

GBAS/SBAS Implementation Workshop - Operational experiences in SBAS

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4 June 2019, Seoul



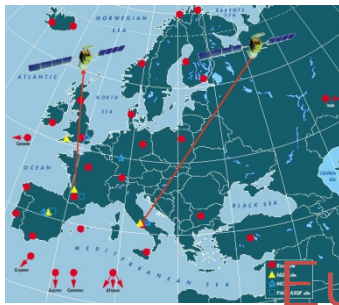
Introduction

Main active working areas in France related to SBAS implementation:

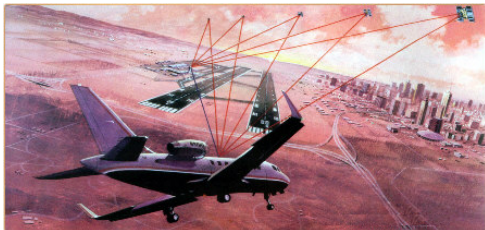
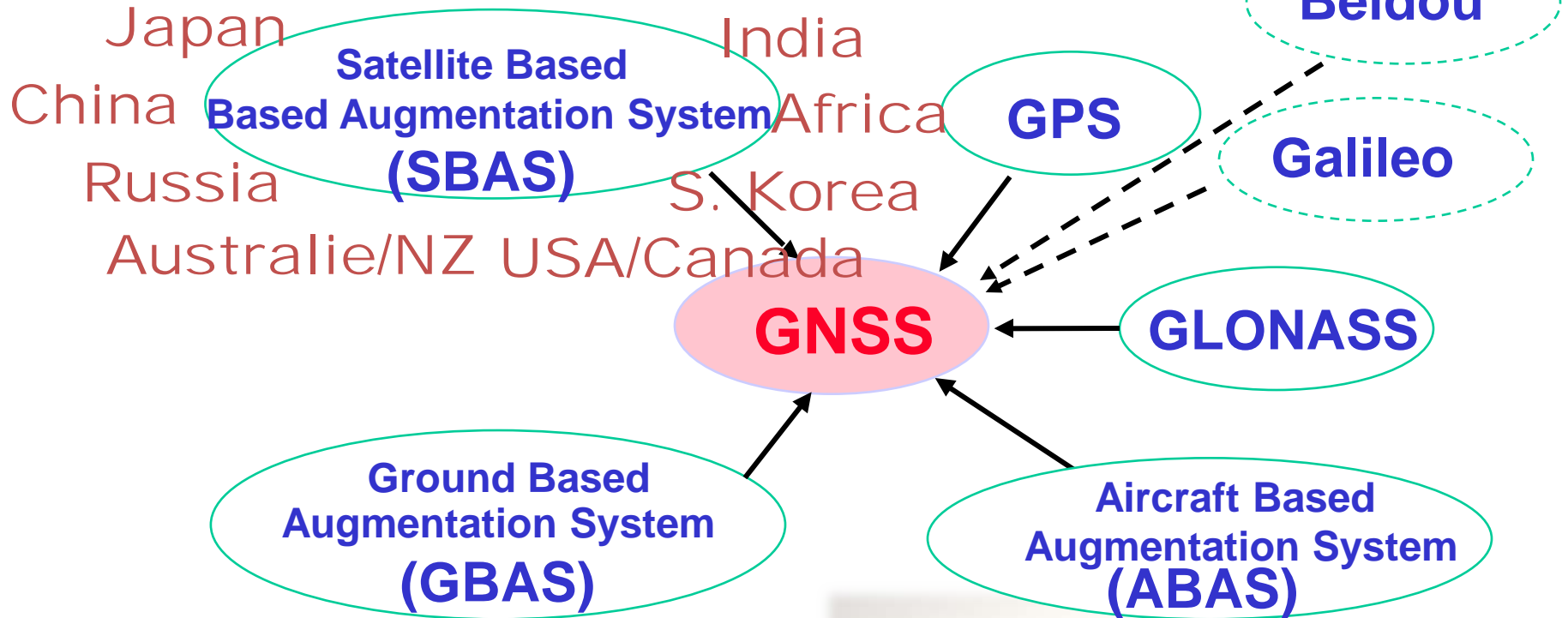
1. **SBAS within a global GNSS Strategy (system layer)**
2. **SBAS within PBN implementation (application layer)**
3. **Minimum Operating Network (MON) achieved with SBAS**
4. **SBAS vulnerability mitigation**
5. **European regulation targets for SBAS**

1. SBAS within a global GNSS Strategy

GNSS: Global Navigation Satellite System



Europe EGNOS



GNSS strategy France 2010 – 2020

- **Implementation of first generation GNSS based upon:**
 - **GPS** augmented with ABAS (RAIM, BaroVNAV), for all phases of flight except precision approaches
 - **EGNOS V2**, the European SBAS, for all phases of flight including Cat I precision approaches
- **NB: Business case not positive for all types of GNSS:**
 - E.g. **GBAS Cat I**, **not implemented** in France due to costs, and limited number of airspace users
 - While EGNOS Cat I is free of charge
- **Initialisation of rationalisation of NDB, VOR, ILS Cat I networks**



– **MON** initial implementation

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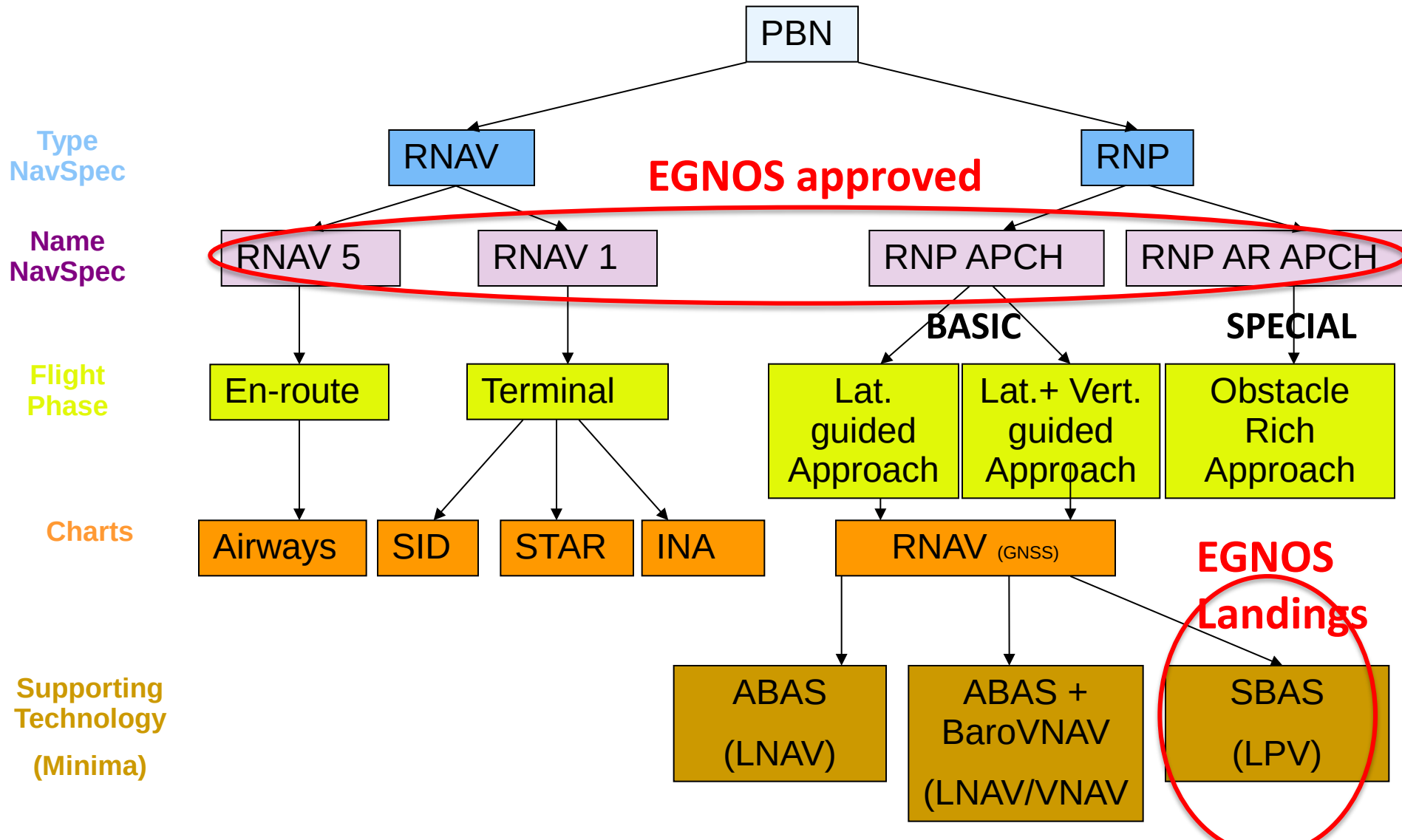
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GNSS strategy France 2020 – 2030

- **Progressive transition toward a second generation GNSS based upon:**
 - **Multiconstellation GNSS**, for all phases of flight except precision approaches, supported by:
 - **GPS modernised open signals**, dual-frequency L1 – L5
 - **Galileo Open Service**, dual-frequency L1 – E5a
 - **EGNOS V3**, for all phases of flight including Cat I autoland and higher availability
 - EGNOS V3 will augment both GPS and Galileo open signals
 - **GBAS Cat II/III**, supporting Cat II/III precision approaches with higher runway capacity than ILS
- **Continuation of rationalisation of NDB, VOR, ILS Cat I networks**
 - Supported by the European **PBN Implementing Rule** voted in 2018
 - The level of continued rationalisation will certainly depend of:
 - the risk of dependency toward a single foreign constellation (GPS)
 - the market penetration of GNSS Multiconstellation avionics
 - the actual level of control of GNSS vulnerabilities

2 – SBAS within PBN implementation

PERFORMANCE BASED NAVIGATION (PBN) OPERATIONS IN FRANCE IN 2019



PBN LANDING CHART

- France implements ICAO charting concept for PBN, down to LPV 250 ft or Cat I

- Supports an easy introduction over airports
- Manages smoothly different generation of avionics

EGNOS
SBAS
minima

GPS
ABAS+BaroVNAV
minima

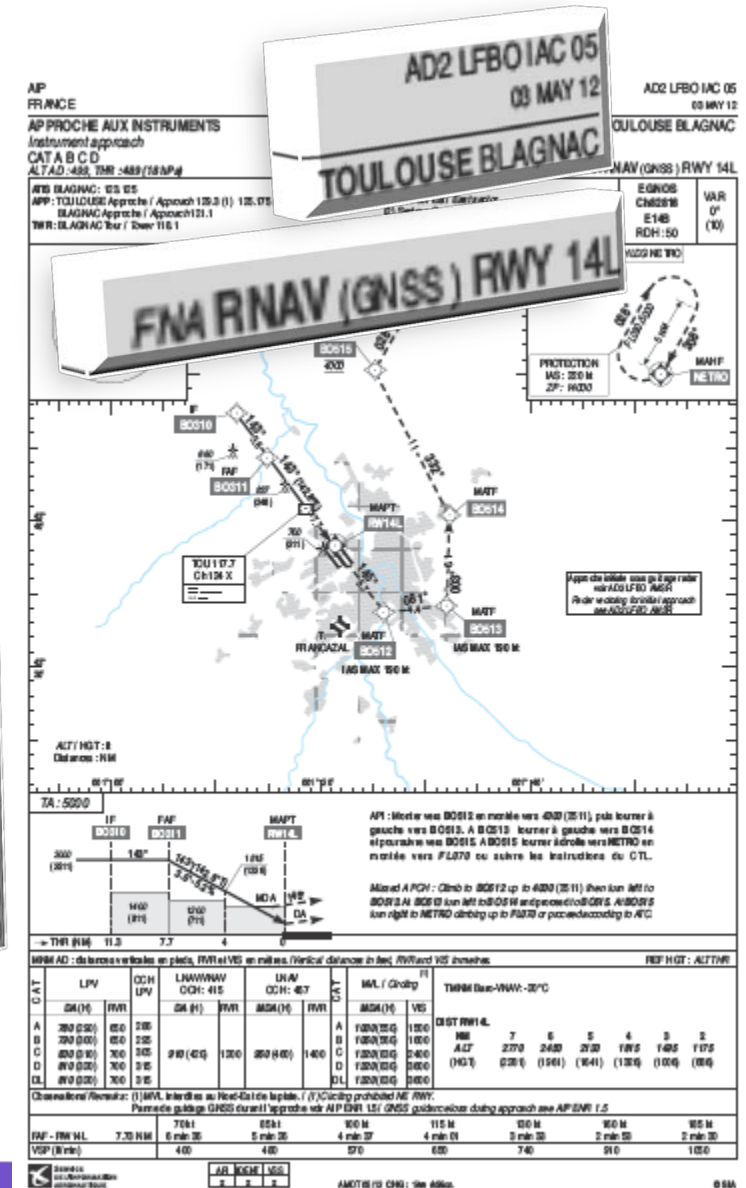
GPS
ABAS
minima

CAT	DA (ft)	RVR	OCH LPV	LNAV/VNAV OCH: 415	LNAV OCH: 457	CAT	MDA (ft)	VIS
A	780 (290)	680	286			A	1030 (580)	1800
B	790 (300)	680	295			B	1050 (580)	1800
C	800 (310)	700	305			C	1320 (830)	2400
D	810 (320)	700	315			D	1320 (830)	3000
DL	810 (320)	700	315			DL	1320 (830)	3000

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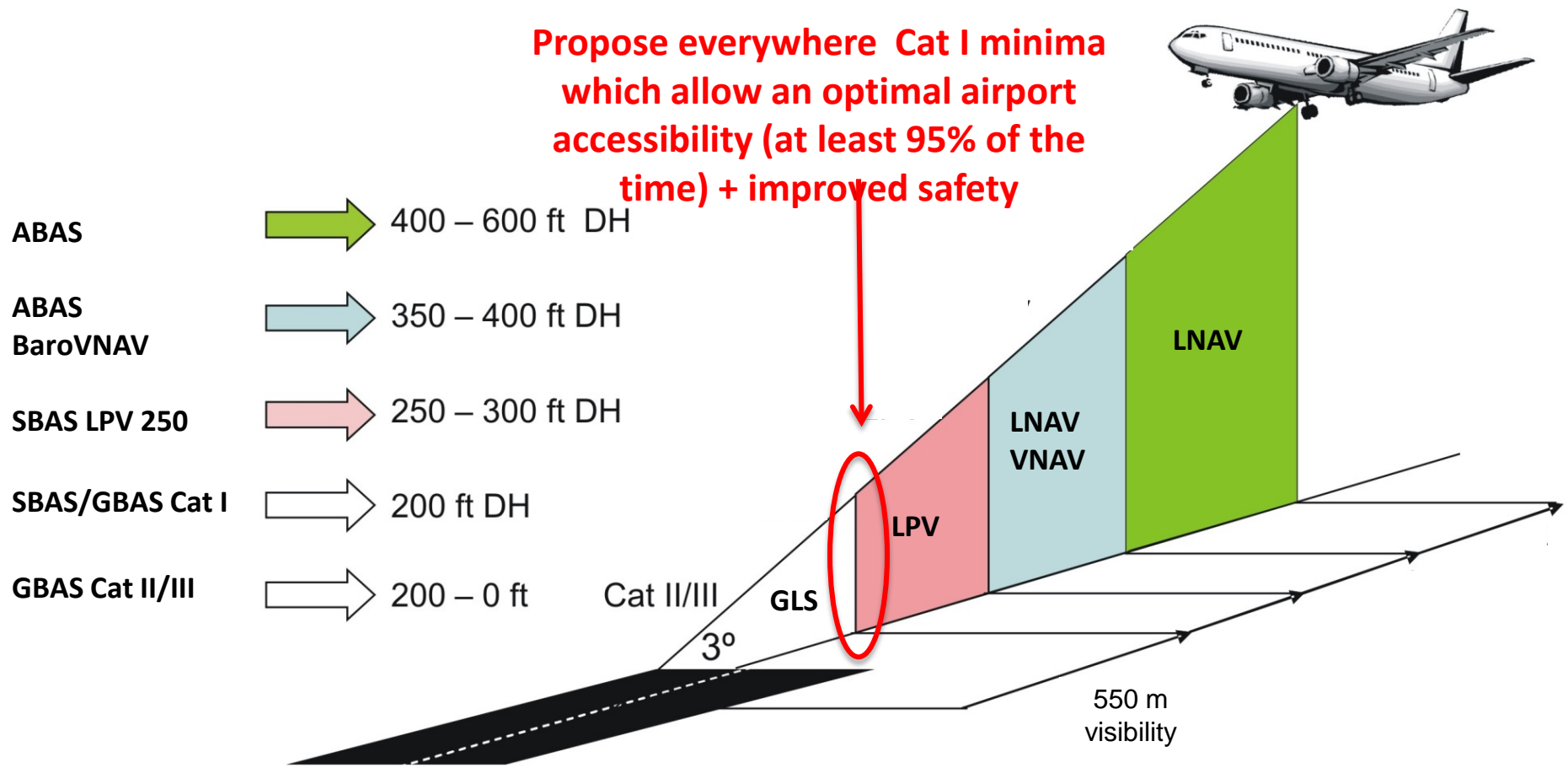
D S N A



PBN LANDINGS

**PBN landings France
upper performance
target:**

**Propose everywhere Cat I minima
which allow an optimal airport
accessibility (at least 95% of the
time) + improved safety**



FRANCE PERFORMANCE BASED NAVIGATION (PBN) & ILS STRATEGY

- **Building a low-cost performing national approach and landing network:**

“Cat I everywhere, everytime”

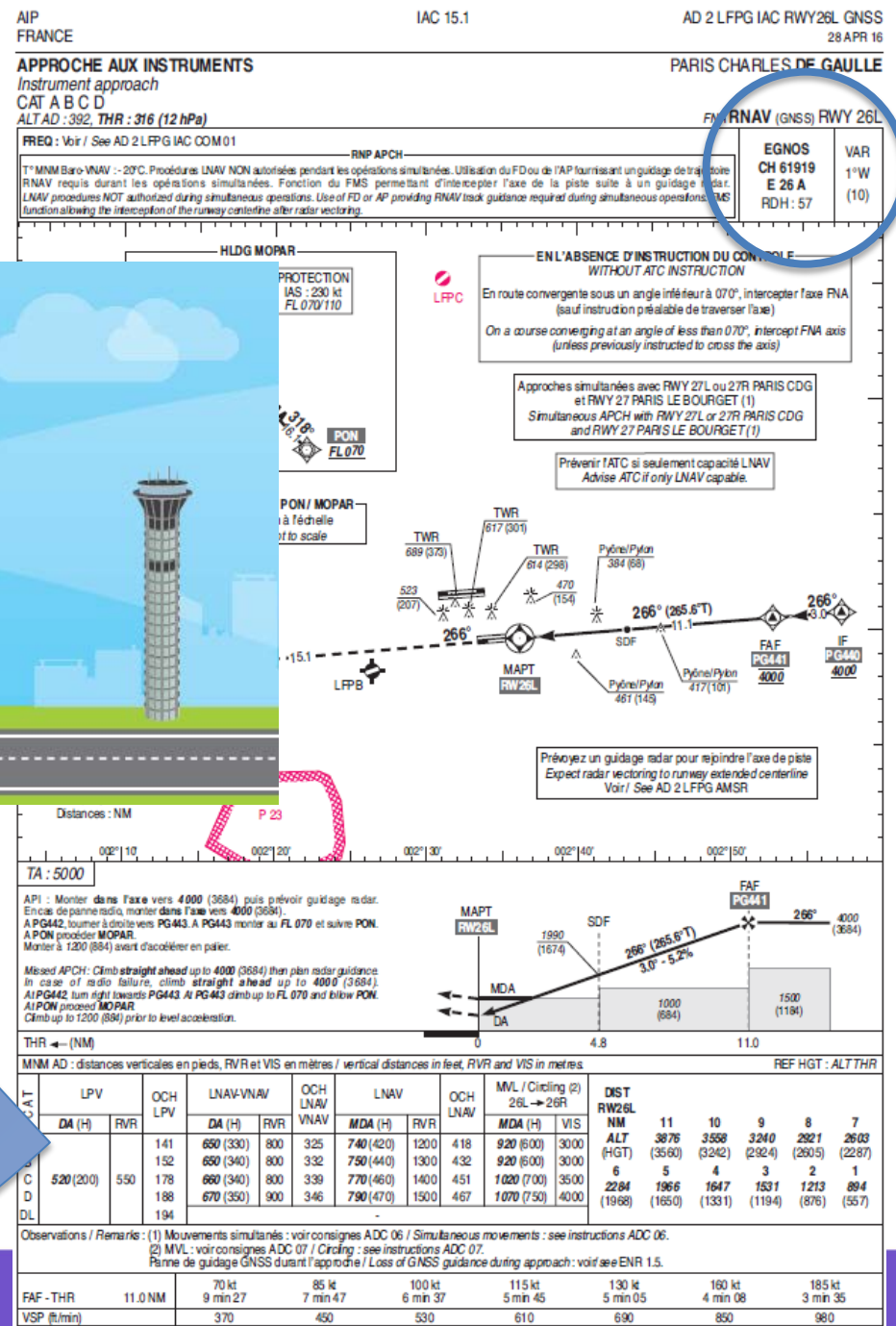
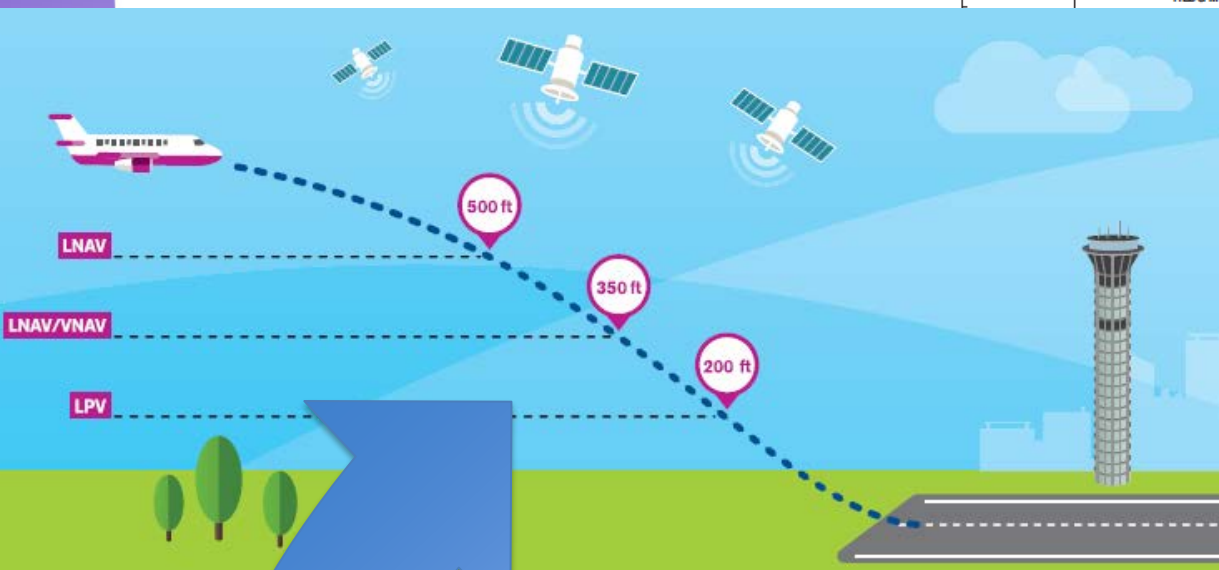
- **This is achieved through a mixed infrastructure: ILS and EGNOS**
 - When the ILS is out of service, or non existing over the runway in service, **equipped airlines will benefit from an additional level of safety and airport accessibility thanks to EGNOS Cat I**
 - Supports ILS reduced networks
- **Also compatible with users not equipped with EGNOS**
 - **GPS and BaroVNAV users**
 - **Airspace users business case decision**

Status of PBN landings implementation in France

AIRAC cycle 1/19

- **France civil aviation (continental + overseas)**
 - **243 PBN** approach charts published
 - **162 LPV** approach procedures, with **71 LPV Cat I** procedures
 - **115 LNAV/VNAV** approach procedures
- **France military aviation**
 - **27 PBN** approach charts published
 - **4 LPV** approach procedures, with **2 LPV Cat I** procedures
 - **3 LNAV/VNAV** approach procedures

EGNOS CAT I BENEFITS



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EGNOS CAT I APPRECIATIONS @ PARIS CDG

- **Jean- Christophe Lair, Airbus Experimental Test Pilot:** “Airbus is pleased to have demonstrated that the A350 XWB complies with the new RNAV (GNSS) approaches with satellite-based augmentation, as implemented at Paris Charles de Gaulle. **These approaches will be a valuable backup to the airport’s traditional ILS approaches** and will maximise runway availability for the A350 by maintaining CAT1 capability, down to 200ft decision height, even **when the ILS ground station is not available.**”
- **Eric Delesalle, ATR chief pilot:** “The LPV system is much more stable and **more reliable in terms of safety, but also more efficient than the ILS approach.** It really makes a difference”
- **Jean-Louis Dumas, Dassault flight test pilot:** “Lowering the LPV minima down to 200ft in Europe is a great improvement enabled by EGNOS, and is **very valuable for business aviation operations**”
- **Peter Koch, chief of the Bombardier C Series fleet at SWISS:** “The accuracy and stability of the LPV guidance is impressive, as completely independent from ground installations. Lowering the LPV minima down to 200ft in Europe is a great improvement and very valuable. **The approach procedure is straight and simple, and there is no necessary changeover regarding the FGS with respect to conventional approach aids**”

PBN APPROACHES LESSONS LEARNED

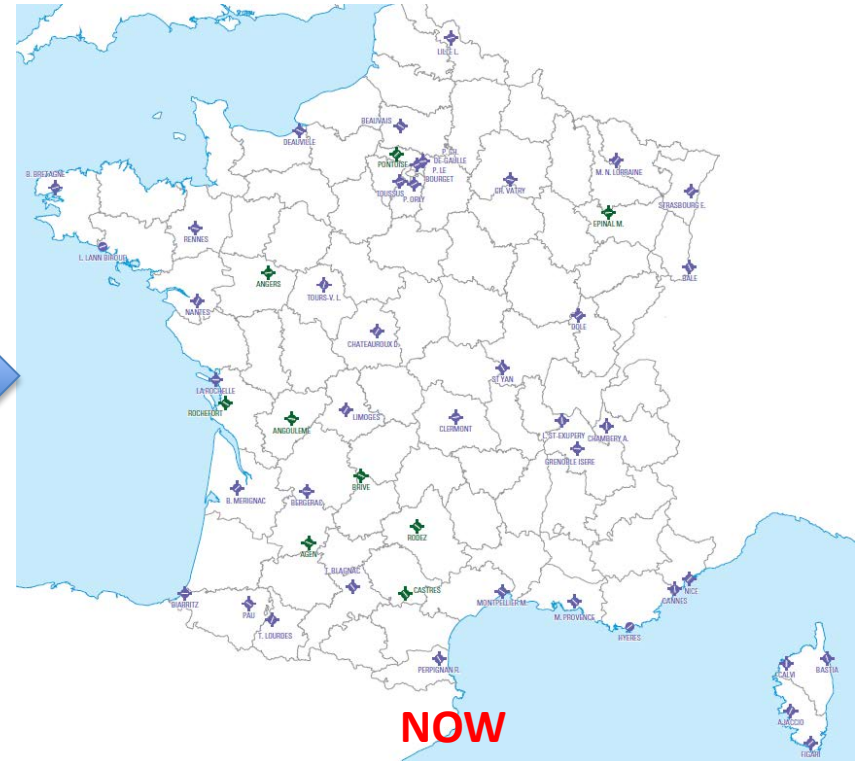
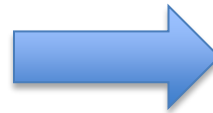
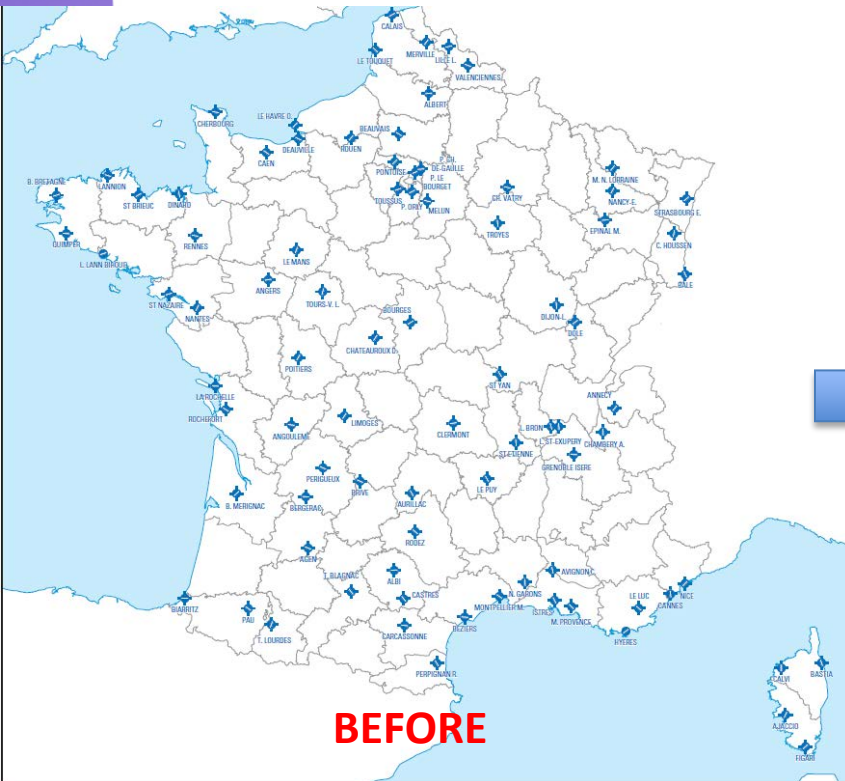
- **PBN with ABAS and BaroVNAV, has limitations in term of airport accessibility and approach safety, wrt PBN with SBAS**
 - **However, ABAS based PBN still represents a progress with respect to LOC, VOR or NDB conventional approaches**
 - **has to be implemented now** to support airspace users avionics status
- **PBN with SBAS seems the right target to seek to complete/rationalize ILS networks**
 - Shows optimal (**ILS equivalent or better**) airport accessibility and approach safety level
 - Consolidated by airspace users feedback
 - This doesn't require users equipment with SBAS technology as a first step, since **PBN landing charts accomodates other technologies**
 - SBAS equipment depends on airspace users CBAs

3 – Minimum Operating Networks (MON) achieved with SBAS

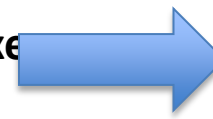
Minimum operating networks implementation in France

- **ILS Cat I MON: Half of ILS Cat I are now no more owned by DSNA, thanks to EGNOS**
 - 31 removed of service
 - 14 transfered to local airport owners, but it is likely that they will not be replaced at their end of life
- **ILS Cat III: No minimal network**
- **VOR/NDB**
 - Target for MON definition finalized 2020
- **DME: No minimal Network**
 - 67 DME En Route network maintained

France ILS CAT I rationalisation plan



**About 5 M€ yearly savings
Contributes to the French tax
reduction program**



2018 : 225,50 €
2017 : 224,45 €
2016 : 227,1 €
2015 : 228,62 €
2014 : 233,23 €



1.4 – SBAS Vulnerability mitigation

GNSS vulnerabilities

- **4 vulnerability areas are worked out by DSNA to maintain a high level of SBAS availability:**
 - Unwanted interferences
 - Interference attacks/Spoofing
 - Space weather impact
 - Cyber-security threats
- **The above involves significant cooperation with relevant France authorities**
- **One DSNA expert team analyses all incident reports**
- **Second generation DFMC systems have a higher potential to mitigate GNSS vulnerabilities, in particular wrt:**
 - Unwanted interferences
 - Space weather impact
 - Cyber-security threats

1.5 – European regulation targets for SBAS

PBN regulation 2018/1048 targets

A red X means that EGNOS plays a major role within this part of the regulation

	03 Dec 2020	25 Jan 2024	6 Jun 2030
PBN transition plan coord. with airspace users	X	X	X
RNP APCH for all IRE, without precision approaches	X		
RNP APCH for all IRE		X	
RNAV 1 or RNP 1 for one route, where SID/STAR established		X	
RNAV 1 or RNP 1 for all routes, where SID/STAR established			X
RNAV 5 for all routes established above FL 150 (except SID/STAR)	X		
RNAV 5 for all routes established below FL 150 (except SID/STAR)		X	
RNP 0.3 or RNP 1 or RNAV 1 for established rotorcraft routes		X	
Exclusive use of PBN			X



PBN regulation 2018/1048 targets highlights

- **Publication of RNP APCH:**

- The regulation requires LPV minima at all European instrument runway ends, in two steps 2020, then 2024.

- **Exclusive use of PBN :**

- After 6/06/2030, for all phases of flight, conventional navigation only accepted in case of loss of PBN. However CAT II and III ILS approaches are exempted

- One significant consequence is that the regulation forces ANSPs to provide, by 2030, CAT I operations through PBN LPV CAT I, while airlines would have the obligation to be equipped, due to other European regulations.

Thank you !



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Complementary slides

RNP AR APCH
GBAS



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DSNA

RNP AR APCH On going & Planned



- Ajaccio (LFKJ) RWY 20 => AIRAC 13/2019
- Saint Denis La Réunion (FMEE) => AIRAC 02/2020
- Nice (LFMN) RWY 22 => planned 2020-21
- Bastia (LFKB) RWY 16 => not planned 2021?
- Dzaoudzi (FMCZ) => impossible due to VSS infringement

GBAS Cat III Ops benefits

- **Reduced Critical and Sensitive area w.r.t. ILS**
 - Expected to support less stringent runway capacity limitation in Low Visibility Conditions
- **The following benefits also apply both to Cat I and Cat III Ops but were not able to sustain a positive business case for Cat I within French airspaces until now:**
 - **1 station for several runway ends**
 - Potential Infrastructure rationalisation on multi-ILS airport
 - Better VHF spectrum efficiency
 - **Reduced maintenance cost w.r.t. ILS (period and duration of the flight test)**
 - **Flexible approach path configuration (FAS DB broadcast can handle Displaced THR, adapted Glide Path Angle)**

GBAS Standardization

- **Step-wise approach, GBAS Approach Service Types - GAST**
 - Current ICAO in Annex 10 volume I 7th edition defines GBAS SARPs to support **CAT-I/II/III GAST-C, GAST-D**
- **Cat II/III - Work in progress**
 - **GAST-D: approved by ICAO, regulation framework ongoing**
 - ground station : MOPS ED-114B open consultation (basis for future approval in Eu regulation framework)
 - airborne MOPS DO-253D already available, Change 1 under FRAC. Change 1 will be the basis for the development for a new airborne TSO development
 - Advisory Circular 20-191 (Airworthiness Approval of Airborne Systems used for Takeoff, Precision Approach, Landing, and Rollout in low-visibility conditions) under completion
 - **GAST-F: under R&D at ICAO level**
 - CAT-II/III with Dual-Frequency, Multi-Constellation (DFMC) studied in SESAR
 - ICAO standardization deadline is currently « TBD »
 - **Improved performances and robustness expected**

DSNA believes that GAST-F additional robustness is a key asset, in particular if ILS CAT-III to be removed, but currently undefined target dates put its emergence at risk

GBAS deployment status worldwide

- **Main countries involved in Cat I:**
 - US, Australia, Russia (specific design), Germany, Spain, Switzerland, Norway, Brazil, Japan, India, China,...
 - But overall deployment limited (at the exception of Russia)
- **Europe : incentives through SESAR Deployment Manager CP2 & INEA calls**
 - CP2 projects at Madrid Barajas and Milano Malpensa Airports
- **Airbus/Indra GBAS Cat III Alliance initiative**
 - Stakeholders coordination initiated through European GBAS Alliance, targeting Cat-III operations in 20 major airports in Europe
 - Workshop 4/5 June in Toulouse, supported by DSNA
- **Aircraft manufacturers Cat III airborne status**
 - Boeing first deployments by 2020 on B777X
 - Airbus, if business case validated, first deployments not before 2023

GBAS deployment status in France

- **CAT-I experimental station deployed at Toulouse-Blagnac:**
 - supports Airbus needs (CAT-I certification) and
 - supports SESAR GBAS GAST-D (CAT-III) development, but
 - no more maintenance framework.
 - Re-use/replacement considered for the short term.
- **CAT-III interest now expressed by Paris CDG:**
 - to restore part of the runway capacity reduction lost under ILS Low Visibility Operations
 - New wide array (32 elements) ILS at CDG less promising than initially expected for LVPs
 - CDG cannot be an experimental airport for such an important migration.
 - Toulouse could then be deployed ahead as a dry-run for initial certification.
 - Main non technical implementation issue: ILS/GBAS mixed fleet situation
 - This would probably require evolution of AMANs to deliver initial benefits