GBAS implementation status: international context and situation in France

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International context:
- GBAS CAT-I implementation
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GBAS CAT-I situation: ground equipment implementation (1/2)

- ICAO GBAS CAT-I SARPs published in 2001
- Honeywell SmartPath GBAS station certified (System Design Approval) by the FAA in 2009
- First worldwide GBAS CAT-I operational approval at Bremen airport (Germany) in 2012
- GBAS CAT-I is now operational at several airports
  - Frankfurt, Zurich, Malaga, Newark, Houston, Sydney, Melbourne notably
  - See next slide
- ~100 GBAS CAT-I installations in Russia (GPS+GLONASS)
  - Russian specific technology
  - Re-use/certify in other part of the world unclear at this stage
Worldwide GBAS Cat I facilities
Honeywell+ Russia

Russia is now developing a Low cost GBAS network (~100 stations)
GBAS CAT-I situation: ground equipment implementation (2/2)

- Planned GBAS CAT-I implementation in
  - Brisbane, Perth, Tokyo Haneda, Shangaï, Tianjin, Singapore, Hong Kong, Chennai, Krakow, Oslo

- Other envisaged locations but overall GBAS CAT-I deployment remains limited

  - In perspective with SBAS, which now supports > 4000 Cat I or near-Cat I approach procedures in the US, and close to 400 now deployed in Europe within a few years.

  - The lesson learned is that this is related to economic rather than technology. GBAS technology is of high quality. Indeed:
    - The cost of a single certified GBAS ground station is from SESAR studies and deployment in Europe 1.5 to 2 M€ per airport
    - Alternatively SBAS signals are free of charge for aviation
GBAS CAT-I situation: A/C implementation

- **A320 family**: GLS Cat I Autoland
  - Certified
  - Selected by **7 customers** (2 additional customers have open the RFC)

- **A380 family**: GLS Cat I Autoland
  - Certified
  - Selected by **9 customers** (2 additional customers have open the RFC)

- **A330/A340 family**: GLS Cat I Autoland
  - Planned to be certified in 2012/2013
    - A330 with GE engines
    - A330 with PW/RR engines
    - A340 with CFM engines
    - A340 with RR engines
  - 5 customers have open the RFC

- **A350 family**: GLS Cat I with autoland
  - Planned to be certified at Entry Into Service
  - Selected by **2 customers

**Update July 2017**

- 300 Airbus aircraft equipped
- 1900 Boeing aircraft equipped

**Boeing Fleet GLS Activation Growing**

Over 1500 airplanes today

- **47%** Boeing deliveries with GLS activated
- **>60** airlines with GLS activated

At Paris CDG, now ~ 4% users equipped
GBAS CAT-II/III situation (1)

- ICAO GBAS SARP\'s to support CAT-III operations are completed
  - Solution based on Single-Constellation Single-Frequency technology (GPS L1 only)
  - Concept called GAST-D. GAST-D SARP\'s Approved by ICAO NSP in December 2016
  - Publication in Annex 10 in 2018
  - Strong involvement of US industry (Boeing, Honeywell, Collins)

- GBAS CAT III capable Ground Station development has already started
  - Honeywell is seeking for System Design Approval on the future GAST-D capable GBAS SLS-5000
  - Schedule to complete SDA dependent on vendor investment decisions & funding for FAA SDA support

- ICAO GBAS CAT-III procedure design criteria under development by IFPP
GBAS CAT-II/III situation (2)

- GBAS GAST-D Avionics
  - RTCA DO-253D GBAS airborne MOPS approved for publication in May 2017
  - Will lead to new or amended GBAS airborne equipment TSO/ETSO

- GLS CAT II/III implementation by airframer will depend on market demand, maturity of standards/regulatory requirements, availability of infrastructure and other business factors
  - Boeing announced the GLS CAT II/III capability on the 777X at EIS (option while GLS CAT I is standard fit), under study for 737MAX in 2020
  - FAA work on advisory circulars related to GAST-D airborne implementation
GBAS CAT-II/III situation (3)

- Work on GBAS CAT III Multi-Constellation (GPS+GALILEO) Multi-Frequency technology (L1/L5) still remains R&D at the moment
  - Will offer more robustness facing some threats (ionosphere effects, radio-frequency interferences, satellite geometry) while potentially introducing complexity
  - Seen by some actors as the only solution to foresee CAT III ILS rationalization
  - Lower involvement from Industry compared to GAST-D solution. European institutions through SESAR2020 may lead the effort toward MF/MC CATII/III GBAS.
Overview of GBAS activities in France
Overview of GBAS activities in France

- DSNA has been involved in GBAS standards and system development for more than 20 years
  - First experience of a Local Area Differential GPS experimental station at Toulouse airport in 1994
  - Key contribution to standardization activities related to GBAS CAT-I and CAT-III (ICAO, EUROCAE)
  - Strongly involved in the CAT-I technical and operational validation phase using a GBAS station operated at Toulouse Blagnac
  - Key partner in SESAR 1 (WP15) related to GBAS CAT-III with the implementation of a GBAS CAT-III (GAST-D) prototype at Toulouse Blagnac
  - Work continuing in SESAR 2020 (PJ14)

- GBAS CAT-I station implemented at Toulouse Blagnac Airport
  - The GBAS Toulouse station is not operational but used by Airbus for development/certification of the GLS function
  - No further CAT-I deployment in France is foreseen at the moment

- DSNA internal analysis to assess the operational benefits that a GBAS CAT-III system could bring at Paris CDG airport
GBAS site at Toulouse Blagnac
GBAS station at Toulouse/Blagnac

**GBAS site**

**Reference Receivers antennas**
GBAS internal study for Paris CDG
Objectives of the GBAS@CDG study

- The main objective was to assess the operational benefits that a GBAS CAT-III system could bring at Paris CDG airport
  - Is it possible to remove some or all of 8 ILS serving Paris CDG?
  - Is it possible to increase capacity under Cat II/III meteorological conditions?

- The potential interest for the nearby Paris Le Bourget business aviation airport was also assessed
  - Assessment of the possibility of a GBAS station installed at CDG to support offset approach (with vertical guidance) at Le Bourget RWY 25

- Conducted by DSNA Technical Directorate (Navigation team) and DSNA ATC service at Paris CDG
Outcomes of the GBAS@CDG study (1)

- Simultaneous triple independent parallel approach operations conducted on LFPG (Paris CGD) 27R, 26L and LFPB (Paris le Bourget) 27
  - Typically supported by CAT III ILS on 27R and 26L, CAT I ILS on LFPB 27
  - Also supported by an PBN approaches on RWY 26L

- The study has shown that a GBAS system could also support this type of operations (one GBAS and two ILS simultaneous approaches)
Outcomes of the GBAS@CDG study (2)

- Offset approach at other LFPB runway
- RWY 25 (2991 m long) used by A/C for which landing distance would make RWY 27 (1853 m) too short
- Approach served by a 26° offset localizer providing guidance nearly parallel to LFPG RWY 26L
  - No vertical guidance
- PBN GNSS approach also available
  - Published with LNAV minima only
- According to the current regulations, no benefits from GBAS are foreseen
  - ICAO PANS OPS* requires the GBAS CAT I final approach track to intersect the runway extended centre line at an angle not exceeding 5°
  - Similar situation with SBAS

*Note: ICAO PANS OPS – Vol II - Part III — Section 3, Chapter 6 - § 6.7.1
Outcomes of the GBAS@CDG study (3)

- GBAS CAT-I station installation at short-mid term to gain operational experience and pave the way for potential future CAT-III operations not seen as relevant:
  - Very few operational benefits compare to the additional complexity to manage mixed equipage
  - Limited interest on GBAS CAT I considering the existence of PBN approaches down to LNAV/VNAV and SBAS Cat I minima

- General concern about the multiplication of approach types and approach plates related to PBN implementation with a low number of users:
  - GLS procedure charts would increase the risk of potential confusions by the pilot while only a few % of GBAS equipped users land at CDG
  - The situation is different for SBAS, which is published on a PBN chart addressing 90% of CDG users
Outcomes of the GBAS@CDG study (4)

- Possibility to replace at mid-term ILS Cat III by GBAS Cat III for the 4 inner runways (departure) not considered as relevant
  - Inner runways are expected to absorb arrival flows in the near future providing a very high flexibility
  - Inner runways are currently used for landing when outer runways or ILS approaches are unavailable
  - Sorting GLS equipped A/C to a GBAS only runway would penalize ILS only A/C (holding cannot be envisaged)
  - Would work only under a very high GLS equipment rate (90%)

- From an economic perspective, ILS infrastructure cost reduction could only be possible once sufficient proportion of GLS equipped A/C is achieved
  - This could require a GBAS equipage mandate
  - Same conclusion now reached by German DFS
Outcomes of the GBAS@CDG study (5)

- **Dedicated GBAS runway to concentrate GBAS equipped A/C not possible**
  - Requires a very high GLS equipment rate to optimize the runway pair utilization
  - Crossing traffic flows coming from North and from South may reduce efficiency and kill any GBAS benefits

- **“Optimized Operations in LVC” concept not applicable with the existing ATC tools**
  - Concept can only be envisaged if ATC radar display indicates the GBAS CAT III A/C capability/pilot intent and provides a spacing management tool (similar to Time Based Separation concept)
  - A/C GBAS capability is not visible to the ATCOs through current French Flight plan system
  - Managing a different spacing for GBAS-ILS and GBAS-GBAS arrivals considered as too complex **without spacing management tool** by ATCOs

- **Capacity gain only foreseen when sufficient GLS equipment rate is achieved**

- **High performance new ILS localizers are scheduled for 26L/08R and 27R/09L at CDG. These LLZ may reduce the size of the critical/sensitive areas and allow to increase the runway throughput under LVC without the implementation of a new technology like GBAS** (same as London Heathrow /Zurich/Geneva)
To summarize...
Worldwide GBAS Implementation is progressing, but still quite limited vs. other GNSS technologies (PBN, SBAS)

GPS/L1 GBAS CAT III technology is available but further work is needed on operational aspects (regulations, standards, ATC tools definition,…)  
- Benefits vs. ILS over main airports may require a high % of GBAS equipage

MC/MF GBAS CATIII technology is still at R&D level with less industry involvement

Implementing GBAS at Paris CDG is considered as too ambitious for a first GBAS CAT III project

However, DSNA confirms his commitment to GBAS technology  
- Toulouse airport has been proposed as an alternate to further progress with GBAS CAT III – ongoing discussions with Airbus
- Pursuing R&D work in SESAR 2020
- Continuing participation to standardization groups (ICAO, EUROCAE)
Thank you for your attention!