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CAR/SAM Regional Planning and Implementation Group (GREPECAS)

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**Agenda Item 2: Global and inter-regional activities**

**2.1 Inter-regional and intra-regional CNS/ATM activities and coordination**

**CONSIDERATIONS REGARDING THE DECISION MAKING IN THE IMPLANTATION OF CAR/SAM REGIONS AUGMENTATIONS**

(Presented by Spain)

**SUMMARY**

This working paper presents the information related to the necessary considerations when we made a decision over the implantation of the different augmentations (GBAS/SBAS/ABAS).

**References:**

ATM/ CNS/ 6 Meeting report

**1. Introduction**

1.1 At present, we have different GNSS elements that arouse doubts over which to install or to operate in the different phases of flight and especially in the TMA, approach and landing phases. Obviously, this decision depends on the multiple factors to take into account; the main ones are the safety and economics.

1.2 In this note, we pretend to carry out an analysis of the suitable selection of one or another solution depending on the aircrafts and movements of the given airport.

**2. GNSS elements**

2.1 Under GNSS concept it is included all those elements that make up the system and go from the basic constellations to the augmentations. Each solution is associated a price which has to be take into account when the solution it is to be made, and will have a direct impact in the cost / benefit of the chosen solution.

2.2 In this moment, there is only one operative constellation, GPS. By itself, GPS gives sufficient performance to the operation on route, under the concept of primary means of navigation, and at present, it is evolving to a multifrequency solution, with L1 and L5. For a long period future, GALILEO will

mean a redundancy of satellites which will allow the operation on complex conditions and the visibility of an elevate number of satellites. This fact will permit the use of both constellations as sole means of navigation for on route operations.

2.3 Based on the GNSS constellations (GPS and GALILEO), on board receiver incorporate the RAIM function, which permits the integrity monitoring on the real time during the flight and assures us that the information we use is correct; this permits us to maintain the given operation. This is valid to its use on route (previous confirmation of the given function, for this, it is necessary to run a simulation which assure us that we have at least 6 satellites in full view during the given route); when there is GALILEO, this number of satellites will be insured. However, for the TMA operations, approach and landing, it is necessary greater integrity, whatever it is need to resort to others augmentations.

2.4 Keep going on with the on board augmentations, it provides the ABAS, that is, the integrity monitoring in autonomous way from with on board elements. For that, it provides hybrid solutions, through the Karman filters use, which use on board sensors, especially the Baroaltimeter and INS, being the last ones, those who provide greater reliability in the operations, mainly, when they are combined with the radioaltimeter, that is what provides NPA approach capability and in the cases of high complexity aircrafts, type APV I (although, at present, is not certifiable).

2.5 In order to give the integrity information for approach and landing requirements and to be available in extended areas, it was designed the SBAS concept which allow to cover continental zones with more or less homogenous performances and also gives the capability of landing with a vertical guidance in any airport or flight field inside this area, permitting to get to CAT I 200ft. This system it seems influenced by elements such as ionosphere that can reduce in a dramatic form its performances. This can be minimized on the basis of the land station optimum distribution and also on the adequate algorithms use. The aircraft equipment is a GPS receiver with the necessary adaptation to reed the SBAS information. And in case to have one's disposal, the FMS adaptations to permit the vertical guidance provided by the system. To all of this, it must be add the problem aroused from the institutional point of view, as per the cover implies various States that may reach the necessary agreements to give service in the space under their own responsibility

2.6 If we focus only on the landing, it is resort to the local augmentation or GBAS, which in its actual state of development allow CAT I operations, in each landing runway of the airport where may be installed, with a coverage of 20NM in a 30° angle to each side of the landing runway axle. These stations require the aircraft equipment with GBAS (VDL +GPS) receivers and its signals processed and pilot presentation, with FMS adapted to fulfil the requirements. In the equatorials areas, the ionosphere may be a problem of this kind of augmentations too.

2.7 All these elements, basic constellations, ABAS, SBAS and GBAS, provide us the opportunity to choose the more suitable solution to each case. But, which is the best? Or how can we make a decision regarding it?

### **3. Searching for the better solution**

3.1 Obviously, the chosen solution is a matter that finally will be centred on economic aspects, such as cost/ benefit and not only from the point of view of Air Navigation service providers, but also from the point of view of the aircraft operators companies. For that, it must be taken into account the land, space, on board equipment cost.

3.2 There is a big number of users of the air space. From the genetic form they may be divided in private, corporative, 3<sup>rd</sup> level, regional aviation, big commercial aircrafts and helicopters users. Each one is subject to some different necessities, and the on board equipments are diverse and with a very different impact on cost.

3.3 Normally, it is talked about the ABAS use as a solution to fulfil the PBN necessities and even to landings with a APV I vertical guidance type, but, what this implies? First of all, it must be taken into account what we are talking about to get to this situation; in the aircraft is necessary to have an equipment which have GPS, Baroaltimeter, Radioaltimeter, INS and FMS. Of course, if we talk about airlines big aircrafts of (B 737, 747, 767,777, 787,A320, 330, 340, 380, etc) your standard equipment use to include all these elements, because the repercussion in the aircraft final cost permits it. But, what is going on if we analyse a regional airplane here we are thinking on CRJ 200 or equivalents from Embraer for example. If we want to equip an aircraft of this type with INS and the FMS ready to operate with GPS with an ABAS solution, the cost oscillate between 300.00\$ and 400.000\$, this means, that this is a very expensive option with views to a complete fleet and difficult to make profitable. If we are talking about corporative, light aviation or helicopters, this is a not feasible solution. Of course, there always remain the RAIM with Baroaltimeter solution, but this left us in TMA. That is, from the aircraft point of view this solution is available for big aircrafts, but it is questionable for the rest of the users, because of the price reasons. This does not imply that the new inertial with the small size laser rings equipments and the calibrate price can not be installed as serial elements in the aircraft, but regarding the ones that are in flight, the cost is very high.

3.4 The following element is the GBAS. This augmentation will permit CAT I operations (the certification is predicted to the 1<sup>st</sup> half of 2009), actually FAA, AENA, the DFS and the Australian CAA are in the testing process to certify the first CAT I station (Honeywell). These augmentations have the advantage of giving service to all the landing runways of the airport, that is why, it is not necessary to have one in each head as with the ILS. Nevertheless, the installation will depend on the operations number, because a new installation of a GBAS station (comprehends previous studies, topologic study, civil work, alimentation, communications, auxiliaries elements, huts and the proper station) may cost around 1.3 M\$ a 1.5 M\$, this means, that in limited movements airports, the profitability solution is not insured. In the case of the aircrafts, the equipment cost may be around 50.000 / 80.000 \$ (if it is equipped with FMS capable to receive the MMR information). It is obvious, that from the aircraft point of view is bearable, but it has to be analysed if it is bearable from the airport point of view.

3.5 Finally, we have the SBAS augmentation. This has been questioned from it's beginning, however 3 has been develop (WAAS, EGNOS, MSAS), GAGAN is in development phase and it is being analyse the SACCSA solution, similar studies for Africa and China are on going in this moment. At present, on the basis of the reached performances, a new CAT I 200ft that can be reached in each aerodrome under the coverage aerial is in the certification process. In the development plans it is fall into the L1 augmentation, there is no definite proposal for the L5, a frequency that could be use to to improve the accuracy (cinematic L1/L5 process), or as alternative to L1, giving to L1 a high width band available in L1 to be centred in integrity and ionosphere corrections. The SBAS advantage is that it shares the GPS antennas and at receiver level, the changes are on SW and firmware level. In this moment, there are numerous on board equipments with SBAS (instead of only GPS, since the cost increasing is very reduced), the light aviation, helicopters, corporative aviation, 3<sup>rd</sup> level and regional may have a capacity with quite low costs (now, Universal, Honeywell and Collins offer this equipment in a certain corporative and regional aircrafts configurations, and in commercial options too, that is why Rockwell Collins, , has FMS with WAAS in PRO line 21 serial equipments the same as Universal Avionics), for example, the Rockwell Collins Pro Line Fusion, which was chosen by Embraer for its MSJ (Midsize Jet) and MLJ (Midlight Jet) that have the WAAS/LPV capacity or the case of Bombardier, that made the same selection

for its future C serial for 100 –149 passengers (Honeywell has equivalent products in Primus II serial) Given the system flexibility, it can be incorporated in some of the actual FMS as GPS upgrade - already incorporated - it provides the LPV capacity with a low cost to be used in any airport by each user. Obviously, a SBAS is a very expensive system if it is seen from a unit price point of view (its cost may be around 350 M\$, and yearly the operation may ascend to 25 M\$), but if we take into account that covers various States, and at the same time give service to all the airports, these costs reduce themselves drastically (if this comes on top of the service availability to be used by any user and with dozens of applications, the impact may be more reduced), besides, the safety increasing in those airports that do not have navaids and because of the operations number is unviable to install a GBAS or a ILS, is too high.

#### **4. Which is the better solution for the CAR/SAM regions?**

4.1 The answer to this question is complex, since the air space of CAR/SAM Regions is very extended and the different forms such as disruptions and geography distribution affect it, and what is good for an area is not so good for another. Nonetheless, there are elements to take into account in order to make a decision.

4.2 In both regions are a huge quantity of airports, but only few of them have a large traffic, there is a big number of airports with not much operations, that is why, when it comes to introduce a land infrastructure (ILS or GBAS) it is not so clear its profitability. In the case of some Navaids, the reposition time is very high and the maintenance costs are increase in a significant way.

4.3 There is a big density of land navaids, but in many cases its location is complicated, so, its maintenance is higher and even its performance is not excellent, this is what makes the satellites based solution to be suitable in the majority of the cases.

4.4 There are big number of aircrafts operating with different configurations, besides of the big commercial ones, the development of the regional and corporative aviation, next to the helicopters, is one of the areas in a big expansion, this is what makes necessary to provide them sufficiently attractive elements to speed up this process, that in the end will cause a lower cost for the user.

4.5 This means that, a horizon GNSS equipment, based on the previous point mentioned, includes the GBAS use in airports with a high operations number that permits to make profitable the equipment installation, but is not too clear if its use is profitable in those airports with low numbers in movements. That is why, it is necessary to analyse el SBAS use as alternative for each airport or heliport, besides of, the supposed flexibility of designing an LPV procedure in each place without the the nedd of land equipment y, this is what will improve in a significant way the operations in a not prepared runways and used by 3<sup>rd</sup> level aircraft. At the aircraft equipment level, only the big commercial ones may get an ABAS equipment which will permit them an autonomy in the navigation to APV I.

4.6 It is necessary to look for those systems that gives the maximum performances with the less cost in aircraft equipment and adapts themselves to the operation type and to the airfields they normally use. Furthermore, these systems should provide operations more efficient than the current ones, with lower consume and more shorter direct routes.

4.7 In the CAR/SAM regions exists the ionosphere problematic, which affects equally the GPS, GBAS and SBAS use with a different impact level because of the each element conception. In the GBAS case, the risk is on the GPS satellites signal loss, will affect both, the station and the on board (in 20NM could be seen the same satellites with the similar geometry) receiver, besides the different elevation given, this may be minimized. In the SBAS case, the biggest risk is on the GEO signal loss (from the L1), it could be mitigate having two or more GEOS, with a different orbital position and properly spaced out, in this way the vision angles are different and the sparkle impact or ionosphere anomaly will affect in a different form each GEOs in full view. To the GPS signals level and to the corrections establishment, one form to minimize this risk is through the adequate algorithms design, optimum mapping function and the fact that it has a big number GPS satellites vision with different angles that permits minimize ionosphere effects. Although it has to be developed specific SBAS algorithms to the region, that has been prove that it is feasible in the RLA/03/902 SACCSA Project.

4.8 It is necessary to fulfil a series of studies at GBAS and SBAS level in the region to see the ionosphere impact in the two augmentations, in this way several GBAS Programs are already initiated in various States and SACCSA, in its Phase III, has the objective to check the adapted and dedicated algorithms implantation viability to the specified characteristics of the CAR/SAM Regions, establishing the necessaries recommendations to implement a SBAS in those regions, besides of evaluating its economic impact and its definition faced to the L1 and L5 availability.

## **5. CONCLUSION**

5.1 In this moment, is necessary to finish the studies series and analysis series to have the sufficient value judgements elements to final decisions making in order to use the augmentations.

5.2 It is necessary that the GBAS Programs analyse the ionosphere impact in the stations located in critical aerals and develop a cost/benefit model to see which airports are profitable and which ones are not.

5.3 In the SBAS is necessary to finish the tests and current and proposed analysis of the SACCSA (RLA/03/902) PHASE III, where all the value judgements elements for the final decision are going to be take into account on the basis of the series of analysis and algorithms prototype, that until now they were not been realized in the region,

5.4 It is to take into account that, for the time being, even it is provided the double frequency and the double constellation, the necessity of the integrity external structure monitoring system will be necessary for precision approach and vertical guidance (perhaps, beyond the 2020 horizon may be receptors and algorithms designed which will allow us to get to a new CAT I on the basis of double constellation and four civil frequency, but for the moment this is something that is in the speculation field and preliminaries developments, like the NIORAIM case).

## **6. Action for GREPECAS**

6.1 The meeting is invited to:

1. To take a note of all shown into this note.

2. To encourage the GBAS and SBAS works, analysing the impact and cost of both, augmentations and problems, for example, what effects the ionosphere may cause over both of them.
3. To support the current National and Regional Projects, inviting to a large participation and a big State numbers and Institution as possible.
4. To advise the optimum solution search on the basis of safety criterions, cost/benefit, service providers and users (air companies) necessities, users from others sectors may be profitable of high benefits and high levels integrity for the augmentations and institutional impact.
5. To recommend that to the adapted solution, it must be taken into account not only the local and specific solutions, but also to consider all involved like a whole, therefore, to be taken into consideration on board equipment, flight operation criteria's, used constellations and augmentations.

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