# EGNOS Ranging and Integrity Monitoring Stations (RIMS)

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**ABSTRACT :**

*EGNOS (The European Geostationary Navigation Overlay System) is the European Satellite Based Augmentation System (SBAS) to GPS and GLONASS. The EGNOS AOC (Advance Operation Capability) space segment is composed of two INMARSAT III satellites (IOR and AORE) plus the ESA ARTEMIS satellite, all being equipped with navigation payloads. The EGNOS ground segment is being developed by a European industrial consortium lead by Alcatel Space Industries under an ESA contract. EGNOS AOC is planned to be operational in end 2003.*

*Inside the EGNOS System architecture, the Ranging and Integrity Monitoring Stations (RIMS) are of essence since, together with the Central Processing Facility (CPF), they drive the System performances.*

*This paper intends to further explain the key role of RIMS within EGNOS.*

*First an overview of EGNOS RIMS technical design is provided. For that purpose, the architecture of EGNOS RIMS split into fully independent measurement channels is explained. Then the key techniques and performances of RIMS are described with a specific focus on receivers (antenna + RF parts + signal processing). Also basic technical considerations on the other RIMS equipment, like atomic clocks and RIMS Core Computer, are provided.*

*The major role of RIMS inside EGNOS System functions and performances is then analysed. For what concerns integrity, a specific focus is given on the role of EGNOS RIMS in the detection of satellite signal anomalies.*

## 1- INTRODUCTION : RIMS IN EGNOS

In its early configuration, the EGNOS ground segment will comprise 33 Ranging and Integrity Monitoring Stations (RIMS) spread over Europe and surrounding continents. Due to the safety related nature of EGNOS, the RIMS hosting sites are secured areas and essentially consist in airports and telecommunication space centers. The list of the EGNOS RIMS sites is given in fig 1.

At architectural level, a given RIMS site will itself comprise 2 to 3 independent RIMS channels (called “A/B” or “A/B/C”) depending whether or not channel C is installed.

RIMS channels A&B constitutes the measurement chains, one feeding EGNOS Central Processing Facility (CPF) with raw data for differential corrections computation, the other feeding EGNOS CPF check chain for comparison and integrity monitoring purposes. In order to avoid common failures, Channels A and B are diversified from a design point of view and are built by different manufacturers. Each of these channels A and B constitute a stand alone measurement chain with its own antenna and its own receiver.

**Fig 1 : EGNOS Ground Segment Sites**

| **Country** | **Site** | **4 MCC<br>7 NLES<br>34 RIMS<br>1 PACF<br>1 ASQF** | | **RIMS channels** |
|---|---|---|---|---|
| France | Toulouse | PACF | | |
| | Aussaguel | NLES | RIMS | ABC |
| | Paris | | RIMS | A |
| | Kourou | | RIMS | AB |
| Germany | Langen | MCC | | |
| | Berlin | | RIMS | ABC |
| | Raisting | NLES | | |
| Spain | Torrejon | MCC, NLES, ASQF | | |
| | Canary Islands | | RIMS | ABC |
| | Malaga | | RIMS | AB |
| | Palma de Mallorca | | RIMS | AB |
| | Santiago de Compostella | | RIMS | AB |
| United Kingdom | Glasgow | | RIMS | ABC |
| | Gatwick | MCC | RIMS | ABC |
| | Goonhilly | NLES | | |
| Italy | Fucino | 2 NLES | RIMS | ABC |
| | Catania | | RIMS | AB |
| | Ciampino | MCC | | |
| Portugal | Azores Islands | | RIMS | ABC |
| | Lisbon | | RIMS | ABC |
| | Madeira | | RIMS | AB |
| | Sintra | NLES | | |
| Switzerland | Zurich | | RIMS | AB |
| Norway | Trondheim | | RIMS | AB |
| | Tromso | | RIMS | ABC |
| Iceland | Reykjavik | | RIMS | AB |
| Denmark | Alborg | | RIMS | AB |
| | Faeroes Islands | | RIMS | ABC |
| Sweden | Gävle | | RIMS | ABC |
| Ireland | Cork | | RIMS | ABC |
| Poland | Warsaw or Cracovia | | RIMS | AB |
| Bulgaria | Sofia | | RIMS | ABC |
| Russian Federation | Murmansk | | RIMS | AB |
| | St. Petersbourg | | RIMS | ABC |
| Turkey | Konya | | RIMS | AB |
| Tunisia | Djerba | | RIMS | ABC |
| Egypt | Mersa Matrouh | | RIMS | AB |
| Israel | Tel Aviv | | RIMS | AB |
| South Africa | Hartebeeshoek | | RIMS | AB |
| Singapore or Japan | Singapore or Naha | | RIMS | AB |
| Canada | Ottawa | | RIMS | AB |

RIMS — Ranging and Integrity Monitoring Station
MCC — Master Control Centre
NLES — Navigation Land Earth Station
PACF — Performance Assessment and Check-out Facility
ASQF — Application Specific Qualification Facility

As concerns RIMS Channel C, it is independent from Channels A and B and contributes to a dedicated integrity function called “Satellite Failure Detection (SFD)” function. This function has been recently specified in ICAO standards and will have to be implemented in all SBAS including EGNOS, at least for Precision Approach (PA) operations. It is further developped in this article.

On a given EGNOS RIMS site the atomic clock is a shared resource in common to all RIMS channels (A/B or A/B/C).

A specific 34th RIMS, equipped with single channel (A), is installed at Observatoire de Paris for performing the EGNOS Time mission.

## 2- RIMS FUNCTIONS :

### 2.1 Functions at Subsystem level

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
- Viterbi decoding (Geo signals)
- data demodulation
- 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). This specific function is only present at the RIMS which is located at Observatoire de Paris.

Beyond the above key functions, the RIMS S/S also performs support functions in order to allow remote monitoring and control from the EGNOS Central Control Facility (CCF). Such functions are for instance built-in-tests actionable either automatically at RIMS or upon remote request from CCF, elaboration of failure diagnostics, mechanisms allowing to accept software downloading from CCF via the EWAN. Such a central M&C concept supported by delocalised functions at individual stations is of essence for optimising the logistic support in a system like EGNOS where the ground stations are spread over a very large geographical area. Without such concept the EGNOS system would be extremely difficult and expensive to monitor and to maintain.

### 2.2 Functions at System level :

RIMS role in System level functions and effects on RIMS definition or on RIMS geographical distribution :

At System level, RIMS measurements are used in most of the main functions of EGNOS.

- <u>EGNOS Network Time elaboration</u> : ENT is a virtual reference time inside EGNOS CPF built with the ensemble of all RIMS atomic clocks times and steered towards GPS time (see paper GNSS 2000 : "EGNOS System Overview and Potential Benefits for the Time and Frequency Community"- S.Basker and all). Medium/long term stability of ENT is obtained by implementing Cesium (Cs) atomic clocks in some of the EGNOS RIMS. Stability of broadcast GPS/GLONASS corrections also imposes short and medium term stability of ENT. For this reason remaining RIMS are equipped with Rubidium (Rb) atomic clocks.

- Satellites Orbit Determination and Elaboration of Clock Corrections : it has to be noticed that the fact that, unlike GPS and GLONASS satellites, Geo satellites are fixed as observed from RIMS stations. This imposes a wide spreading geometry of the RIMS observation sites otherwise the quality of Geo Orbit Determination would be poor. Therefore some of the EGNOS RIMS stations have been placed in remote areas like Canada, South America, South Africa and Asia.

- Ionospheric Corrections elaboration : these corrections are necessary to be broadcast over this part of the zone of service where precision approach service is to be provided, which in the case of EGNOS AOC means ECAC land masses. Ionospheric corrections for a given sub area of the ECAC land masses are computed by EGNOS CPF using those RIMS L1/L2 GPS measurements at the ionosphere pierce points (IPP's) located in the vicinity of this area. Since ionospheric corrections quality (e.g. availability, accuracy, integrity) is directly driven by the density of ionospheric pierce points, this drives also the RIMS network density over ECAC.

Signal Quality Monitoring : in EGNOS the high level diagnostic on signal quality monitoring function is generally performed in a central manner at CPF level, based on local data or local diagnostics from individual RIMS stations. Two types of signal anomalies have to be distinguished :

- local anomalies like local interference or multipath at RIMS site : this type of anomaly can degrade measurements towards one or several satellites at the same time on a given RIMS channel (ex: due to interference). Thanks to their powerful design, the RIMS subsystem already perform efficient local mitigation and detection of such events, which is then further reinforced by CPF.

- signal anomalies generated at satellite level : such type of anomaly has already been observed on GPS satellites SV19 in year 1993. It is generally considered as a consequence of problem onboard the broadcasting satellite, like navigation payload failure, and it is modeled accordingly. The effects of such failure are generally global since the measurements to the failed satellite can be degraded for all RIMS stations simultaneously. In order to detect this type of failures, diagnostics are performed on the shape of the measured satellite signal correlation function. In EGNOS the satellite failure detection diagnostics are performed by dedicated RIMS channels named "RIMS channel C". RIMS channel C settle flags towards CPF upon detection of a satellite signal failure. The CPF then performs majority voting in order to secure the diagnostic. RIMS C channels are installed in 15 of the 33 RIMS sites. This allows each EGNOS monitored satellite to be observed by at least 3 stations equipped with RIMS C and make the CPF voting diagnostic robust in terms of missed detection and false alarm rate.

UTC function : the receiver of the RIMS located in Observatoire de Paris is connected to a reference atomic clock "UTCk" of BIPM UTC, which is itself connected to UTC. The measurements performed by this RIMS receiver allows, once processed by EGNOS CPF, to measure the time offset between the clock "UTCk" and the EGNOS Network Time (ENT). This offset is then broadcast to the time users community. Since time users using simple EGNOS receiver are able to measure ENT in real time, they can easily deduce UTCk time thanks to the broadcast offset UTCk/ENT. Furthermore since Time Users are also regularly informed of the offsets between UTCk and UTC (via UTC BIPM), they can finally have access to UTC thanks to their ENT measurements.

## 3- RIMS ARCHITECTURE DESCRIPTION

### 3.1 RIMS channel architecture

An example of RIMS channel architecture is provided herebelow in figure 2. It comprise the following main elements :

- a Radio-frequency Front -End
- a GPS/GLONASS/Geo receiver
- a core computer

an atomic clock (shared among all channels co-localised on a same site)

Each of the main individual equipment of a RIMS channel are detailed hereafter.

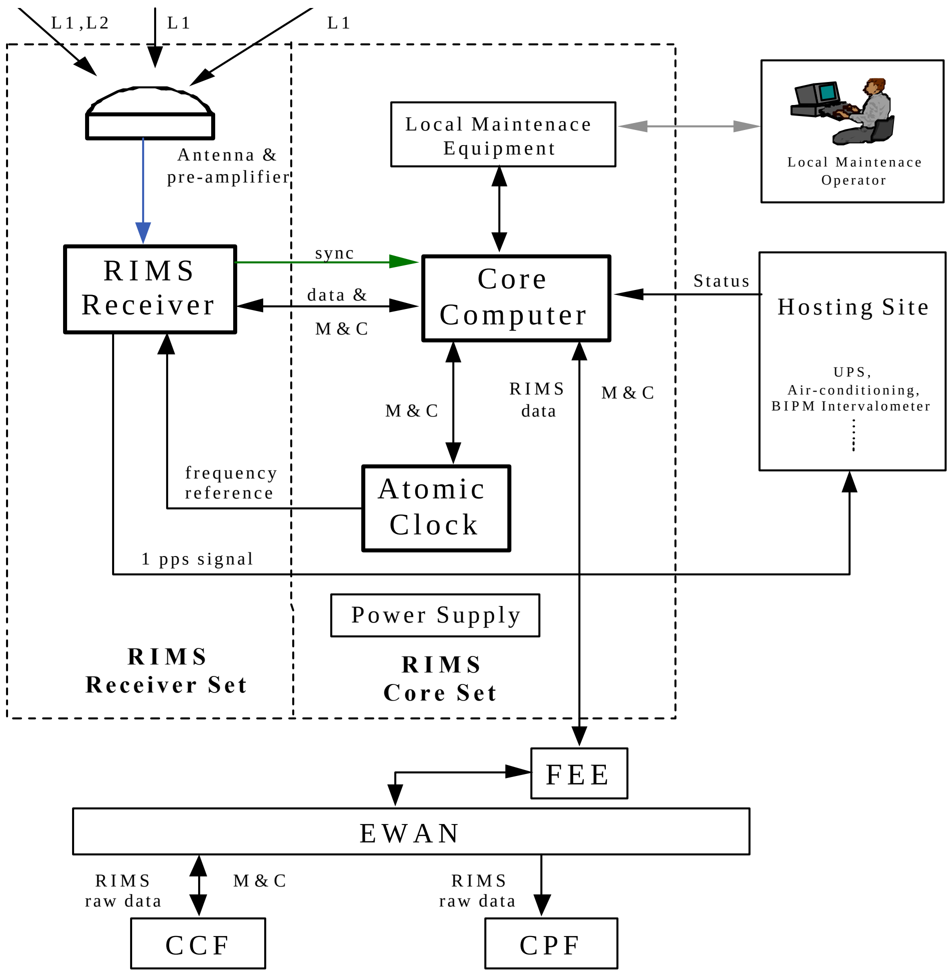
- Radio-frequency Front End (RFE) The RFE comprise an antenna and a pre-amplifier antenna : in terms of performances it has to offer an omnidirectional coverage in L1 and L2 radio frequency bands. For multipath mitigation EGNOS RIMS antennas will present low gain and good axial ratio performances at low elevation. Antennas equipped with choke ring ground plane are part of the envisaged candidate for this purpose.

Preamplifier : it mainly consists in diplexer/combiner, RF band pass filters and amplifiers (Low Noise Amplifier (LNA) and Medium Gain Amplifier). Cumulated gain is around 30dB and overall noise figure is less than 4dB.

Receiver RIMS receivers are a key element in EGNOS realizing the following overall functions :
Processing of all in view L1/L2 GPS and L1 GEO/GLONASS precise raw measurements (pseudorange & accumulated doppler),

Demodulation and processing of Satellite navigation messages,

Monitoring of signal quality by elaboration of signal quality indicators or by implementation of specific processing for instance satellite failures monitoring (RIMSC receiver)




# Fig 2 Example of a RIMS channel architecture

The above functions are performed by steps inside the receiver. This stepped processing is further detailed herebelow.

- First RIMS Receiver performs RF signal Processing:

The signal first goes through a series of diplexers realizing L1/L2 bands splitting and then, in L1 band, further GPS/GLONASS separation to feed the different IF processing chains.

The signal is then processed in RF channels performing IF filtering, signal amplifications, frequency down conversion and finally digitization.

- once digitized, the signals are delivered to the Digital Signal Processing boards which performs the following :

Raw measurements processing with typically Time search, Frequency search, Carrier frequency and phase tracking, Code tracking and multipath rejection, Code and carrier measurements

Satellite navigation message processing with data demodulation and with the constraint to ensure a continuous output data flow to avoid EGNOS data transmission overflow when considering the amount of data transferred to CPF from the 33RIMS A, B, C channels. In order to simplify CPF post-processing, the RIMS receiver also takes care of frames synchronization and control when sampling the satellites navigation messages. On top of that for GEO navigation messages, the receiver applies VITERBI decoding and specific algorithms in order to correct errors and provide navigation data bits

- After data collection and processing, the RIMS Receiver performs signal quality monitoring functions in order to support EGNOS system integrity performance. This is done as follows :

> - signal quality indicators (C/N0, Code carrier coherency) are built to trap possible signal corruption resulting from hostile environment as undesirable interference and multipath or satellite signal failure. For that the receiver is implementing local diagnostic features simple enough to remain compatible with time to alarm constraints. Sophisticated mechanisms like spectrum analyzer for interference detection have not been retained, considering their tremendous induced complexity and their lack of real time diagnostic capability. Instead, local monitoring features have been implemented at RIMS channel level relayed by CPF centralized monitoring. This approach offers the significant advantage of error sources segregation based on cross-checking mechanisms from the 33 RIMS multiple observation points. This capacity is recognized as one of the advantage of Wide Areas Systems of EGNOS type being able to dissociate between satellite or environmental types of failure.
>
> - Finally so called "evil waveform (EWF) detection" is performed by RIMS Channel C receiver. Characteristics of EWF failures is to cause a distortion of the receiver correlation function only detectable by comparison over multiple types of correlators. Therefore RIMS C receiver implements multiple correlators and is elaborating detection metrics from its correlators outputs. These metrics are afterwards compared to thresholds in order to reveal presence of EWF on input signals. Considering volume of data to be processed, the entire detection mechanisms is performed locally at RIMS level. At CPF level a simple majority logic is then performed over at least 3RIMS C results in order to consolidate local diagnostic.

<u>- Core computer</u>
The Core computer performs the following functions :

monitor and control the individual RIMS channels components (core computer itself, frequency standard, receiver and RFE )

monitors hosting site parameters.

manages the RIMS channel modes and States transition,

processes the remote commands received from the CCF through EWAN, distributes them inside the RIMS channel and manages relevant actions and/or answers.

Handles channel I/O interfaces. It manages the processing of external commands and support the formatting of messages exchanged between the RIMS and EWAN interface, acting as an essential interface layer allowing flexibility and evolution capability.

<u>- Atomic clock :</u>
2 types of Frequency Standard are currently foreseen to be used in the frame of EGNOS program. Among the 33 RIMS sites, 23 of them will be equipped with Short and Medium Term stability performance (SMS) frequency standard and 11 with Mid and Long Term stability performance (MLS) frequency standard.

The main characteristics and performance drivers are summarized in table below:

| | |
|---|---|
| SMS Stability | $<3^{E}$ -12 over 300s |
| | $<1^{E}$-13 over 10000s |
| MLS Stability | $<1^{E}$-13 over 10000s |
| | $<1^{E}$-13 over 100000s |
| Number of 10MHz RF outputs | 4<br>(3 operational for RIMS channels (A, B, C) and 1 for AIV and maintenance) |
| Operational conditions | Temperature : 22°C +/-2°C<br>Max Temperature variation : 2°C/hour<br>Relative Humidity : less than 70% |
| MTBF | 90000hours |
| Maintainability | 15 years |

Considering the spreading of EGNOS RIMS sites over Europe and surrounding areas, logistic aspects are of essence. Therefore investigations are currently on going on Frequency Standard procurement and should end in the best compromise between performance, cost and logistic support constraints.

For instance in case of MLS frequency standard so called “high performance” frequency standard ensures a stability better than $1^{E}$ –13 over 10000s but with Cesium tube life around 5years while other suppliers offer also Cs product with slightly less performance (ex: mid-term stability performance are around $2^{E}$ –13 over 10000s) but with extended tube life duration (~10years).

In case of SMS frequency standard, trade-off is to be performed between performance and cost. Typical mid-term stability reached for Rubidium clock is within $2^{E}$-13 over 10000s. Better stability can be reached, but is satisfied by selection among the units, with cost implication.

**3.2 RIMS channel performances :**

RIMS receivers focus on the quality of the raw measurements which directly drive the best performances one can expect at CPF algorithms output and finally also at end user receiver output. It is therefore understandable that state of art techniques are used in RIMS receivers in order to deliver accurate and integer measurements (pseudoranges, accumulated Doppler) even under severe environmental conditions (interference and multipath).

<u>RIMS-CPF apportionment</u>

RIMS channel performances have been derived to constrain receiver signal processing performances with respect to System and CPF needs. On the other hand, signal processing is restrained in order to ensure a maximum flexibility at CPF level on RIMS collected data. In this spirit, any filtering or smoothing which can be indifferently performed at RIMS or CPF level has rather been reported into CPF, this approach leading to Receiver DLL bandwidth limitation at 1Hz. RIMS data are gathered in CPF processing set (responsible for corrections elaboration) and in CPF check set (responsible for integrity check).Filtering time on RIMS Data contributing to corrections elaboration are adjusted in CPF processing set in function of the performance constraints but also of the dynamic of the effects to be corrected (which is different between ephemeris, clock or ionosphere).

CPF Filtering time on RIMS Data contributing to integrity check is tuned in CPF check set to be compatible with time to alarm constraints and in accordance with the type of processing performed at User level.

Interference Robustness

EGNOS system is to deal with very stringent interference specification as currently defined in standard (ICAO SARPS and RTCA MOPS D0229). It concerns all together out-band interference, in-band interference, mutual protection between GNSS bands (GPS and GLONASS L1 bands) as well as pulse interference.

- For what concerns out-band rejection, increased complexity comes from the necessity to ensure interference high rejection and at the same time to maintain reasonable in-band group delay stability over operational temperature range, over the whole GNSS frequency band and over the 15years EGNOS lifetime (aging effects).

Enhanced rejection are achieved through preamplifier optimisation with selection of narrow RF filters but most of selectivity is realized by IF filters with introduction of SAW filters technology on top of conventional LC filters. Introduction of SAW filters also enables to ensure a satisfactory interference protection between GPS and GLONASS L1 bands to a level above 50dB. On L1 upper band, a trade-off is to be realized between Near-band interference rejection (with MSS threat) and the capability to ensure appropriate processing for GLONASS upper-band satellites. With enhanced interference rejection, all filters (RF, IF), and in particular preamplifiers filters due to large operational temperature range will exhibit high group delay variation due to SAW transfer function for instance, increased filter order and reduced filter bandwidth. In order to cope with, the EGNOS RIMS receivers implement group delay equalisation mechanisms, either with a-priori calibration (pre-stored look-up tables) or real time calibration.

For what concerns in-band interference, it has revealed to be a system performance driver both in terms of accuracy and integrity performances. On the other hand, performance required have appeared to be very demanding with respect to capability of receivers already implementing states of the art techniques. It has therefore become a priority to secure this issue and, even if still targeting high level performances, to concentrate effort on real representative conditions. In this spirit, measurement campaign have been performed in order to characterize interference conditions under representative operational conditions. From these conclusions, scenarios are currently under definition to address typical conditions in which EGNOS will satisfy accuracy and availability performances and extreme conditions in which integrity and continuity is to be satisfied. As an example, performances currently targeted at RIMS level under nominal conditions are summarized in the table below :

| | GPS L1 | GEO L1 | GLONASS L1 | GPS L2 |
|---|---|---|---|---|
| Typical conditions | | | | |
| Code | 0.5m | 1m | 1m | 1m |
| Phase | 0.005m | 0.005m | 0.005m | 0.005m |

Figures above are based on DLL 1Hz bandwidth.

For L1 signals, these performances have been confirmed as feasible with receiver implementing state-of-the-art techniques.

For GPS L2, the problem is more complex because of the use of signal processing techniques (e.g. semi-codeless technique) which induce C/N0 degradation. To overcome this problem of low C/N0 on GPS L2, signal integration is performed on L2 with no major consequence for CPF processing if one considers that L2 is mainly used for ionospheric computation with low dynamic constraint.

Phase accuracy figures presented account for the different following contributions satellite clock contribution, receiver oscillator contributions, RIMS clock contributions

Multipath Mitigation

From literature currently available and past experience it has been noticed that the link between receiver multipath performances under lab test environment and receiver multipath performances under representative site conditions is not direct and has revealed to be a rather difficult exercise. In this situation EGNOS is trying to have a pragmatic approach and is currently tackling 3 complementary objectives :

ensure that RIMS Receiver intrinsic performances versus multipath are optimised,

ensure that constraints and cautions for RIMS sites selection and for installation are properly established,

ensure that CPF and system performances are verified under multipath conditions that are representative of future EGNOS RIMS sites

The first objective is exercised at RIMS channel level towards RIMS channel intrinsic performances. Current level of performance is being adjusted to state-of the art multipath mitigation technique (see fig.3), commonly illustrated in publications by multipath rejection curves of MEDLL, DDC/NC/strobe techniques. Available rejection curves are generally obtained when exciting receivers with single path multipath affected signal, which, if properly adapted for receiver acceptance, is not so representative of real site conditions.

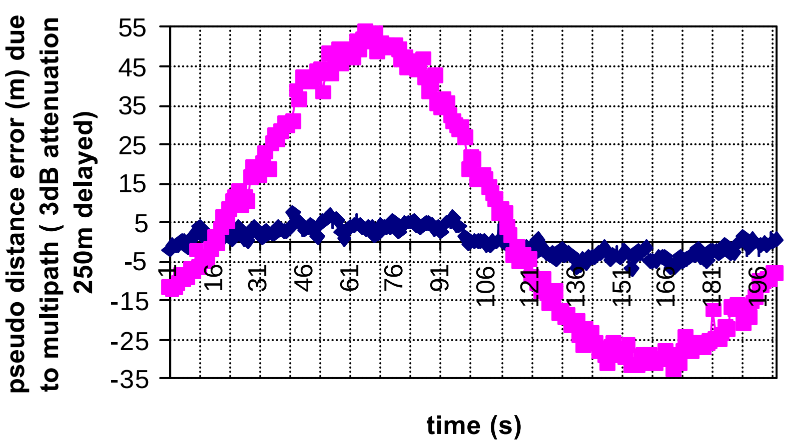



**Fig 3 : multipath mitigation**

**Comparison state-of-art technique (DDC) vs standard technique**

The second objective is tackled by defining some simple constraints for site selection and by issuing clean rules of RIMS channel installation.

The third objective is to establish multipath site conditions on which the overall EGNOS system performance is to be verified, accounting for the large spectrum of RIMS site surrounding : various type of reflective source, multiple multipath signals, multipath dependency with elevation. In order to satisfy this objective, a multipath survey campaign has been performed with test reference receivers. It is intended to base EGNOS verification scenarios on representative multipath conditions and/or effects.

<u>Inter-frequency bias</u>

On EGNOS concept, all raw measurements used at CPF have to be adjusted to a common time reference to be able to be commonly used in CPF. On a given RIMS channel and at a given site, raw observables are referenced towards each receiver local time and CPF is in charge to estimate and compensate for RIMS reference stations time difference. On the opposite, CPF is not able to account for RIMS channel intrinsic errors like inter-frequency bias which is RIMS channel dependent varying with receiver unit intrinsic performance or local environmental conditions. Such a compensation is therefore accounted at RIMS channel level as previously described with imbedded calibration. Current pursued performance is to limit inter-frequency bias to 0.1m error.

## 4- RIMS SITE ENVIRONMENT AND CONSTRAINTS

Special attention is given to the appropriate hosting of the RIMS through organizations with related experience, who are capable to fulfill the technical, safety, and security requirements and who are prepared to provide support during the deployment and on-site integration and validation phase

The most significant technical constraints concerning RIMS hosting are mentioned hereafter.

<u>Antenna separation distance</u> : in order to feed the CPF processing and integrity chains with two independent measurement flows, RIMS channel A and B antennas on a given site shall be separated by several tens of meters : not less than 60 meters, with an objective of 120m (when feasible taking into account site constraints). The necessity for such antenna separation distance was verified to some extend, using preliminary site survey results performed on representative RIMS sites and observing the spatial decorrelation of residual multipath errors between the outputs of two differently located receivers. At the same time, cable run from receiver to antenna must not exceed 80 meters in order to limit the RF losses.

<u>Masking:</u> The site shall allow a RIMS antenna location with clear horizon above 5° elevation. In the case that this very stringent condition cannot be met, a limited masking angle above 5° could be tolerated provided that the following conditions are respected :

- in terms of solid angle, the cumulated blinded angular zone remains limited
- Blinded directions always remain at low elevation angle.

<u>Environmental conditioned equipment room:</u> the performances of the atomic clocks as well as the performance of some of the EGNOS RIMS receivers being to some extend dependent

on temperature range or on temperature variation rate, the RIMS indoor equipment hosting room will be equipped with temperature control devices.

RIMS channel sizing and packaging : each individual EGNOS RIMS channel indoor equipment (i.e. excluding the RFE) is packaged in a 19 inches rack. The overall channel is itself assembled in an about 2m height cabinet.

Antenna positioning and mounting : The coordinates of the RIMS antenna phase center shall be very accurately determined once installed on a site (to within few cm accuracy in WGS 84 referential). Furthermore the antenna mounting structure for a given channel will be installed so that it does not create any RF mask effects towards the other collocated RIMS channels.

The final site selection is dependent on the results of site surveys, which will last several days for a given RIMS site, and which will especially include a multipath and electromagnetic interference survey. Alternative sites will be identified in the case that site survey concludes in the non-feasibility of a proposed site.

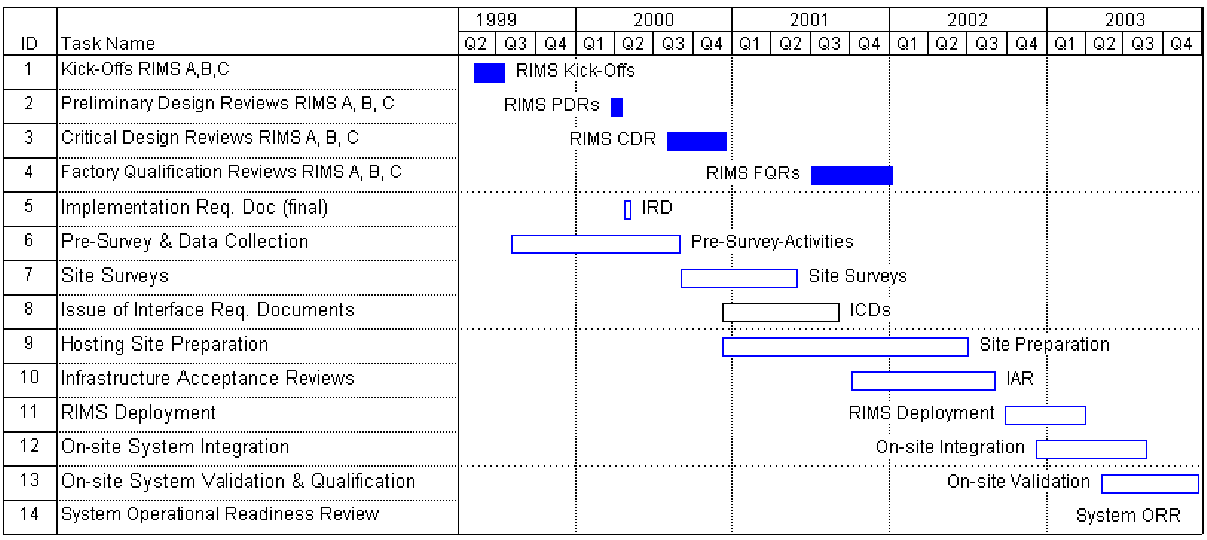
Security: with regard to security, RIMS stations will have a level of protection commensurate with a key strategic installation of critical national importance.

## 5- INDUSTRIAL ASPECTS / DEVELOPMENT / DEPLOYMENT

The three EGNOS RIMS channel manufacturers in EGNOS are the following :

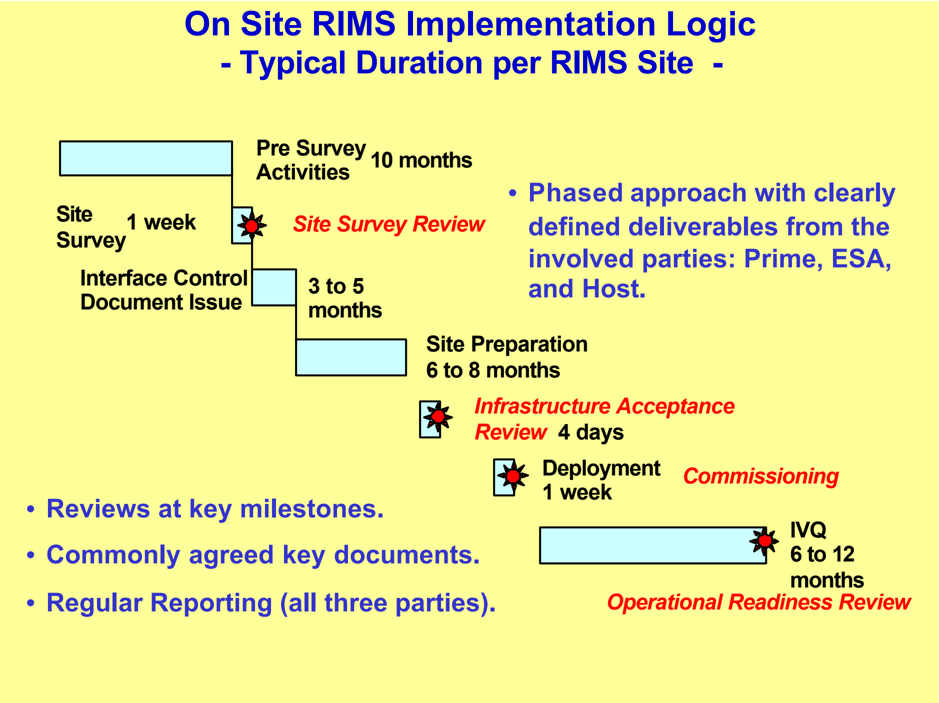
- INDRA(Spain)/SEXTANT AVIONIQUE (France) for RIMS A
- ALENIA / LABEN(Italy) / SEATEX(Norway) for RIMS B
- RACAL AVIONICS (UK) / NOVATEL (Canada) for RIMS C

The development planning for the EGNOS RIMS subsystems is given hereafter.




It should be noticed that the RIMS Channels development planning is stringent due to fact hat these channels have then to be deployed on the 34 RIMS sites and then integrated and validated until EGNOS Operation Readiness Review (ORR).

An example of typical implementation logic is given herebelow in order to illustrate the complexity and duration of the implementation for each individual site.




## 6- CONCLUSION

In EGNOS the RIMS subsystem, like CPF, is essential due its direct contribution to all system performances. Therefore in order to secure the system level performances, state-of-the art techniques have been implemented in EGNOS RIMS design definition, and very skilled and experienced companies have been selected for the RIMS channels development.

Beside the RIMS channel development phase, the RIMS sites selection process and the RIMS sites survey and sites deployment phases will also have to be carefully managed and performed.

Finally RIMS related activities will be a real challenge for ESA and for the Industrial Consortium all along the EGNOS Project and even beyond.

As a matter of fact the perspective of extending the EGNOS service outside the ECAC area is of great interest for Europe not only at technical level but also at commercial and political ones. As EGNOS service expansion will need deploying additional RIMS stations in surrounding continents, Europe will be as more credible for that purpose since a solid technical background will be acquired and demonstrated in the field of RIMS development and deployment during the EGNOS AOC phase.