7-8 October
Lisbon

The EGNOS Service Provision workshop

ESSP
We certify you're there.

European Global Navigation Satellite Systems Agency

funded by the European Commission

AGENDA (14:30 – 16:15)

14:30-15:45 **Successful EGNOS implementation stories in Aviation (I)**

- Introduction
  Luc Tytgat *– Director of Pan-European Single Sky (EUROCONTROL)*
- Implementation of advanced EGNOS operations in Switzerland
  Laurent Delétraz *– Sales and business development mngr (Skyguide)*
  Marc Troller *– Navigation Expert (Skyguide)*
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- Training: The key to success
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Implementation of advanced EGNOS operations in Switzerland

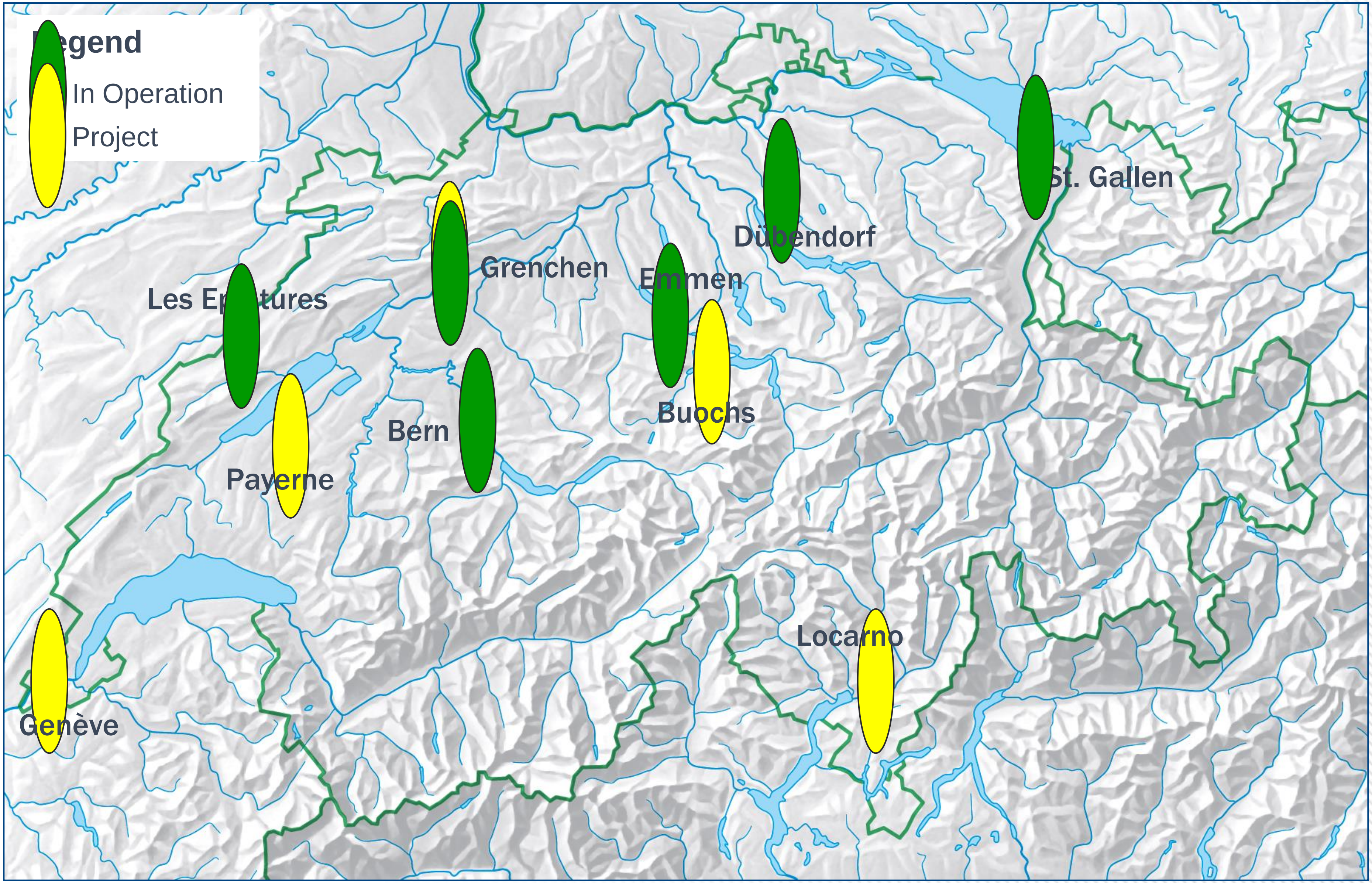
Marc Troller
CNS expert group

Laurent Delétraz
sales and business development manager

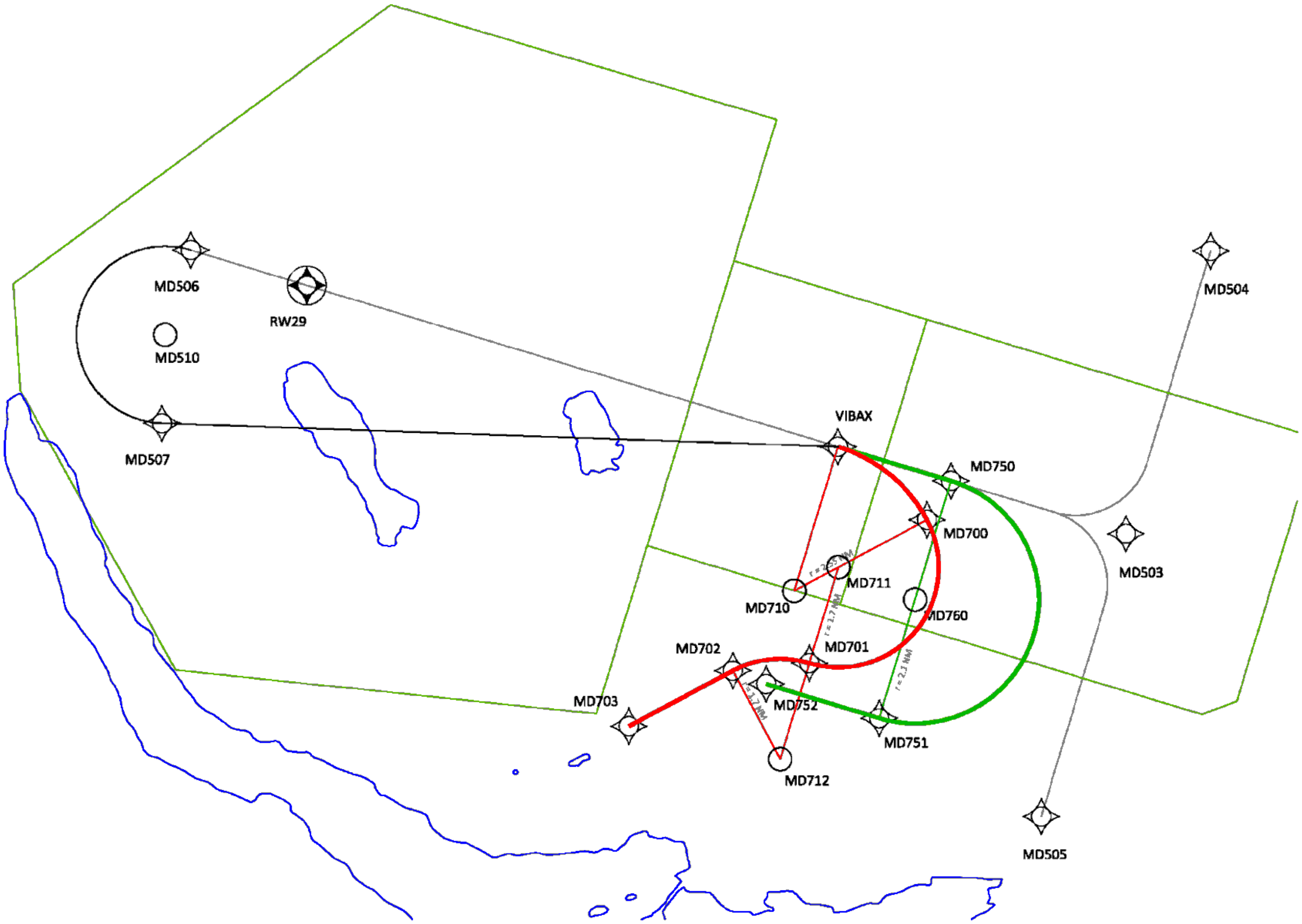
skyguide

member of FABEC

Current Swiss applications of EGNOS



RF leg flight trials – procedures



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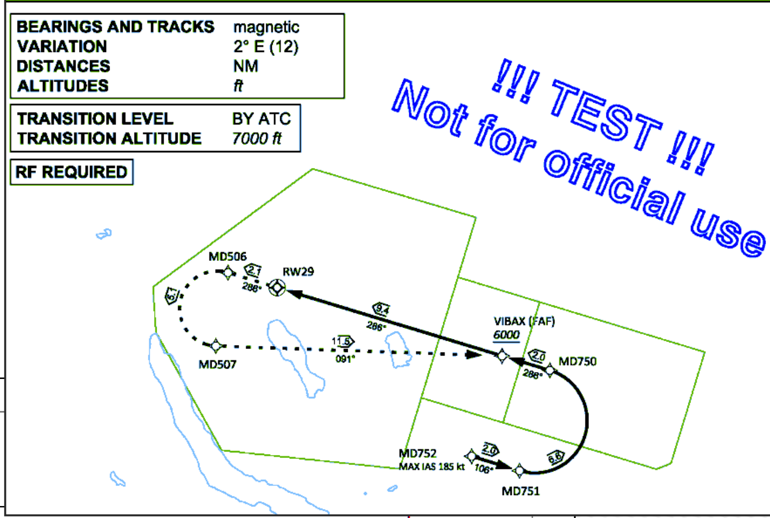
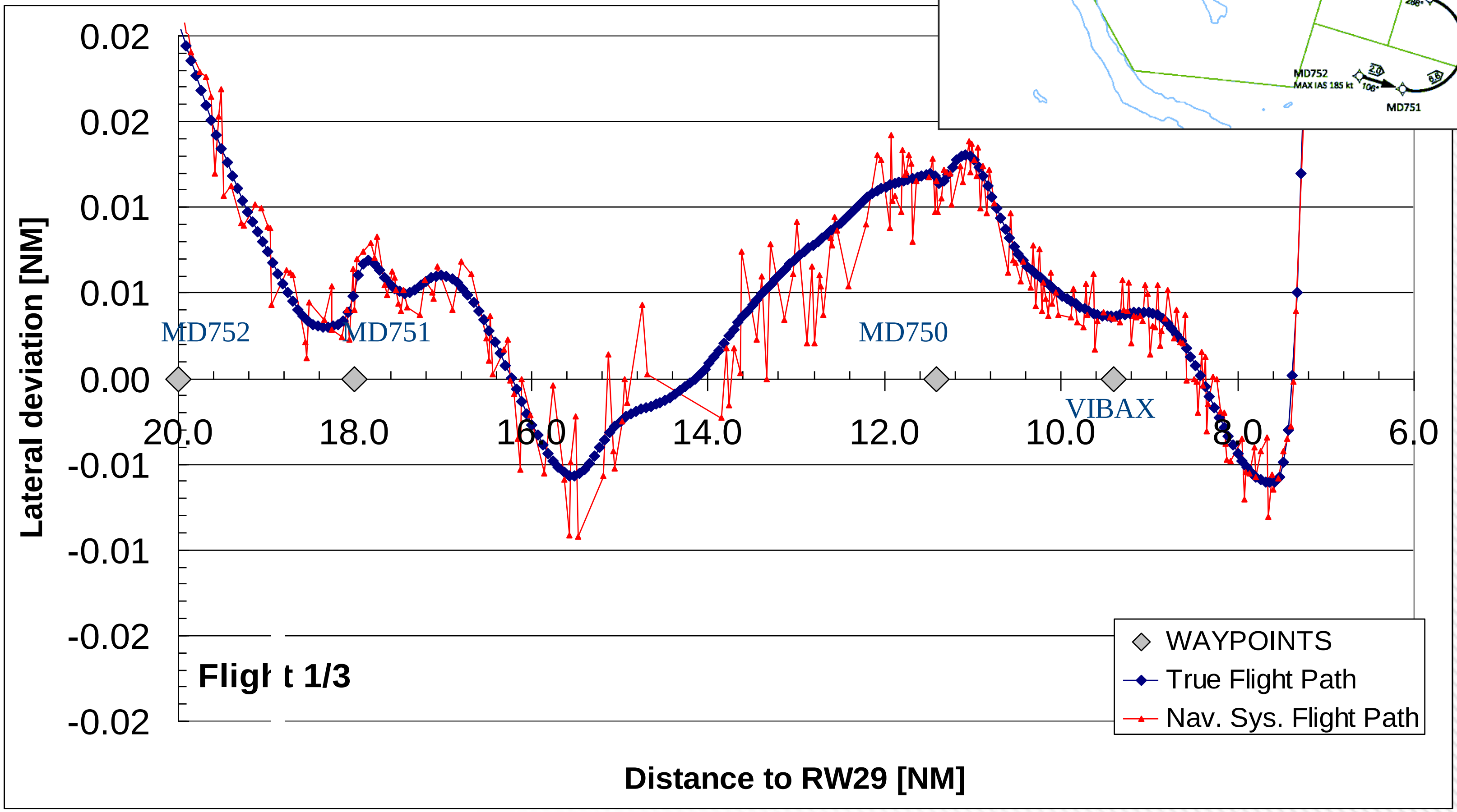
Aircraft

› Super King Air of the Swiss Airforce
› Rockwell Collins ProLine 21 WAAS(EGNOS)/LPV
› Rockwell Collins GPS4000S GPS/SBAS receiver
› RF leg functionality

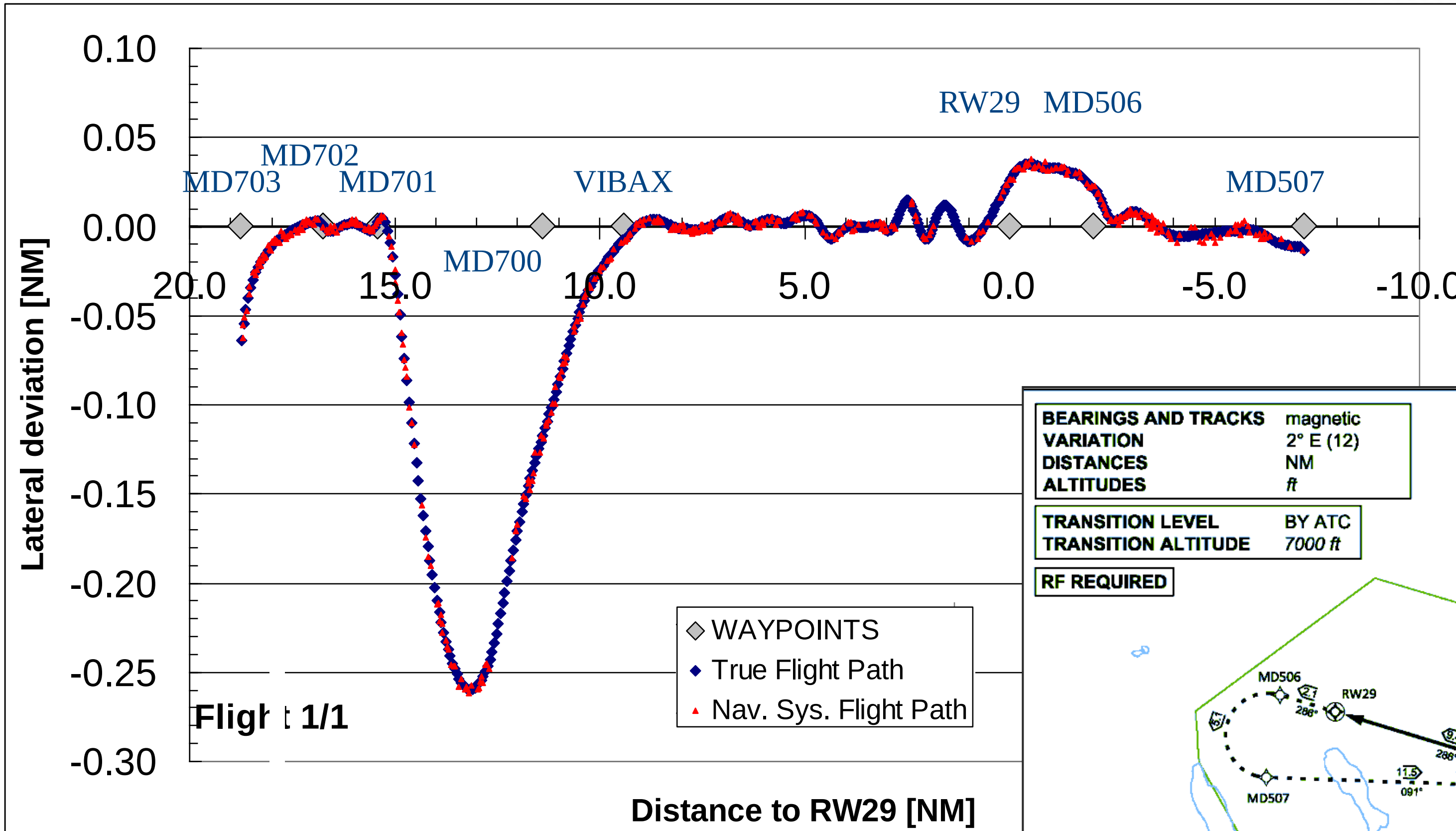
› Goal: Ability to test avdvanced PBN procedures and functionalities

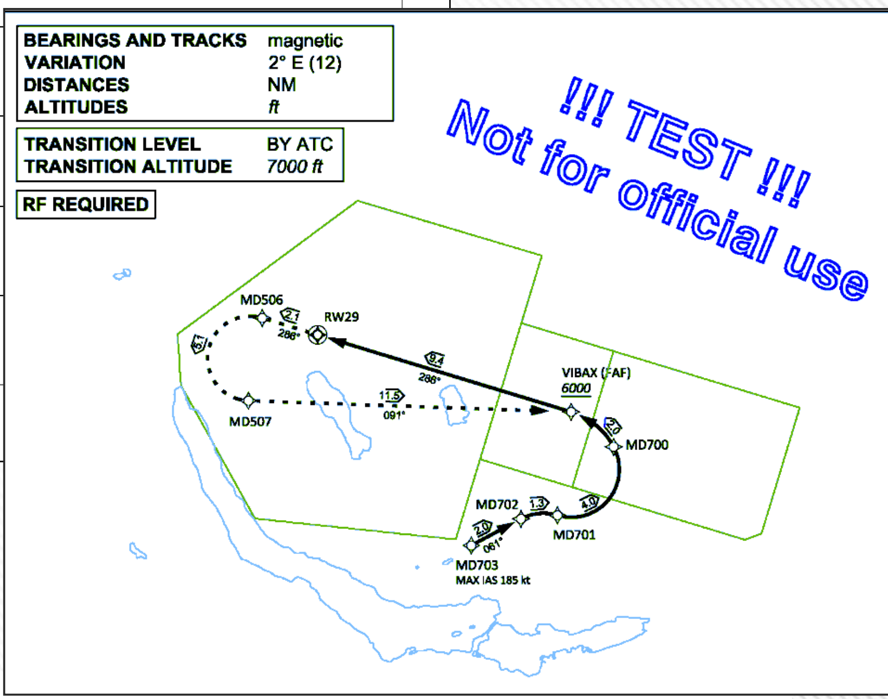
Analysis Procedure 1



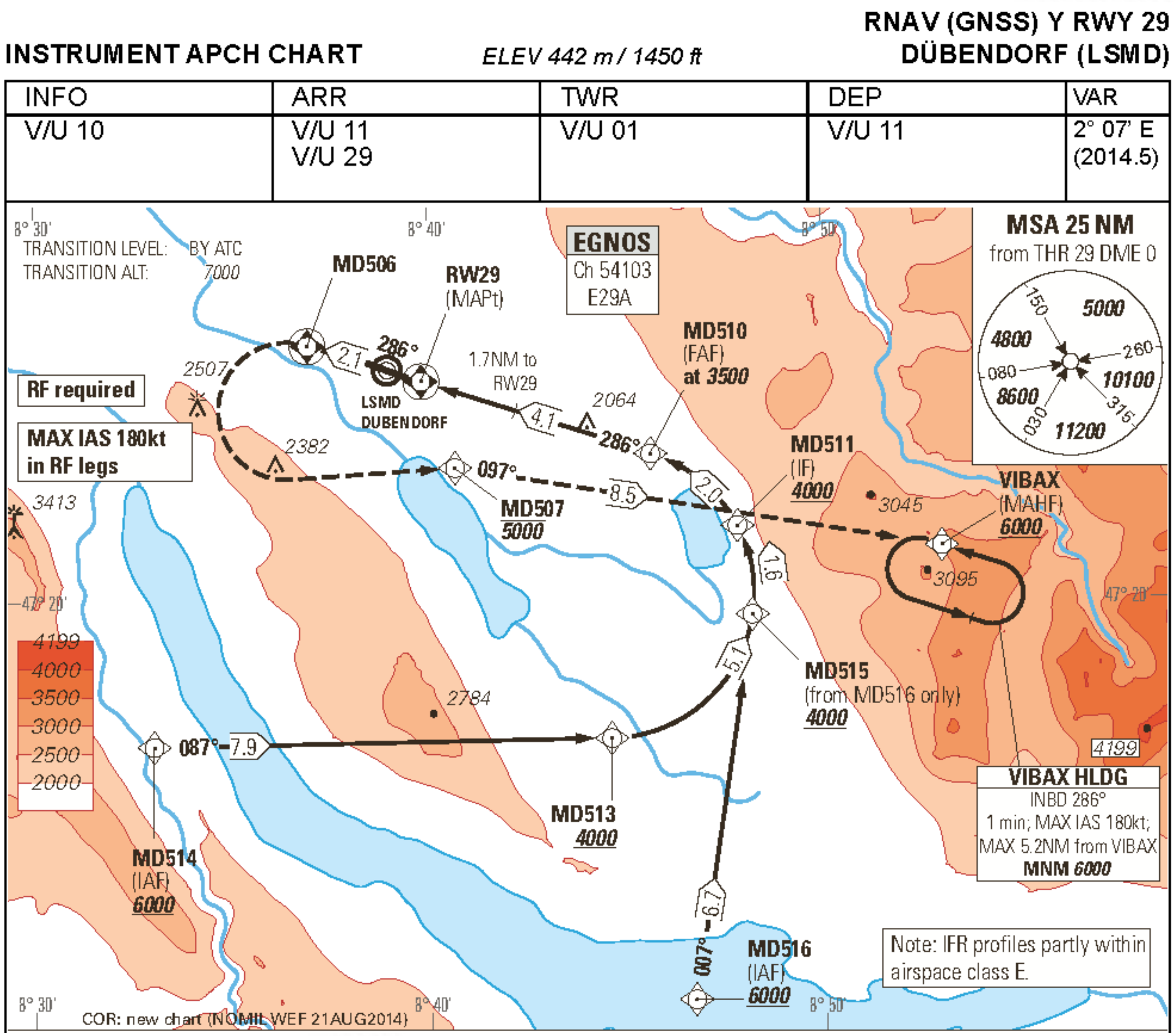


Analysis Procedure 2





Instrument APCH chart LSMD (1)



DUB

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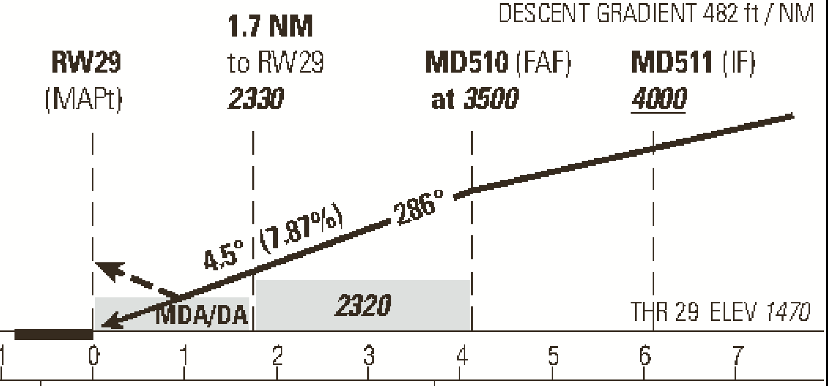
Instrument APCH chart LSMD (2)

MISSED APPROACH
Climb straight ahead. At MD506 turn left direct to MD507 (MAX IAS 180kt). Climb to *5000*.
After MD507 continue climb to *6000*.
Proceed to VIBAX and hold.
MNM climb gradient 4.4% required to reach *6000* at VIBAX.

RDH 50



DIST to RW29	2.0	3.0	4.0
ALTITUDE	*2480*	*2960*	*3440*

	MACG	A	B	C
LNAV MDA(H)	2.5%	***2610*** (1140)		
	5.3% up to *3000*	***2180*** (710)		
LPV DA(H)	2.5%	***2250*** (780)	***2270*** (800)	***2290*** (820)
RVR m		1500		
LPV DA(H)	5.0% up to *2600*	***1970*** (500)	***1990*** (520)	***2010*** (540)
RVR m		800		
CIRCLING		*3200* (1750)		
VIS		2500m		

Notes: - 0.6 NM BFR THR29 right of centreline visual segment surface (VSS) penetrated by trees up to *1710ft* AMSL (LNAV only).
- non-standard approach angle.

RNAV (GNSS) Y RWY 29 47° 23.9' N 008° 38.9' E **DÜBENDORF (LSMD)** DUB

 2 - 1

Implemented: 21 August 2014

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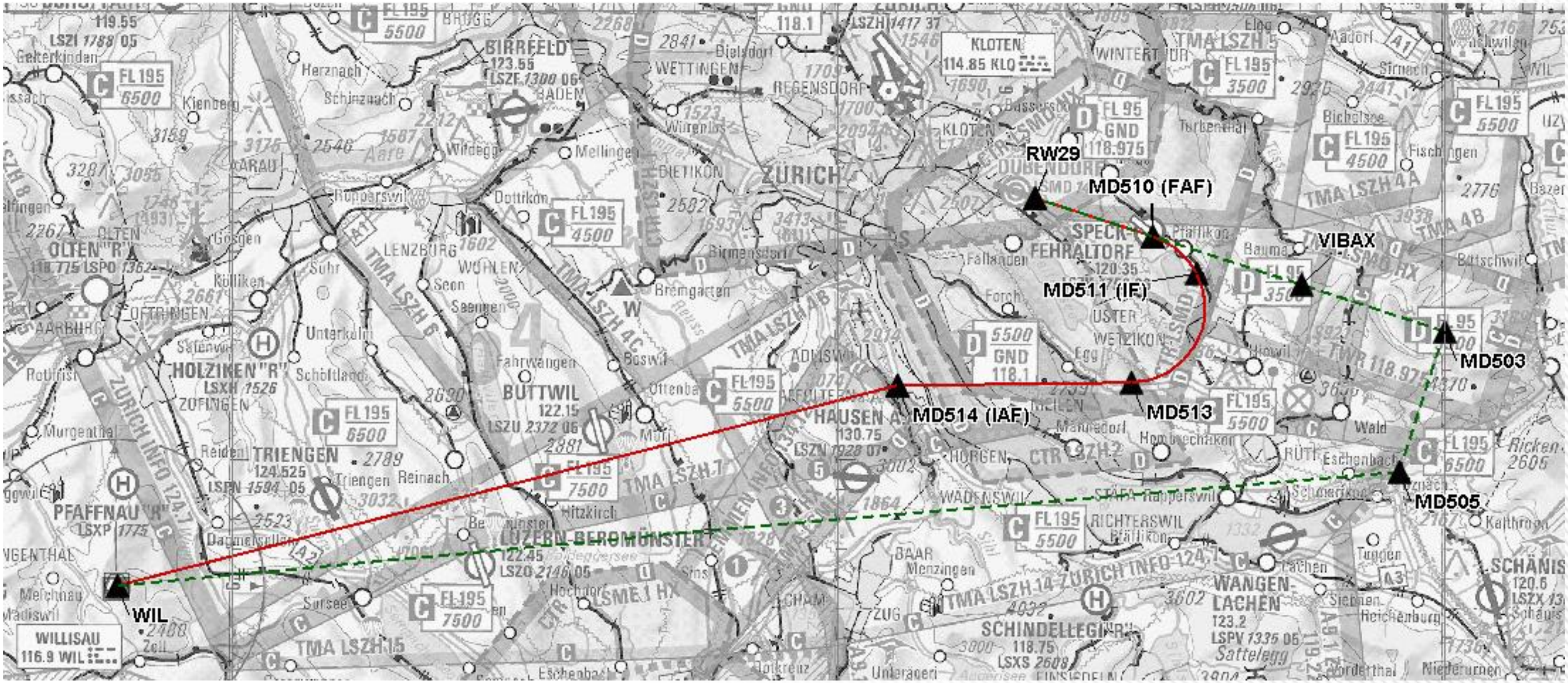
LSMD operational benefits

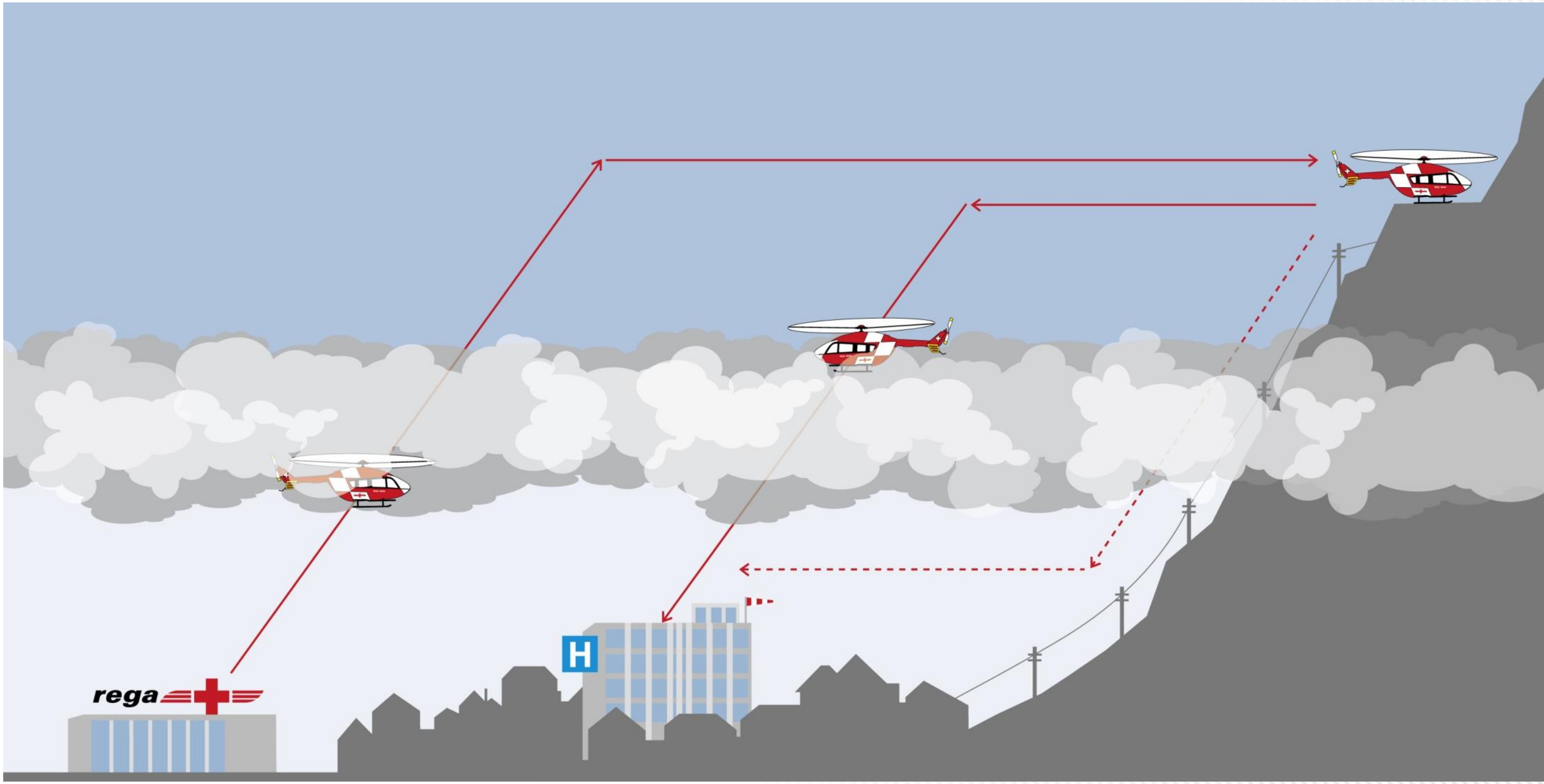


Green track: 63 NM

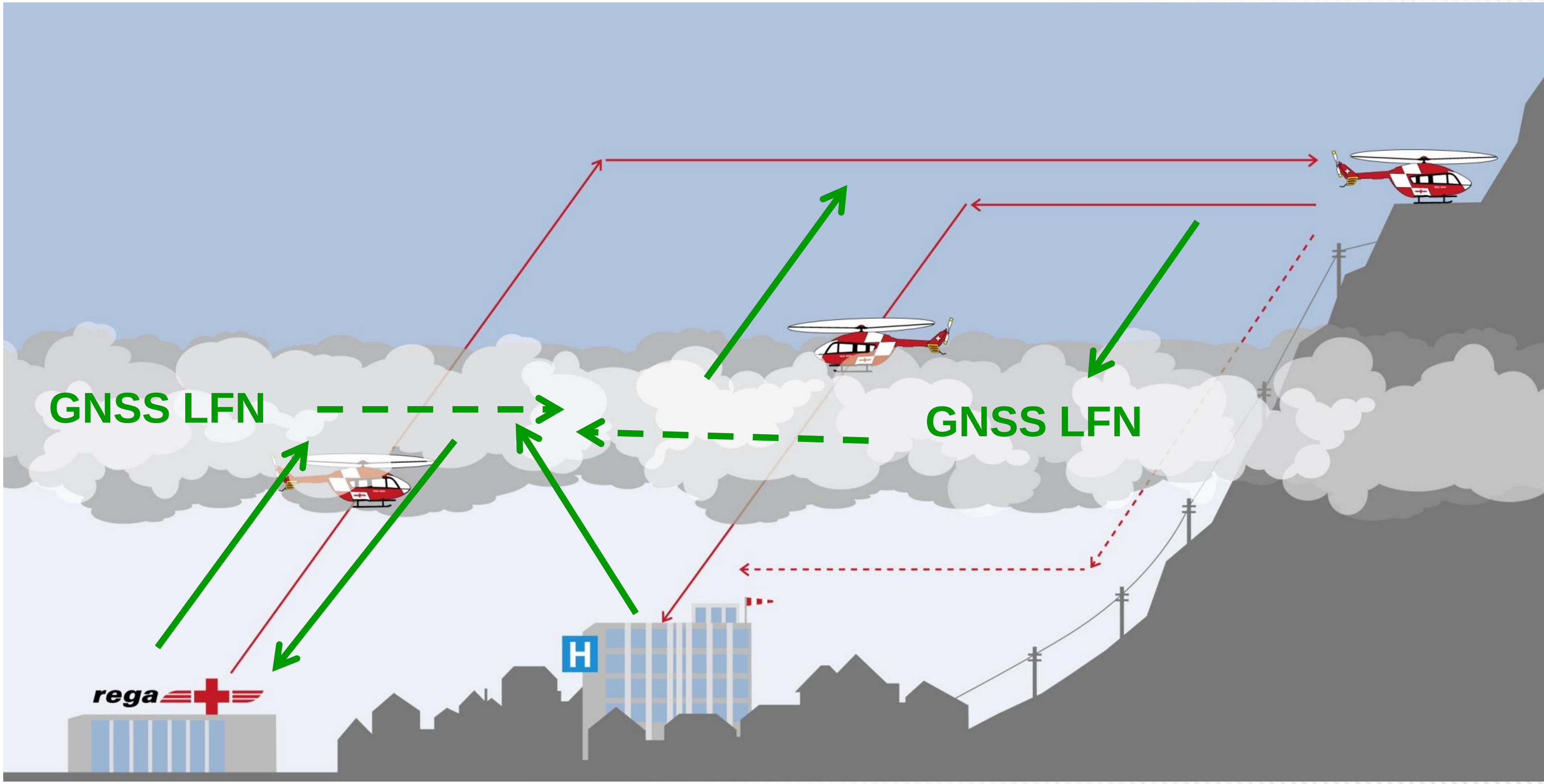
Red track: 46 NM

→ Savings: 17 NM (27%)

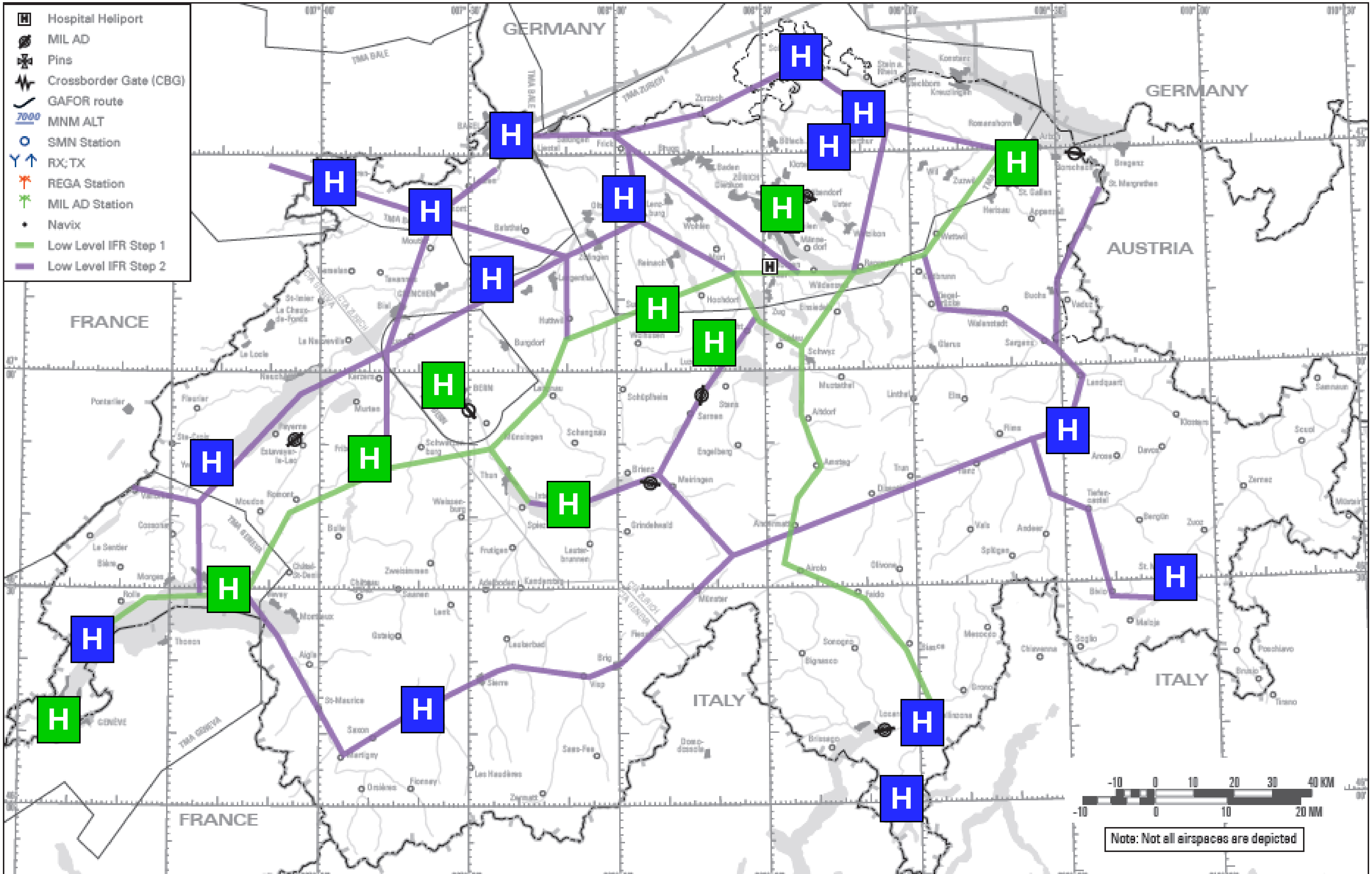
Swiss GNSS LFN (Low-Flight-Network)



Swiss GNSS LFN (Low-Flight-Network)



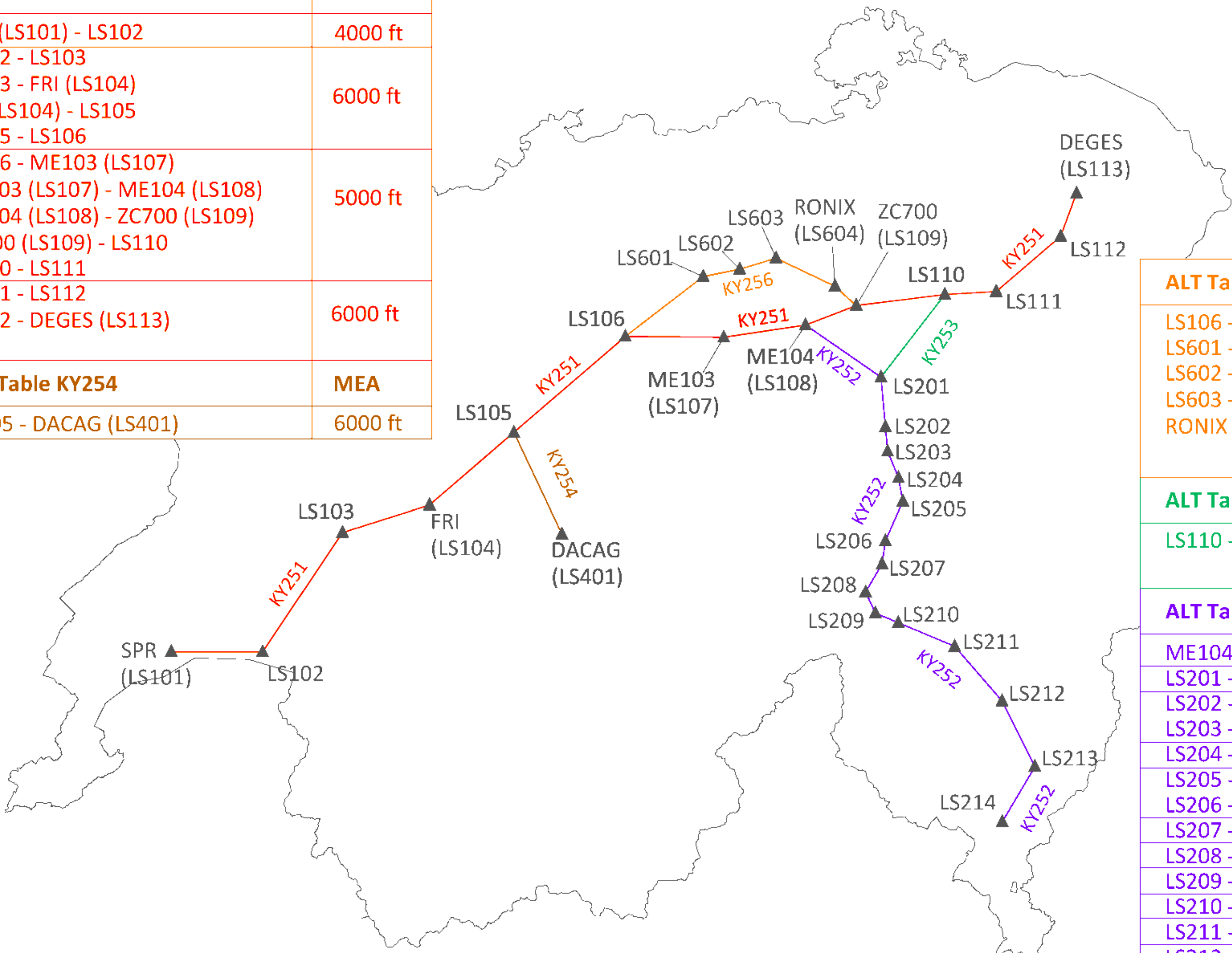
GNSS LFN CH : phase 1 (green) & phase 2 (magenta)



GNSS LFN CH routes phase 1

ALT Table KY251	MEA
SPR (LS101) - LS102	4000 ft
LS102 - LS103 LS103 - FRI (LS104) FRI (LS104) - LS105 LS105 - LS106	6000 ft
LS106 - ME103 (LS107) ME103 (LS107) - ME104 (LS108) ME104 (LS108) - ZC700 (LS109) ZC700 (LS109) - LS110 LS110 - LS111	5000 ft
LS111 - LS112 LS112 - DEGES (LS113)	6000 ft

ALT Table KY254	MEA
LS105 - DACAG (LS401)	6000 ft



ALT Table KY256	MEA
LS106 - LS601 LS601 - LS602 LS602 - LS603 LS603 - RONIX (LS604) RONIX (LS604) - ZC700 (LS109)	5000 ft

ALT Table KY253	MEA
LS110 - LS201	7000 ft

ALT Table KY252	MEA
ME104 (LS108) - LS201	6000 ft
LS201 - LS202	7000 ft
LS202 - LS203 LS203 - LS204	8000 ft
LS204 - LS205	9000 ft
LS205 - LS206 LS206 - LS207	10000 ft
LS207 - LS208	11000 ft
LS208 - LS209	12000 ft
LS209 - LS210	12000 ft
LS210 - LS211	11000 ft
LS211 - LS212	9000 ft
LS212 - LS213	7000 ft
LS213 - LS214	7000 ft

GNSS LFN phase 1 planning

› Planned Implementation Date: 5 March 2015

› Navigation Specification: RNP 0.3

› Challenge: No EASA AMC available

› Aircraft Used: Helicopter only with
  - CMA-5024 GPS/SBAS receivers
  - Chelton GPS/SBAS receivers

GNSS LFN infrastructure requirements

7.2 IMPLEMENTATION CONSIDERATIONS

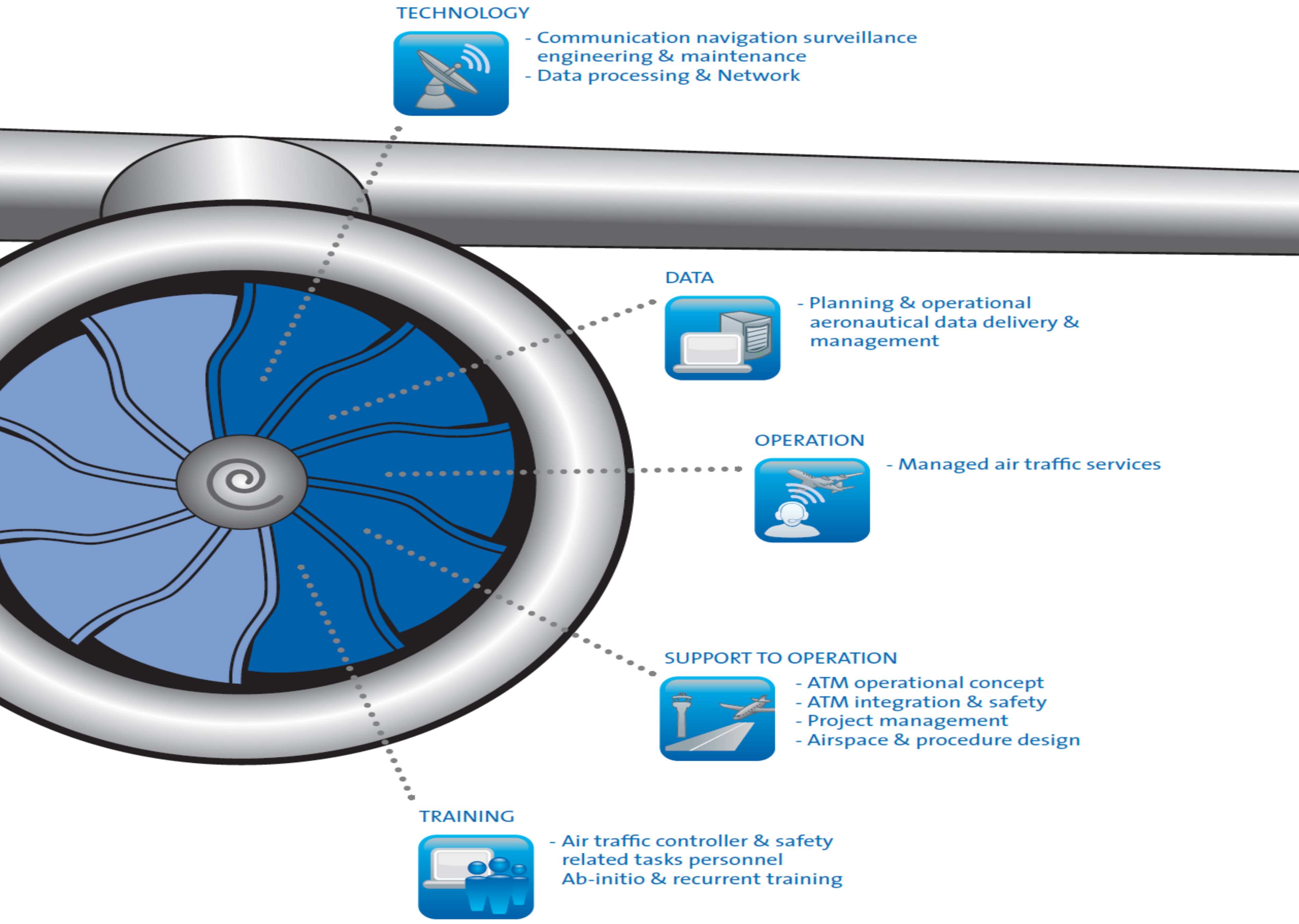
7.2.1 NAVAID infrastructure considerations

The RNP 0.3 specification is based upon GNSS; its implementation is not dependent on the availability of SBAS. DME/DME based RNAV systems will not be capable of consistently providing RNP 0.3 performance, and States should not plan on implementing RNP 0.3 operations through application of DME/DME-based navigation. States must also not use RNP 0.3 in areas of known navigation signal (GNSS) interference. Operators relying on GNSS are required to have the means to predict the availability of GNSS fault detection (e.g. ABAS RAIM) to support operations along the RNP 0.3 ATS route. The on-board RNP system, GNSS avionics, the ANSP or other entities may provide a prediction capability. The AIP should clearly indicate when prediction capability is required and acceptable means to satisfy that requirement. This prediction will not be required where the navigation equipment can make use of SBAS augmentation and the planned operation will be contained within the service volume of the SBAS signal.

Note.— Should the State permit the operator of an SBAS-equipped aircraft to disregard the requirement for a RAIM prediction when the RNP 0.3 operation occurs in an SBAS service area, then it is recommended the State consider establishing a requirement for that operator to check SBAS NOTAMS prior to the flight to ensure the availability of the SBAS SIS.

ICAO PBN manual, Part C, Chapter 7

→ Request to ESSP to provide RNP 0.3 EGNOS NOTAMs


TECHNOLOGY
- Communication navigation surveillance engineering & maintenance
- Data processing & Network
DATA
- Planning & operational aeronautical data delivery & management
OPERATION
- Managed air traffic services
SUPPORT TO OPERATION
- ATM operational concept
- ATM integration & safety
- Project management
- Airspace & procedure design
TRAINING
- Air traffic controller & safety related tasks personnel Ab-initio & recurrent training

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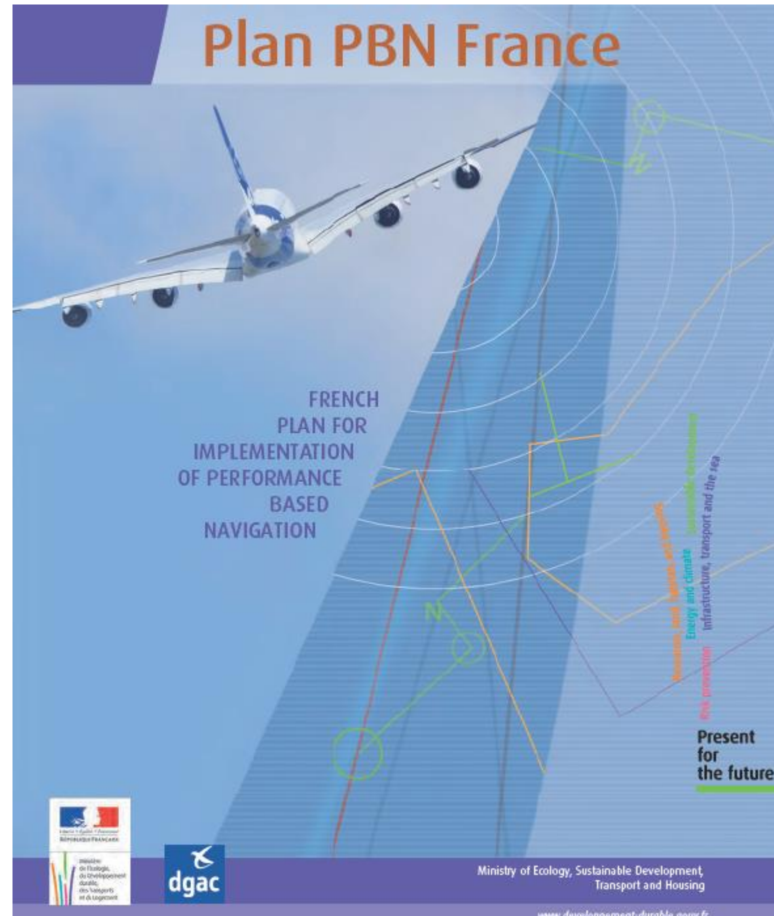
PBN Implementation for approaches

FRENCH EXPERIENCE

Corinne Bousquet
DSNA/DTI

PBN IMPLEMENTATION DRIVERS IN FRANCE

- ICAO directions towards PBN implementation
  - Improve Safety and Airspace Capacity, Reduction of Environmental impact
  - ICAO ASBUs
- European environment
  - SESAR
  - FABEC
- Airspace users consultation
  - PBN National implementation plan
  - Open PBN forum with airspace users and airports
- GNSS systems strategy



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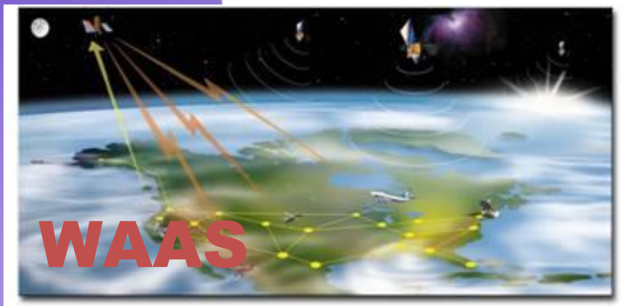
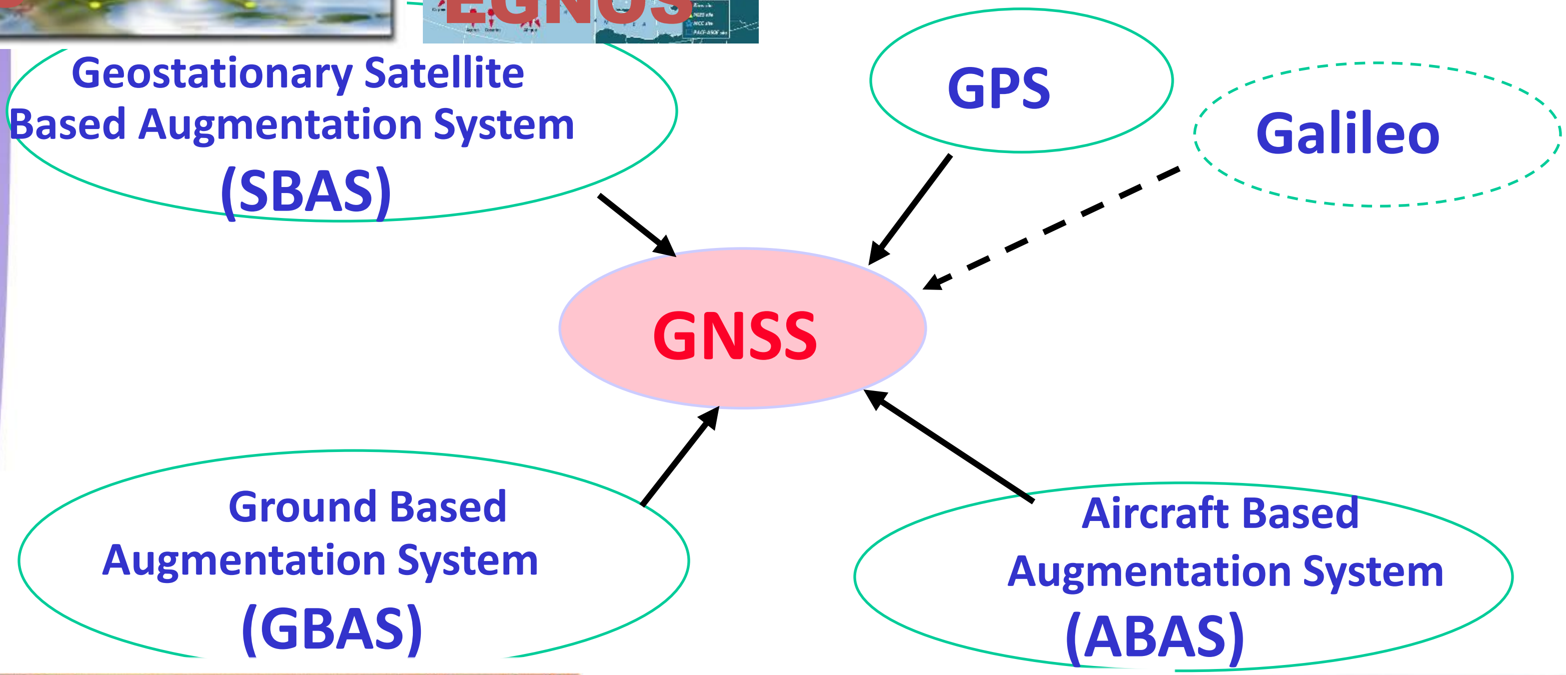
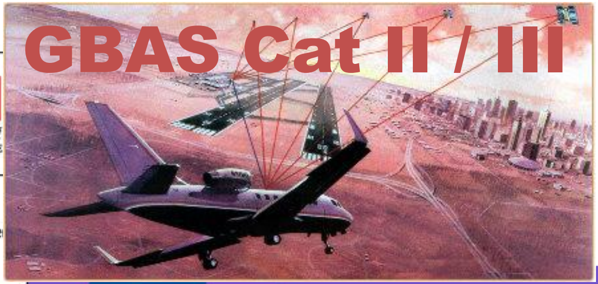
Ministère de l'Écologie, du Développement durable et de l'Énergie

dgac
DSNA

GNSS SYSTEMS INCLUDED IN DSNA STRATEGY







GNSS SYSTEMS INCLUDED IN DSNA STRATEGY

- **GPS**
  - Supports the vast majority of flights today, with GNSS ABAS
    - Includes approaches with vertical guidance, for BaroVNAV equipped users
- **EGNOS**
  - Supports approaches with vertical guidance with performances comparable to ILS Cat I by augmenting GPS
    - Also supports better availability than GPS for conventional approaches
    - Aims to progress in performances and coverage toward EGNOS V3 (> 2020)
- **GBAS**
  - Aims to support a capacity improvments under Low Visibility Procedures conditions, with GBAS Cat II/III (>2020)
    - GBAS cat I not planned to be deployed operationally in France
- **Galileo**
  - Aims to provide a robust GNSS positioning when integrated with GPS under the multiconstellation concept (> 2020)
    - Expected to be augmented by EGNOS from 2020

DSNA GNSS STRATEGY
2010 – 2020 TIME FRAME

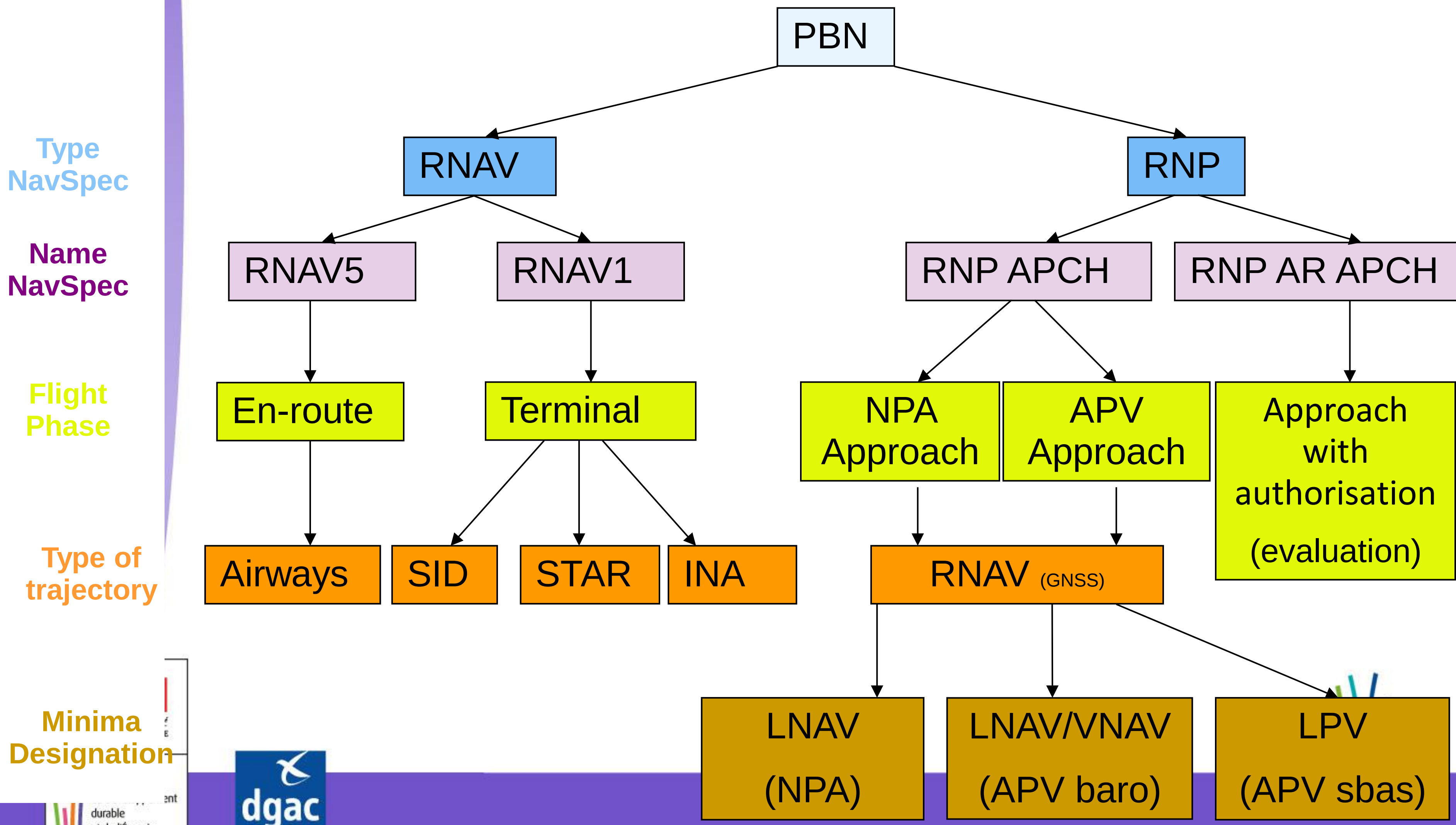
- Implementation of a **first generation GNSS network,** based upon:
  - **GPS**, augmented by airborne techniques ABAS (RAIM, BaroVNAV), deployed through PBN Enroute, Terminal, Approaches
  - **EGNOS,** improves safety and accessibility of approaches, as a natural complement to ILS Cat I Approaches
- **Still important reliance on Conventional navaids**
  - but rationalisation initialisation for NDB, VOR, ILS Cat I
    - reduced network concept now explored

DSNA NAV SYSTEMS STRATEGY
2020 – 2030 TIME FRAME

- Consolidation of GNSS services with a **second GNSS generation,** based upon:
  - **Multiconstellation GNSS,** for En route, Terminal, Approaches
    - **GPS modernised open signals**, dual-frequency L1 – L5
    - **Galileo Open Service**, dual-frequency L1 – E5a
  - **EGNOS V3**, for Cat I Approaches
    - expected to provide the **Galileo SoL service regionally** from 2020 in addtion to GPS L1/L5 augmentation
  - **GBAS,** for Cat II/III Approaches

- **Continued rationalisation of Conventional systems**
  - The rationalisation scale will depend upon deployment of **mandate/implementing rules** for user avionics
  - Also depends upon the remaining **GNSS vulnerabilies mitigation**

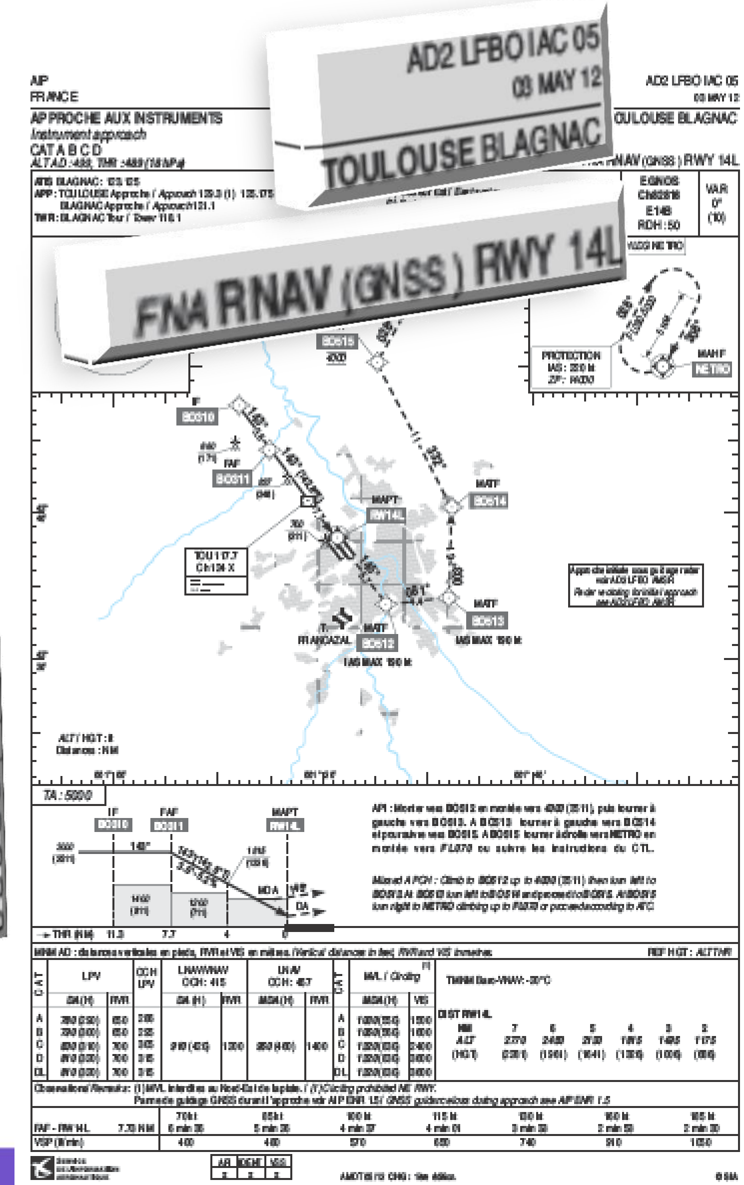
PBN OPERATIONS IN FRANCE IN 2014



dgac
DSNA

PBN APPROACHES TYPICAL CHART

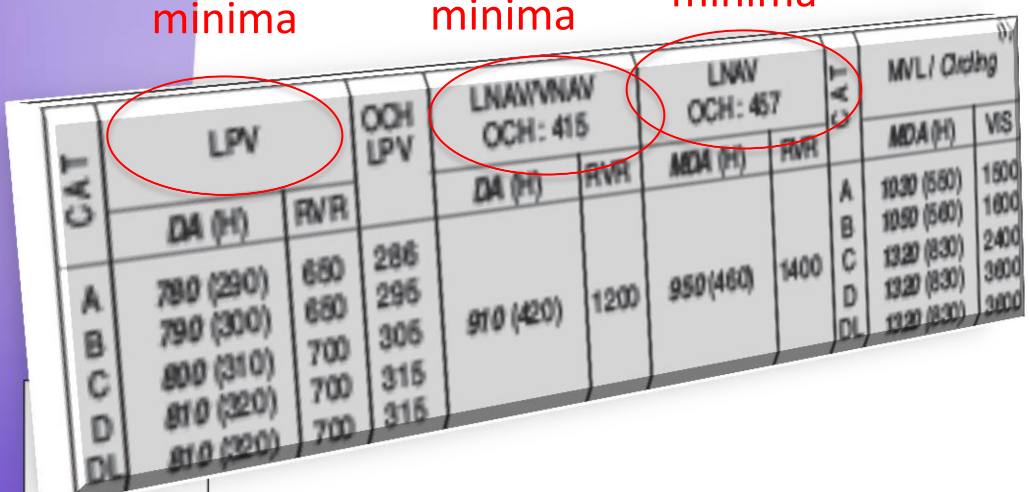
- Flexible ICAO concept
  - Differently equipped users managed by ATC on the same path/chart



GPS + SBAS minima

GPS +BaroVNAV minima

GPS + RAIM minima



CAT	LPV DA (H)	LPV RVR	OCH LPV	LNAV/VNAV OCH: 415 DA (H)	LNAV/VNAV RVR	LNAV OCH: 457 MDA (H)	LNAV RVR	CAT	MVL / Circling MDA (H)	MVL / Circling VIS
A	780 (290)	650	286	910 (420)	1200	950 (460)	1400	A	1030 (560)	1500
B	790 (300)	650	295					B	1050 (560)	1600
C	800 (310)	700	305					C	1320 (830)	2400
D	810 (320)	700	315					D	1320 (830)	3600
DL	810 (320)	700	315					DL	1320 (830)	3600

PBN APPROACHES OPERATIONAL PHILOSOPHY

- Spread widely and clearly information within AIC:
  - https://www.sia.aviation-civile.gouv.fr/dossier\aicfrance\AIC_A_2012_21_EN.pdf

Direction des Opérations Service de l'Information Aéronautique 8, avenue Roland Garros - BP 40 245 F-33698 Mérignac cedex http://www.sia.aviation-civile.gouv.fr	SALES DEPARTMENT ☎ : 33 (0)5 57 92 56 68 Fax : 33 (0)5 57 92 56 69 ✉ : sia-commercial@aviation-civile.gouv.fr TECHNICAL SERVICE ☎ : 33 (0)5 57 92 57 57 Fax : 33 (0)5 57 92 57 77 SFA : LFFAYNYX	AIC A 21/12 FRANCE PUB : SEP 20

SUBJECT: Implementation of RNP APCH type instrument approach procedures commonly called RNAV(GNSS) approaches - Correct version.

This AIC cancels and replaces AIC 06/12

1 INTRODUCTION

For the application of provisions of resolution A37/11 from the ICAO, aiming at covering all IFR-certified runway ends with approach procedures using GNSS, including with vertical guidance where possible, the DGAC (French Civil Aviation General Directorate) publishes many approach procedures giving rise to charts under the RNAV(GNSS) title. These publications comply with RNP APCH type navigation specification, as defined in Performance-Based Navigation Manual (PBN), Doc 9613 of ICAO.

The GNSS systems concerned by this AIC are based on the possible use of the GPS constellation, as well as on the following two ICAO reinforcement systems:

- ABAS: Airborne Based Augmentation System,
- SBAS: Satellite Based Augmentation System.

MAIN PBN CHALLENGE FOR APPROACHES TODAY

Modernizing/rationalizing French landing system infrastructure, thanks to EGNOS performance equivalent to ILS Cat I, in particular

- GPS only equipped users also included in this plan
- improve safety, airport accessibility
- reduce ANSP's costs (technology transition)

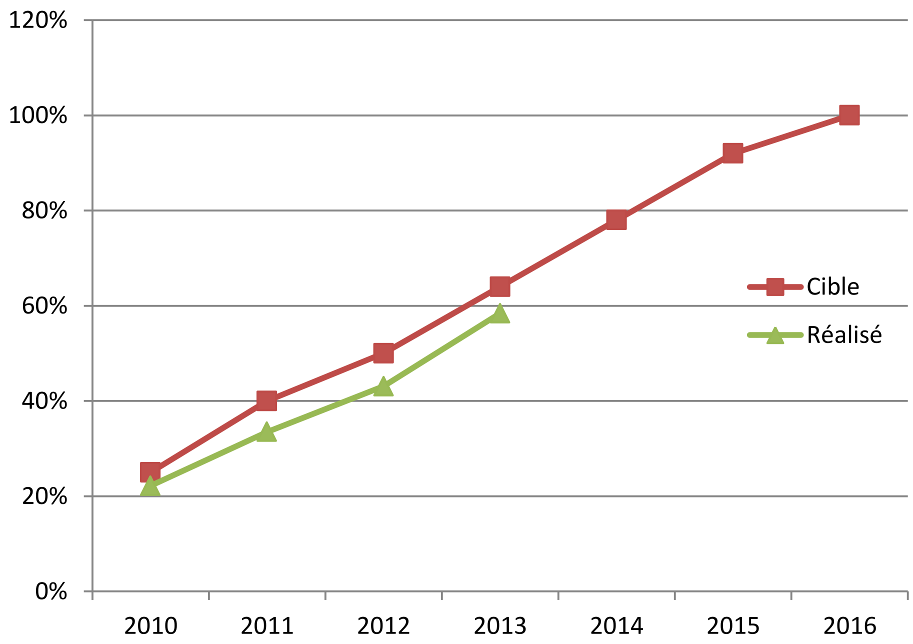
- PBN target for primary runways:
  - Good quality backup to ILS (outages, maintenance, renewal ,etc…)
- PBN target for secondary runways:
  - More direct paths, increased safety (vertical guidance in final), increased airport accessibility vs. conventional navaids
- PBN target for about 50 small/medium airports:
  - Cut landing infrastructure costs (ILS Cat I) by transitioning to PBN

ACTIONS TAKEN

- Identify all areas of work to support PBN implementation in Terminal areas
  - Safety cases, charting, AIS, ATC training, phraseology, NOTAM, GNSS legal recording tools, national regulations, Flight check, Flight planning, Management of Interference …
- Set up National WGs combining experts of different domains (public & industry)
  - Analyse of issues, solutions acceptable and adapted to all stakeholders
- Include all airspace users & Industry to reach agreement on proposed solutions

PBN APPROACHES STATUS

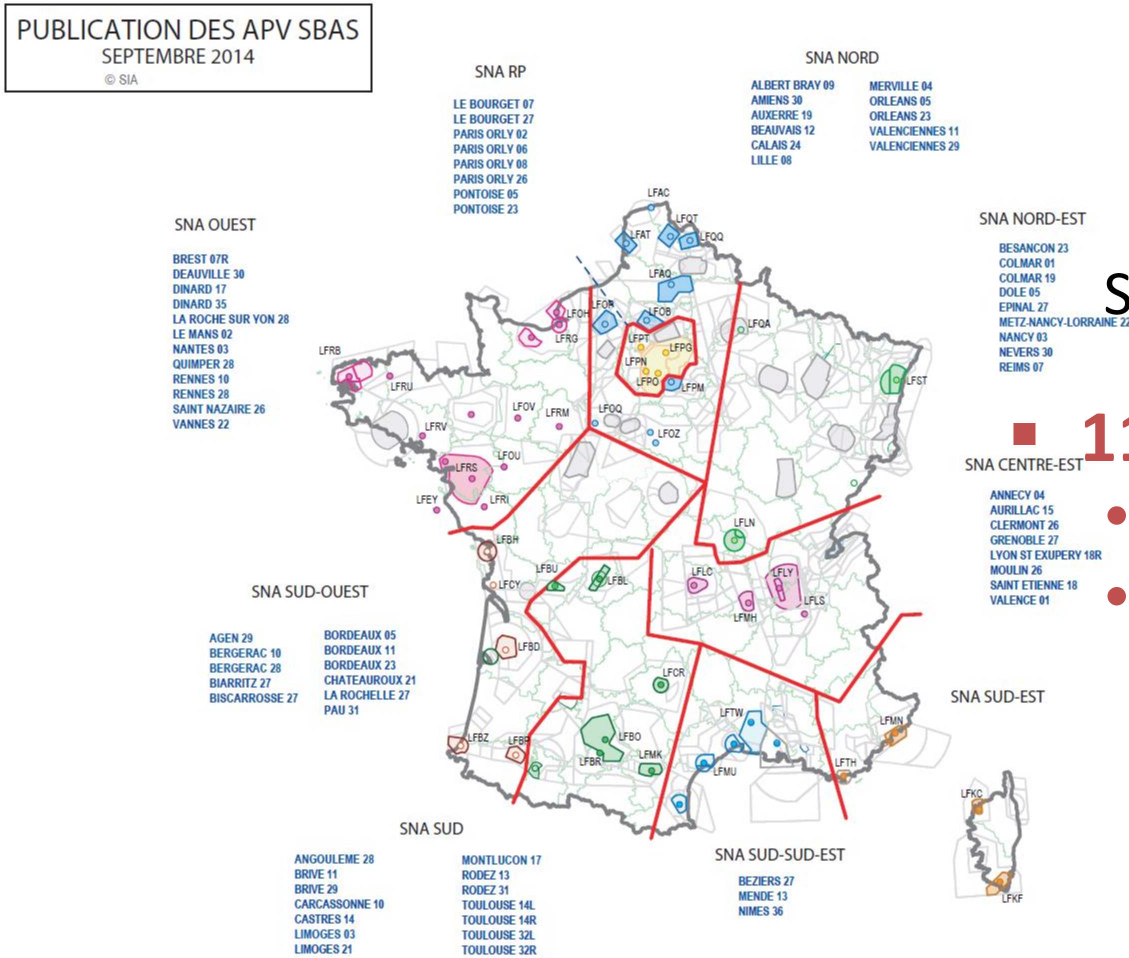
- Approx. **200 runway ends** included in France **RNP APCH plan**
- RNP APCH with LNAV implemented since 2004, LPV since 2011; LNAV/VNAV since 2012
  - Military airports also equipped now with LNAV & LPV



ICAO PBN RNP APCH A37-11 target

Yearly achieved rate

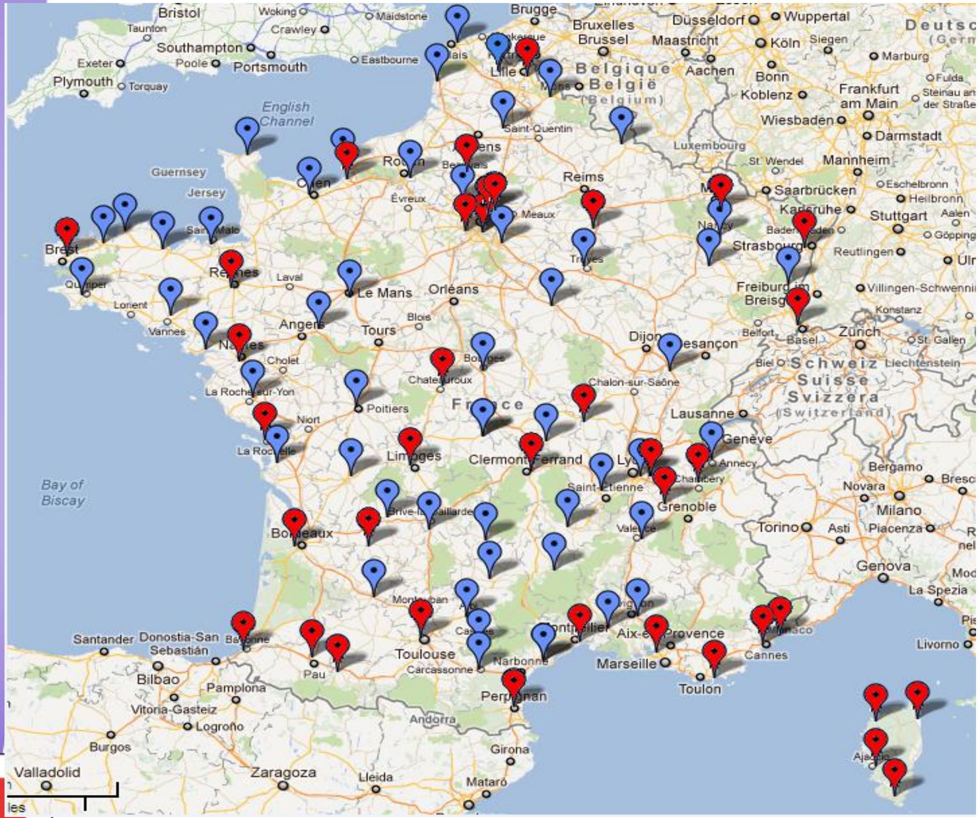
PUBLISHED PBN PROCEDURES



Status Sept. 2014:

- **114 RWY with RNAV APP**
  - **76 LPV** (40%)
  - **29 LNAV/VNAV**

ILS rationalisation plan



2016 ILS reduced network

Airports where the existing ILS Cat I is proposed to be replaced by a RNP APCH

NEW PBN AREAS FOR APPROACHES WORKED OUT NOW

– RNP approach connected to xLS
  - xLS = Instrument LS, GBAS LS, SBAS LS,…

– Several technologies or concepts investigated
  - **Operational interest for some environmentaly and obstacle constrained airports**,
  - Visual RNAV, RNP APCH + RF , RNP AR APCH

GNSS PROCEDURES FOR ROTORCRAFT

- Lot of interest from the helicopters community
- Much more interest in LPV avionics
  - High flexibility of LPV guidance (slope)
  - No need of helipad or runways to fly LPV
  - Associated with PINS procedure

FRENCH CAA CURRENT POSITION

- Only accepted :
  - LNAV, LPV, PINS on aerodrome with ATS
- Forseen after conduction of trial
  - PINS (LNAV or LPV) on hospital
- Still issues to solve
  - Minima in case of steep angle in LPV final
  - Operational validation process to define

SOON : WHAT TO DO TO REACH CAT I SBAS APP?

- Wait for appropriate EGNOS release !
- Re design intermediate, final and straight missed approach of existing LPVs
  - New critria available in PANS OPS from November 2014
- Compute new OCH
- If acceptable :
  - DH of 200ft available (RVR 550m)

WHAT ABOUT AIRLINES TO FLY CAT I SBAS APP?

- If operational approval for LPV 250ft
  - No need for supplementary approval of airline to reach 200ft (at least in France)

BUT

- Some Aircraft certified for LPV are limited to 250ft (AFM limitation) because their TAWS function does not take into account the LPV for the Excessive Glide slope deviation alert.

- Modification of the TAWS and additional certification would be needed to reach 200ft.

PBN APPROACHES ROADMAP LESSONS LEARNED

- It's there, use it!
  - Yes… but still a lot of work required in the background within strongly regulated environments like Europe, be aware!
- Coordination is key
  - Mixing national experts of different topics
  - Involving Industry, Airspace users, Airports, Regional organisations
- Synchronisation of user equipment with procedure design is key
  - Flexible ICAO concept of a single approach chart is very useful
  - Coordination with airlines is a key element

PBN APPROACHES OPERATIONAL LESSONS LEARNED

- **EGNOS LPV are high performance approaches, and highly appreciated by equipped users, even wrt ILS Cat I**
- **LNAV and LNAV/VNAV also appreciated, wrt VOR/NDB/Circling type approaches, by equipped users**
- **But have a lower level of performance wrt LPV:**
  - Higher approach minima due to less performing lateral and vertical guidance
  - Issue of « RAIM holes » when RNP APCH is the prefered approach (e.g. Nice airport)
    - daily LNAV and LNAV/VNAV un-availabilities may exist depending upon the avionics,
    - it is not possible to make ATC aware of on-board LNAV and LNAV/VNAV unavailability
  - Lower safety level:
    - lack of vertical guidance for LNAV,
    - QNH mis-setting events from the ground or airborne side have been reported for LNAV/VNAV

EXPECTED ADDITIONAL GUIDANCES FROM ICAO

Approaches

The experience gained by implementing on a large scale LNAV, LPV, and LNAV/VNAV approaches highlighted several areas where additional guidance will be useful :

- PBN phraseology (Doc 4444):
- PBN procedure charting (Annex 4 and associated document),
- Safety case methodology (Doc 9906),
- GNSS signal qualification (Annex 10),
- PBN initial approach (to intercept ILS) (Doc 8168),
- DME/DME usage (for RNP) (Doc 9613),
- WGS 84 vs. alternative reference frames (Doc 9674 and 9906).

HOW TO STEER USER INTEREST TOWARDS EGNOS?

- **Identify the region different communities and their potential interest in EGNOS:**
  - **General aviation**
  - **Business aviation**
  - **Taxi and regional airlines**
  - **Helicopters**
  - **Transport aviation**

- **Adapt the actions and communication depending on the different level of interest and timelines of expected benefits**

- **Avoid direct confrontation between « in favor » and « against »communities.**
  - **Aim is to show that EGNOS is giving significant benefits now to segments of the region users,**
  - **and that long term avionics deployment will facilitate the transition of users reluctant to retrofit at this stage.**

Thank you for your attention

Any question?

AGENDA (14:30 – 16:15)

14:30-15:45 **Successful EGNOS implementation stories in Aviation (I)**

- ☞Introduction
  Luc Tytgat *– Director of Pan-European Single Sky (EUROCONTROL)*
- ☞Implementation of advanced EGNOS operations in Switzerland
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- ☞DSNA implements PBN with EGNOS
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- ☞Training: The key to success
  Richard Bristowe *– Head of Training (Aviation Southwest)*
- ☞Regional aviation, a key market for EGNOS
  Jaap Horsten *– Engineering Consultant (VLM)*

15:45-16:15 **Coffee break**

TRAINING: THE KEY TO SUCCESS

Richard Bristowe, *Aviation South West*

EGNOS Service Provision Workshop
Lisbon, 7-8 October 2014

Contents

- The Flight School
- ACCEPTA and the partnership with Exeter airport
- Regulatory issues
- Flight validation experiences
- One final task
- Lessons learnt and future actions

The Flight School (i)

Aviation South West

- **Aviation South West** is a Flight Training Company based at Exeter International Airport in the South West of England
- Training of
  - Private and Commercial Pilots and
  - Flight Instructors
- Provision of EASA Examiner Seminars
- Mixed fleet of single and twin-engined light aircraft

The Flight School (ii)

- Early 2000s: ASW equipped its fleet with RNAV LNAV (Garmin)
  - Installations were granted EASA approval in 2008.
- Then UK CAA selected six airports to trial LNAV APCH procedures.
  - ASW was asked to carry out the flight validations at Exeter Airport (one of the trial airports) and subsequently at Plymouth Airport.
  - ASW Instrument Rating training manual was amended to include training pilots to fly LNAV approaches and approved by the regulator (CAA).

ACCEPTA and the partnership with Exeter (i)

- Joint bid with Exeter Airport for ACCEPTA funding by 2011:
  - ASW to upgrade two aircraft
  - Exeter to upgrade its existing LNAV approaches to LPV.

The joint bid was successful

ACCEPTA and the partnership with Exeter (ii)

- Exeter Airport is a Regional Airport in the South West of England.
  - 2007: >1 million passengers.
  - 2013: 741,465 passengers, (5.7% increase from 2012)
- Scheduled and holiday charter flights within the UK and Europe.
- Main Operators:
  - FlyBe, Thomson, Thomas Cook, Air Malta, Transatlantic bizjets, Isles of Scilly, Air Taxi Operators and Military and Civil training flights.
- Approaches: ILS, NDB, SRA, LNAV and now LNAV/VNAV and LPV.

ACCEPTA and the partnership with Exeter (iii)

- For Aviation South West:
  - Replacement of the existing GPS equipment and aerials (STCs available)
  - Reduced panel space so there was a lot of ironmongery work
  - Adding LNAV to the Frasca simulator was straightforward but LPV glide-path was unreasonable.
- For Exeter Airport:
  - Existing CAT 1 ILS and LNAV on both runways
  - CAA's published Policy Statement (June 2009) on the Validation of Instrument Flight Procedures.
  - The regulator required:
    - A full resurvey of the airport environs and
    - Fully encoded data source as part of the validation

Regulatory issues (i)

Aviation South West

Was the regulator right?

- Flight validation must use a datacard with the FAS datablock encoded.
- NOTAMed procedures were not allowed by the CAA for validation
- The UK Air Accident Investigation Board published:

"***Misuse of the GPS is a contributory factor in the majority of light aircraft accident/incidents.***"

Given the lack of mandatory training in the use of aircraft GPS equipment, and just how close to the ground an LPV brings the pilot, the need for a trial datacard - and the need for proper training - cannot be denied.

Regulatory issues (ii)

So what about the survey?

- We sought evidence to show that the time and expense of a complete new survey was unnecessary.
- We even researched what the FAA views were, unfortunately (for us), they reported that:

"***In almost all cases of problems with LPV approaches the fault lay with the use of legacy survey data.***"

So - as has occurred time after time on this project, our regulator has been absolutely right!

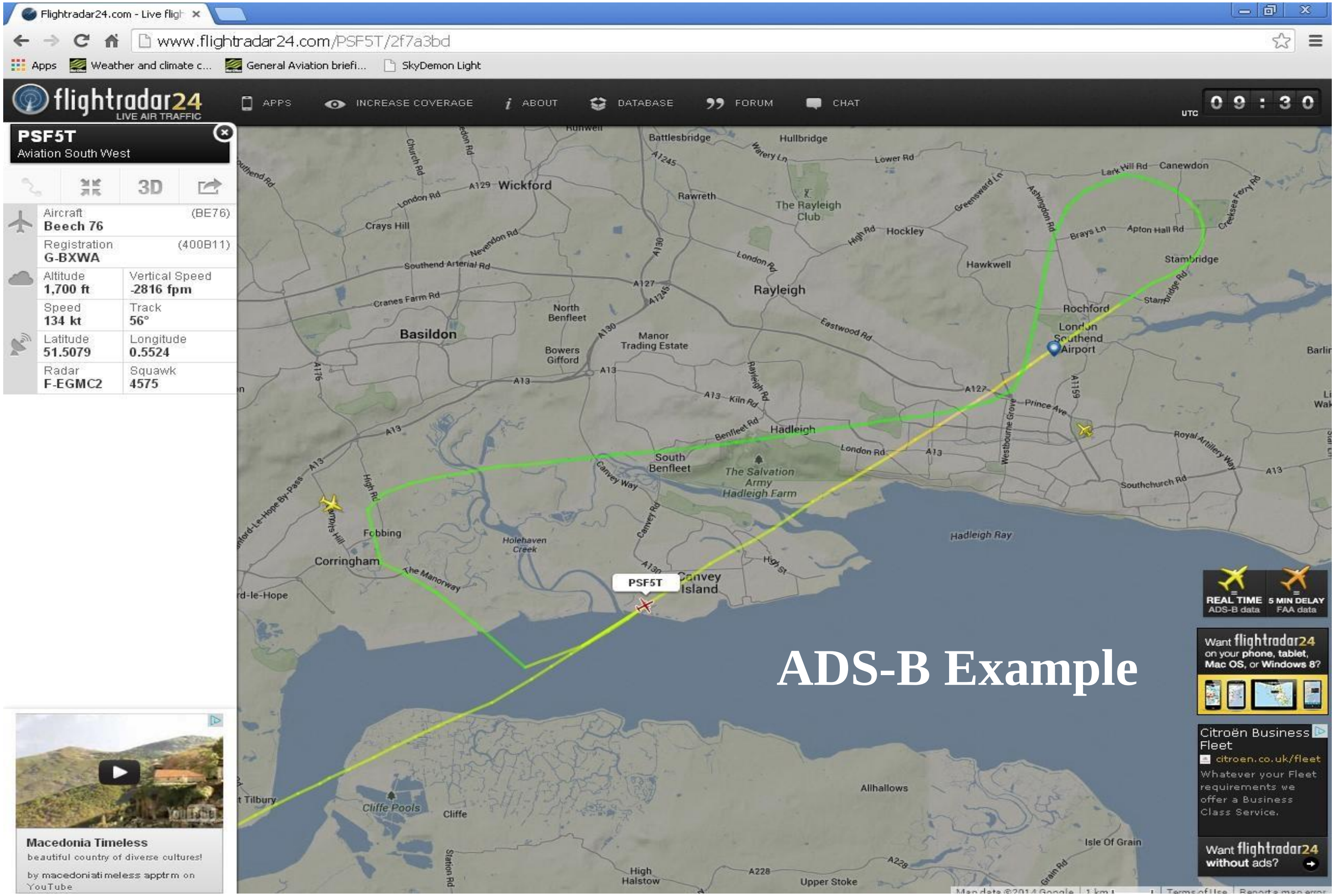
The Flight Validation experience (i)

Aviation South West

- Datacard cost = card cost + cost per approach encoded.
  - ✓ Combine Exeter, Bristol and Southend APCHs onto one card
- Regulator’s requirements: aircraft equipped and approved for LPV + ADS-B transponder + data-logger.
  - ✓ Aviation South West’s BE76 successful in tendering to all three airports
- Separate statements of work agreed with the regulator for each scenario
  - ✓ key element was the vertical component from FAF to MA:
    1. Normal to check the equipment display, the ILS lookalike and the missed approach procedure
    2. Flying below the glidepath at half scale fly-up to check for obstacles.
    3. Flying to 50’ above the runway to confirm the PAPIs and other indications held true and steady.

The Flight Validation experience (ii)

Aviation South West



The Flight Validation experience (iii)

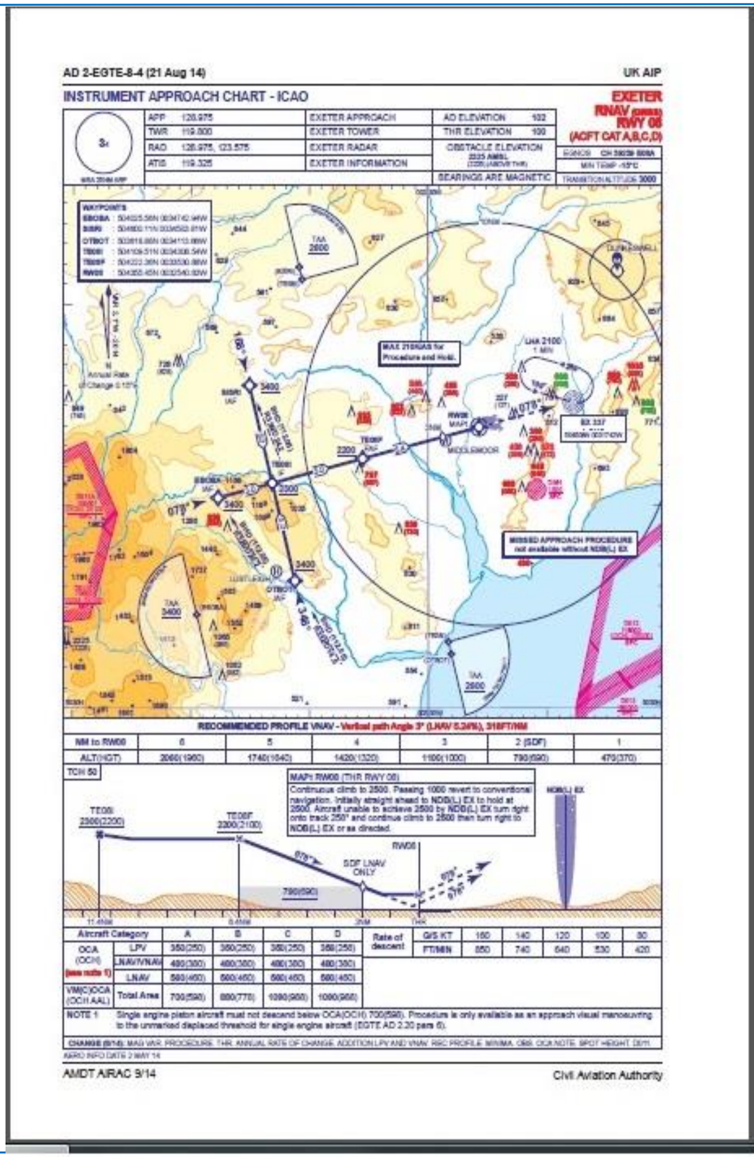
ILS Look-alike

The Flight Validation experience (iv)

Aviation South West

Datalogger file

The Flight Validation experience (v)



The Result!

One final task (i)

Aviation South West

One final task (ii)

During first week of publication:

11 commercial aircraft (from 146s to 757s) flew to Exeter to train on the LPV approach

Lessons learnt and future challenges (i)

Aviation
South
West

So – What are the issues?

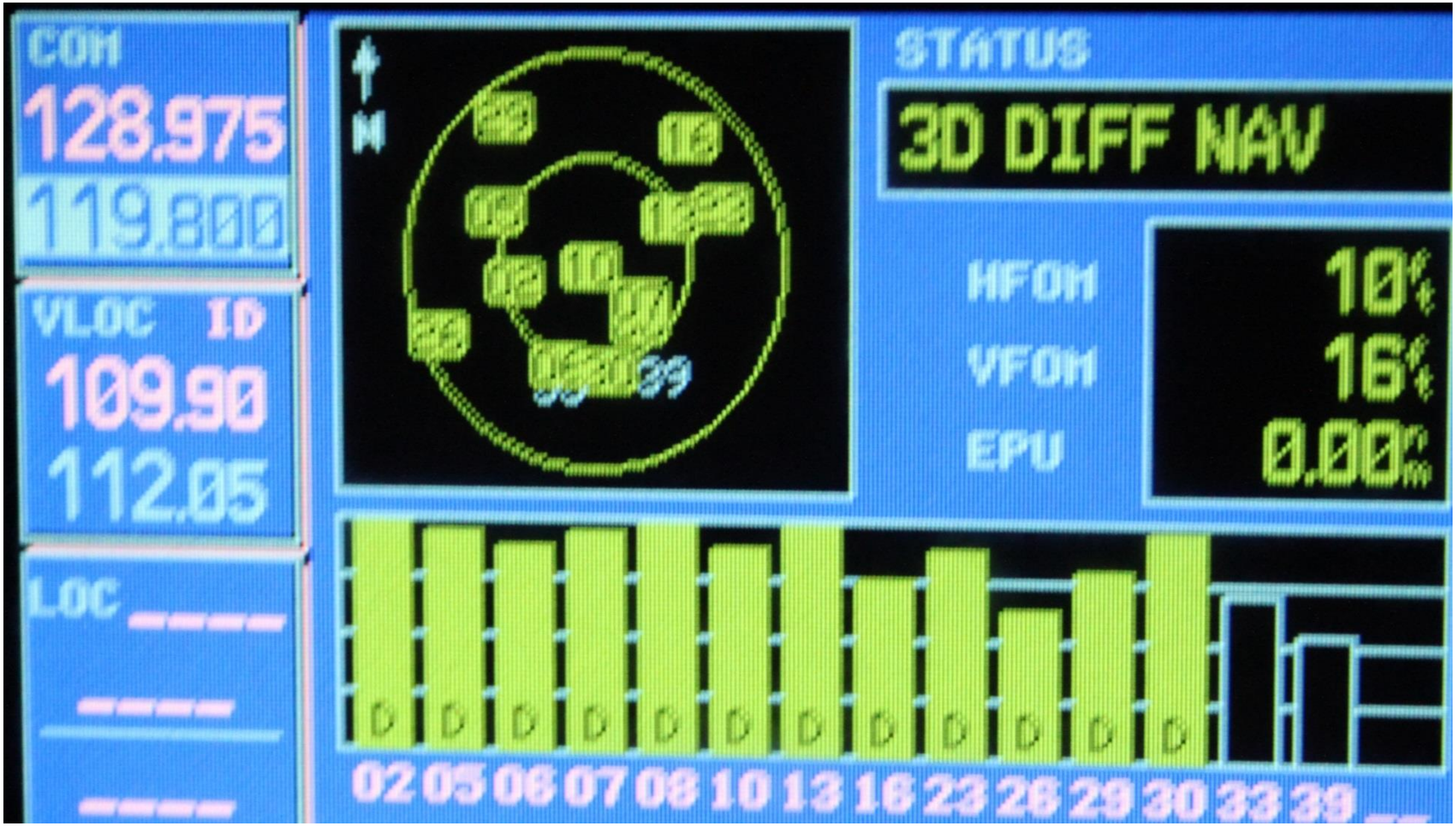
Approach requirement is +/- half scale deflection yet

Oh gosh!

Lessons learnt and future challenges (ii)

Aviation South West

En route and terminal area wing tip clearance is generally 5 nautical miles, yet:



Lessons learnt and future challenges (iii)

There is a real danger of complacency

Lessons learnt and future challenges (iv)

We believe that *training* – of pilots, of instructors and of examiners – is key to the successful implementation of LPV approaches. Happily we are not alone:-

European Aviation Safety Agency — Rulemaking Directorate

Notice of Proposed Amendment (NPA) 2013-25

Revision of operational approval criteria for performance-based navigation (PBN)

RMT.0256 & RMT.0257 (MDM.062(A) & (B)) — 20.12.2013

Lessons learnt and future challenges (v)

Aviation
South
West

- At Aviation South West we have a **comprehensive training programme** covering both **theoretical** and **practical** training.
- The practical element involves both **simulator** and **aircraft flights**. This has proved highly successful for students, instructors and examiners alike.

Aviation South West Ltd Instrument Rating Manual 2.1
RNAV Supplement Page 63 Last updated 18/4/2014

GNSS RNAV Training

Training requirements Theory

Lessons learnt and future challenges (vi)

Lessons learnt:

1. Establish a close relationship with your regulator. It can make all the difference.

2. Group together with other airports to save costs.

3. You don't need the expense of a calibrator aircraft for the flight validation.

4. Training is essential - NPA2103-25 will make it mandatory, but don't wait for that.

Lessons learnt and future challenges (vii)

and

5. Once Operators get the hang of it they love it:-

Lessons learnt and future challenges (viii)

But even more than that, EGNOS enables approaches that you would not have thought possible:

Questions

Aviation South West


Aviation South West
Big enough to matter; small enough to care
CORSAIR
G-BTID

AGENDA (14:30 – 16:15)

14:30-15:45 **Successful EGNOS implementation stories in Aviation (I)**

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- Regional aviation, a key market for EGNOS
  Jaap Horsten *– Engineering Consultant (VLM)*

15:45-16:15 **Coffee break**

Regional Aviation, a key market for EGNOS

Implementation of EGNOS in the Fokker 50

by

Jaap Horsten & Yonatan Tekle

VLM Airlines N.V.

- VLM Airlines: Regional, Europe
- Base: Antwerp, Belgium
- Fleet: 12 Fokker 50
- Business: ACMI, Charter (30-40 destinations)

Fokker 50: probably the best turboprop ever built

Network

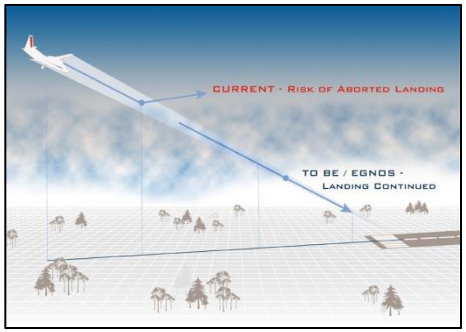
Glasgow
Edinburgh
Malmo
Durham Tees Valley
Blackpool
Leeds Bradford
Manchester
Dublin
London Luton
Cambridge
Groningen
Braunschweig
(LPV)
Berlin Tegel
Cardiff
London City
Amsterdam
Poznan
Rotterdam
Leipzig Halle
Antwerp
Paderbon (LPV)
Dresden
Dusseldorf
Brussels
Maastricht
Guernsey
Beauvais Tille (LPV)
Koln/Bonn
Jersey
Lille
Deauville
Saarbrucken (LPV)
(LPV)
Metz-Nancy-Lorraine
Brest
(LPV)
Le Bourget
(LPV)
Stuttgart (LPV)
Paris
Colmar-Houssen
(LPV)
Nantes
(LPV)
Le Mans-Arnage
Nevers (LPV)
Clermont-Ferrand
Auvergne (LPV)
Milaan-Malpensa
Brive
Lyon-Saint Exupery
(LPV)
Verona Villafranca
Bologna
Rodez Marcillac
(LPV)
Bayonne (LPV)
(LPV)
Toulouse-Blagnac
Beziers Vias
(LPV)
(LPV)
Roma/Ciampino
CityJet Network
Cityjet & Charter destinations with out EGNOS
Cityjet & charter destinations with EGNOS

EGNOS project Goals

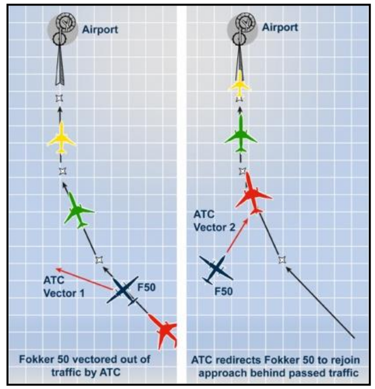
- To continue the success of the VLM Airlines Fokker 50 operation
- To become P-RNAV approved
- To equip the Fokker 50 aircraft to achieve EGNOS-based LPV approaches
- To gain Operational approval for LPV

Anticipated Benefits

1. Efficiency & Operational benefits



EGNOS
Versus NPA & ILS back-up



EGNOS – Avoided:
ATC priority to other traffic

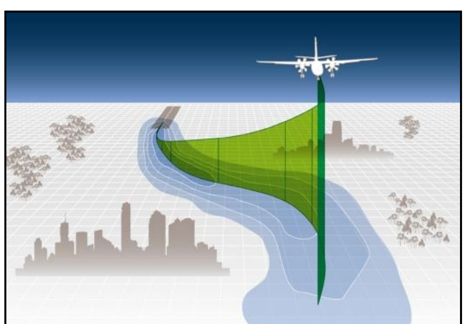
2. Flight Safety improvements

The F50 EGNOS avionics and PBN concept increase the level of safety due to:

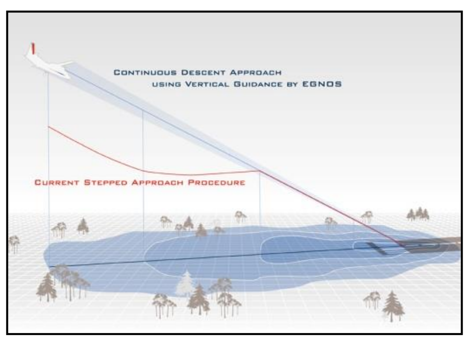
1. Vertical guidance to the runway with a reduction of accident rate by 80% (CFIT)
2. Increased situational awareness
3. Reduction in human errors and its consequences
4. Higher navigation accuracy with lower risk of traffic conflicts
5. Single integrated system (FMS linked to A/P and EFIS), with reduced workload during critical phases of flight

No compromise to flight safety

3. Environmental benefits



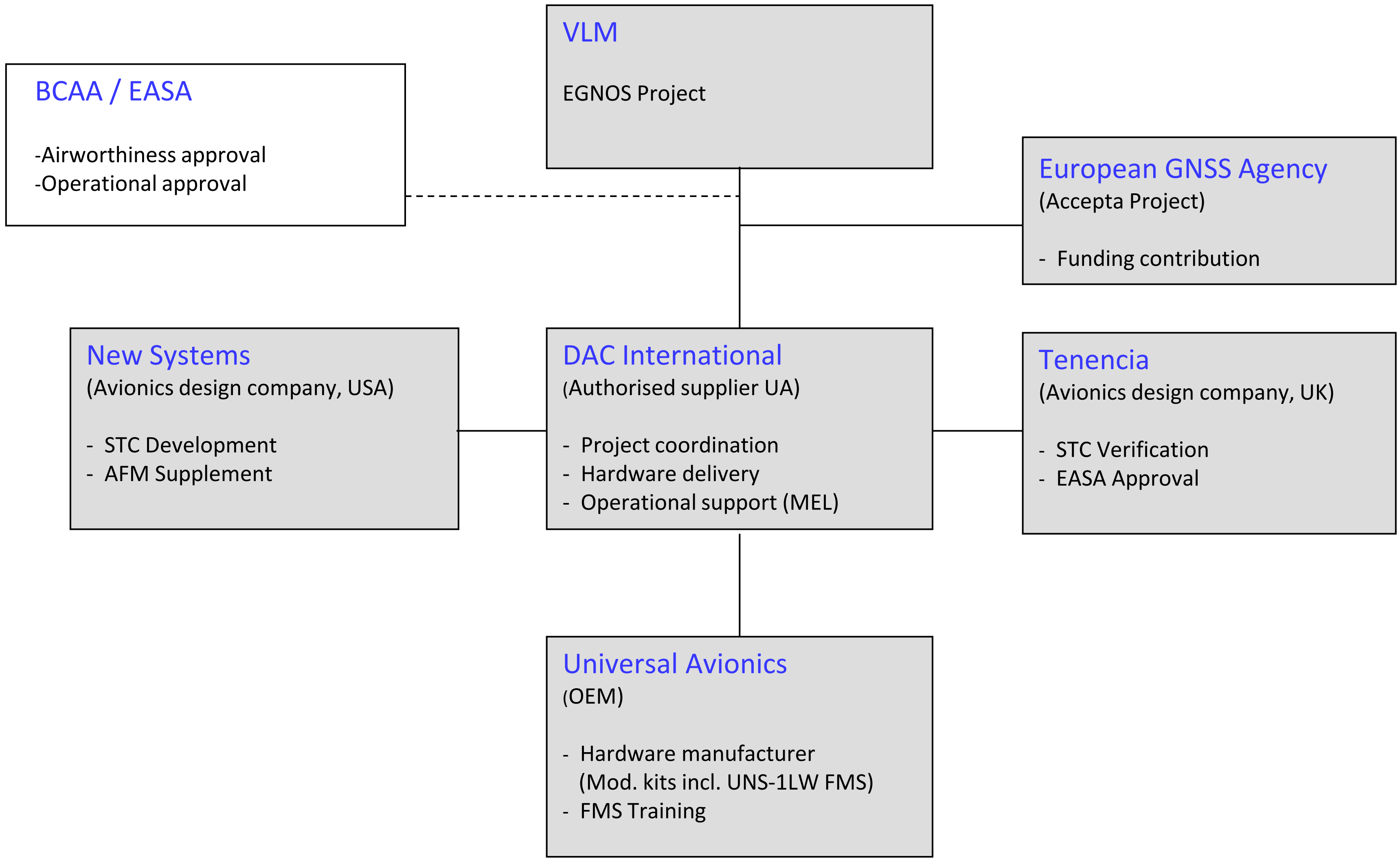
EGNOS – Improved noise abatement footprint



EGNOS – Continuous Descent Approaches (CDA) capability

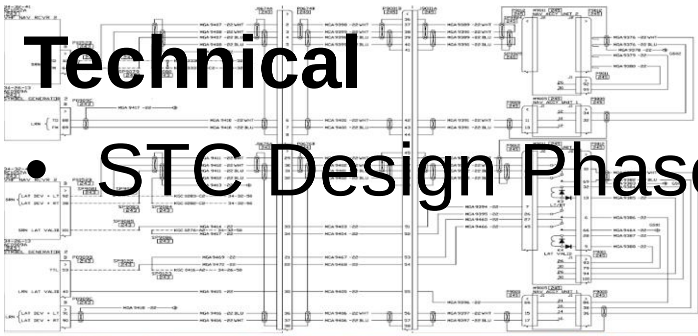
4. Improved Cost Efficiency

Project Organisation



Implementation steps

Technical



- STC Design Phase

- Modification of A/C
- STC Certification

European Aviation Safety Agency

SUPPLEMENTAL TYPE CERTIFICATE
10033789

This Supplemental Type Certificate is issued by EASA, acting in accordance with Regulation (EC) No. 216/2008 on behalf of the European Community, its Member States and of the European third countries that participate in the activities of EASA under Article 66 of that Regulation and in accordance with Commission Regulation (EC) No. 1702/2003 to

and certifies that the change in the type design for the product listed below with the limitations and conditions specified meets the applicable Type Certification Basis and environmental protection requirements when operated within the conditions and limitations specified below:

Original Product TC Number : EASA.A.036
TC Holder : FOKKER SERVICES
Model : F27 MK 050 & F27 MK 0502

Description of Design Change:
Installation of a Single UNS-1Lw Universal Avionics Flight Management System.

EASA Certification Basis:
The Certification Basis for the original product remains applicable to this certificate/ approval. The requirements for environmental protection and the associated certificated noise and/ or emissions levels of the original product are unchanged and remain applicable to this certificate/ approval.

Operational

- Procedure Development

- Flight Crew Training
- Operational Approval

Federal Public Service Mobility and Transport

Belgian Civil Aviation Authority
Technical Directorate

Challenges

- Project approval within VLM (only after being awarded with European funding through ACCEPTA).
- Fokker 50 Airworthiness approval (mature aircraft, first generation EFIS).
- To perform a complex modification (with unexpected design issues), while airline maintenance and operations continue.
- Operational approval for P-RNAV and for LPV approaches.
- Fokker 50 fleet with various navigation equipment

VLM Fokker 50 Avionics

Before EGNOS

Trimble GPS 2101 i/o (5 Aircraft)	Bendix KNS 660 (4 Aircraft)	Allied Sig. GNS-XLS (1 Aircraft)	Universal UNS-1L (2 Aircraft)
3 A/C with EFS-10 EFIS 2 A/C with SG-802 EFIS	4 A/C have EFS-10 EFIS	1 A/C has SG-806 EFIS	2 A/C have SG-806 EFIS
5 A/C have Non LNAV FMP & EFIS CP	7 A/C have LNAV FMP & EFIS Control Panels (CP)		

After EGNOS

Universal Avionics UNS-1Lw		
7 A/C with EFS-10 EFIS	2 A/C with SG-802 EFIS	3 A/C with SG-806 EFIS
All A/C have LNAV FMP & EFIS Control Panels (CP)		

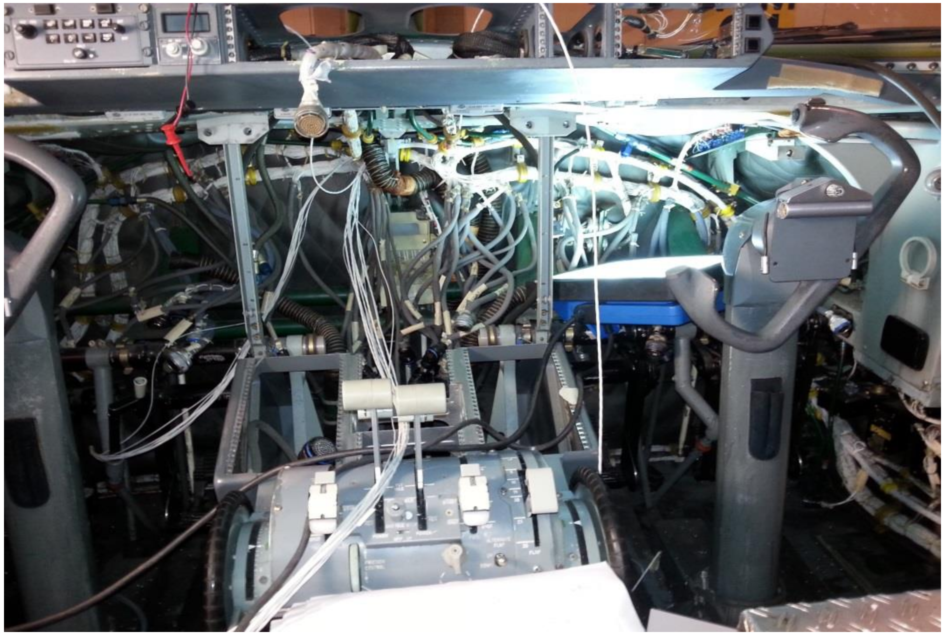
Fokker 50 EGNOS modification

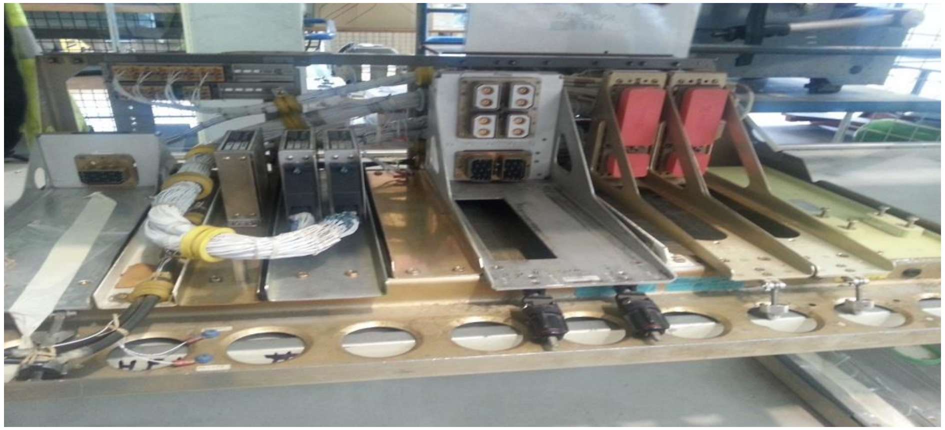
- Single Universal UNS-1Lw FMS + LP/LPV Monitor

(WAAS/ EGNOS) GPS Antenna (2x)

FMS Integration kit

The modification





Technical Challenges

- Integration kit (wire finishing, wiring adjustments)
- Differences between Fokker WM and A/C physical situation
- All FMS annunciators are on all the time
- Pseudo-ILS (P-ILS) not working
- No Vertical deviation on ND in both FMS and P-ILS mode
- No FD coupling in normal FMS mode
- No waypoints shown on the ND
- No waypoint identifiers (shown in numbers)
- Distance to waypoints shown incorrectly
- No FMS bearing pointer
- FMS-SG communication issue (no VNAV display on PFD and ND)
- PFD shows VLF instead of FMS when LNAV selected
- Amber warning light (AFCS?) displayed on PFD when LNAV selected

Project Status

Airworthiness

• STC developed (minor changes required for different a/c)	Dec 2013
• Modification 1st a/c (EFS-10, operates in single FMS)	Jan 2014
• Modification 2nd a/c (SG-802, operates in single FMS)	Jun 2014
• First EASA certification flight	Jul 2014
• Second EASA verification flight	Oct 2014
• EASA STC approval expected	Nov 2014

Operational

• Procedures developed for P-RNAV and LPV	Dec 2013
• Training program developed	Jul 2014
• P-RNAV approval to be received	Oct 2014
• LPV approval expected	Feb 2015

Summary

- Fokker 50 almost ready for EGNOS based LPV.
- VLM operation approval expected thereafter.
- LPV approach on ANR rwy 11 (VLM base) under development.

Regional Aviation is a key market for EGNOS

and

VLM is anticipating on LPV opportunities in its European ACMI/Charter network

The EGNOS Service Provision workshop

ESSP

We certify you're there.

European Global Navigation Satellite Systems Agency

funded by the European Commission

AGENDA (16:15 – 17:15)

16:15-17:15 **Successful EGNOS implementation stories in Aviation (II)**

- WAAS' successful implementation and return on experience in the US
  Bill Wanner – *WAAS program Test Director (FAA)*
- Success on A-350 EGNOS flight test
  Jean-Christophe Lair – *Test Pilot (AIRBUS)*
- Practical EGNOS avionics solutions
  Alain Beaulieu – *GPS Program and Product Mngr (CMC Electronics)*

17:15-17:30 **EGNOS awards and Conclusions**

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17:15-17:30	**EGNOS awards and Conclusions**

Wide Area Augmentation System (WAAS) Overview

Presentation to EGNOS on WAAS successful implementation and return on experience in the US

By: Bill Wanner, Navigation Branch Manager

FAA William J. Hughes Technical Center

Date: October 8, 2014

Wide Area Augmentation System

- WAAS includes ground based and space based elements that augment the GPS Standard Positioning Service (SPS)
- WAAS provides availability, accuracy and integrity allowing for uniform and high quality worldwide air traffic management
- WAAS provides coverage over North America, with a precision approach capability at over 4,000 runway ends in the United States and Canada

3 Geostationary Satellite Links

2 Operational Control Centers

38 Reference Stations

3 Master Stations

6 Ground Earth Stations

WAAS Benefits

- **WAAS-provided messages improve the accuracy, availability and safety of GPS-derived position information**
- **WAAS results in safety and capacity improvements in the National Airspace System (NAS)**
- **WAAS will reduce FAA operations costs by enabling the decommissioning of numerous ground-based navigation aids**
  - All new CAT I Approaches in the NAS shall be WAAS LPV Approaches
  - FAA committed to making a decision on the drawdown of CAT I ILS in 2016

WAAS Benefits

- **WAAS provides a cost-effective means of integrating a precision approach capability into the cockpit**
- **Over 4,000 WAAS procedures are available with many published at runways that previously had no precision approach capability**
- **WAAS has many users outside of aviation, despite being designed for aviation use**
  - Mapping, surveying, and boaters are the largest user base

WAAS Development Phases

- **Phase I: IOC (July 2003) Completed**
  - Included development of a robust safety architecture
  - Included establishment of WAAS expert panel to evaluate potential integrity threats
- **Phase II: Full LPV (FLP) (2003 – 2008) Completed**
  - Completed a Safety Risk Management Decision (SRMD) to support LPV-200 (VAL of 35m)
  - Expanded WAAS coverage to Mexico and Canada while modifying the System to address observed Ionospheric threats
- **Phase III: Full LPV-200 Performance (2009 – 2013)**
  - Completed System updates to improve performance during moderate ionospheric activity
  - Supported continuous monitoring of system data that contributes to continued integrity assurance
  - Began transition of Second Level Engineering from contractor based to organic FAA capability
- **Phase IV: Dual Frequency (L1,L5) Operations (2014 – 2044)**
  - Includes the transition from use of L2 to L5 in WAAS reference stations
  - Infrastructure modifications to support future L1/L5 user capability
  - Support sustainment of WAAS GEOs

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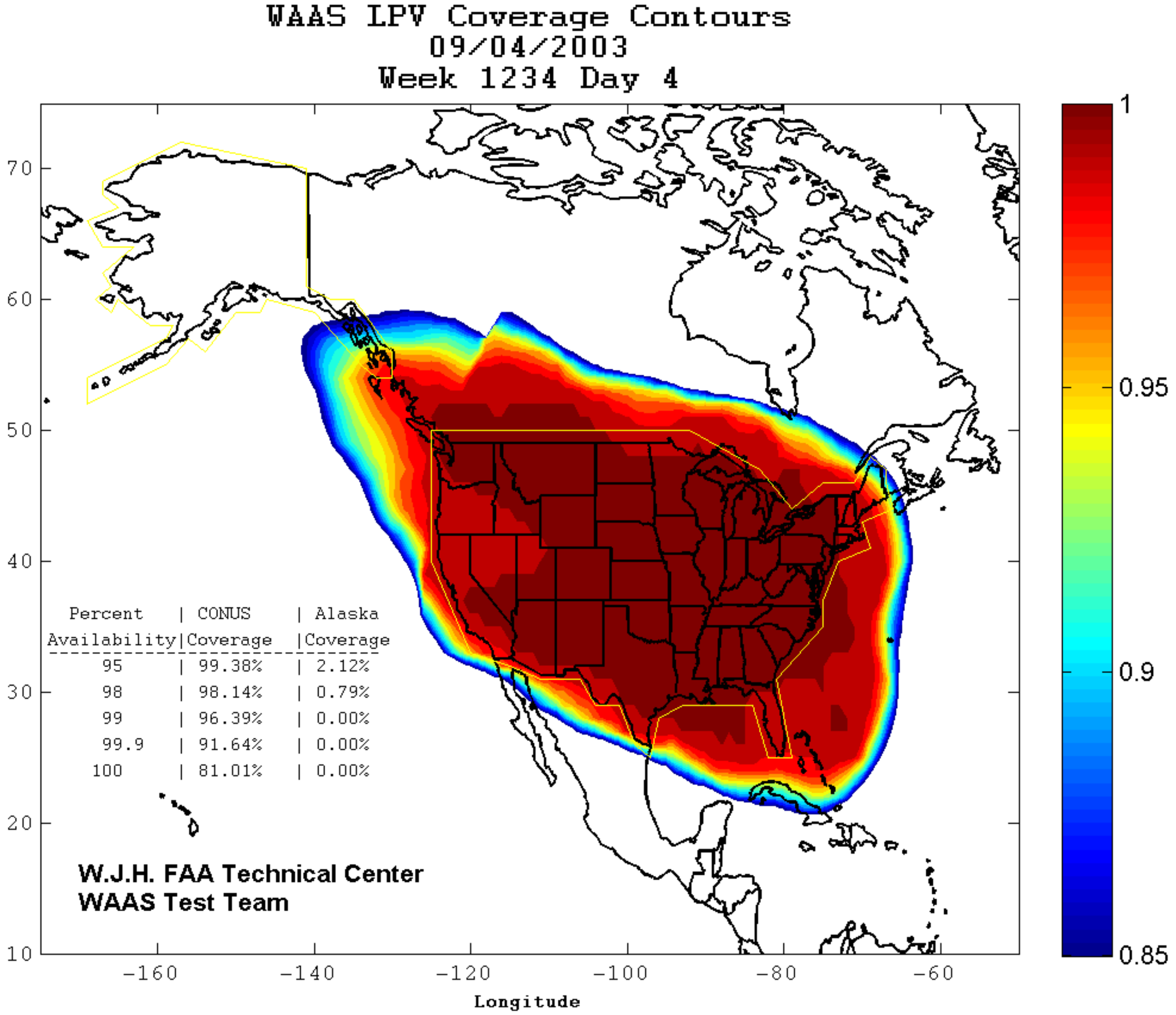
WAAS LPV Coverage Contours
09/04/2003
Week 1234 Day 4
Percent | CONUS | Alaska
Availability | Coverage | Coverage
95 | 99.38% | 2.12%
98 | 98.14% | 0.79%
99 | 96.39% | 0.00%
99.9 | 91.64% | 0.00%
100 | 81.01% | 0.00%
W.J.H. FAA Technical Center
WAAS Test Team
70
60
50
40
30
20
10
-160
-140
-120
-100
-80
-60
Longitude
1
0.95
0.9
0.85

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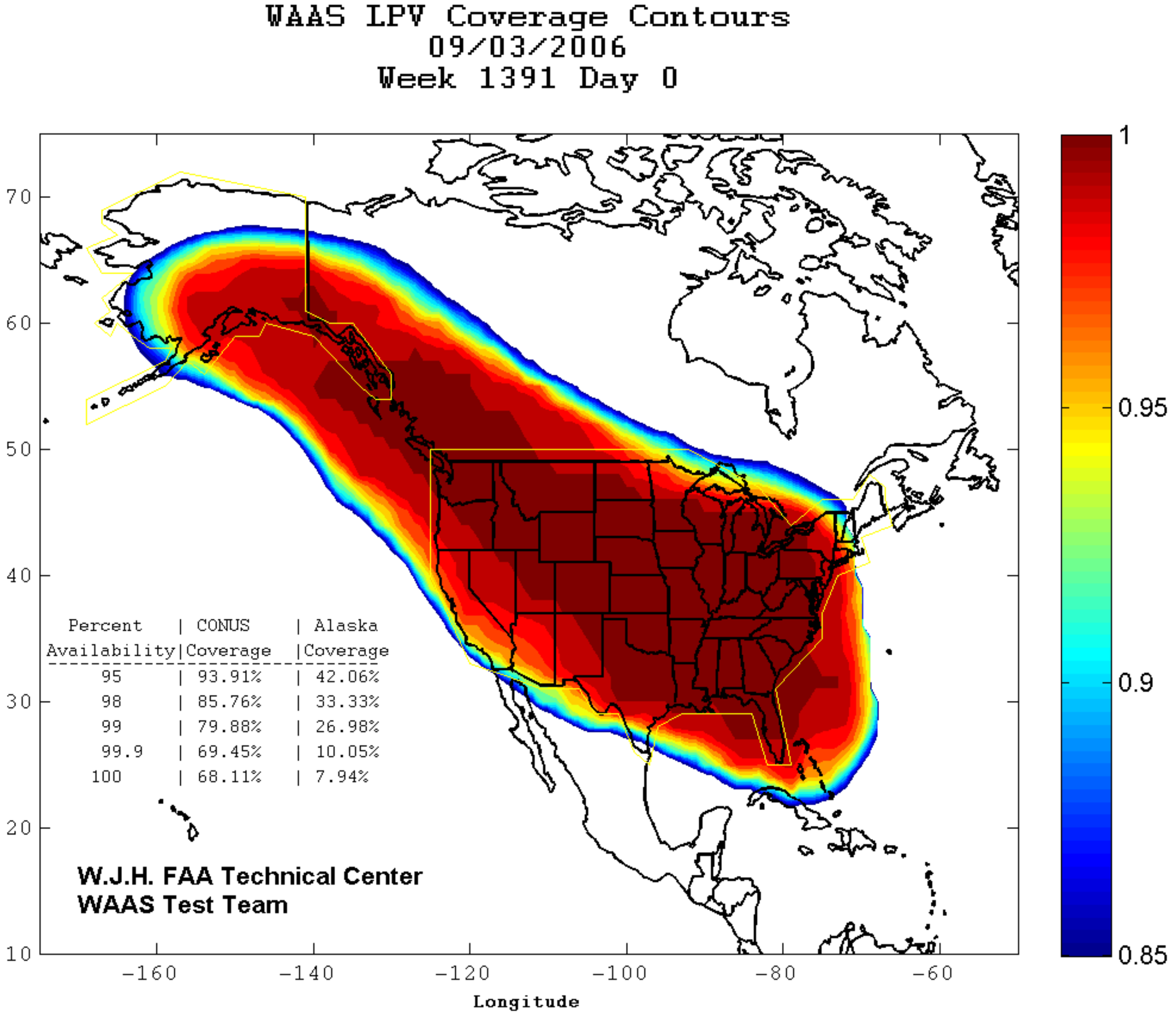
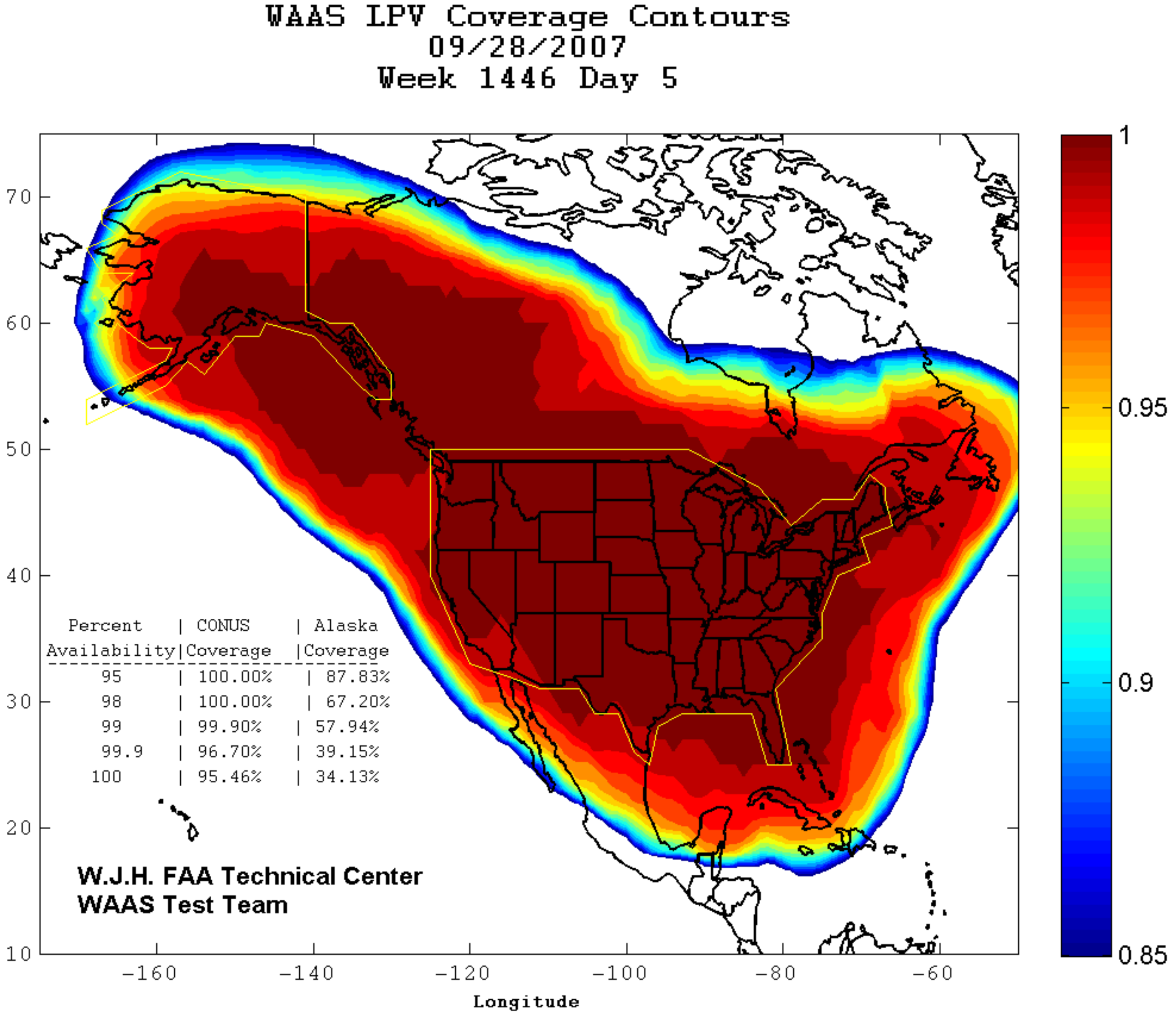
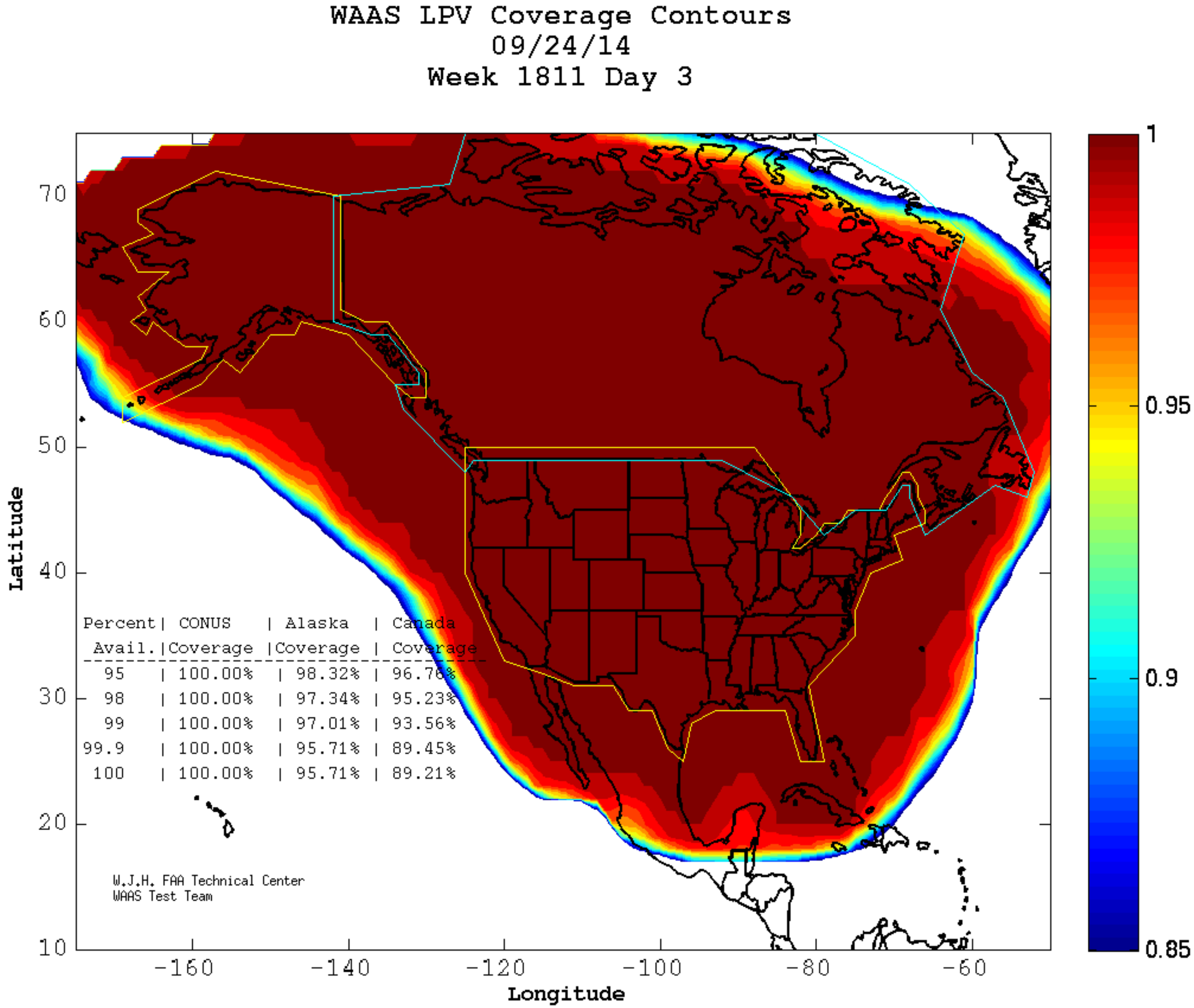

WAAS LPV Coverage Contours
09/03/2006
Week 1391 Day 0
Percent Availability | CONUS Coverage | Alaska Coverage
95 | 93.91% | 42.06%
98 | 85.76% | 33.33%
99 | 79.88% | 26.98%
99.9 | 69.45% | 10.05%
100 | 68.11% | 7.94%
W.J.H. FAA Technical Center
WAAS Test Team
70
60
50
40
30
20
10
-160
-140
-120
-100
-80
-60
Longitude
1
0.95
0.9
0.85



WAAS LPV Coverage Contours
09/28/2007
Week 1446 Day 5
Percent | CONUS | Alaska
Availability|Coverage |Coverage
95 | 100.00% | 87.83%
98 | 100.00% | 67.20%
99 | 99.90% | 57.94%
99.9 | 96.70% | 39.15%
100 | 95.46% | 34.13%
W.J.H. FAA Technical Center
WAAS Test Team
Longitude
70
60
50
40
30
20
10
−160
−140
−120
−100
−80
−60
1
0.95
0.9
0.85

WAAS Development Phases

- **Phase I: IOC (July 2003) Completed**
  - Included development of a robust safety architecture
  - Included establishment of WAAS expert panel to evaluate potential integrity threats
- **Phase II: Full LPV (FLP) (2003 – 2008) Completed**
  - Completed a Safety Risk Management Decision (SRMD) to support LPV-200 (VAL of 35m)
  - Expanded WAAS coverage to Mexico and Canada while modifying the System to address observed Ionospheric threats
- **Phase III: Full LPV-200 Performance (2009 – 2013)**
  - Completed System updates to improve performance during moderate ionospheric activity
  - Supported continuous monitoring of system data that contributes to continued integrity assurance
  - Began transition of Second Level Engineering from contractor based to organic FAA capability
- **Phase IV: Dual Frequency (L1,L5) Operations (2014 – 2044)**
  - Includes the transition from use of L2 to L5 in WAAS reference stations
  - Infrastructure modifications to support future L1/L5 user capability
  - Support sustainment of WAAS GEOs


WAAS LPV Coverage Contours
09/24/14
Week 1811 Day 3
Percent | CONUS | Alaska | Canada
Avail. |Coverage |Coverage | Coverage
95 | 100.00% | 98.32% | 96.76%
98 | 100.00% | 97.34% | 95.23%
99 | 100.00% | 97.01% | 93.56%
99.9 | 100.00% | 95.71% | 89.45%
100 | 100.00% | 95.71% | 89.21%
W.J.H. FAA Technical Center
WAAS Test Team
Latitude
Longitude
70
60
50
40
30
20
10
-160
-140
-120
-100
-80
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1
0.95
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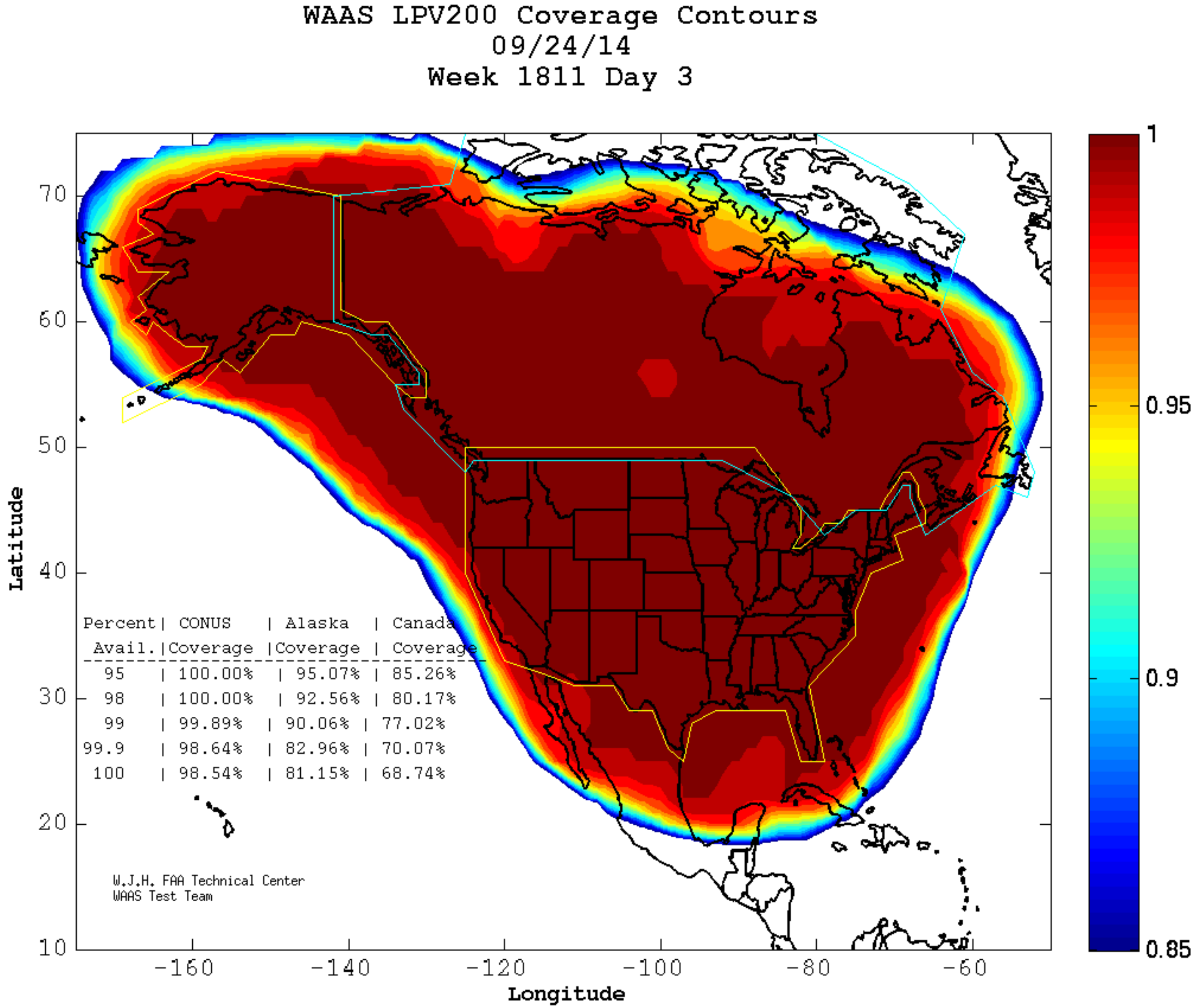
WAAS LPV200 Coverage Contours
09/24/14
Week 1811 Day 3
Percent | CONUS | Alaska | Canada
Avail. |Coverage |Coverage | Coverage
95 | 100.00% | 95.07% | 85.26%
98 | 100.00% | 92.56% | 80.17%
99 | 99.89% | 90.06% | 77.02%
99.9 | 98.64% | 82.96% | 70.07%
100 | 98.54% | 81.15% | 68.74%
W.J.H. FAA Technical Center
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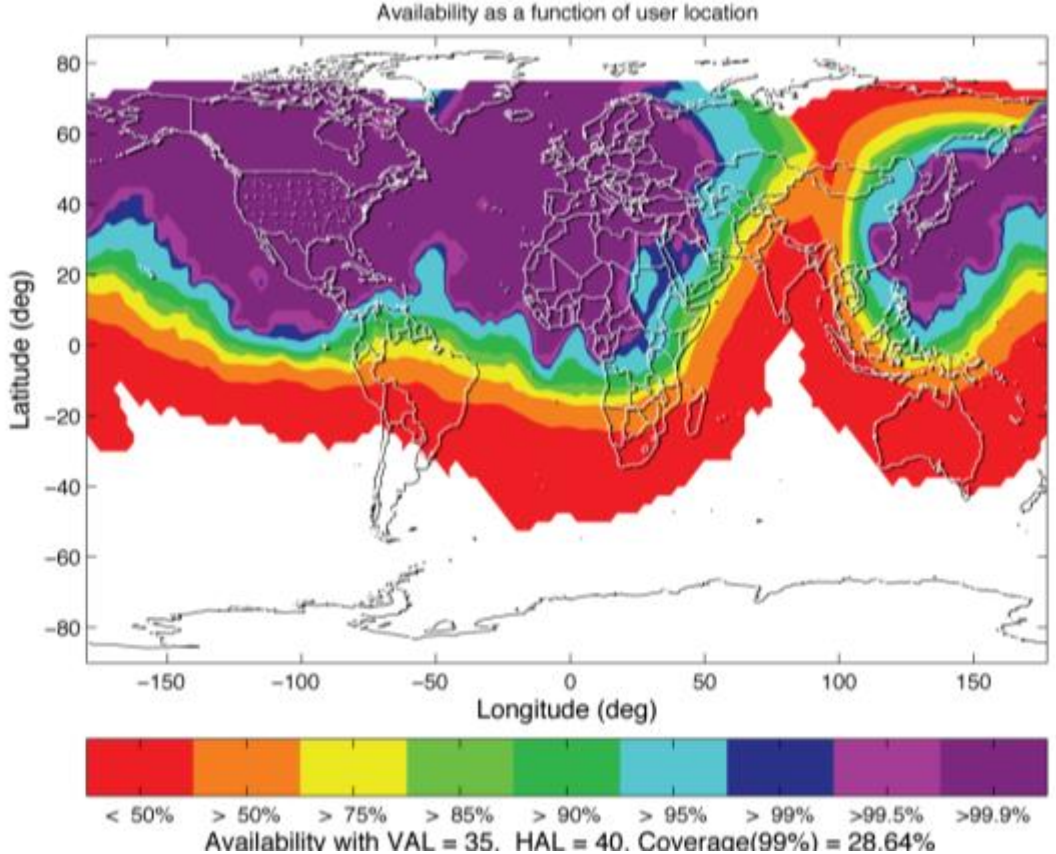
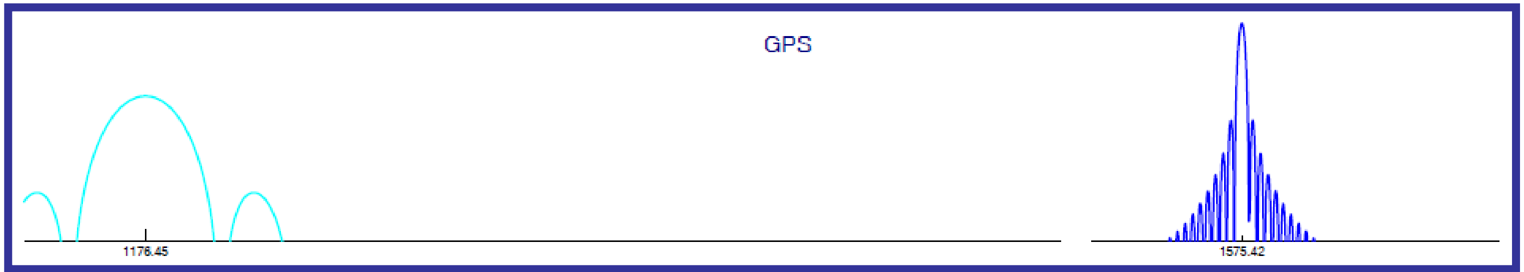
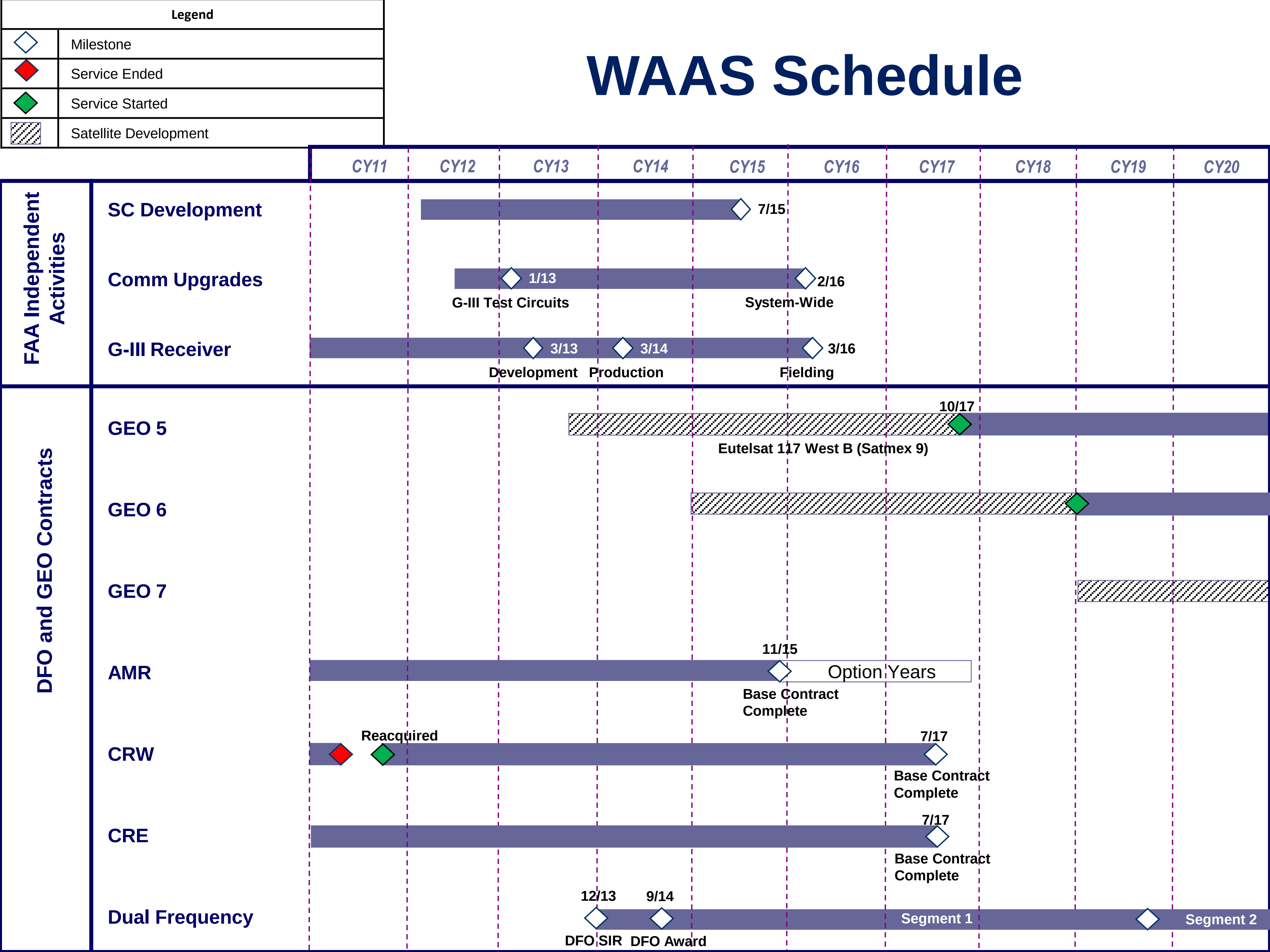
Future LPV-200 Coverage(Dual Frequency GPS)

WAAS
EGNOS
MSAS



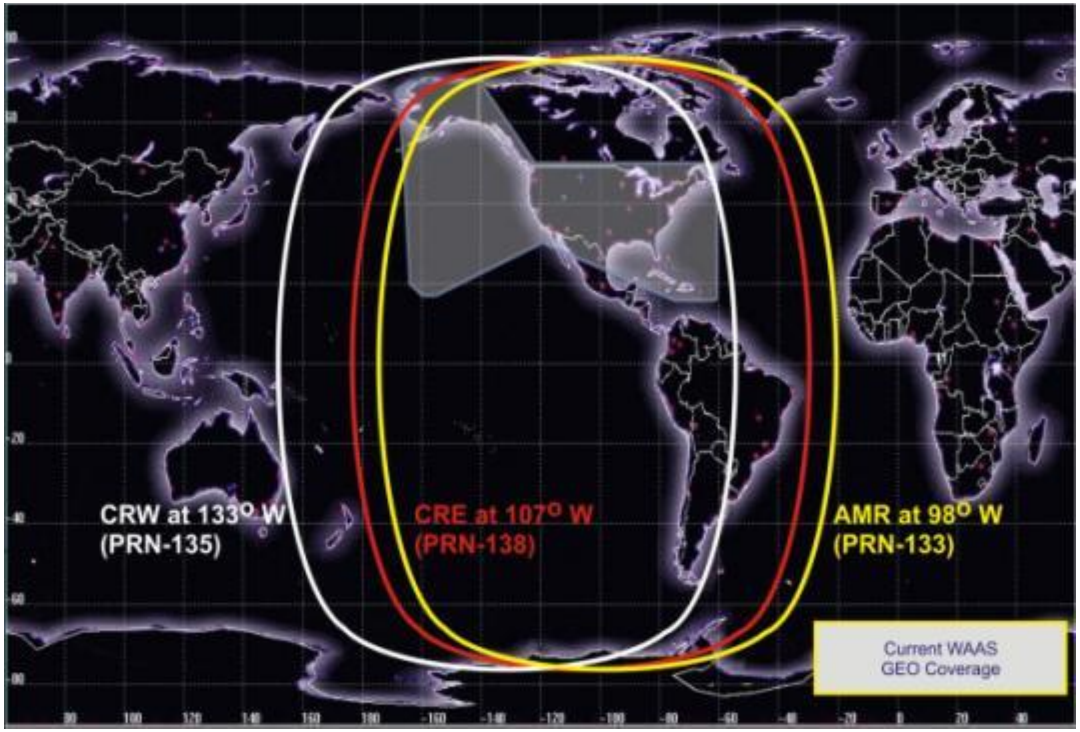


WAAS Schedule



GEO Activities

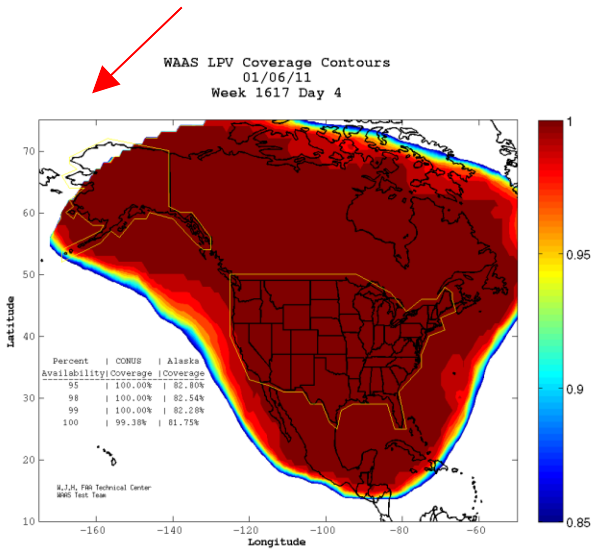
- **Current WAAS GEO satellites**
  - Intelsat Galaxy XV (CRW)
  - Anik F1R (CRE)
  - Inmarsat I4F3 (AMR)
- **GEO 5 and GEO 6**
  - GEO 5 Contract awarded September 2012



GEO Loss Realized

- **Impact of GEO Loss**
  - April 5 2010: Total loss of Telemetry Tracking and Command (TT&C) resulted in uncontrolled easterly drift of Intelsat Galaxy 15 (CRW)
  - As CRW drifted, NW Alaska lost WAAS service
  - In addition, a large portion of Alaska was now provided service by a single GEO (CRE)
    - WAAS Users Experienced Outages During Switchover of CRE uplink stations from primary to backup
    - Temporary Loss of Service Approximately 5 Minutes Per Event
    - Occurred 3-6 Times Per Month for CRE during 2010
  - WAAS Program implemented third GEO satellite (AMR, PRN 133)
    - GEO operational in Nov 2010
    - Does cover as much of Alaska as CRE does
    - Still had service outage in much of Alaska when CRE was not transmitting
    - CRW came back into service in March 2011

White area in NW Alaska shows where there is single GEO coverage from CRW.



GEO Sustainment

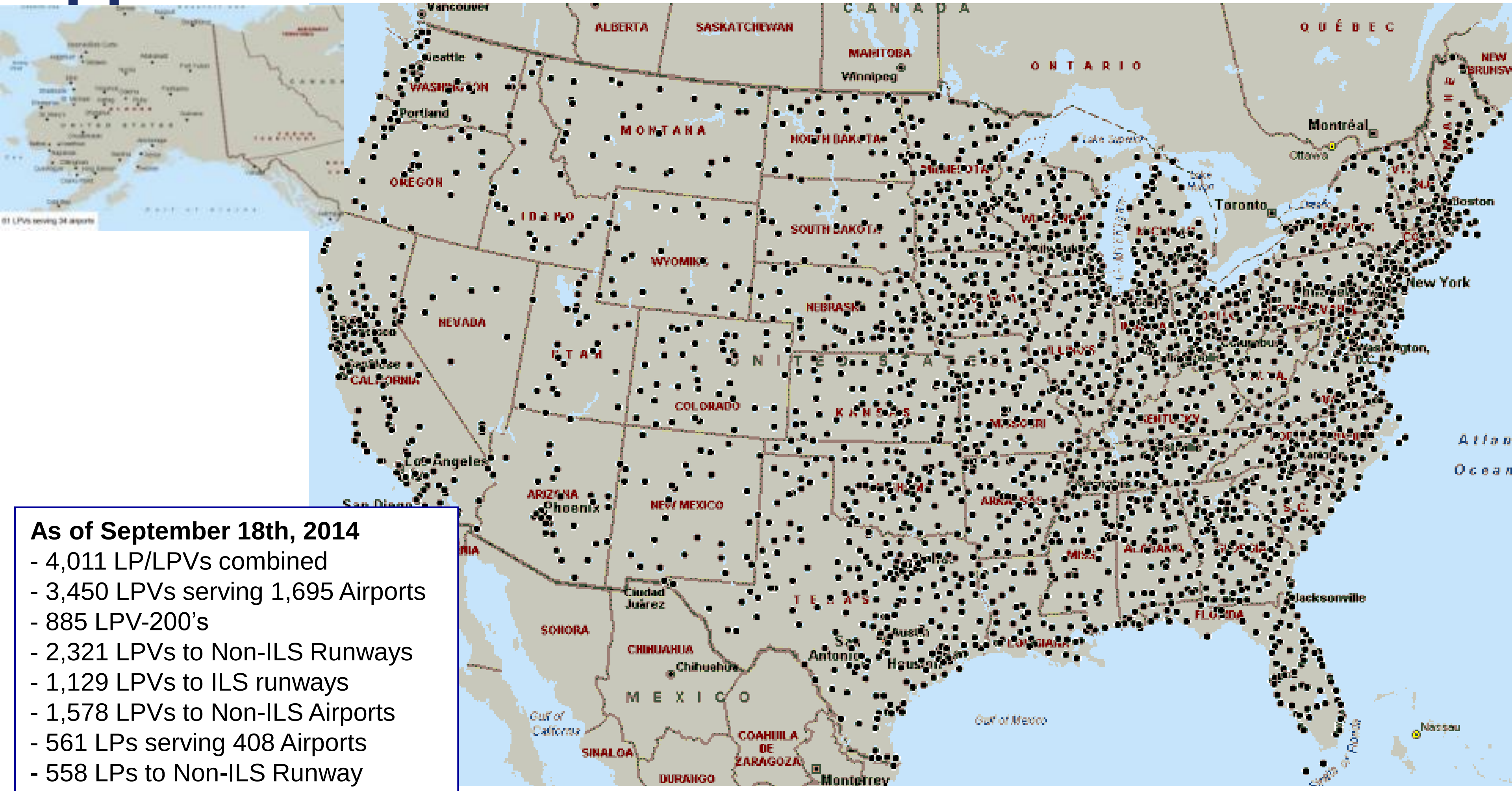
- **GEO 5 and GEO 6 Satellite Acquisition**
  - Awarded GEO 5/6 Satellite Service Lease contract September 2012
  - Eutelsat 117 West B (formally called SatMex 9) satellite will host the WAAS GEO Satellite Payload
    - Orbital slot (117 degrees West) will provide full coverage over CONUS and Alaska
    - Critical Design Review (CDR) completed July 2014
    - Scheduled for operations in 2017
  - GEO 6 Satellite opportunities currently under investigation

WAAS Operations and Maintenance

- **WAAS is operated 24/7 by WAAS Operations Specialists**
  - Washington DC and San Diego CA
- **Operations Support**
  - Second Level Engineering
  - Baseline management
  - Performance Monitoring
  - Logistics
  - Modifications

WAAS Operations and Maintenance

Airports with WAAS LPV/LP Instrument Approaches



As of September 18th, 2014

- 4,011 LP/LPVs combined
- 3,450 LPVs serving 1,695 Airports
- 885 LPV-200’s
- 2,321 LPVs to Non-ILS Runways
- 1,129 LPVs to ILS runways
- 1,578 LPVs to Non-ILS Airports
- 561 LPs serving 408 Airports
- 558 LPs to Non-ILS Runway
- 3 LPs to ILS Runways

WAAS LPV Equipped Aircraft August 2014 (Estimated)

Garmin –68,743
- GA Aircraft (See FAA Garmin Approved Model List (AML)). Most GA Part 23 aircraft.
- GTN series – Lear 35/35A, 36/36A,24 – Phenom300 with G-3000

Universal Avionics – 2,289 aircraft
- 122 fixed wing and 12 helicopter types and models

RockwellCollins – 1,929 aircraft
- 37 Types and models

Honeywell /CMC Electronics) – 921 aircraft
- 22 types and models

Avidyne – 238 aircraft
- 6 types and models (Cirrus SR 20 & 22, Piper Matrix & Mirage, Piper Saratoga NX, and EA-500)
- IFD 540 WAAS LPV - (STC complete July 2014 – AML STC approved for over 1,000 aircraft makes and models)

Genesys Aerosystems (Chelton) – 247 aircraft
- Bell-407 & 412, Cessna 501, 550, Piper PA-42, Beechcraft C-90&A, EurocopterAS-350, AgustaAW109SP, Beechcraft T-34B, Kawsaka

Innovative Solutions & Support (IS&S) – 200 aircraft
- Eclipse 550/500
- Boeing 737-400 (pending)
- MD-88/90 (pending)

Thales – 5 aircraft
- Airbus A300-600ST (Beluga)
- Airbus A400M (Military)
- Airbus A350XWB - pending

TOTAL Estimated WAAS LPV Equipped Aircraft – 74,572

Current WAAS Projects

- **Garmin RF Turn**
  - Updating TSO & STC for GTN-600/700 series avionics
- **ExpressJet Airlines**
  - WAAS data collection in progress
  - Completed Mexican LPV Procedure Developer Training
- **Horizon Air Regional Airline Project**
  - The goal of this work is to collect Flight Technical Error (FTE) with HGS to support operational approval to conduct RNAV (GPS) approach operations to minima as low as 150 feet DA and 1800 RVR
  - Horizon experiencing pilot exodus/shortage and currently unable to dedicate simulator time to project
  - MOU currently in final staffing in Flight Standard
- **UAS/UAV**
  - Coordination with Conoco Phillips
  - Completed collection 1st set of pre-WAAS data
  - Currently reviewing data

Future Applications

- **WAAS is an enabler for multiple FAA initiatives**
  - Performance-based navigation (Area Navigation) (RNAV)
  - Required Navigation Performance (RNP)
    - WAAS meets the requirement for RNP AR as defined in FAA Advisory Circular 90-101A
    - No restriction due to temperature
  - Point in Space (PinS) procedures
  - Automatic Dependent Surveillance Broadcast (ADS-B)
    - WAAS is currently the only technology that meets all of the most stringent requirements for a positioning source for ADS-B

Questions?

AGENDA (16:15 – 17:15)

16:15-17:15 **Successful EGNOS implementation stories in Aviation (II)**

- WAAS' successful implementation and return on experience in the US
  Bill Wanner – *WAAS program Test Director (FAA)*
- Success on A-350 EGNOS flight test
  Jean-Christophe Lair – *Test Pilot (AIRBUS)*
- Practical EGNOS avionics solutions
  Alain Beaulieu – *GPS Program and Product Mngr (CMC Electronics)*

17:15-17:30 **EGNOS awards and Conclusions**

Jean-Christophe Lair

Airbus Test Pilot

Feedback on EGNOS from A350 flight tests

Development of LPV approach capability on a large transport aircraft

A350 XWB in figures (A350-900)

- Dimensions
  - Length: 68.89m
  - Wingspan: 64.75m
  - Height: 17.05m
- Engines
  - 2 x Rolls Royce Trent XWB
  - Thrust Rating: 84,000 lbs
- Max takeoff weight: 268t
- Fuel Capacity: 110T (138,000l)
- Typical cruise speed: Mach 0.85
- Maximum CRZ altitude: FL430

Already 750 firm orders (end Aug. 2014)

A350 XWB in Flight Test

- 5 prototype A/C
  - Maiden flight of MSN1 on June 14th, 2013
  - Most recent A/C MSN5 joined the fleet on June 20th 2014
- 640 flights and 2700 Flt Hrs (mid Sept. 14) for development and certification
  - EASA certification achieved on Sept. 30th 2014
  - Current flight test activities linked primarily to functions introduced at Entry Into Service (EIS)
- GLS and SLS functions (GBAS and SBAS) are certified part of this “EIS” package as a combined option
  - On board all 5 prototype A/C
  - Selected by most customers (including launch customer QTR Airways)

AIRBUS

The background: Airbus xLS concept

- ILS is the reference instrument approach system for all pilots
- xLS concept provides ILS “look alike” crew interface for all possible sources (all possible x)
  - MLS and GLS (GBAS) were the first applications of the xLS concept
- When developing the A380, Airbus introduced FLS (FMS Landing System), which provides an xLS solution for Non Precision Approaches with Baro-VNAV guidance:
  - Conventional (e.g. VOR, NDB,..)
  - RNAV(GNSS) (RNP APCH)
  - LOC only (or G/S transmitter failed)

AIRBUS

The background: Airbus xLS concept

- xLS is based on:
  - Identification of the final approach reference segment (Lateral and Vertical)
  - Computation of LOC and G/S deviations from the reference segment

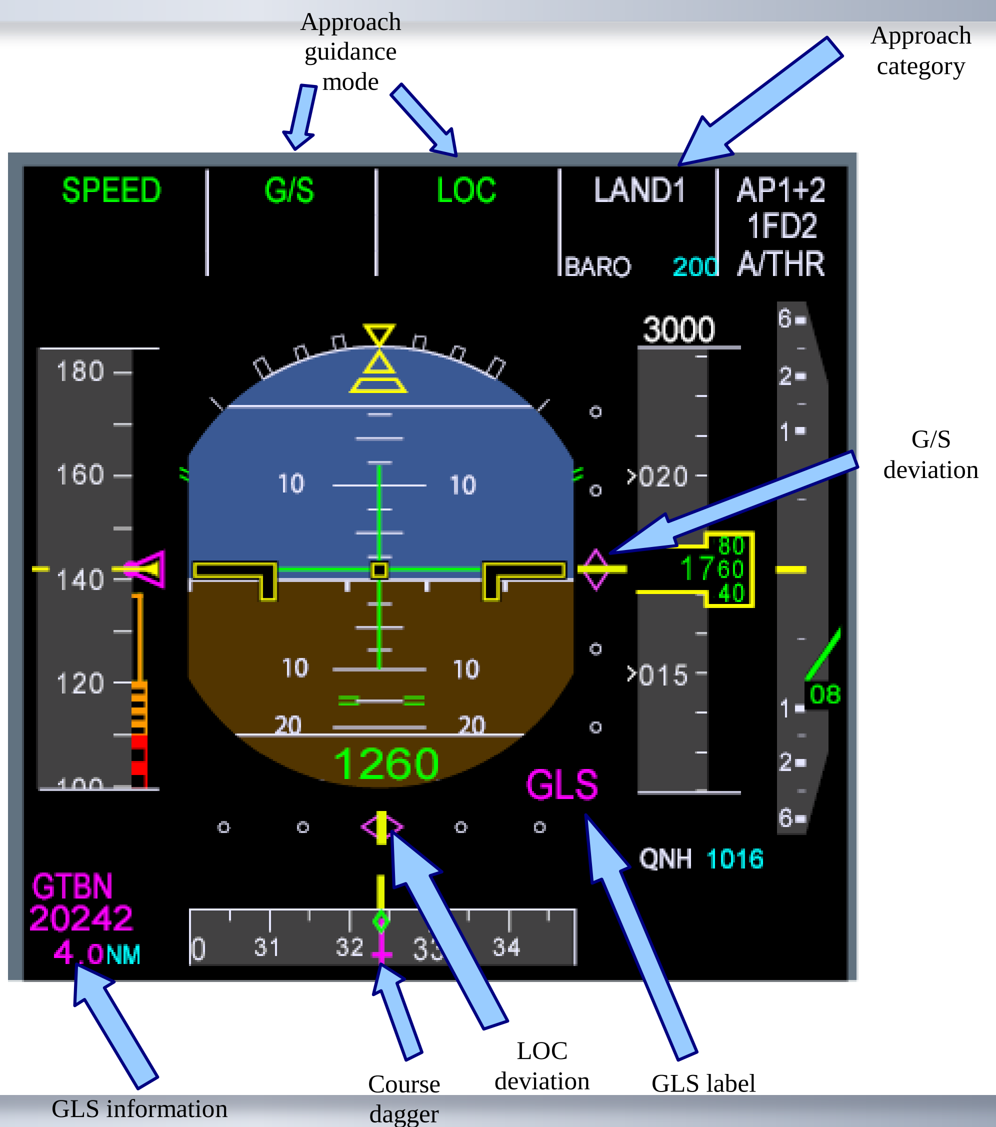
- Final approach segment is equivalent to the ILS beam
- LOC and G/S deviations are used by pilots (and A/C systems) in the same way as for ILS deviations

➢ Pilots get similar interfaces for all xLS applications (e.g. ILS, GLS, or FLS)

➢ Multi Mode Receiver (MMR) manages the radio sensors, computes deviations, and ensures interface with display and guidance systems

➢ xLS expands the ILS operational benefits to all kinds of approaches

xLS data on Primary Flight Display

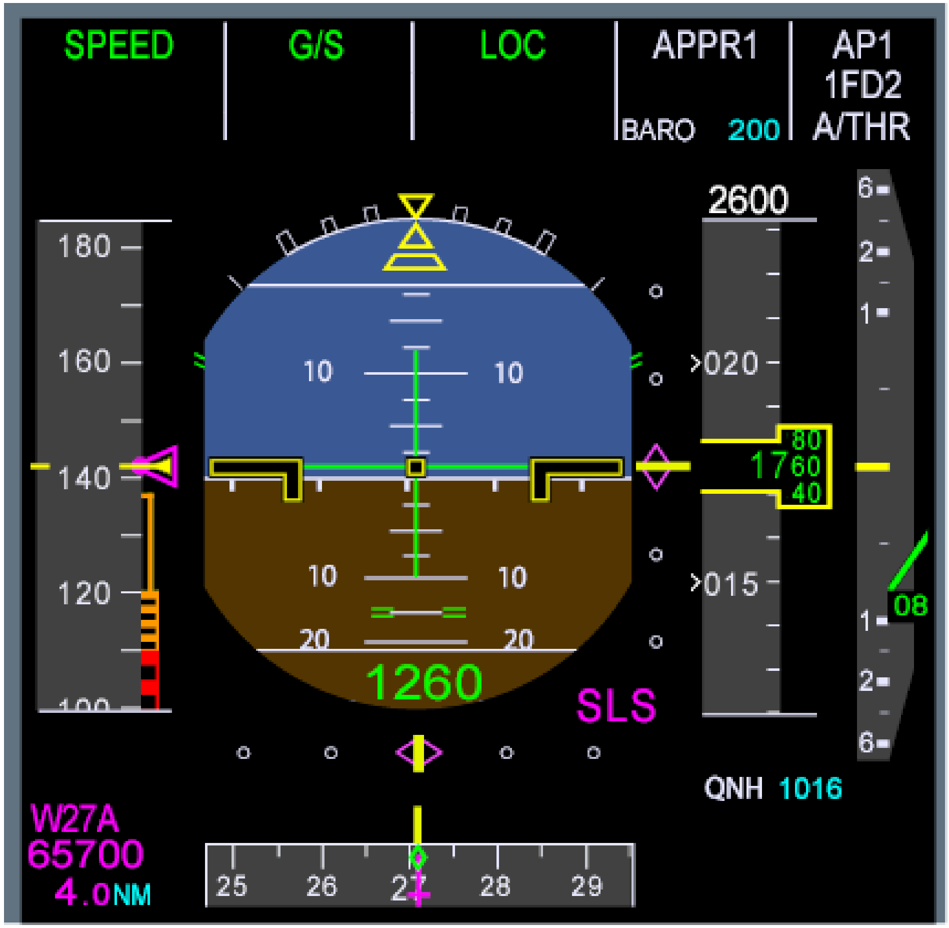


SBAS / LPV approaches: Airbus SLS function

- The new SBAS / LPV approaches are halfway between RNAV(GNSS) and GLS approaches:
  - Technology is very similar to GLS
  - Charting is made through RNAV approaches (with LPV minima)
- RNAV/LPV approaches obviously fit perfectly into the xLS concept
- SLS acronym was selected for the A/C function supporting SBAS applications (LPV or LP)

➢ Airbus SLS function is first introduced on A350 XWB

SBAS / LPV approaches: Airbus SLS function



SLS / GLS functions comparison

SLS is a subfunction of MMR very similar to GLS:

- GLS:
  - Based on GBAS technology
  - Selection of **GLS** appr. in FMS (back-up tuning possible by ident / channel)
  - FAS Data Block uplinked from ground station
  - GPS correction data transmitted by local ground station
  - xLS type HMI, LOC and GS guidance modes with Autoland capability
- SLS:
  - Based on SBAS technology
  - Selection of eligible **RNAV** approach in FMS
  - FAS Data Block retrieved from FMS Nav DB
  - GPS correction data transmitted by geostationary satellite
  - xLS type HMI, LOC and GS guidance modes currently without Autoland capability

Use of SLS function for LPV approach

- LPV approaches are published as RNAV(GNSS) or RNAV(GPS) **with LPV minima**

- A single RNAV(xxx) chart may therefore support
  - SBAS based approach (with LPV minima), and
  - "Basic" RNAV APCH based on non-augmented GPS (with LNAV/VNAV or LNAV only minima – flown with FLS function)

- When selecting RNAV (xxx) approach with both LPV and LNAV/VNAV minima :
  - SLS function is selected by default (for LPV minima)
  - FLS function is available as back-up (for LNAV/VNAV minima)

AIRBUS

RNAV – LPV approach chart

Approach Name

SBAS Channel and Ident

Applicable minima

- **LPV** minima apply when SBAS is available
  => using the SLS function
- **LNAV/VNAV** minima apply when SBAS is not available => using the FLS function
- **LNAV** minima may also exist => using the FLS function

AIRBUS

SLS / LPV – Standard Operational Procedure

- LPV approaches with SLS function are flown like ILS approaches

- Approach preparation = same as usual
  - Select the appropriate approach from the list stored in NavDB according to the desired approach chart
  - Verify approach parameters on EFIS regarding the approach chart
    - Ident, Channel, Course (on PFD & ND)
    - Approach segment (on ND)

- Approach execution = same as usual
  - Fly the approach with an “ILS look-alike” operational procedure

AIRBUS

SLS / LPV – Pilot feedback

- Absolutely no issue with EGNOS service in our current Flight Test experience
- SLS shows its value every day we use it for approach

- FAS DB really brings robustness compared to usual FMS coding
- Geometric Glide Path is a real asset compared to Baro VNAV

- SLS / LPV signal as observed on A350 is operationally equivalent to Cat1 ILS and sometimes even better:
  - A/C position relative to the FAS is always available and reliable
  - No false LOC or GS side lobes
  - No perturbation linked to ILS protected area (potential for closer separation)
- Excellent feedback on A350 from Airbus Flight Crew and Authority Pilots

SLS / LPV – Pilot feedback

SLS / LPV solutions, based on SBAS technology, can really benefit to flight operations of transport aircraft of any type:

- Can be made available at almost any runway end (without additional ground infrastructure)
- Provide increased Performance and Robustness compared to “normal” GNSS approach

Benefits potentially apply to all categories of airports:

- LPV is an ideal back-up solution on main runways currently equipped with ILS (e.g. in case of failure or maintenance)
- Allows creation of instrument approaches at many runways which do not currently have Precision Approach capability
- Can also help in case of diversion to an en-route alternate

SLS / LPV – a pilot's wish list

EGNOS and WAAS already enhance flight operations, by making precise and safe instrument approaches possible at many runways in Europe and North America

There could be larger benefits to the air transport community with some involvement from the stakeholders

This is what I'd like to see as an operational pilot:

- LPV approaches at all runways within adequate SBAS coverage
- Additional SBAS constellations / regions
- LPV200 capability and "real" Cat1 minima
- LPV solution on more A/C types

AIRBUS

Happy LPV and A350 landings…

AGENDA (16:15 – 17:15)

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  Alain Beaulieu *– GPS Program and Product Mngr (CMC Electronics)*

17:15-17:30 **EGNOS awards and Conclusions**

Esterline | CMC Electronics

Practical EGNOS Avionics Solutions

Alain Beaulieu, Program Manager GPS

MONTREAL • OTTAWA • CHICAGO

www.cmcelectronics.ca

Over 100 Years of Innovation

Esterline Overview

- Headquarters: Bellevue, Washington
- Public company (NYSE: ESL) founded in 1967
- Key markets:
  - Commercial aviation (40%)
  - Military aviation (40%)
  - Industrial applications (20%)
- Employees: > 12,000
- Revenues: $ 2 billion

Avionics and Controls
Avionics systems and components, technology interface systems, including lighted switches and displays, pilot grips and wheels for commercial and military aircraft, military vehicles.

Sensors and Systems
High-precision temperature and pressure sensors, power distribution equipment, motion control components, related systems.

Advanced Materials
High-performance elastomer products, insulation and thermal protection systems, combustible ordnance, electronic warfare countermeasure products.

CMC Electronics Overview

- Headquarters: Montreal, Quebec
- Incorporated in 1903
- Key markets:
  - Commercial aviation (49%)
  - Military aviation (51%)
- Sales distribution:
  - United States (56%)
  - Canada (13%)
  - International (31%)
- Employees: >1,000

Cockpits and Systems Integration
Cockpit Retrofits
New Cockpit Builds
Human Factors Engineering

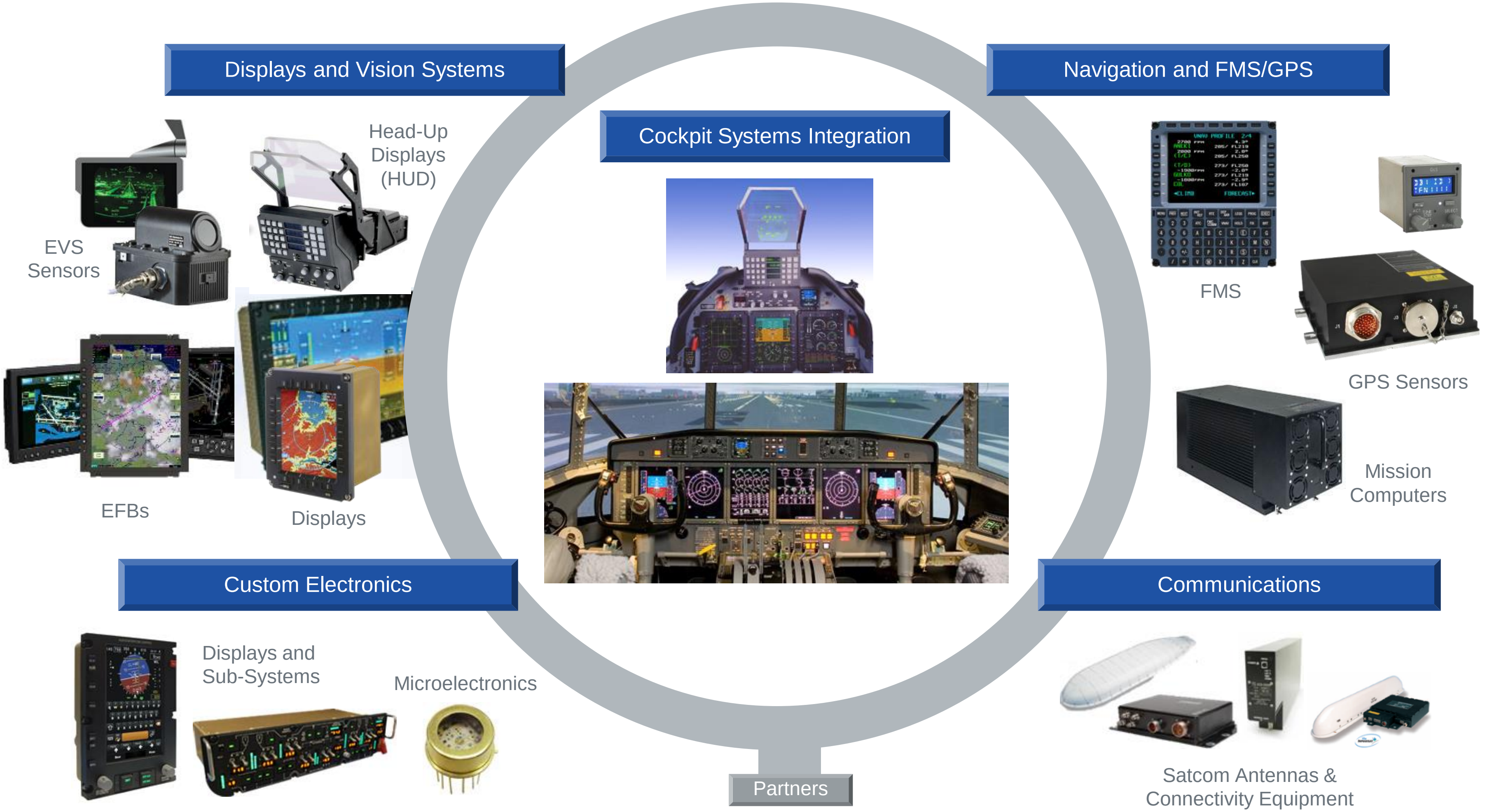
Aviation Products
Navigation and FMS
Displays and Vision Systems
Airborne Communications

Custom Electronics
Avionics Components
Displays and Sub-systems
Hybrid Microcircuits

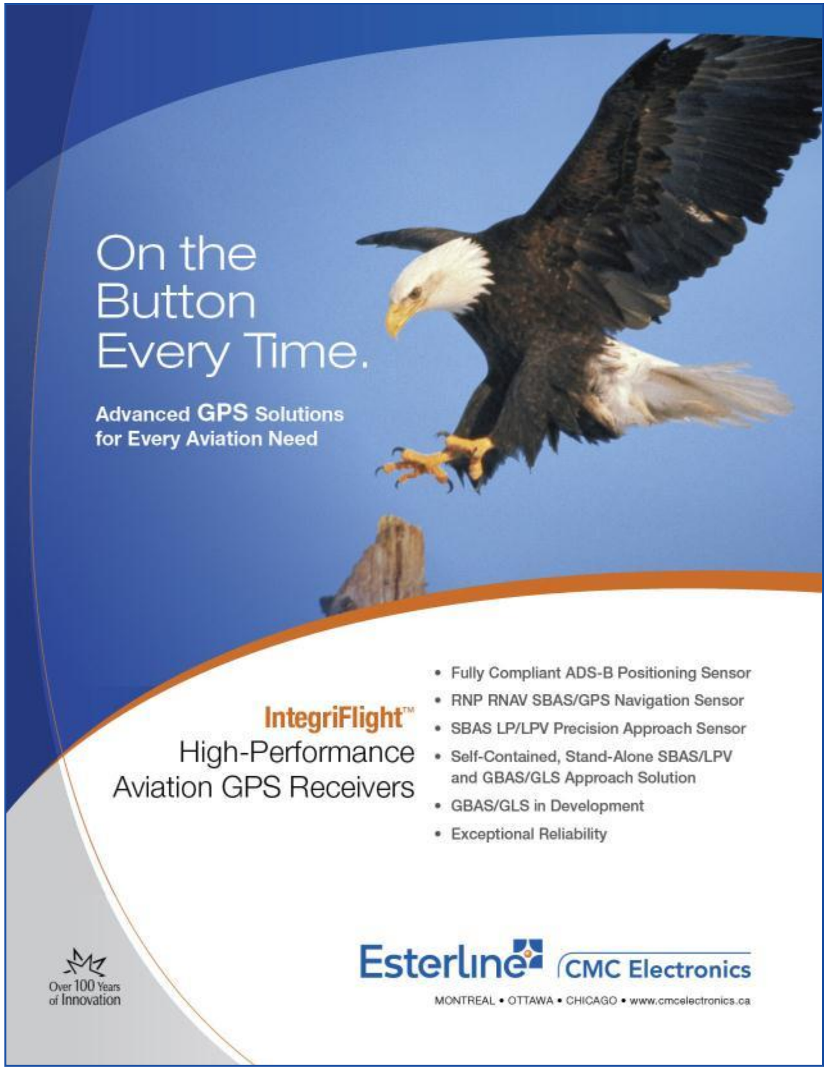
NavComm Electronics
Communications and electronics systems for land and marine applications

CMC Avionics Portfolio

- Innovative avionics products and integrated cockpit systems solutions
- Addressing need to modernize cockpits meeting international regulatory mandates

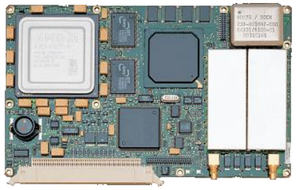


Product Offering(s): *CMA-5024/25 GLSSU*



CMA-5024 GLSSU

CMA-5025 GLSSU Control Panel



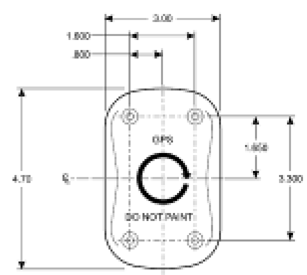
CMA-4124 GNSSA

CMA-5024 GLSSU - Characteristics

- State-of-the-art Patented 24 – channel Narrow Correlator ® ARINC 743B compliant SBAS sensor unit
  - Three SBAS and twenty-one GPS continuous channels with full RTCA/DO-229D message processing
- TSO-C145c Beta-3 GPS receiver
  - TSO C145c incorporate more stringent standards that outperform TSO - C129a in all operating conditions
    - FAA has cancelled TSO-C129a and does not allow re-certification to that standard
  - GLSSU meets or exceeds any TSO-C196 GPS (only) receiver
- TSO-C146c Delta-4 Landing system
- Software certified to RTCA/DO-178B Level B
- Hardware certified to RTCA/DO-254 Level B
- Software upgradeable to GBAS/LAAS
- The GLSSU includes an Aircraft Personality Data file (APD File) that contains aircraft-specific Configurations
  - Provide the flexibility of adapting GLSSU to the needs of several aircraft within a large fleet.
- Active antenna compliant with TSO C-190
  - Allow to install the GLSSU in any location

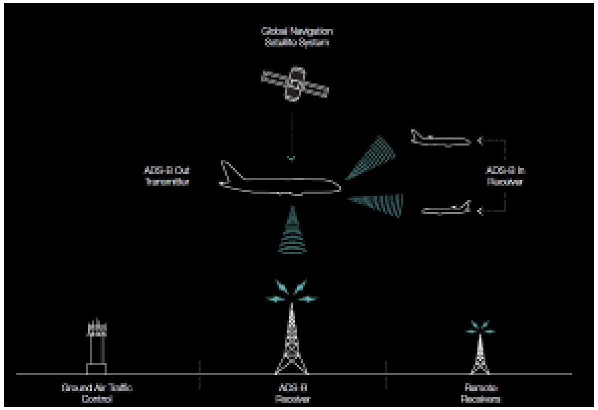
CMA-5024

TSO-C190 Antenna



CMA-5024 GLSSU - Navigation

- High-integrity SBAS Beta-3/ Delta-4 Navigation source with the highest levels of integrity and availability for RNP RNAV
  - FMS can immediately benefit from an improved RNP navigation performance
- GPS/SBAS Primary Means of Navigation
- Velocity Accuracy < 0.5 knots, 95%, velocity as per RTCA/DO-229D Appendix F
- Navigation Accuracy: RNP0.1 >99.999% availability with SBAS, and Primary Means Navigation as per RTCA/DO-229D
- SA-Aware (SA-OFF) when out of SBAS coverage
  - Fault Detection and Exclusion (FDE) and predictive RAIM with automatic pressure altimeter incorporation
  - Provide significantly improved level of integrity compares to equipments approved based on TSO C-129 Standards
- Supports all legacy FMS certified under TSO C-129a without modification, all legacy data and wiring retained per ARINC-743B



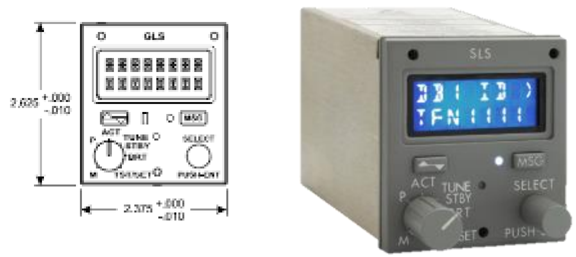
ADS-B

RNP

CMA-5024 GLSSU - Landing System

- Self-contained GPS approach solution with an integrated digital high-integrity switch and a companion control head
  - FMS not required to enable LPV
    - LPV is activated via the annunciator panel and managed via the CMA-5025 Control Panel
  - With CMA-5025 Control Panel, it provides a fully functional, stand-alone LPV system.
  - The CMA-5024 provides supports for ARINC-743B,709 and 710 with DME, ILS look-alike guidance signals to the autopilot and displays.
- The CMA-5024 includes a built-in digital high integrity switch for approach selection between ILS and GPS (SBAS or GBAS).
- LPV minima are typically lower then RNP minima
  - Provide CAT 1 equivalent approach capability with decision height of 200 feet and visibility minimums as low as 1/2 mile
- Can host entire SBAS worldwide approach database

CMA-5024



CMA-5025

LPV annunciators

CMA-5025 GLSSU Control Panel

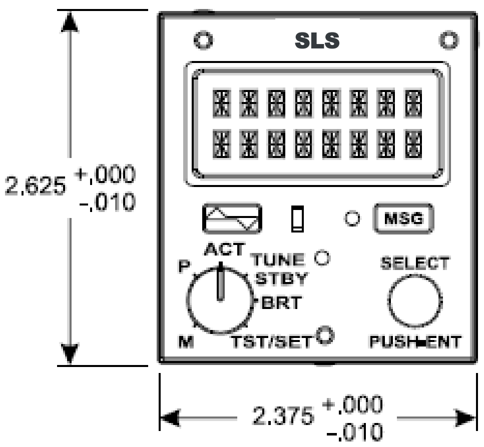
- With CMA-5024, it provides a fully functional, stand-alone LPV system.
  It is used to select/enable LP/LPV approach.

- Meets all RTCA/DO-229D LPV approach requirements without waiver or exception.

- FMS not required to enable LPV
  - A fully independent stand-alone LPV capability, “bolts-on” to existing aircraft
  - Integrated OEM FMS solutions possible

- GBAS capable, RTCA/DO-253B GLS approach ready

CMA-5025



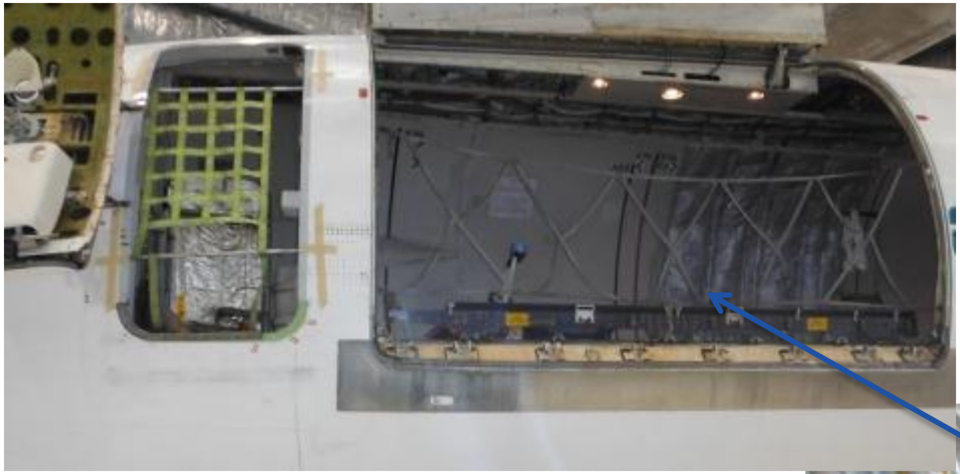
Some problems LPV is helping to resolve

- Schedule reliability for charter or scheduled flights due to absence of traditional ground-based approach aids on remote destinations.
  - Issues: Runways without ILS, severe weather, and night landing
- Cost of new infrastructure
  - ILS is costly to install compared to publishing an LPV approach
  - Maintenance: periodic LPV re-survey versus ILS antenna re-cal
- NPA are designed with step-down level-off segments: fuel burn
- ILS Weaknesses
  - Clear surrounding area (multipath issues)
  - Must be “on the runway”
  - ILS ground support equipment failures
  - Occasional glide-slope “glitches” causing go-arounds
- Reduce airport maintenance with planned removal of ILS facilities
  - Re-confirmed by FAA during LPV progress meeting (Feb 2013)
- World wide, the government are looking at decommissioning ILS Cat-1 on Tier II/III airports

One GPS Solution for Many Platforms

ADS-B Installation on the B-737

- **CMA-5024 GLSSU**



GLSSU location

Annunciator Panel

RNP/LPV Installation on the B-737

- **Standalone LPV on MMR Aircraft**

CMA-5025 Control Panel

CAT-I LPV Deviations

LPV Installation on FAA Convair

- **FAA Convair – CAT-I LPV**

LPV Annunciator

CMA-5025 Control Panel

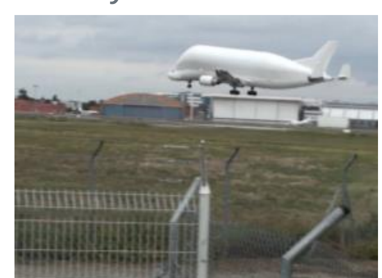
Nav/LPV - Installation on A300/A310

- A310 and A300-600ST (Beluga)
  - DND
    - GLSSU for Nav, and ADS-B
    - LPV next

  - ATI

Successful Flight Test (Airbus/EASA in September 2013):

- Beluga landing with LPV all the way to touch down, in autoland mode with autoflare. This is the second time that the Beluga team performed and autoland with LPV under EGNOS (previously tested October 2012)



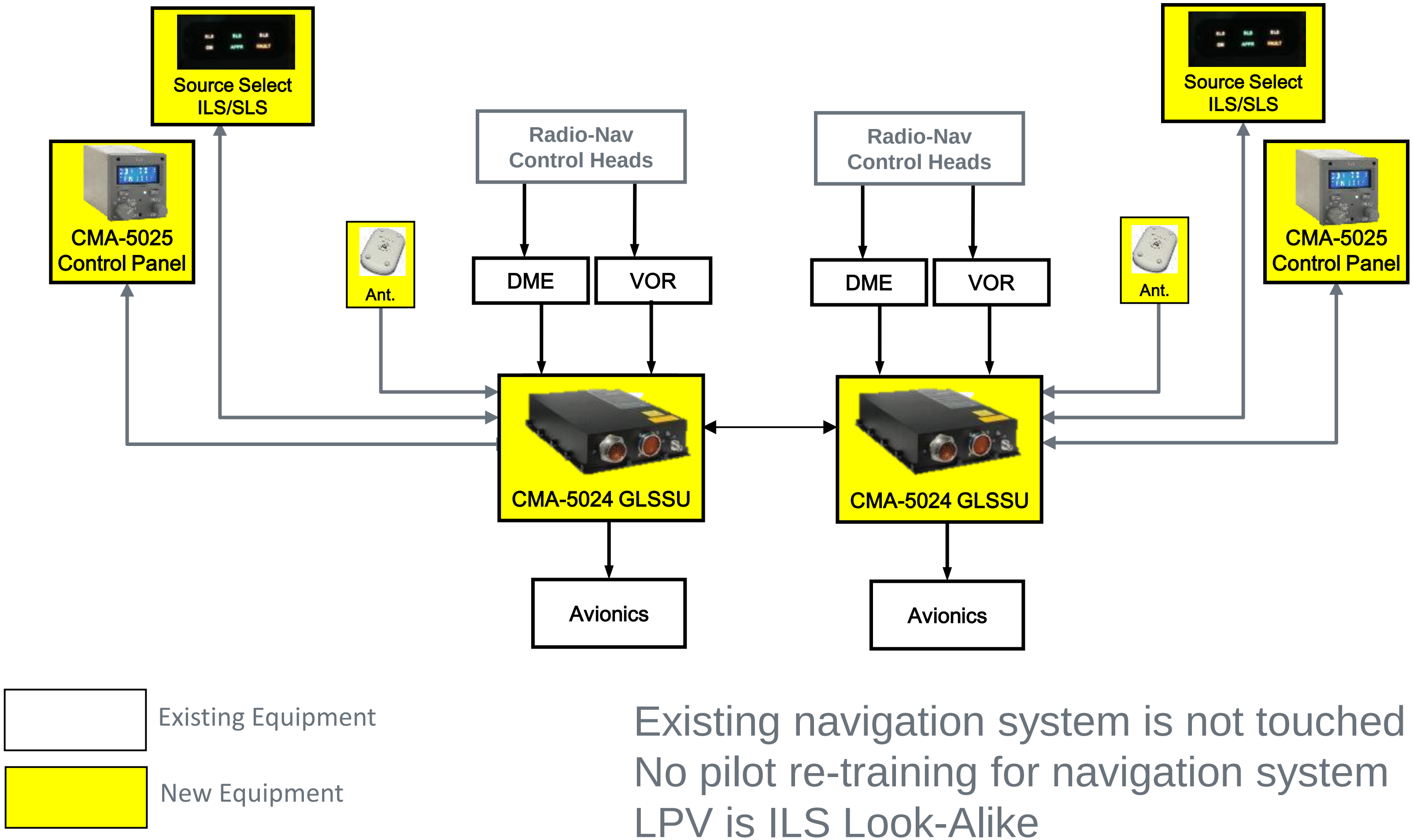

Beluga LPV approach test with
Autoland; Toulouse - Blagnac
16 September 2013
CMC Electronics CMA-5024 GLSSU & CMA-5025 Ctrl Panel

Installation on Helicopter – Nav/LPV

- AW 139 – LPV
  - LPV Based on both SBAS CMA-3024 and HI Primus Epic as a dual config SBAS

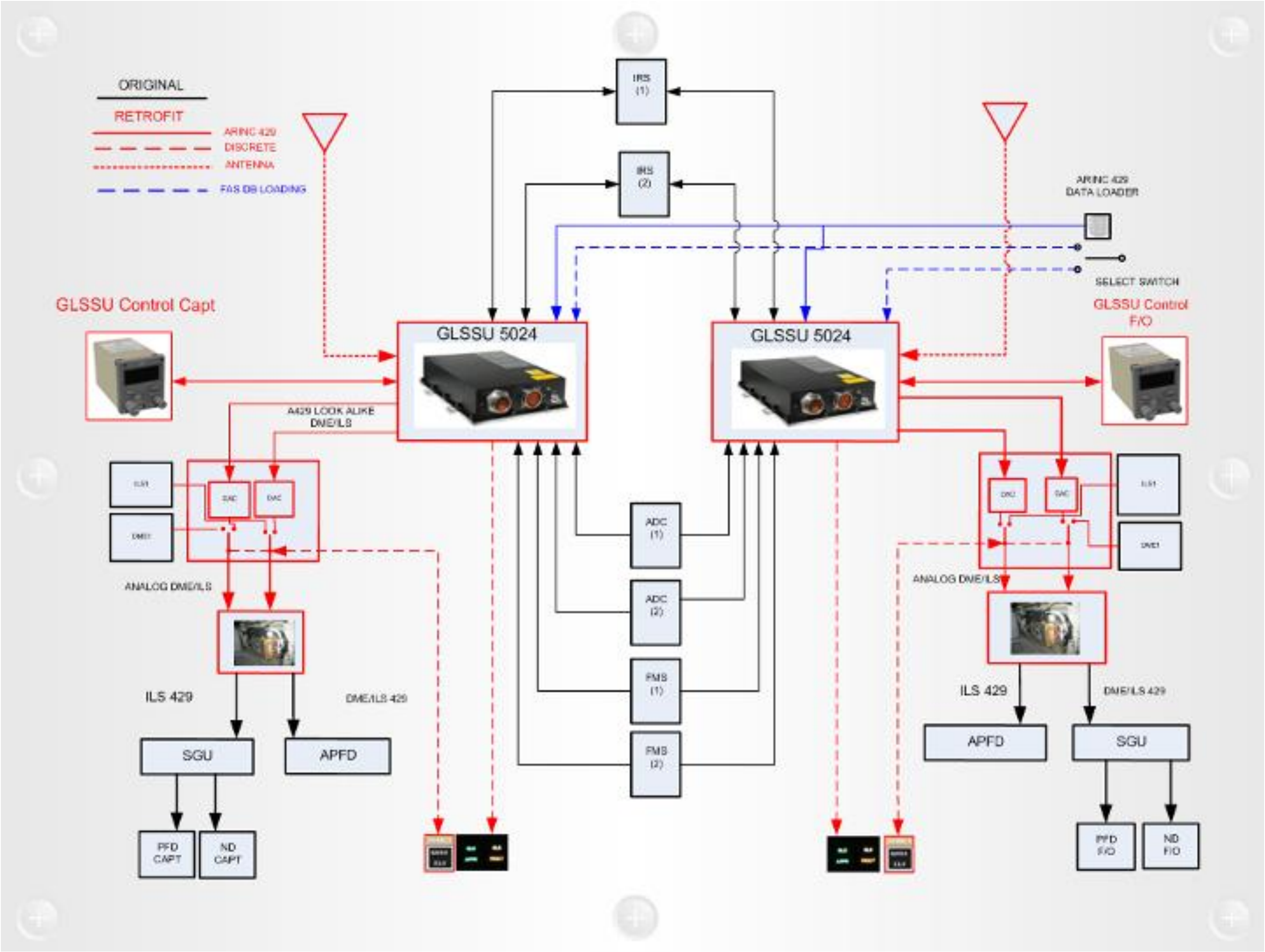
- Eurocopter
  - Currently working on an integrated solution with CMA-5024 GPS and CMA-9000 FMS

LPV Update Generic Block Diagram



Existing navigation system is not touched
No pilot re-training for navigation system
LPV is ILS Look-Alike

B737 LPV Block Diagram



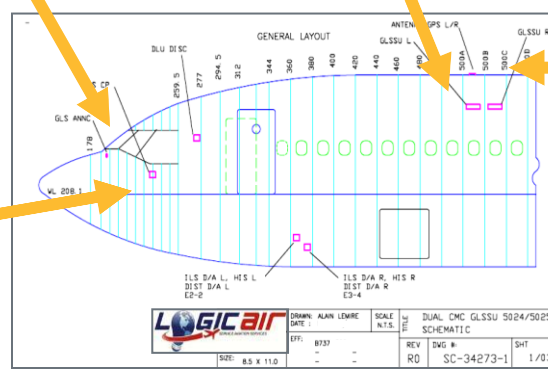
Boeing 737 Installation Pictures - GLSSU

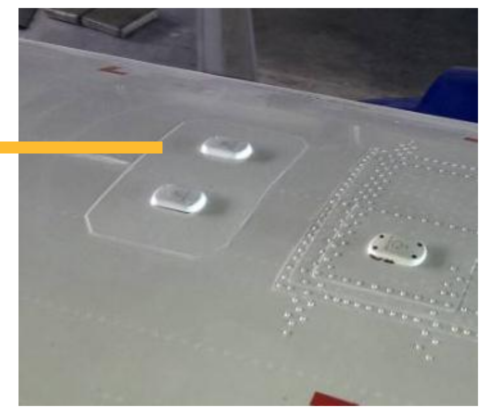
- Annunciators

- CMA-5024 GLSSU

- GLSSUs are installed in the ceiling of the B737 500 Area
- Use the Boeing provisioned supports when available

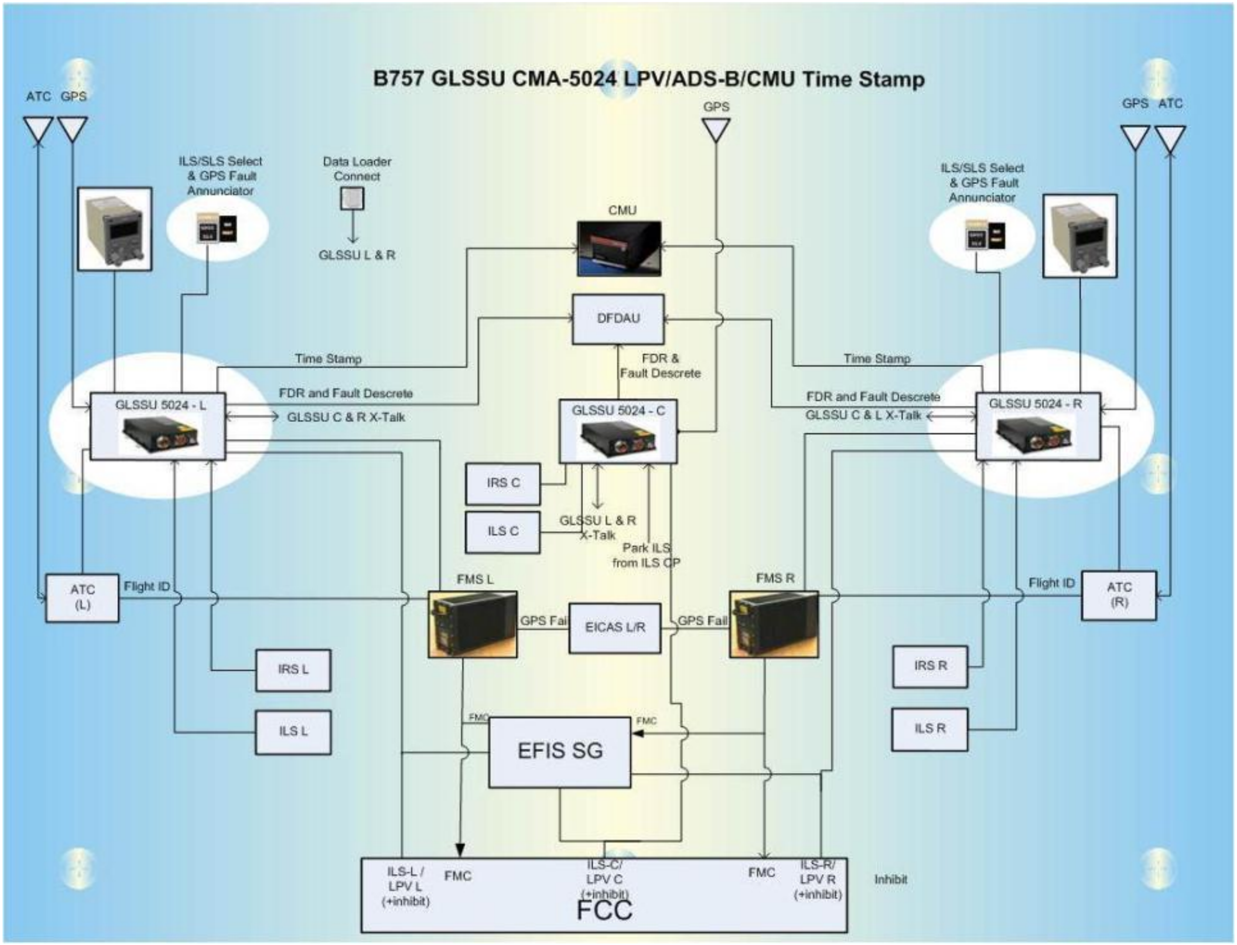
- CMA-5025 GLSSU CP





- TSO C190 Active Antenna

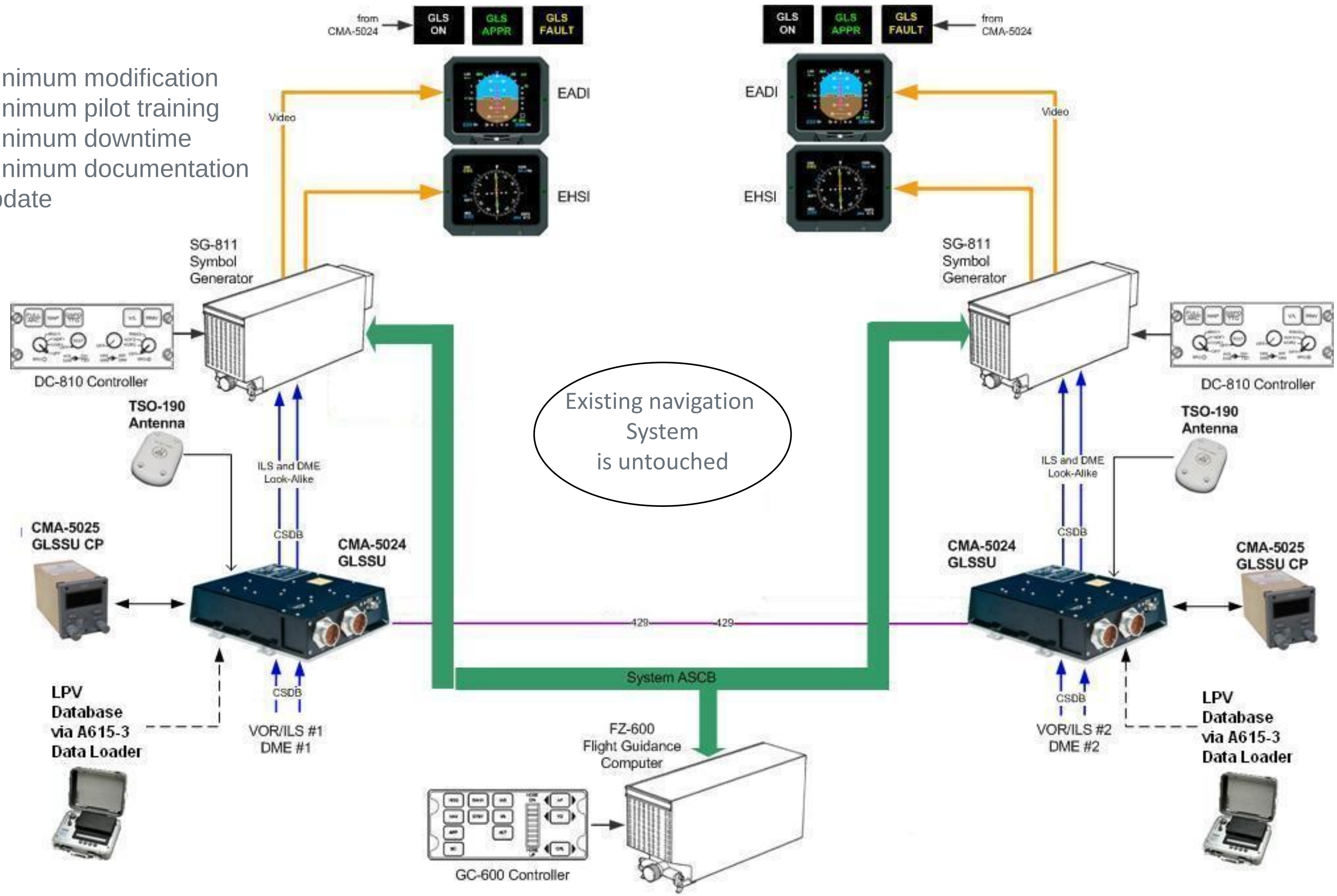
Boeing 757/767 Design



- CMA-5025 installed on the Pedestal
- Annunciators installed in Pilot Primary Field of View
- Interface Transponder for ADS-B, if required
- Interface FMS for Navigation (RNP), if FMS H/W, OPC permits

ATR 42/72 -200/300/500 Proposed Design

Minimum modification
Minimum pilot training
Minimum downtime
Minimum documentation update

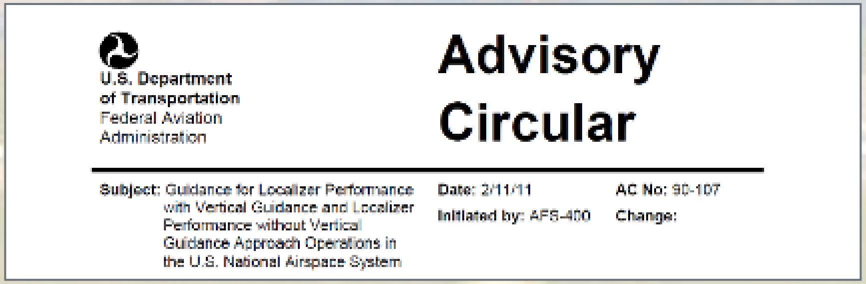


Operation

Operationally: Similar to an ILS approach

Operation

- LPV approaches/vertical guidance derived *exclusively* from SBAS and are not affected by temperature.
- Design criteria is very much like an ILS and can be as low as 200 with a half mile visibility.
- AC 90-107 provides guidance for operational approval


U.S. Department of Transportation
Federal Aviation Administration

Advisory Circular

Subject: Guidance for Localizer Performance with Vertical Guidance and Localizer Performance without Vertical Guidance Approach Operations in the U.S. National Airspace System

Date: 2/11/11

Initiated by: AFS-400

AC No: 90-107

Change:

- OpSpec/MSpec/LOA paragraph C052 and C053 provide guidance on training requirements

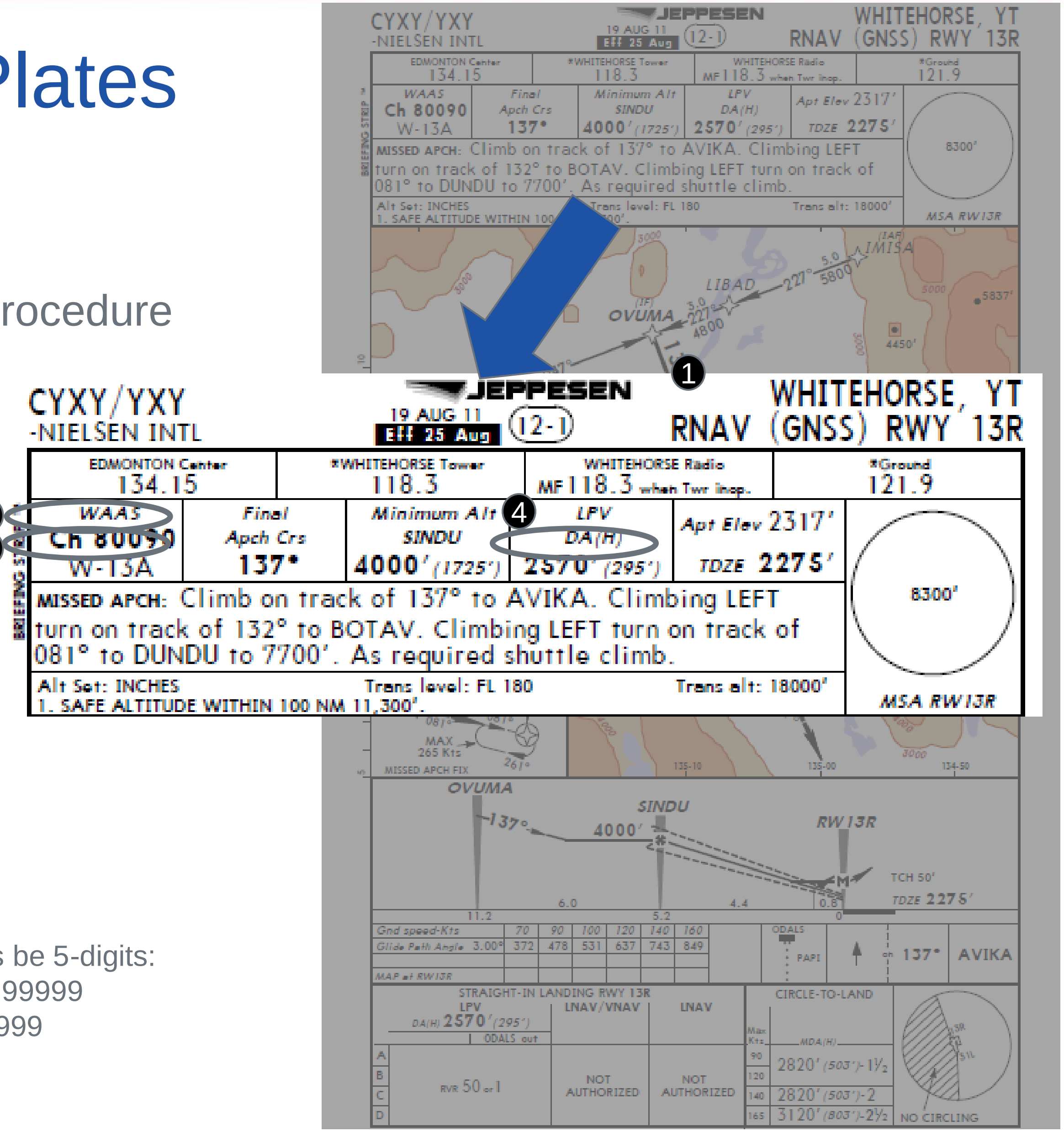
Operation - Plates

❶ LPV is a RNAV (GNSS) procedure

❷ 5 digit WAAS Channel Number SBAS Ch 80090

❸ WAAS Approach ID:
W=WAAS, Runway 13,
A= 1st approach on that Runway

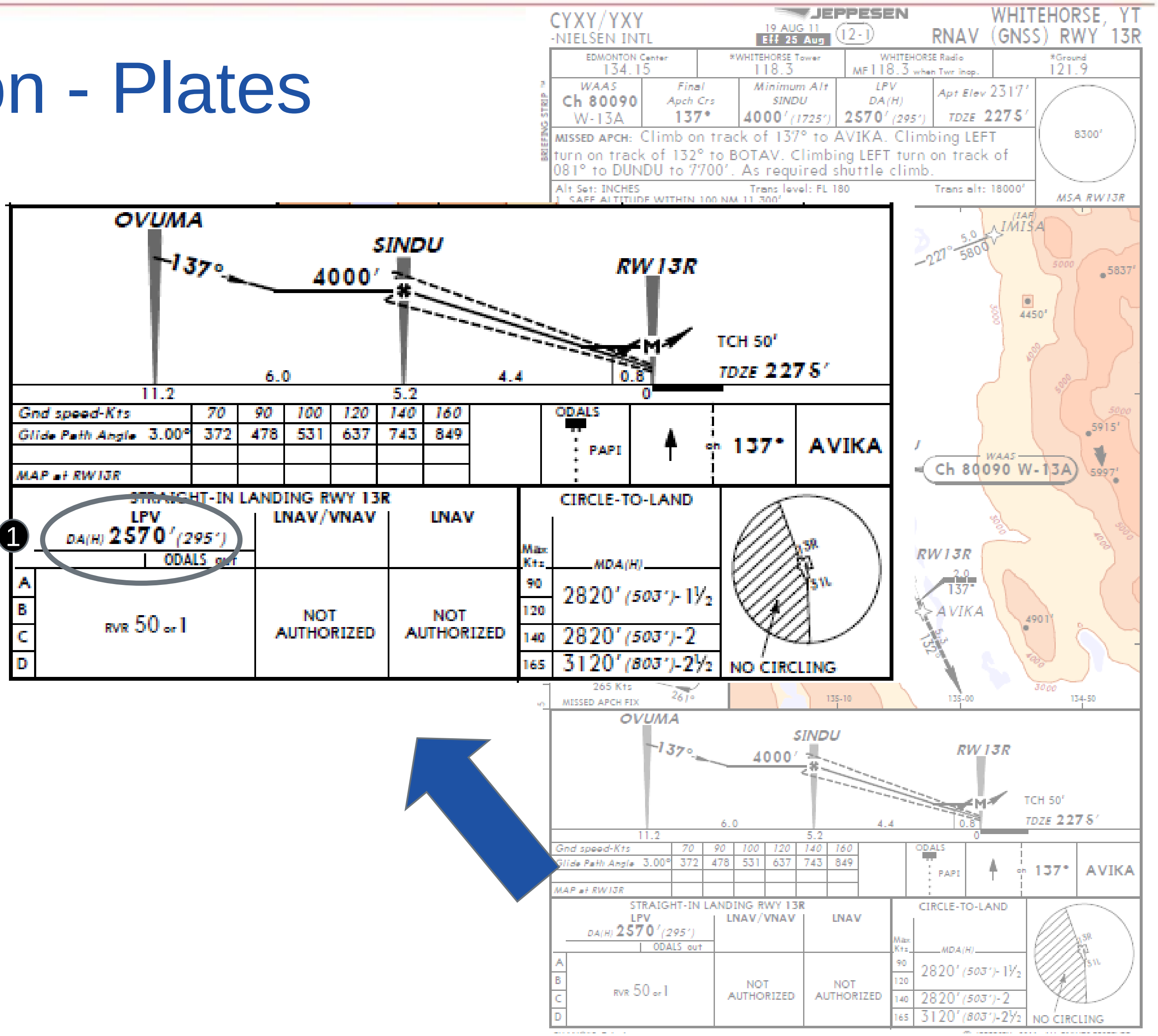
❹ LPV DA (H)



By definition, channel number will always be 5-digits:
LP/LPV channel numbers from 40000 to 99999
GLS channel numbers from 20000 to 39999

Operation - Plates

❶ LPV Minima



Operation - Example

- Flight Crew Actions
  - Select a RNAV Approach plate for Runway (example RNAV 13R) for the LPV approach
  - New Action: Enter the 5 digit number into the Control Panel, the 5 digit number is obtained from the approach plate's WAAS Channel Number, eg 80090.
  - New Action: Select LPV approach using source select switch on forward instrument panel.
  - Maintain map mode on ND during approach
  - Select LAND/ILS mode on autopilot
  - Autopilot transitions to ILS/LPV as per normal
  - FMS indicates normal precision approach
  - Pilot flies LPV like a standard Cat I ILS approach procedure
    - Missed approach as per ILS

Operational Benefits - LPV

- Operational Benefits
  - LPV is ILS Look-Alike
  - LPV plates are RNAV procedures
  - LPV is here and is expanding globally.
  - Implementation brings immediate savings
  - Installation in all aircraft is a reasonable and achievable bolt-on task
  - The CMA-5024 is certified, airline proven-in-service, with LPV
  - Reduced dependence on terrestrial navaids
    - Improved dispatch reliability SIDS (use SBAS as navigation source)
    - Improved STARS (use SBAS as navigation source & LPV)
    - Can continue LPV operations when ILS is out-of-service to all runways
  - Enhanced operational safety due to the vertical guidance provided
  - No false-glideslope capture
  - No operational limitation due to cold weather

Infrastructure Benefits - LPV

- Infrastructure benefit
  - Terrain variation does not impact publication of a LPV approach
  - No maintenance (contrast this to ILS continual flight inspection)
  - All SBAS services are interoperable (WAAS, EGNOS etc.) so only one type of SBAS receiver is required
- FAA – LPV published advantages: (source: Federal Aviation Administration Implementation of WAAS LPV Procedures) – published in 2004
  - Procedure Integrity
  - Lower Minimums
  - Significantly increases the number of available instrument approaches

Operation - Customer feedback - LPV

Multiple A/C operating in Canada, Air North flies LPV approaches daily

Chris Drossos, 737-300 project pilot for Canadian North

"The addition of LPV capability to our aircraft permits us to provide significantly improved schedule reliability for our scheduled and charter clients, given the absence of traditional ground-based approach aids at many of the remote Canadian destinations we serve. From the pilot's perspective, CMC's LPV system provides a clean, straightforward interface which behaves exactly like an ILS, but with the exceptional SBAS performance and availability."

And prepared for the future… GBAS

- GBAS/GLS is very similar to SBAS/LPV operationally, both currently deliver CAT-I performance.
- GBAS will be delivering CAT-I to CAT-III operations; however, CAT-II/III MOPS are still in development, and GBAS CAT-I not deployed yet.
- Differences between the systems
  - LPV receives error corrections from SBAS geostationary satellites, GLS receives error corrections via uplink from GBAS ground station.
  - LPV Final Approach Segment (FAS) is hosted in the avionics database, GLS FAS uplinked via VHF Data Link from the GBAS ground station.
  - Concepts between GBAS/GLS and SBAS/LPV are highly similar except GBAS GLS requires ground stations to work, SBAS LPV is self-contained
- CMA-5025 already provide GBAS capability

CMC Electronics

at your service

Thanks you

7-8 October

Lisbon

The EGNOS Service Provision workshop

ESSP

We certify you're there.

European Global Navigation Satellite Systems Agency

funded by the European Commission

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Cooperation Agreement signature

between:

ASECNA & ESSP

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