





Pullen, S., et al. *Proposed LAAS VDB WAAS Repeater Protocol*, briefing to GNSS Strategic Advisory Team (GSAT), 7 March 2005.



LPV guidance via GLS (a GAST-A type of approach service)

Thomas Dautermann, Thomas Ludwig



Knowledge for Tomorrow



IGWG Denver

A synchronized common approach is crucial to break the wall and create a positive momentum on GBAS technology deployment



ANSPs:

- Reduced cost of operation after decommissioning of ILS Technology (at least partially)
- *Implement concepts of operations (and motivate ATCOs), that deliver benefits to Airlines to push equippage rate (e.g. Best Equipped Best Served concept)*

Airports:

- Reduced impact of aircraft noise by higher glide slope intercept altitudes (avoid low level flight segments) or steeper glideslopes
- Higher airport capacity in low visibility operations (LVO)
- *Establish concepts to clear traffic off the runways in LVO*

Airlines:

- Strive for high equipage rates of aircraft crucial to realize beneficial effects and to decrease ATC controllers workload (traffic differentiation)
- *Train and motivate pilots to execute GBAS approaches*

Manufacturers:

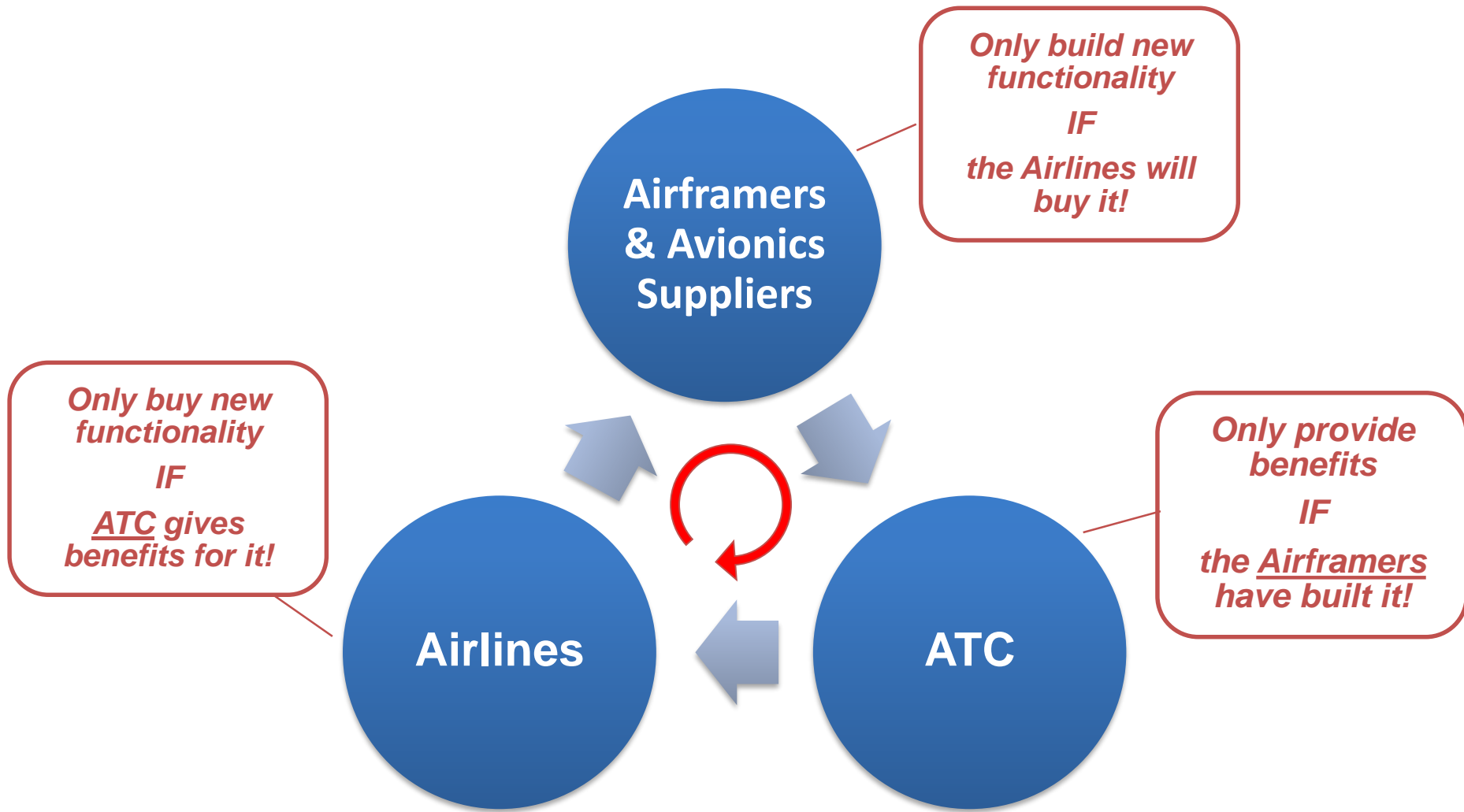
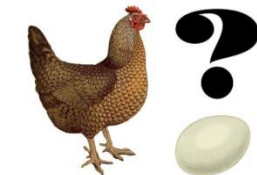
- *Support Airlines (Air) and ANSPs/Airports (Ground) to create business cases for investments and align Ground/Air efforts*

ICAO/Regulators:

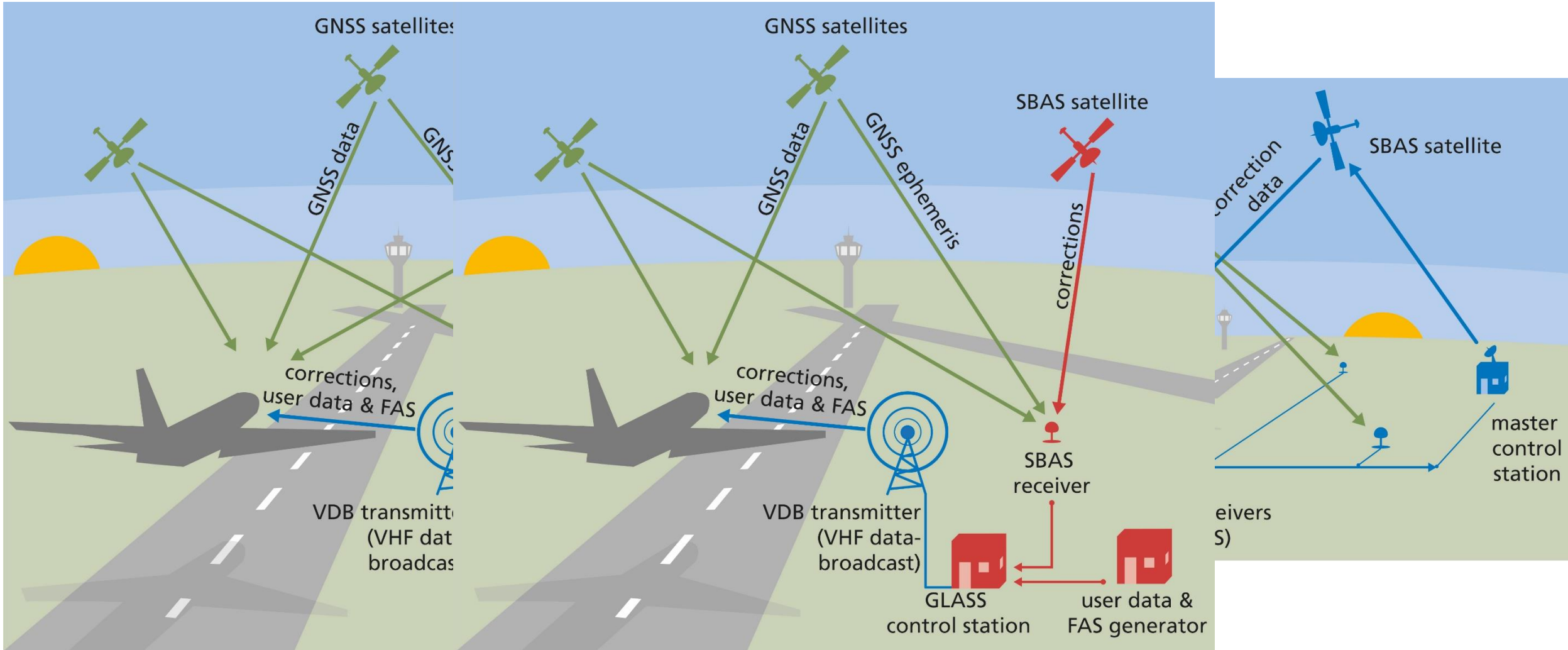
- *Deliver appropriate framework to allow quick progress*



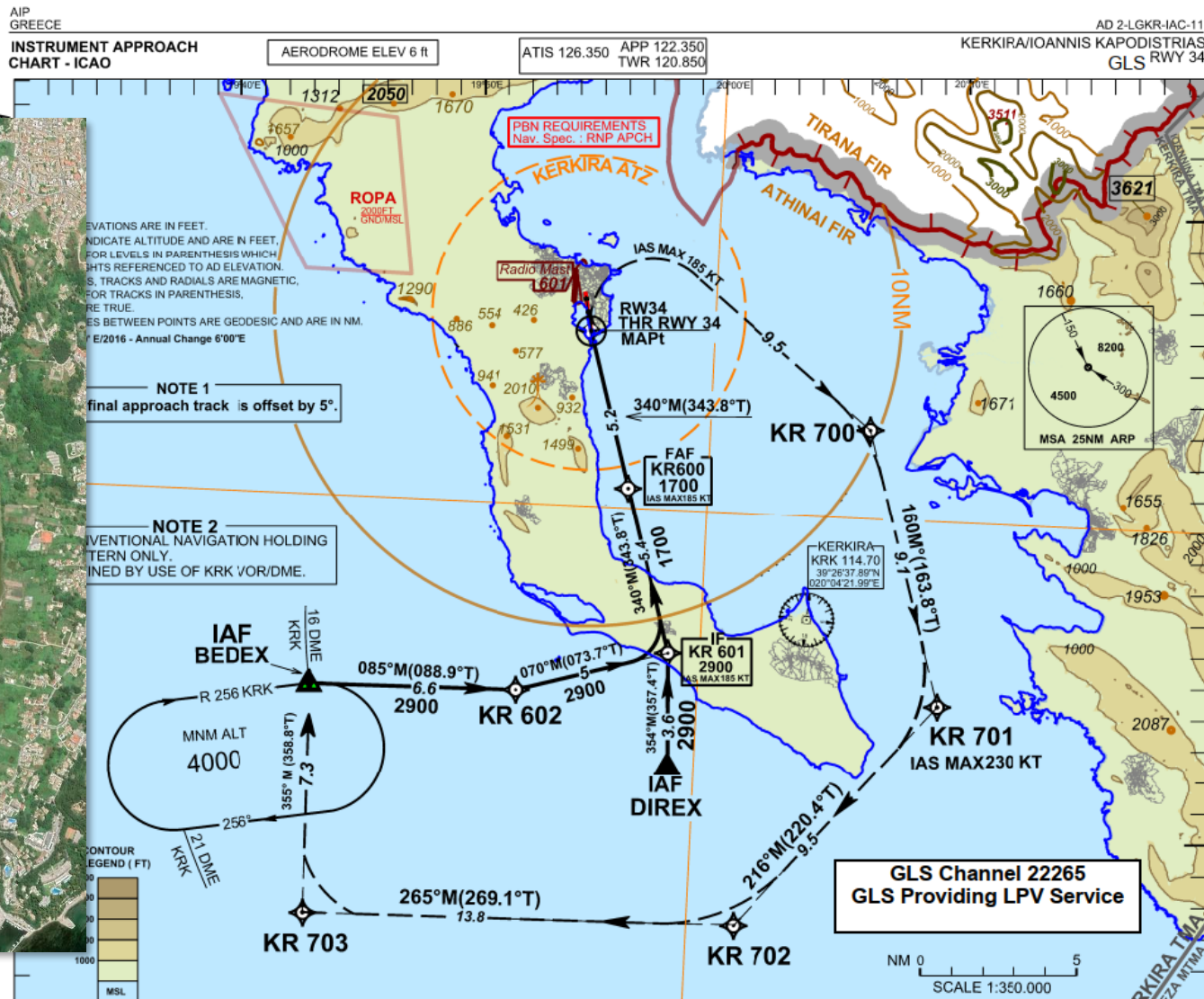
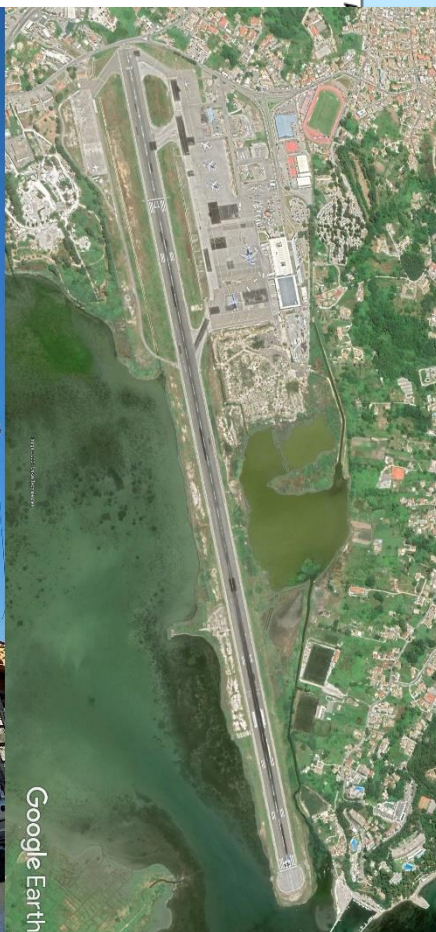
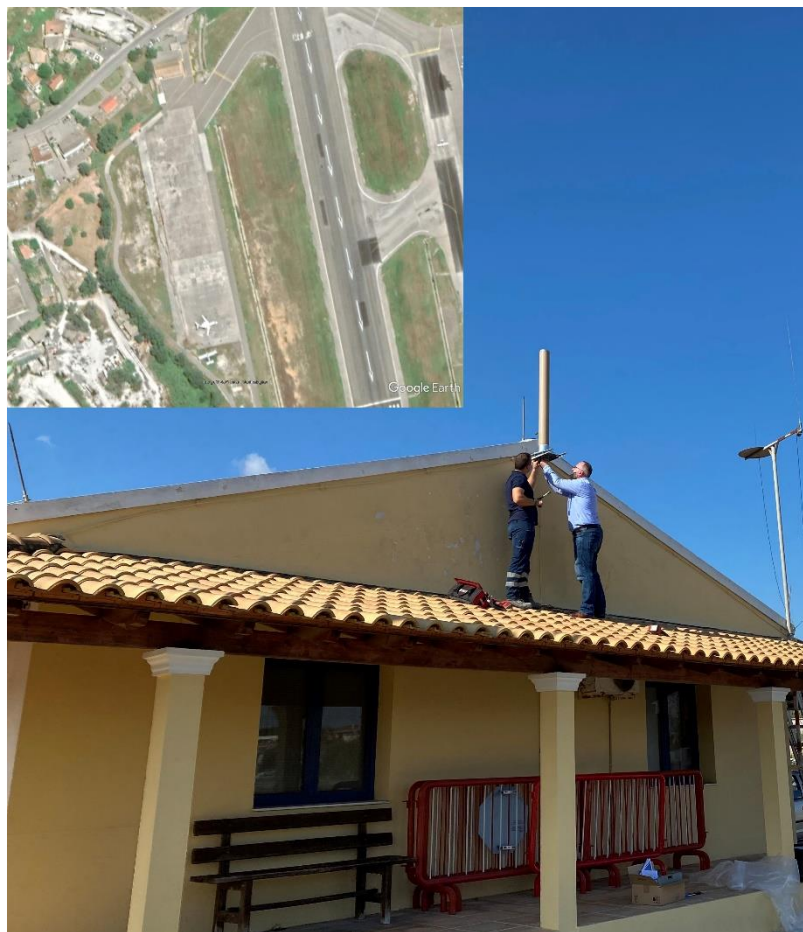
GLS ... “Chicken-and-Egg Problem”



Background - From GBAS & SBAS to GLASS

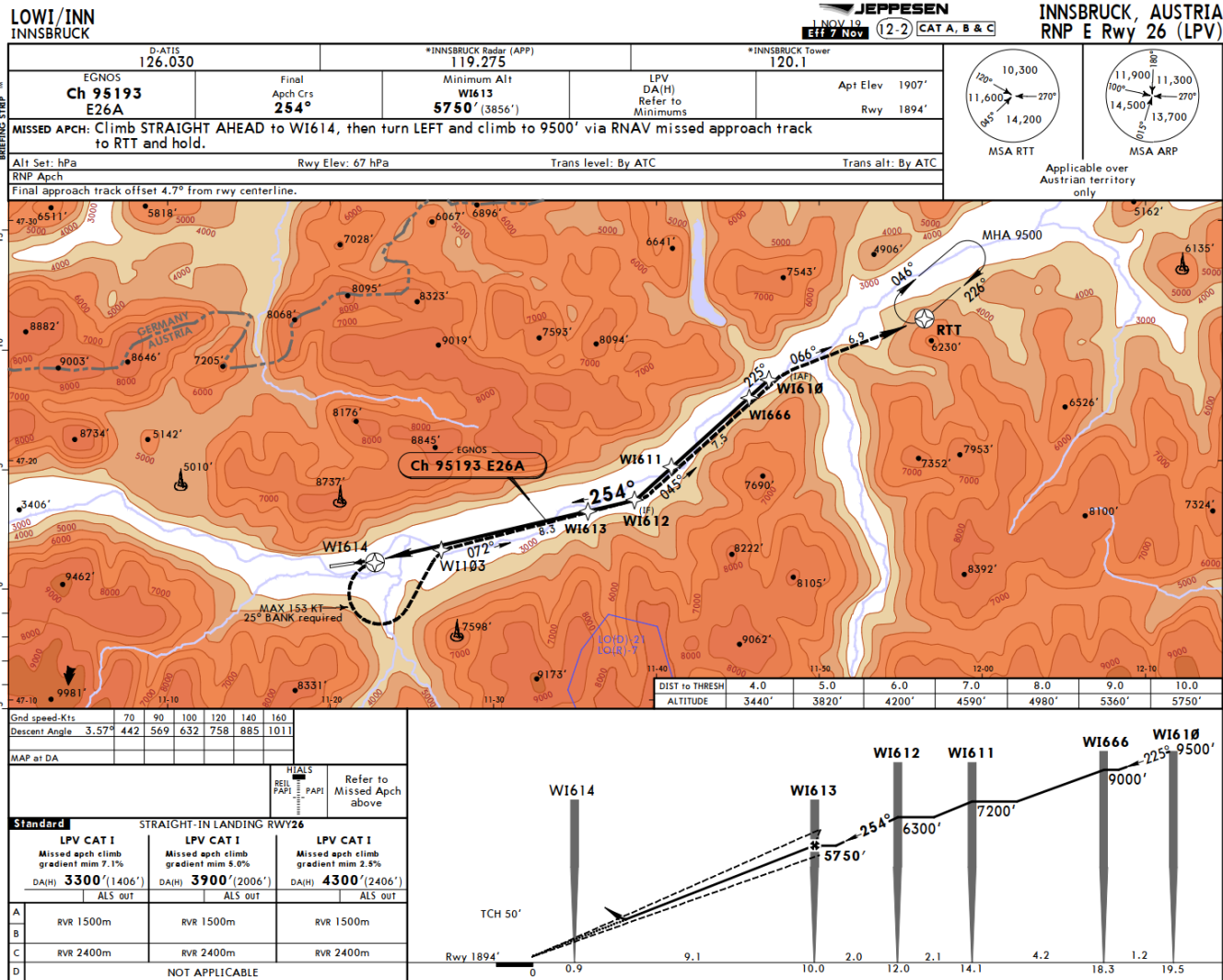


Business Case: Constraints at Airports

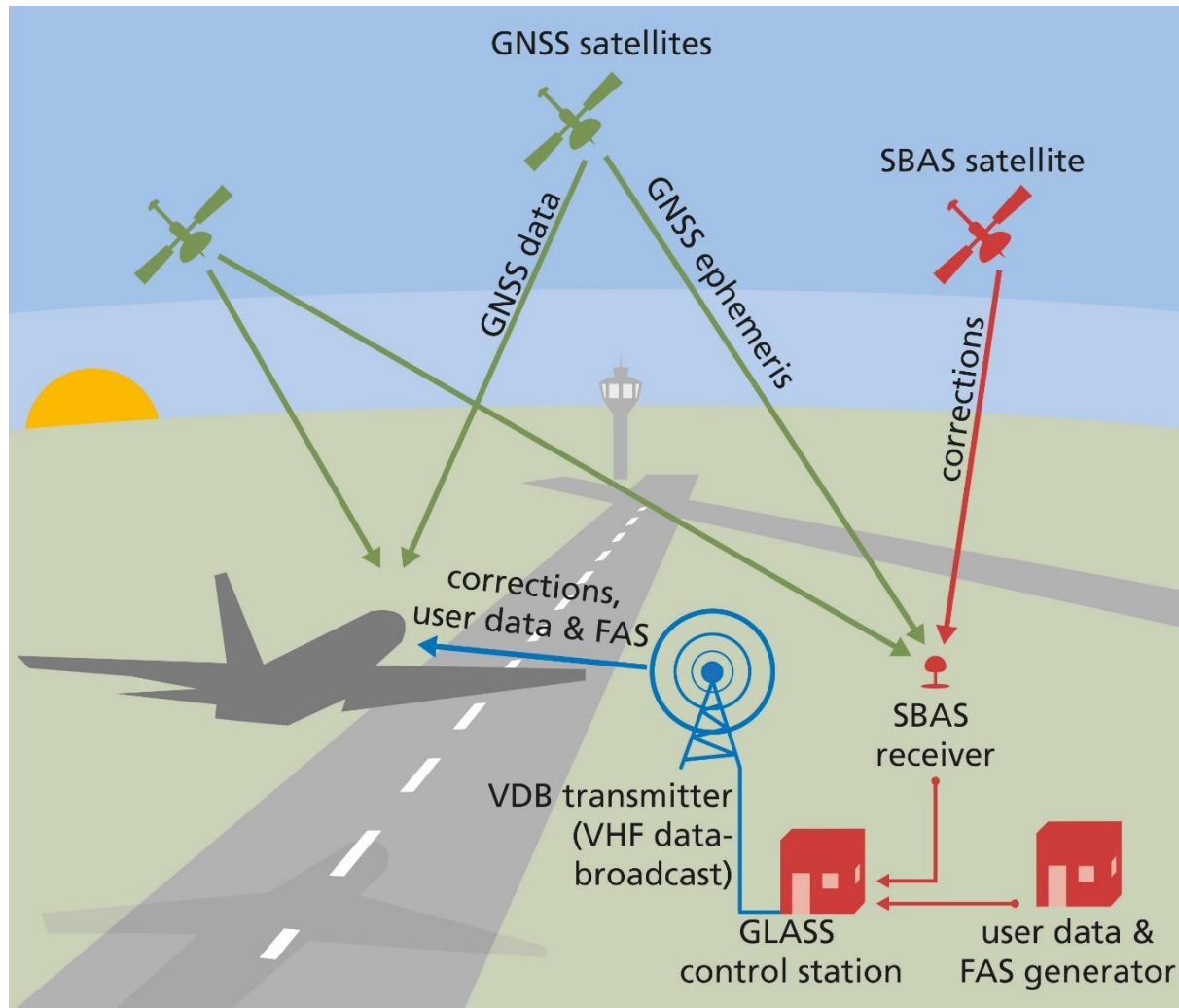


LNAV Minimum 770ft

Business Case: Approaches with LPV Only



From GBAS & SBAS to GLASS (GLS Approaches using SBAS)



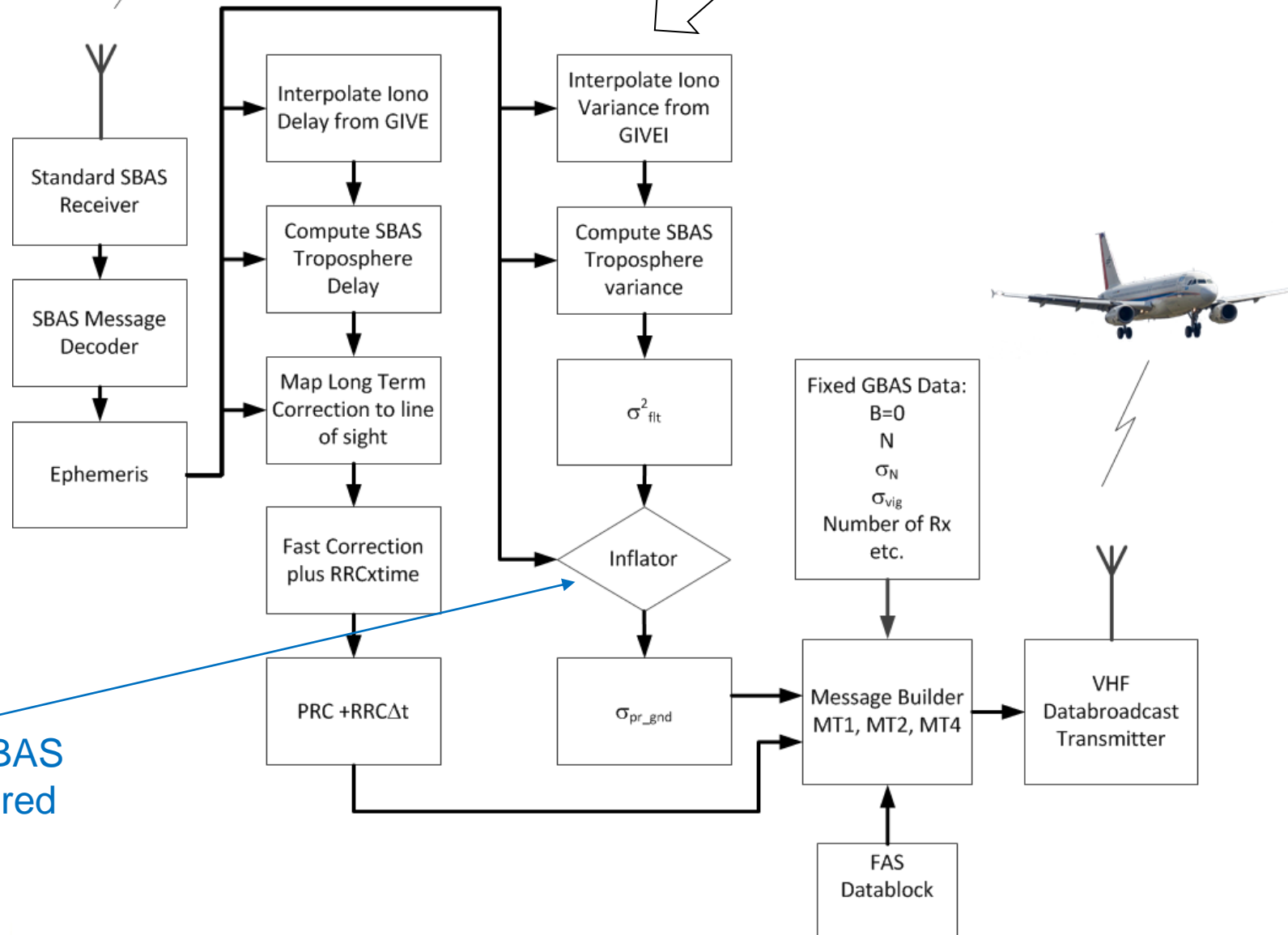
Dautermann T., Ludwig T., Geister R. *et al.* Extending access to localizer performance with vertical guidance approaches by means of an SBAS to GBAS converter. *GPS Solutions* **24**, 37 (2020). <https://doi.org/10.1007/s10291-019-0947-7>

SBAS Satellite

GLASS Technical Flow

$$\rho_{corrected,i} = \rho_{CSC,i} + PRC_i(t_{ofA}) + RRC_i(t_{ofA}) \times (t - t_{ofA}) TC_i + c\Delta t_{sv,corr} + IC_i$$

$$\sigma_i^2 = F \sigma_{pr_gnd_x}^2 [i] + \sigma_{tropo}^2 [i] + \sigma_{pr_air}^2 [i] + \sigma_{iono}^2 [i]$$



Inserted, if mapping of SBAS HPL to GBAS LPL is desired

FAS DB & Associated Issues

| GLAS S26A** | | GLAS S26B | | GLAS S08B | | GLAS S26I | |
|---------------------------------|---------------|-----------------------|---------------|-----------|--|-----------|--|
| Operation Type | 0 | SBAS Service Provider | 0 | | | | |
| Airport ID | ETNW | Runway | 26 | | | | |
| Approach Performance Designator | 0 - GAST-A/B | Route Indicator | A | | | | |
| Reference Path Data Selector | 1 | Reference Path ID | S26A | | | | |
| LTP/FTP Latitude | 52.4539889 ° | LTP/FTP Longitude | 9.44570000 ° | | | | |
| LTP/FTP Altitude | 94.80 m | Delta FPAP Latitude | -0.00265917 ° | | | | |
| Delta FPAP Longitude | -0.02946972 ° | TCH | 50.00 ft | | | | |
| Glide Path Angle | 3.00 ° | Course Width | 114.00 m | | | | |
| Delta Length Offset | 0.00 m | Vertical Alert Limit | 25.40 m | | | | |
| Lateral Alert Limit | 40.00 m | | | | | | |

Approach Performance Designator APD=0

Would be desirable to trigger a multiplier of 2 for the coded FASVAL → not evaluated by CMA-6024, GLU925, INR

Image Credit: AERODATA, taken with AERO FIS – CMA-6024 Receiver



The “Time to Alert” Question

APV-1 → Requires 10s Time-to-Alert

Calculation for the GLASS System:

- The SiS TTA is the 5.2s from SBAS (unpublished proof in “*EGNOS Signal-in-Space System Safety Case Part A (Design, Development and Deployment) Issue 3 from 21 February 2008.*”)
- 3.5s for the missed message allocation
- $10s - 3.5s - 5.2s = 1.3s$

Processing on a Standard Linux PC takes about 20ms



Flight Validation

Flight Calibration Services performed standard GBAS Flight Validation



AD-AFIS-220 V6.0.3 (Operator) OFFLINE/REPLAY D-CFME FCS BRC ICAD Special 2018-11-12_D-CFME_EDVE_GBAS_DLR_5

Session Inspection Control View Positioning Config Window Help

OFFLINE/REPLAY
 2018-11-16 16:09:58 UTC
 17:09:58 Local

Replay 1x [Stop] [Play]

EDVE 2.6 VDB AS
 Replaying

AMSLHGT 2840 2510 [ft]
 IAS/GS 156 174 [kts]

Mode INS+GPS+H
 EPE 0.20 [m]
 GNSS EDGES
 LT ? ?

Marker [On] [Off] [On] [Off]

99:36 h
 00:00.00
 Start Reset

Overview | Tacan | NAV | GNLU-930

Channel 22453 Mode GLS GPS GBAS

GBAS | SBAS

Correction data | Reference position | FAS Data

Message header
 Message type 4 Station ID GLAS Message length 92

GLAS G26A | GLAS G08A

| | | | |
|---------------------------------|------------|----------------------|-----------------|
| Operation type | 0 | LTP/FTP latitude | 50.32029472 [°] |
| SBAS service provider | 0 | LTP/FTP longitude | 10.57569472 [°] |
| Airport ID | EDVE | LTP/FTP altitude | 130.40 [m] |
| Runway | 26 | Delta FPAP latitude | -0.00213639 [°] |
| Approach performance designator | 1 - GA87-0 | Delta FPAP longitude | -0.03513261 [°] |
| Route indicator | 2 | TCH | 16.46 [m] |
| Reference path data selector | 3 | Glide path angle | 3.00 [°] |
| Reference path ID | G26A | Course width | 114.00 [m] |
| | | Delta length Offset | 312.00 [m] |
| | | Vertical alert limit | 25.38 [m] |
| | | Lateral alert limit | 40.00 [m] |

System Alerts
 Flightlist
 Main Status Bar
 EFIS
 Frequency Dis...
 Receiver

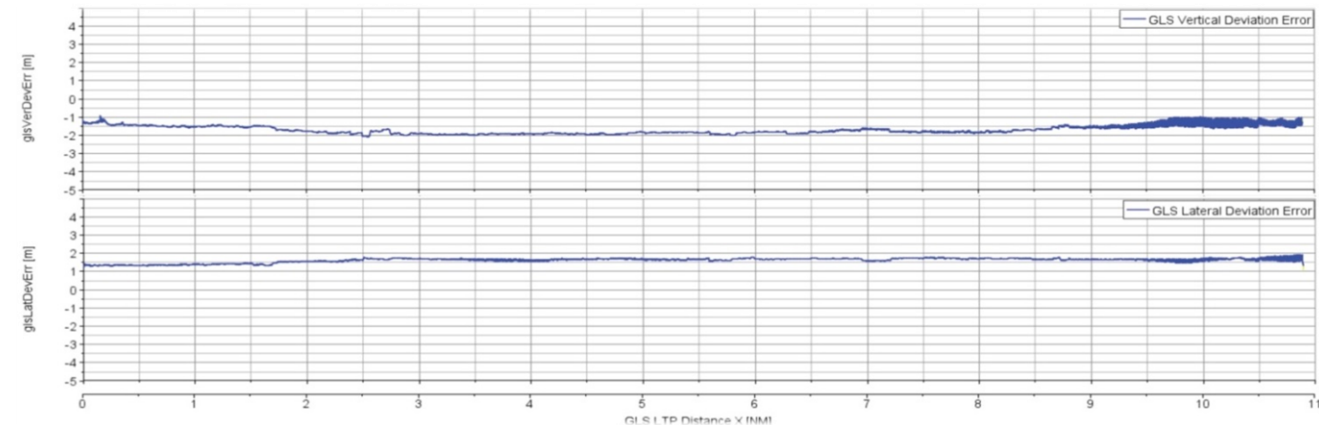
PFD
 3290
 156
 2685
 GS 174
 1032 HPA

EHSI
 FI PILS
 CRS 263
 THR 7.6 NM
 REF GBAS
 GARR 9.2 NM
 VAR 1.7E

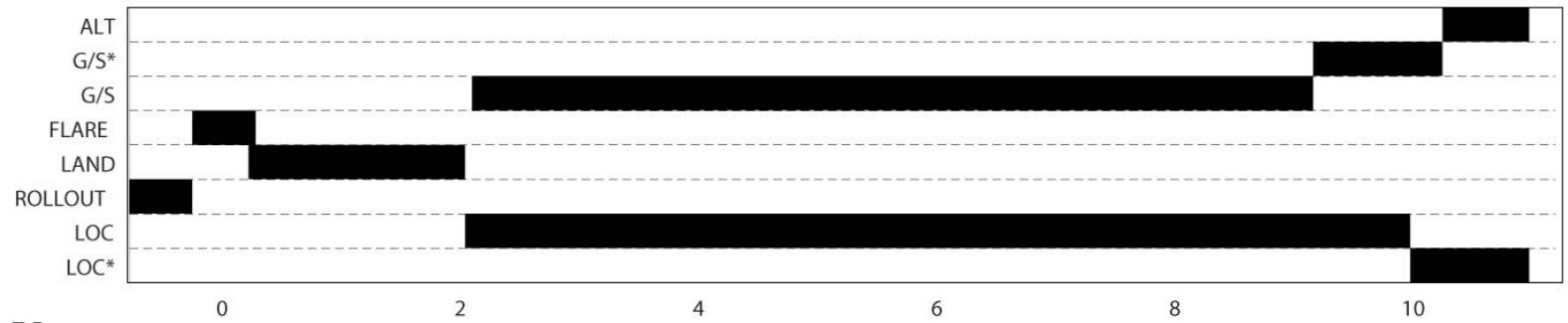
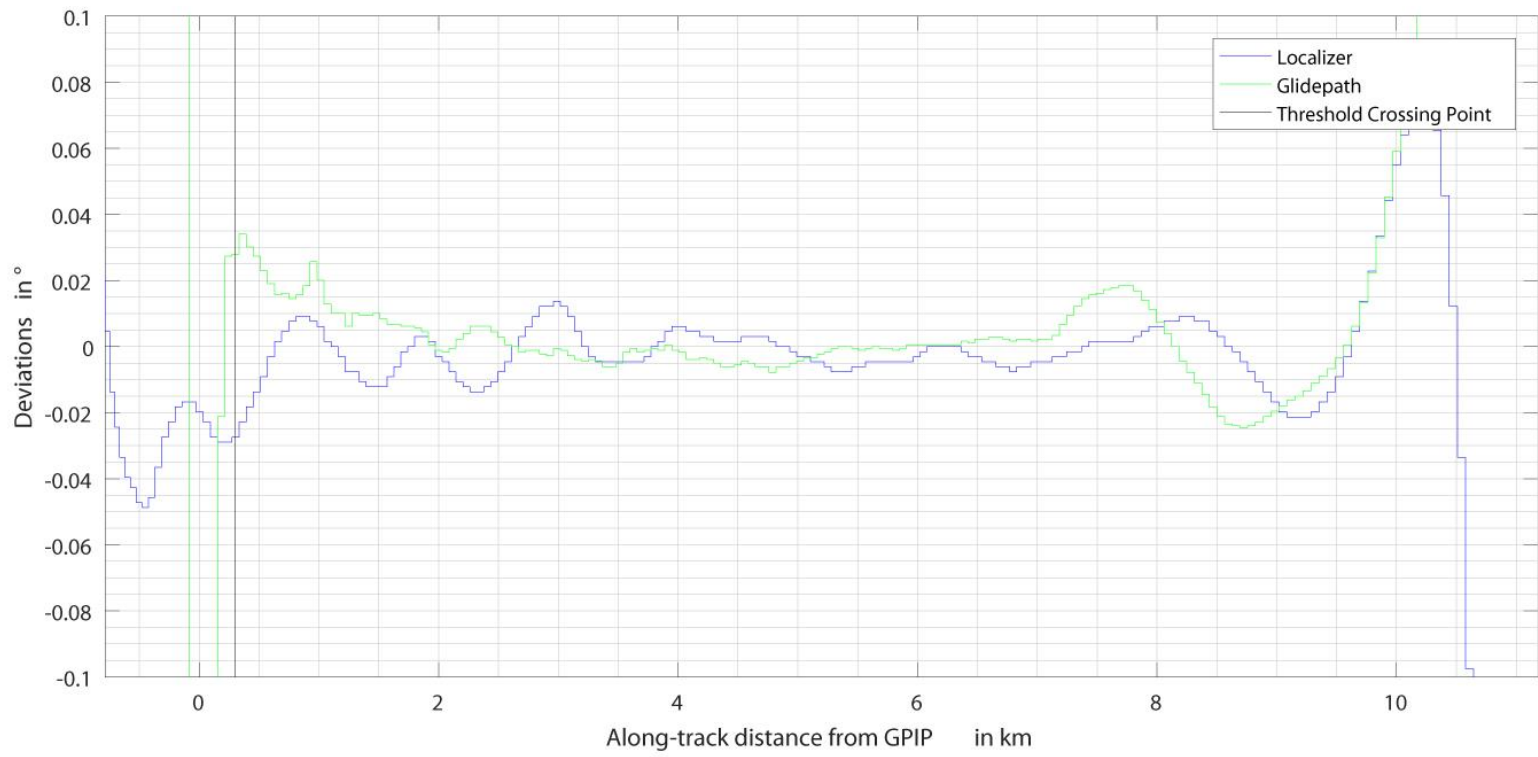
MAP
 REPLAY

Frequency Display

| | | |
|------|------------|------------|
| NAV1 | 111.10 | 111.10 |
| NAV2 | 111.10 | 111.10 |
| TAC1 | 111.10 | BWG 48% |
| TAC2 | 111.10 | --- |
| DME1 | 111.10 | BWG 48% |
| DME2 | 111.10 | BWG 48% |
| ADF1 | 427.00 | 427 |
| EB1 | 1575420.00 | |
| GLS1 | 117.950 | G26A 22453 |



Lufthansa Charter D-AIBI (A319)



Industry Transfer

- Interest from Airports, Airlines and Avionics manufacturers is there
- Not all destination airports can afford an ILS, so they use RNP procedures with LPV



Questions for the Group

Leave GAST-A/B in the Standards

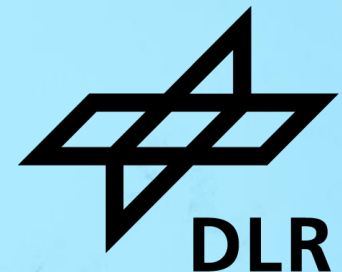
Can fill the “void” left by GRAS

Why not use GAST-A when a low minimum is not rqd.



AIRLINE TRIALS GLASS4GREECE(G4G)

TUIfly and Ryanair Feedback - CFU and SKG Airports

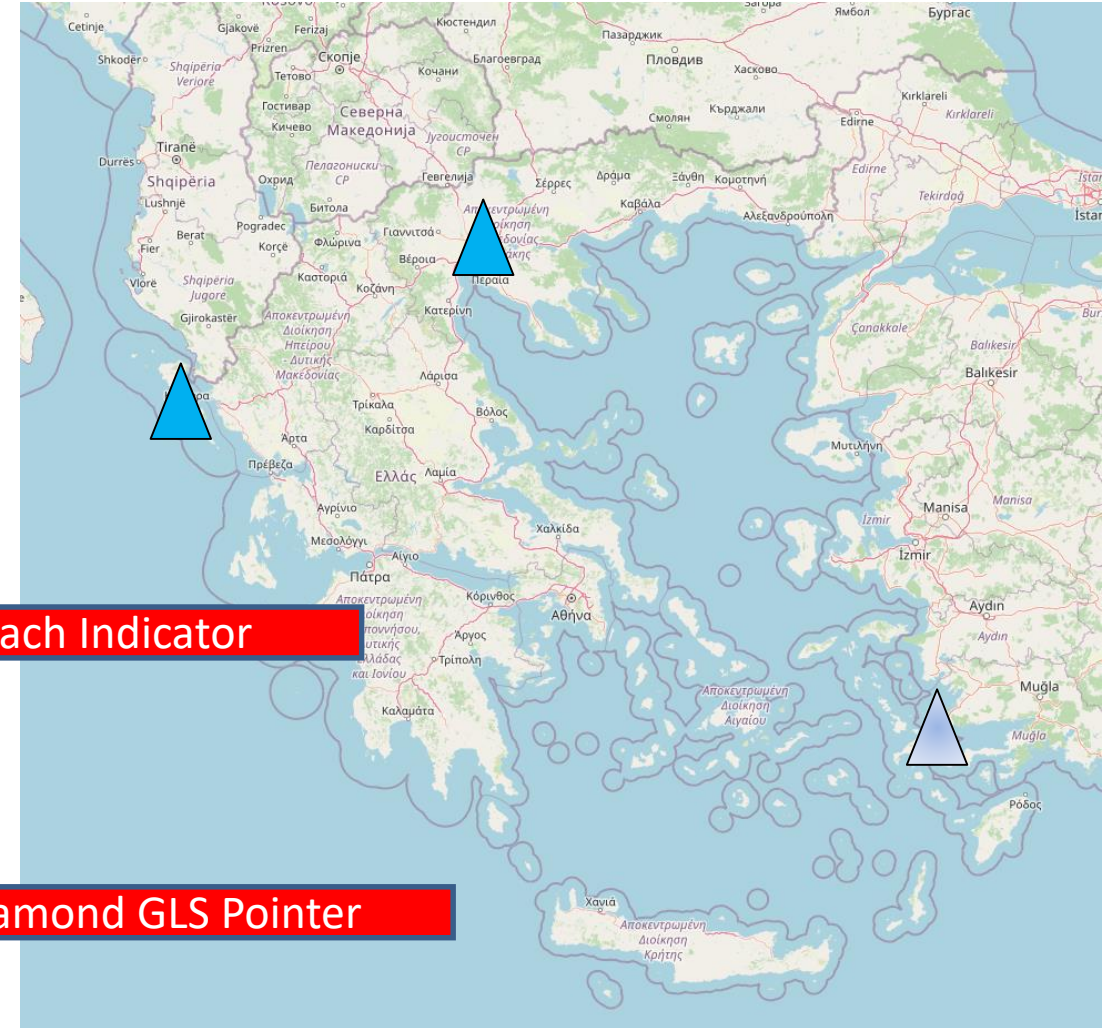


Primary Flight + Navigation Display 737 (Ryanair SKG)



Operational Trials Greece (since March 2022)

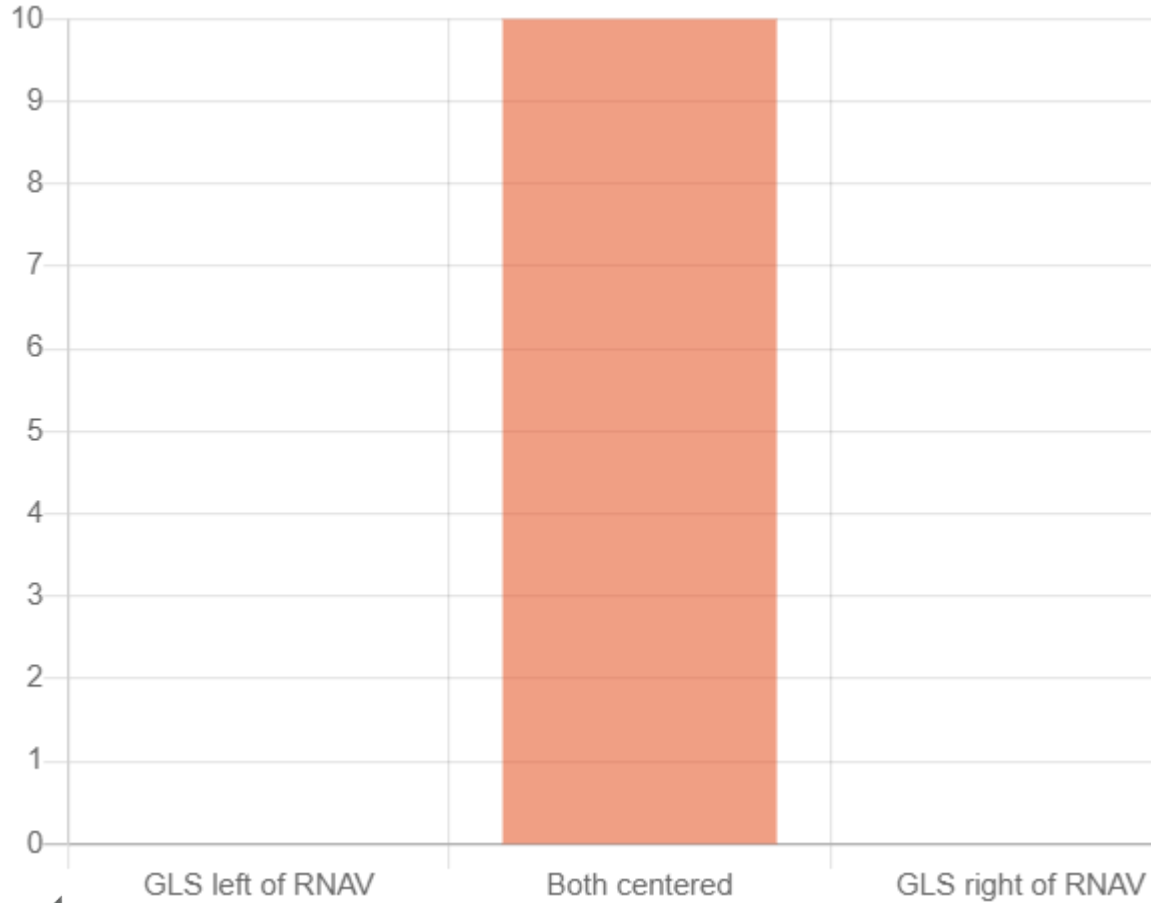
- Installations at Kerkira (CFU), Thessaloniki (SKG) and Kos (KGS) Airports
- Ryanair and TUIfly airlines are monitoring the GLS while flying RNP approaches at CFU and SKG airports.
- Initiation of trial flights at KGS airport during S23 by TUIfly.



White Diamond GLS Pointer

Statistics Being Collected (excerpt)

How the lateral GLS guidance is compared with the lateral RNAV guidance ?



How the GLS vertical guidance is compared to the vertical guidance from the RNP approach ?

