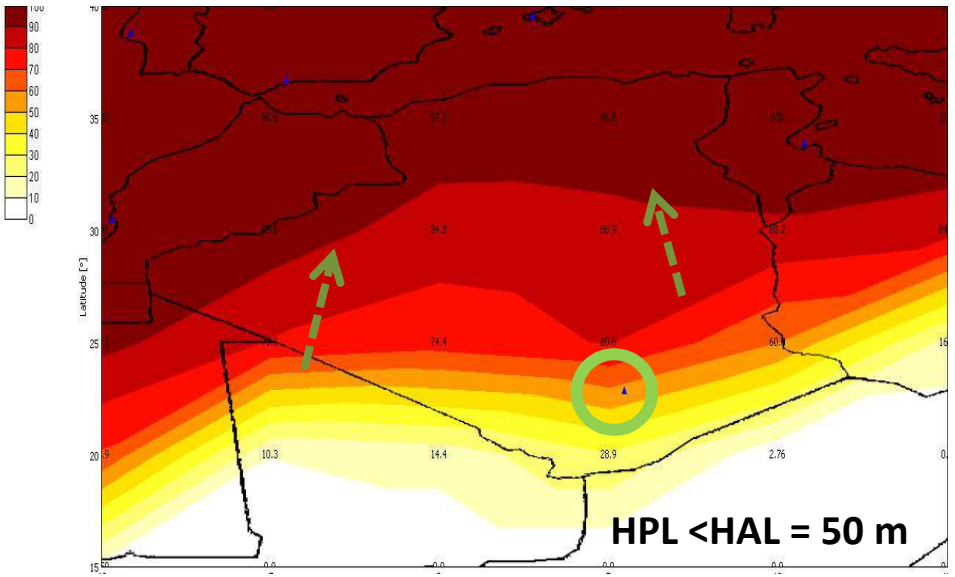
Network : 39 RIMS stations + chosen site for Algeria (proposal stations)

APV-I Availability simulation: Tamanrasset site

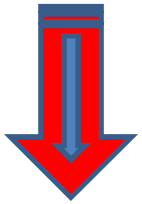




The results of the **Tamanrasset** simulation show that the addition of this station don't **significantly improve the EGNOS coverage** surrounding the site concerned or further south, but ensures a better coverage in the direction of the main network stations RIMS **(to Europe, therefore further north).**



Conclusions of the site of Tam



Mainly, the conclusions of the **Tamanrasset simulation** site show that :

- Corrections provided by each RIMS station are **dependent on the nearest stations**;
- EGNOS service improvement **is inside RIMS station network**;
- The range between Tam station and the other RIMS stations is important; it means that the individual stations **have practically less influence.**

RIMS station in Tamanrasset

Initially the site of **Tamanrasset** has been proposed by the ESA (**2005**), however the site was considered **technically not very favorable** for interference reasons **(site survey : June 2009; Feb 2012 by BT);**

British Telecommunications

this site is conditionally suitable for the installation of a **VSAT system** in support of an EGNOS RIMS AB system providing, it is exempt from the usual performance and continuity terms in the VSAT RIMS SLA.

RIMS and VSAT antenna in La Palma (Canary Islands)

- There was a very high level of radio altimeter **interference** recorded during the survey
- This can be achieved by locating the antenna **to the North** of the RIMS shelter

New RIMS site proposal

- During the meeting of **February 5, 2015** which includes the Algerian and EU representatives regarding the site in question; they agreed the following:

  1. Close definitively the choice of the **Tamanrasset site**.
  2. Begin work on the selection of a **new other site** (Ghardaia)

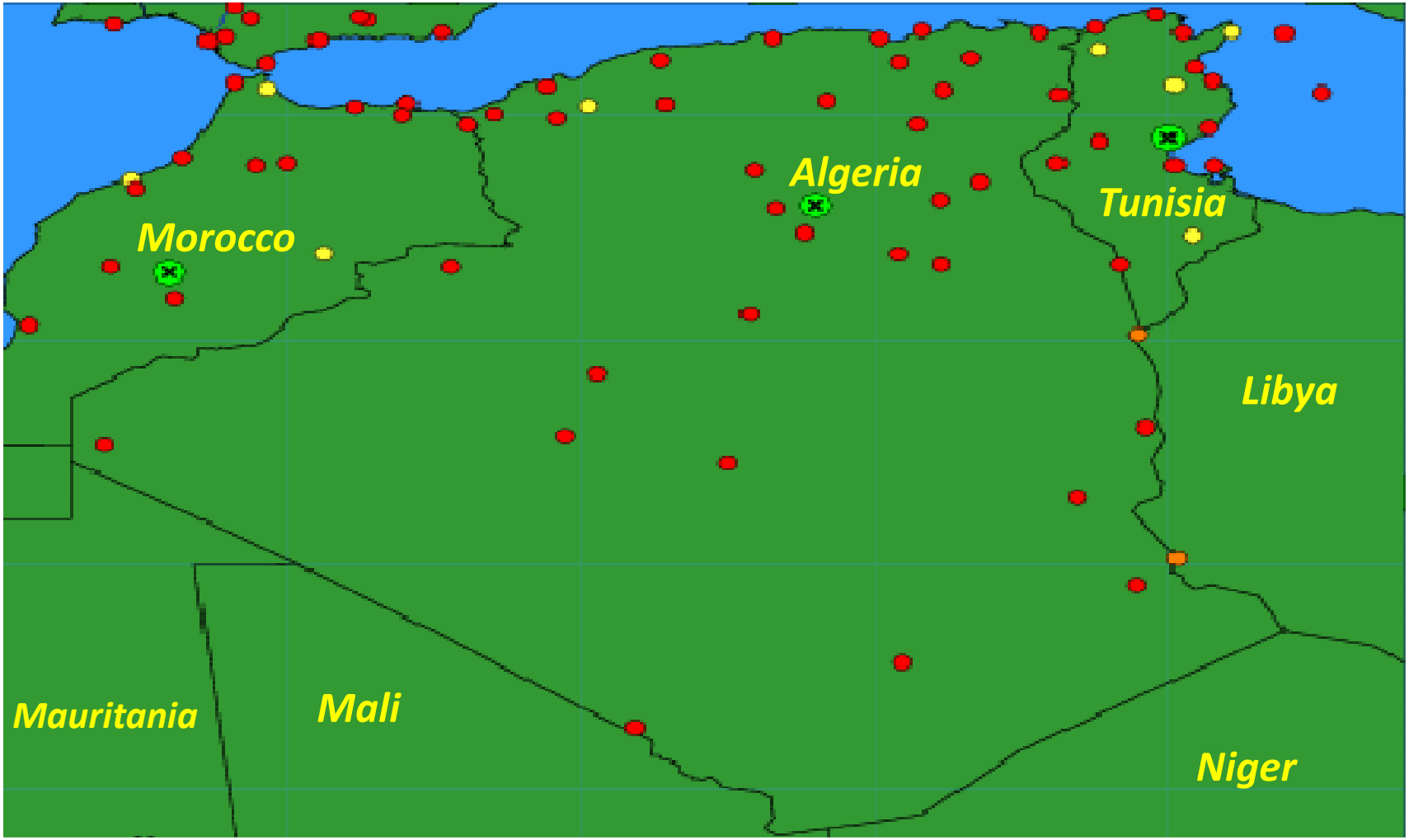
The experts of the ESA requested to move this site to another Algerian airport. The future site will be chosen located between latitudes ($30^\circ < \varphi < 35^\circ$) .

Optimal site must have several usual criteria as :

- Technical **performance**
- Operational **accessibility** (**security access** of the emplacement for the EU personal)
- **Viability** in the long term period (logistic access for the maintenance)
- Without radio **interference**

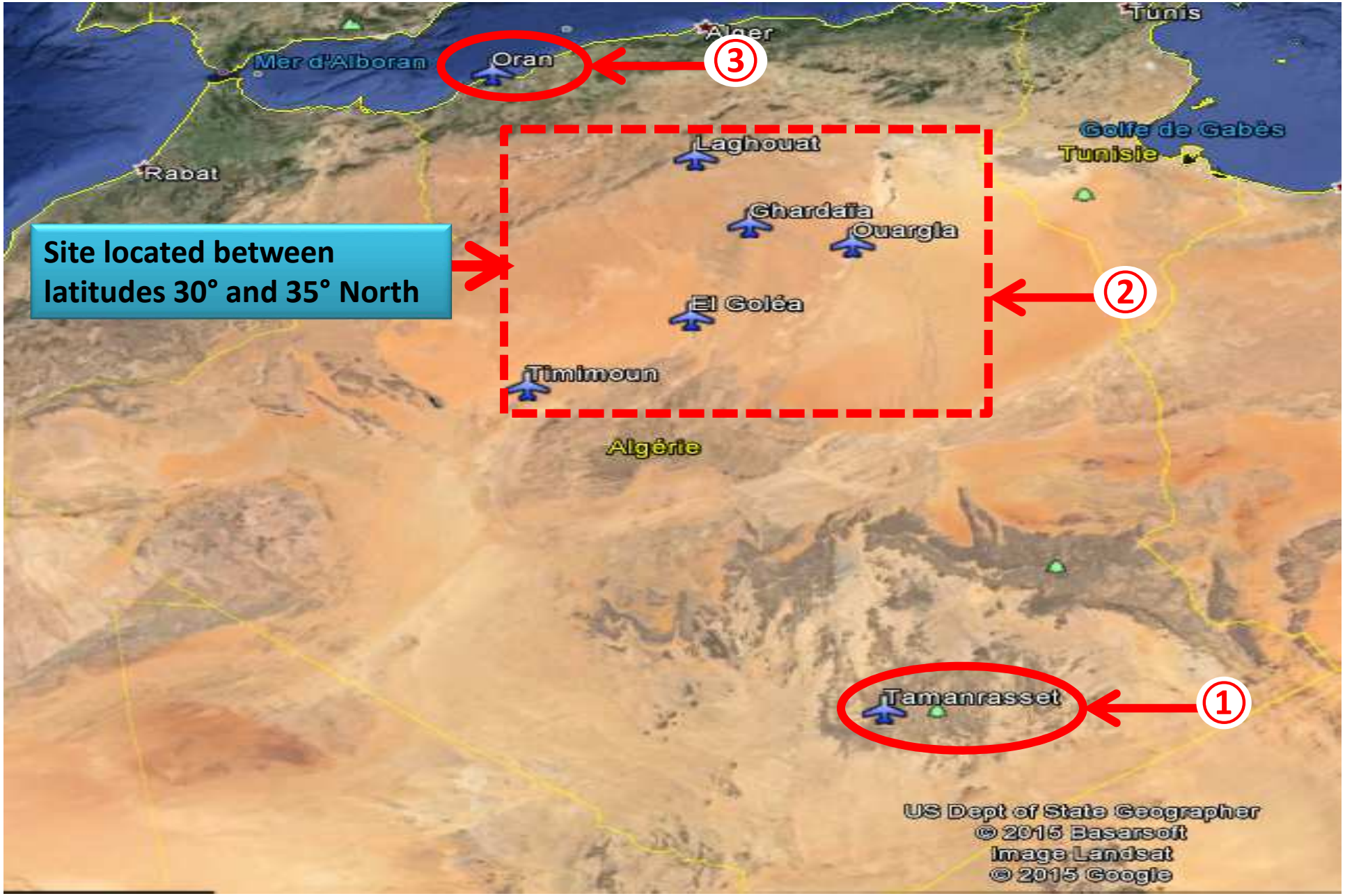
Airports in Algeria

Algerian airspace includes 36 airports where 11 are international

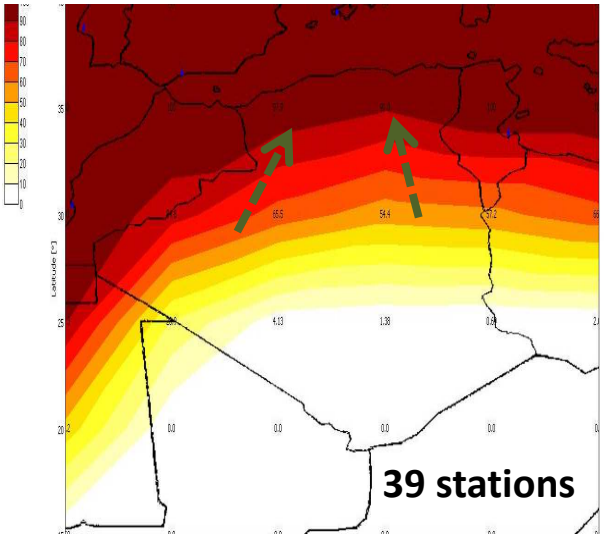


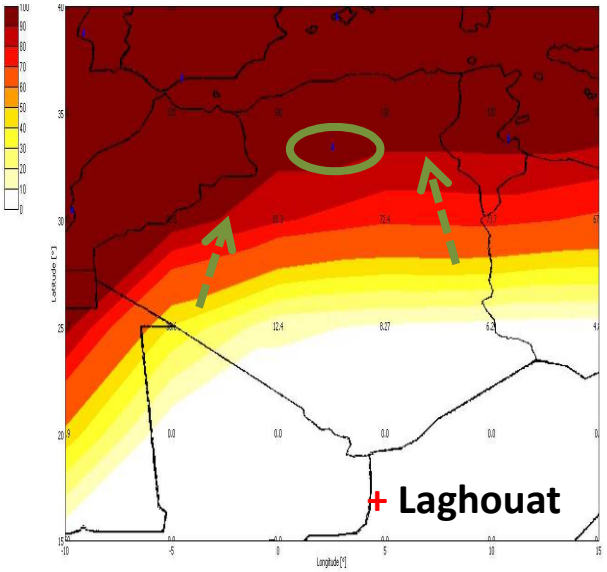
The implementation of **EGNOS** in Algeria is dependent on the current state of procedures, existing navigation equipment and the programmed development projects.

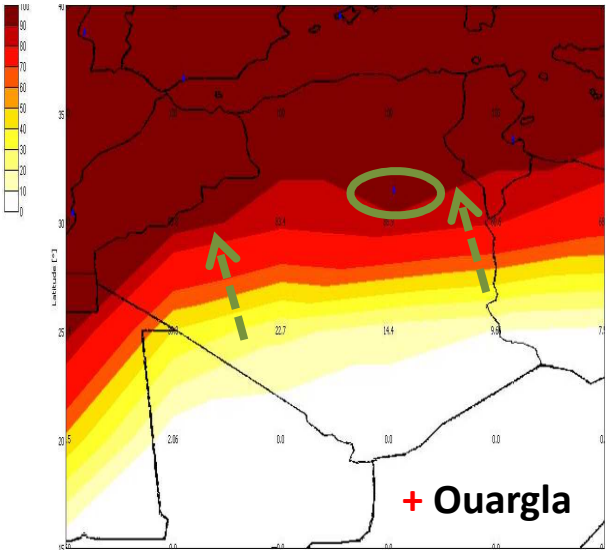
Airports used for simulation

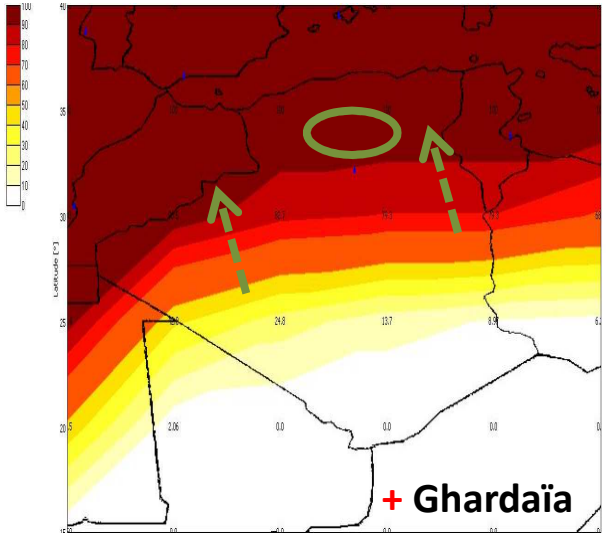


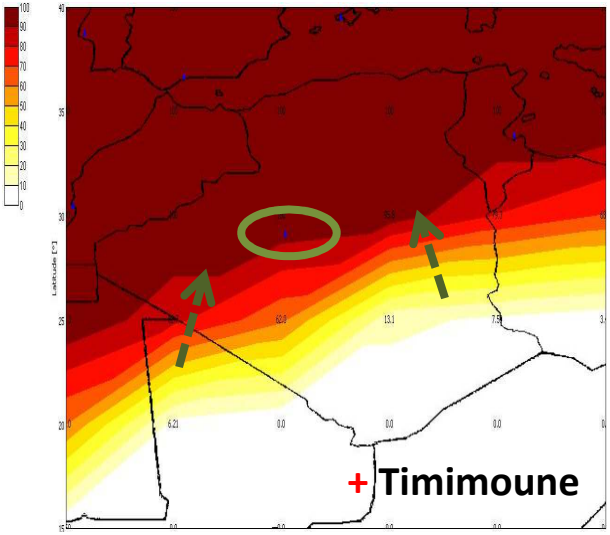
APV-I Availability simulation : Horizontal

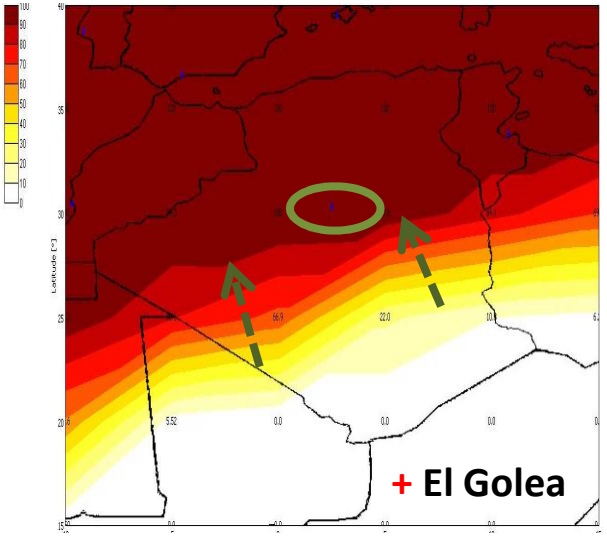






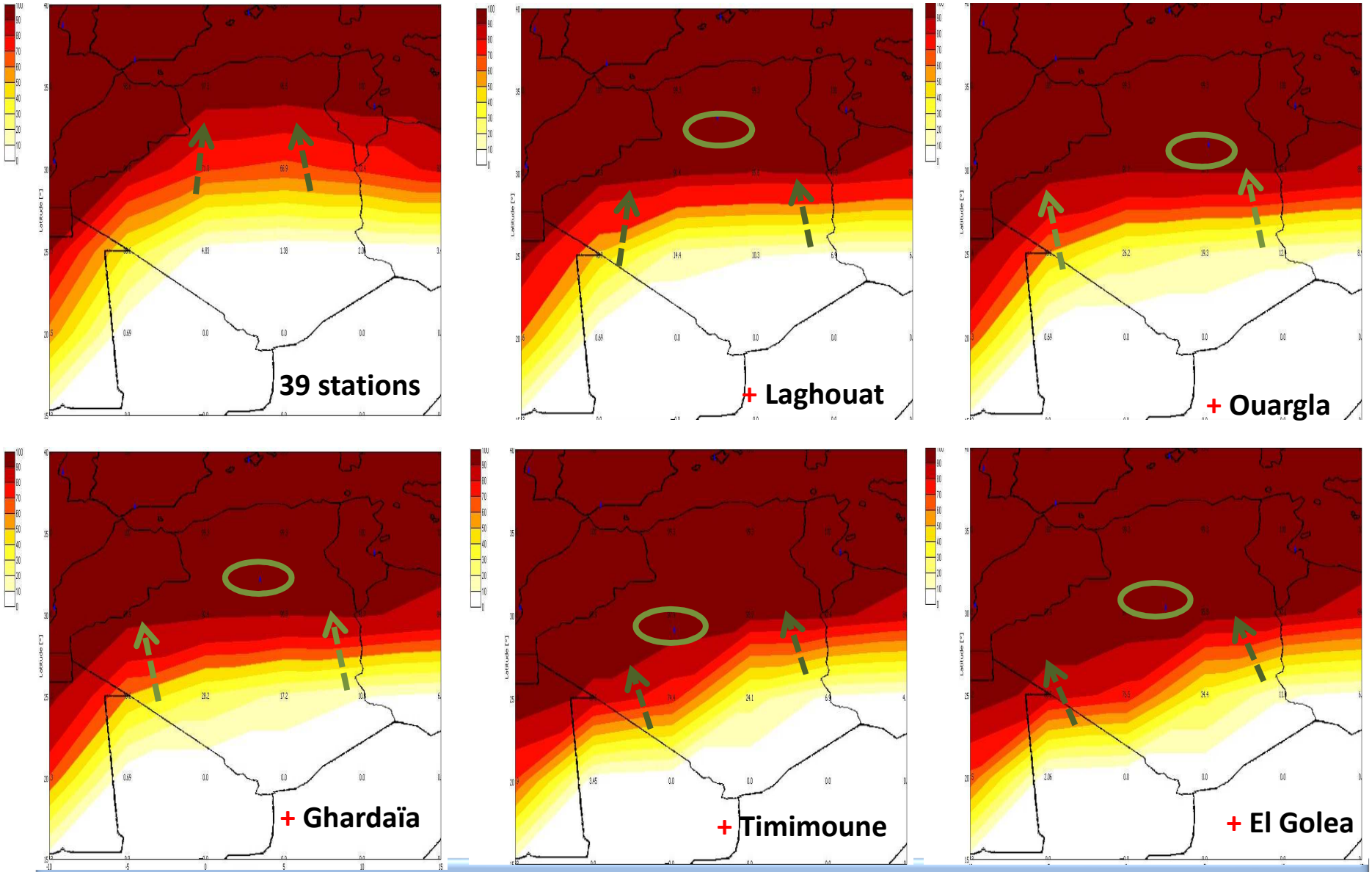






The HPL Availability is thus "the percentage of time where the Horizontal Protection Level is below the "Horizontal Alert Limit" for this APV-I service (HPL<40m)

APV-I Availability simulation : Vertical

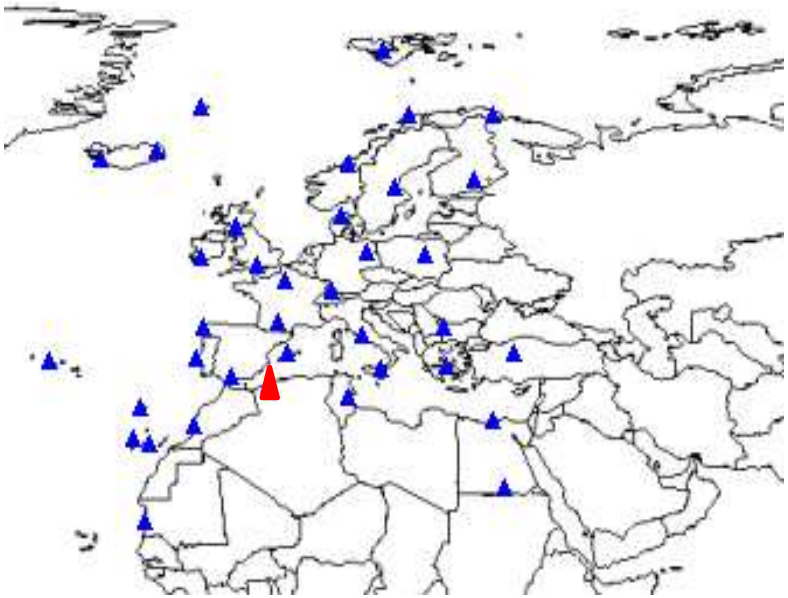


The VPL Availability is thus "the percentage of time where the Vertical Protection Level is below the "Vertical Alert Limit" for this APV-I service (VPL<50m)

The sites of El Golea, Timimoun, or even **Ghardaïa,** allow to have the best results particularly above **25° latitude** → the addition of one of these stations can significantly **improve coverage of EGNOS**.

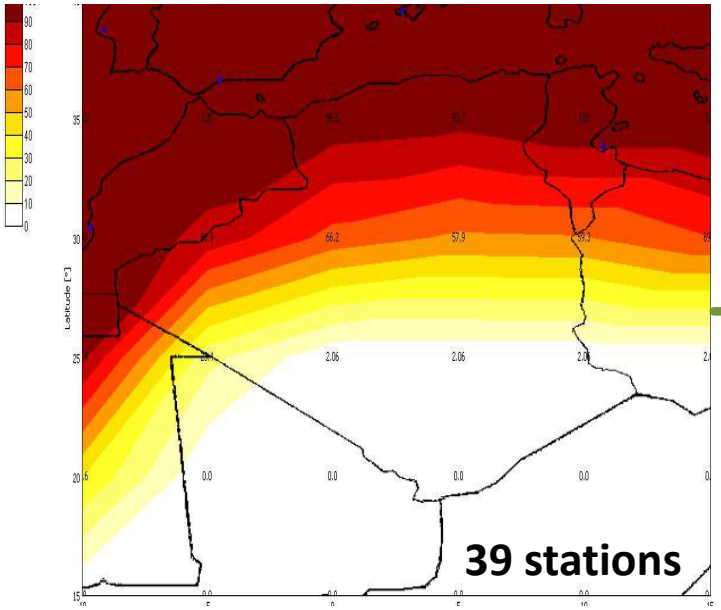
However, in the start of august 2015, the EC rejected the Ghardaia site and proposed another site located in Oran

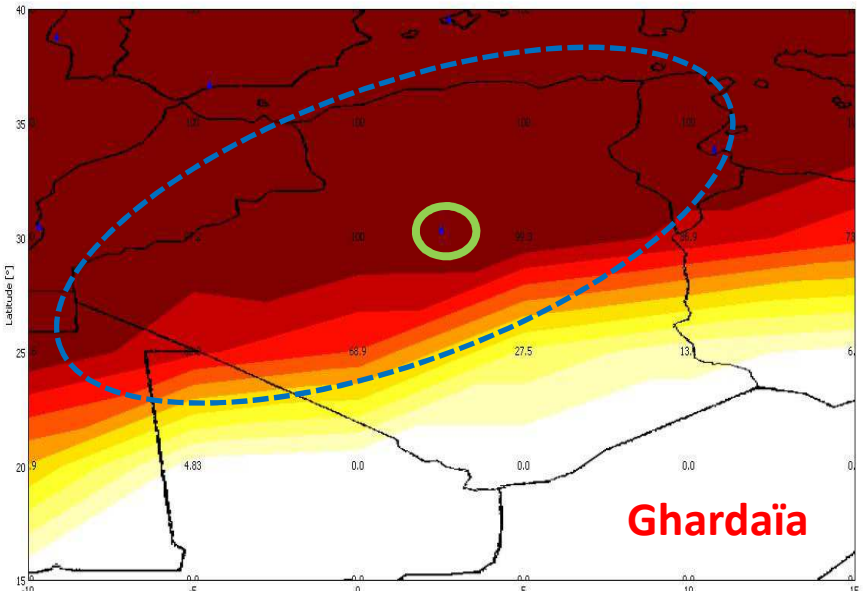
- **Why Oran site is proposed ?**
- **What are the criteria that prompted the ESA to choose the site of Oran, as this site is not optimal for the Algerian area ?**

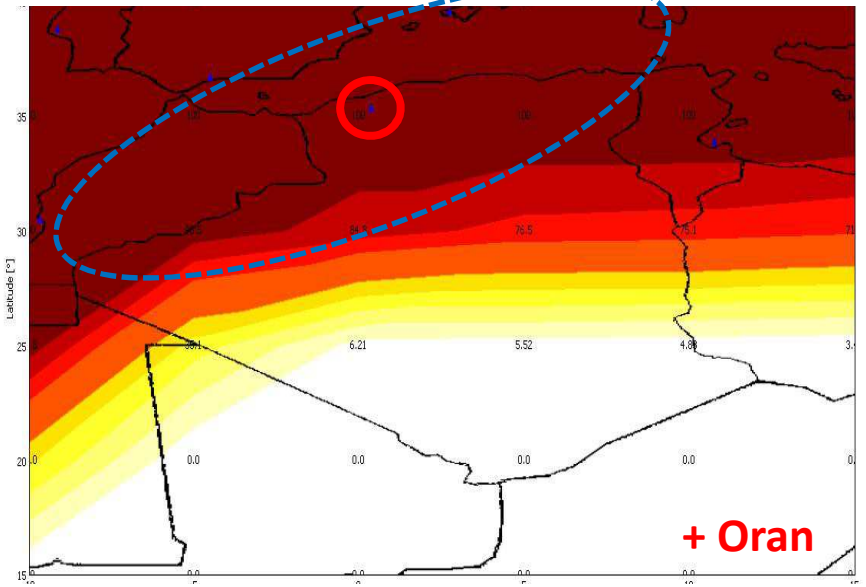


APV-I Availability simulation : Horizontal

HPL <HAL = 40 m



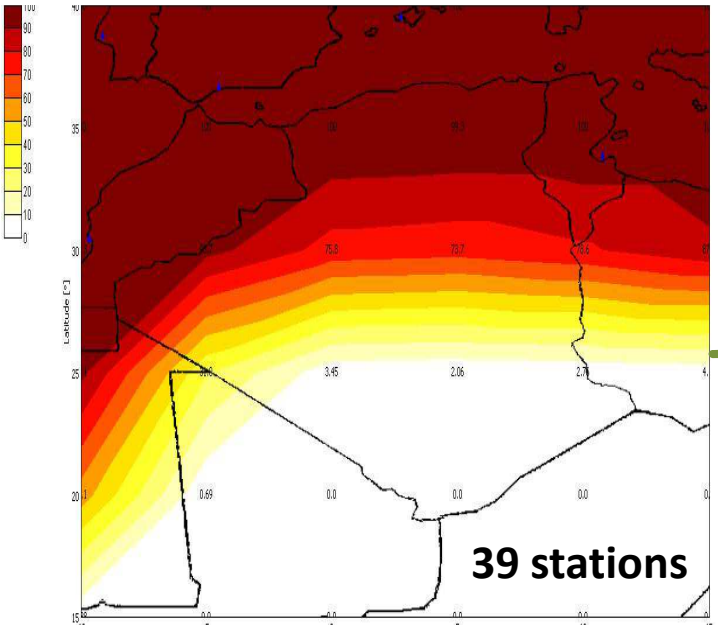


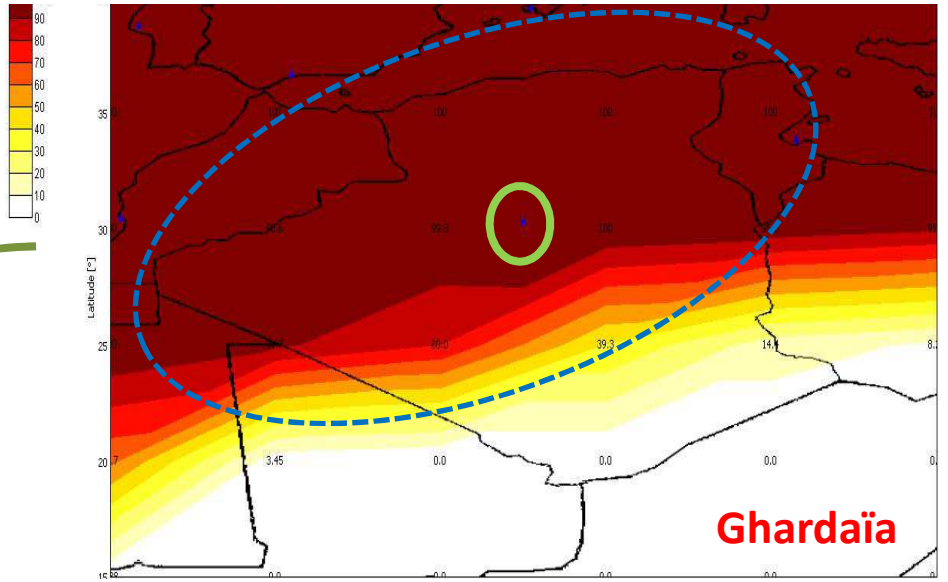


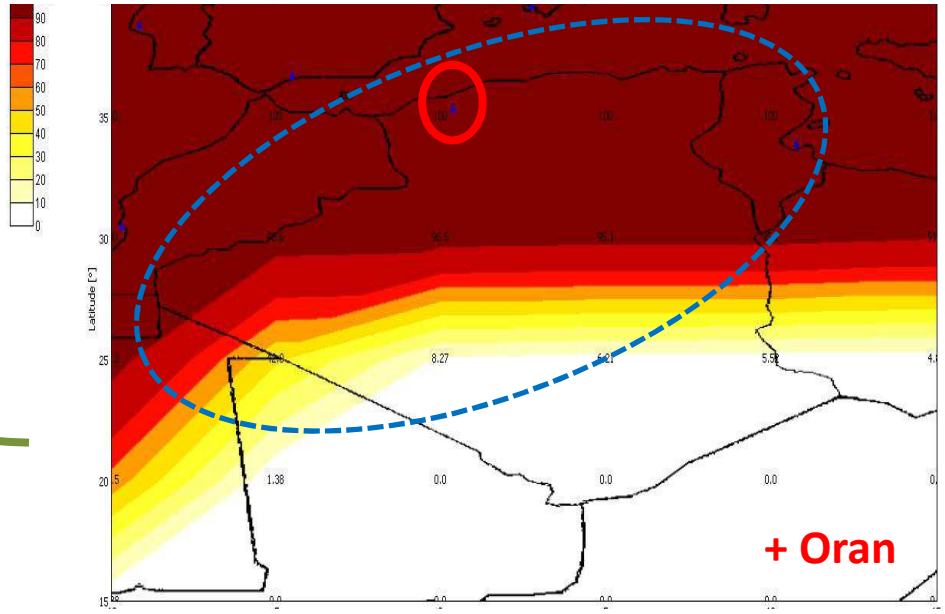
Sites \ φ : Latitude, λ : Longitude	25° [0° 5°]	30° [0° 5°]	35° [0° 5°]
39 stations	2.06	[57.9 66.2]	[93.7 96.5]
39 stations +Oran	[5.52 6.21]	[76.5 84.8]	100
39 stations + El Goléa	[27.5 68.9]	[99.3 100]	100

APV-I Availability simulation : Vertical

VPL <VAL = 50 m



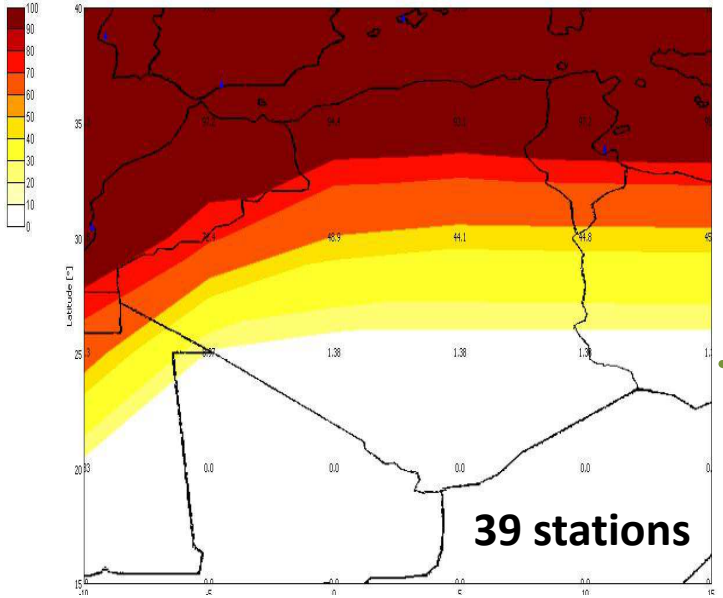


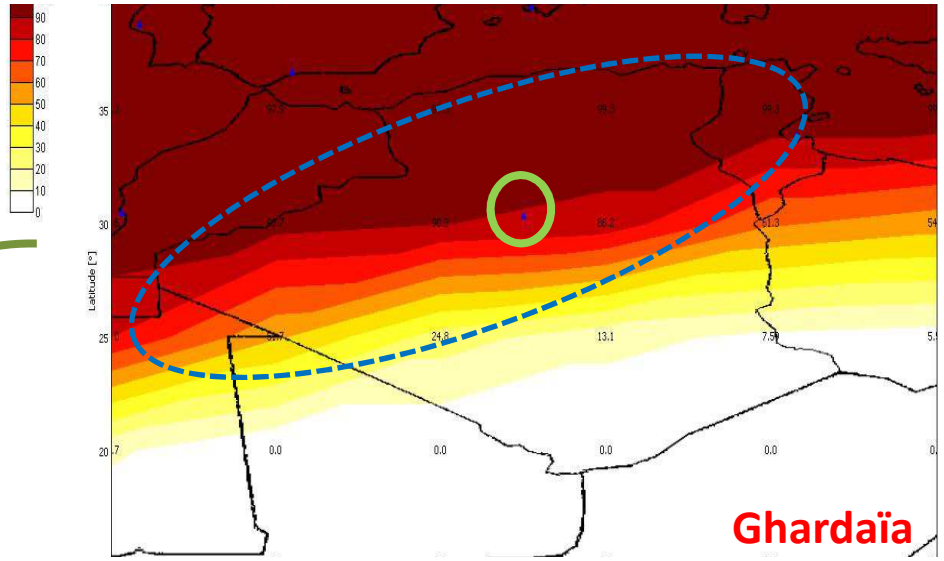


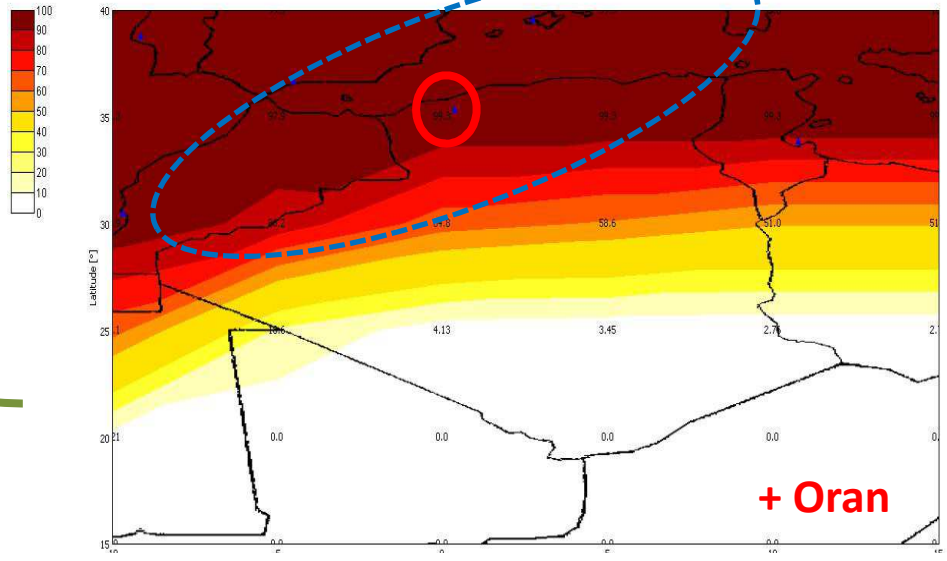
φ : Latitude / λ : Longitude / Sites	25° [0° 5°]	30° [0° 5°]	35° [0° 5°]
39 stations	[2.06 3.45]	[73.7 75.8]	[99.3 100]
39 stations +Oran	[6.21 8.27]	[95.1 96.5]	100
39 stations + El Goléa	[39.3 80]	[99.3 100]	100

APV-II Availability simulation : Vertical

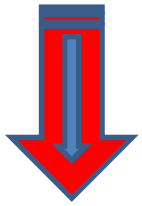
VPL <VAL = 20 m







Sites \ φ : Latitude, λ : Longitude	25° [0° 5°]	30° [0° 5°]	35° [0° 5°]
39 stations	1.38	[44.1 48.9]	[93.1 94.4]
39 stations +Oran	[3.45 4.13]	[58.6 64.8]	99.3
39 stations + El Goléa	[13.1 24.8]	[86.2 90.3]	99.3



- The results of the simulation of **the Oran site** can not improve the EGNOS performance in Algeria.

- This site improves probably the geographical distribution of RIMS stations in **West Mediterranean** area and allows to improve the homogeneity of the (actual) network for the EGNOS system.

Conclusions

① The preliminary results of the feasibility study of the choice of **EGNOS RIMS station site in Algeria** show that setting up a site in the **centre of the Algeria (Ghardaia)** will allow to have **a better use** of the EGNOS system and at the same time the expansion of its service area.

② In order to select the best RIMS location optimising the EGNOS service coverage for the area, and considering EGNOS products (**ionospheric grid** as example), the improvement will potentially perform different **other** precise GNSS applications.

③ The criteria to select the best location for a RIMS station depends on many factors, **not only technical** but also institutional and other operationality and security considerations (Ghardaia ?)

④ **Last proposal (end of November 2015) : two RIMS sites in Algeria (probably Ghardaia and Oran)**

⑤ **.....**

Centre of Space Techniques

Thank you for your attention

S. Kahlouche