Esterline CMC Electronics

Commercial Aviation

# Modern ARINC 743B DO-229D and DO-253C GLSSU Solutions For Retrofit

**Presented to**

**AEEC**

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# The Classic Retrofit Challenge

- **Financial:**
  - ***Operating budget year financing***
  - ***ROI payback: 1-2 years max***
  - ***Investment usually comes from reduced fuel budget: save enough on gas in 1-2 years to pay off the investment in the avionics.***

- **Retrofits make sense when the avionics bring new capability measurable in better fuel economy at a reasonable retrofit cost to airframes with long lives ahead.**

- **Retrofit aircraft equipage assumptions:**
  - ***GNSS with or without inertial navigation***
  - ***Minimal or no FMS modifications***
  - ***Retrofit solution must "bolt-on" solution, not a gut and re-equip***

# What do these Terms have in Common?

**ADS-B** **DO-229D** **SBAS** **RNP0.1**

**GBAS** **ARINC 743B** **Integrity**

**LPV** **TSO-C145c Beta-3** **CAT-I** **DO-253C**

**Gagan** **SA-Aware** **99.999% Availability**

**EGNOS** **TSO-C146 Delta-4** **Airbus A-350 LPV!**

**GLS** **Primary Means of Navigation Worldwide**

**TSO-C161a/C162a** **CAT-I/II/III** **Autoland** **NextGen**

# Some Answers:

- **All are "added" features**
  - ***Enabled through augmented GPS receivers & integrated with aircraft operation***
  - ***Provide substantial new benefits to air transport operators***
  - ***but which are <u>not</u> generally supportable by 1st gen GPS receivers, of which there are thousands in current airline service, even if updated as "SA-Aware"…***
  - ***Positioned to take advantage of the "Next Gen" Airspace***

- **The ARINC 743B Characteristic captures the current GPS L1 receiver augmentations:**
  - ***SBAS enabled navigation and LPV***
  - ***GBAS GLS***
  - ***All in one ARINC 743B GPS receiver (+ VDB receiver).***

- **The GPS L1 signal remains to be fully exploited:**
  **it remains to exploit SBAS&LPV + GBAS GLS in an all-in-one receiver as a total navigation and approach solution.**

- **The ARINC 743B Characteristic allows growth to an expanded GNSS receiver with essentially the same aircraft interface.**
  - ***Equipment impact: the GPS receiver & antenna will probably be replaced as a minimum.***
  - ***Remark: an expanded GNSS may bring additional benefits to commercial aviation, but these need better definition.***

# Focus on Augmented GPS: SBAS/GBAS Receivers

- **Non-Augmented GPS receivers do not have the required integrity-availability-continuity to support the transition to a performance-based navigation infrastructure**
  - ***Shift from ground-based to satellite-based services***
  - ***Eventually navaids like VOR and NDB will be "divested"***
  - ***NAS-wide services for enroute, terminal and approach, including backup for approach and landing, are all GNSS based***
- **With SBAS augmentation:**
  - ***By far the most accurate, highest integrity navigation system there is with Primary Means Navigation (not so with a SA-Aware only Rx)***
  - ***Enhances RNAV, RNP navigation & RNP SAAAR (RNP0.1)***
  - ***Meets ADS-B requirements (position integrity & velocity with FOM) especially in the terminal area***
  - ***LPV, CAT-I equivalent available today***
- **With GBAS augmentation:**
  - ***GLS CAT-I today, but no Federal Acquisition Program for LAAS***
  - ***CAT-II/III in future, being worked, using GPS L1 only.***



# Capability of an ARINC 743B Receiver

- **Is self-contained and focuses only on GNSS navigation and approach capability (does not drag around classical receivers such as VOR, ILS, etc…) as part of its characteristic.**
- **Accounts for DO-229D, SBAS Navigation and LPV**
- **Accounts for DO-253C, GBAS GLS**
- **Enables RNP0.1 (RNP SAAAR) & Primary Means of Navigation**
- **Address ADS-B position & velocity outputs, including ADS-B operations in the Terminal Phase of Flight**
- **Address retrofit aircraft cost effectively**
- **Allows for growth to new GNSS and augmentations without significant impact to aircraft or systems.**

# SBAS/GBAS ARINC 743B Receiver

- **GBAS and SBAS combined in one receiver**
- **New approach connector is defined for Alternate Form Factor GLSSU receiver**
  - **Glide Slope and Localizer look-alike guidance, identical to ILS provided on ILS look-alike bus**
  - **Provides DME look-alike, identical to DME provided on DME look-alike bus**
  - **Retain existing ILS, displays, FMS, and avionics in general**
  - **add "bolt-on" GPS/SBAS navigation & SBAS/GBAS approach solution**
  - **Has built-in digital High Integrity Switch to intercept ILS and DME busses and replace with GLSSU derived LOC/GS and DTG**
  - **Rectilinear guidance also provided as required by GBAS MOPS for both GBAS and SBAS approaches on GLS bus**
  - **Fresh 10 Hz navigation & approach data provided on GLS bus for flexibility to compute guidance on other equipment**

# SBAS/GBAS Navigation Receiver

- **Primary Means Navigation with SBAS**
  - **SBAS receiver uses SBAS differential GPS data, and integrity information to:**
    - ✓ **Produce a more accurate navigation solution**
    - ✓ **Produce a better integrity (smaller HIL, HPL) and much better availability**
  - **RNP0.1 Integrity >= 99.999% under SBAS coverage**
  - **RNP0.3 Integrity = 100% under SBAS coverage**
  - **Coverage is entire SBAS satellite footprint (continental)**
  - **SA-Aware when not under SBAS coverage**
  - **Certification is TSO-C145c for navigation, TSO-C146c for approach guidance, may have both**
  - **In general, C145c equipment performs as well as or outperforms C196 (SA-Aware) equipment.**

- **Better Local Area Navigation with GBAS**
  - **GBAS receiver uses GBAS differential GPS data and integrity information to:**
    - ✓ **Produce a more accurate navigation solution**
    - ✓ **Produce a better integrity (smaller HIL, HPL) and much better availability**
  - **Coverage limited to 23 nmi operational radius defined by VDB link budget**
  - **LAAS TSO-C161a + base a certification, one of: TSO-C129a, TSO-C145c, or TSO-C196**

- **Impact of SBAS + GBAS on Aircraft Navigation Interface (ARINC 743A):**
  - **No impact on navigation interface, no impact on standard ARINC 743 navigation connector**
  - **Same labels for position solution, same label for integrity information**
  - **Only difference is that data is more accurate, better integrity availability**
  - **Impact on ARINC 743: no impact, aircraft is presented with a better solution**
  - **Optional labels exist, if exercised, then there will be modifications, but not needed.**

# SBAS/GBAS Approach Receiver

- DO-229D GPS/SBAS receiver classes
  - Defines a Beta and Delta class receiver (Gamma class not discussed)
    - ✓ Beta class is a navigation receiver, does NOT provide Glide Slope or Localizer guidance, relies on some other equipment to do guidance (FMS?)
    - ✓ Beta Class receiver interface is essentially unchanged for navigation, the standard connector is the “navigation connector” with same navigation interface definitions.
    - ✓ Delta class is an approach receiver, provides Glide Slope and Localizer guidance
    - ✓ Delta Class receiver interface defines a new approach connector
    - ✓ Delta class receiver can have its own FAS or it down-load the FAS from the FMS
  - Beta + Delta class receiver can be combined as one receiver
  - Beta + Delta class receiver can be a complete stand-alone navigation and approach receiver
    - ✓ Approach does not have to be driven by a FMS
    - ✓ Navigation solution used by FMS as if GPS only

- DO-253C GBAS receiver
  - No equipment classes
    - ✓ GPS or GPS/SBAS navigation outside range of GBAS ground station
    - ✓ GBAS Differential navigation within range of ground station if that service is provided by the GBAS ground station
    - ✓ Approach guidance within range of ground station

# SBAS/GBAS Approach Receiver, How It's Done

- **The Guidance Solution**
  - **Must be ILS Look-Alike: Glide Slope and Localizer outputs**
  - **Must be DME Look-Alike: Distance to LTP/FTP**
  - **Delta Class receiver behaves exactly as an ILS receiver – aircraft systems see Delta Class receiver as an ILS receiver – true ILS look-alike. Result: no aircraft systems need to be modified**
  - **Ability to switch between ILS and GPS approach with built-in High Integrity Switch**

- **Impact on FMS and aircraft**
  - **In retrofits, maximize use of existing aircraft displays, autopilot without modifications. This is the key to low cost.**
  - **However, FMS must provide for:**
    - ✓ ***FMS procedures for GPS RNAV, guidance to FAF, "same as for ILS"***
    - ✓ ***FMS procedures for GPS RNAV missed approach, "same as for ILS"***
  - **FMS does not have to be modified to control GLSSU receiver, can be done with a separate control head**
  - **FMS does not have to host the LPV database, GLSSU can host 2 cycles of the entire world-wide LPV database, CMC GLSSU: 12Mb/cycle, 2 cycles (total = 24 Mb).**

- **Impact on Aircraft Approach Interface:**
  - **Provides Glide Slope and Localizer look-alike guidance, identical to ILS**
  - **Provides DME look-alike, identical to DME**
  - **Retain existing ILS, displays, add "bolt-on" GPS approach solution**
  - **Potential FMS impact to provide RNAV and Missed Approach Guidance**

# SBAS/GBAS Approach Receiver, What It Delivers

- **DO-229D**
  - **Defines a Beta and Delta class receiver**
    - ✓ **Beta class is a navigation receiver, does NOT provide Glide Slope or Localizer guidance**
    - ✓ **Delta class is an approach receiver, provides Glide Slope and Localizer guidance**
    - ✓ **Delta class receiver can have its own FAS or have it down-loaded from the FMS**
  - **Beta + Delta class receiver can be combined as one receiver**
  - **Coverage tends to be entire continental airspace**
  - **Beta + Delta class receiver can be a complete stand-alone navigation and approach receiver, fully independent of a FMS**

- **DO-253C**
  - **GBAS receiver uses GBAS differential GPS data and integrity information to:**
    - ✓ **Produce a more accurate navigation solution**
    - ✓ **Produce a better integrity (smaller HIL, HPL) and much better availability**
    - ✓ **provides Glide Slope and Localizer guidance**
    - ✓ **CAT-I Approach capability, CAT-II/III TBD approval with GPS L1 signal.**
  - **Coverage limited to 23 nmi operational radius as defined by VDB link budget**

- **Impact on Aircraft Navigation Interface (ARINC 743):**
  - **None foreseen**
  - **Same labels for position solution, same label for integrity information**
  - **Only difference is that data is more accurate, better integrity availability**
  - **Impact on ARINC 743: no impact, aircraft is presented with a better solution.**

# Practical Example of an ARINC 743B receiver retrofit

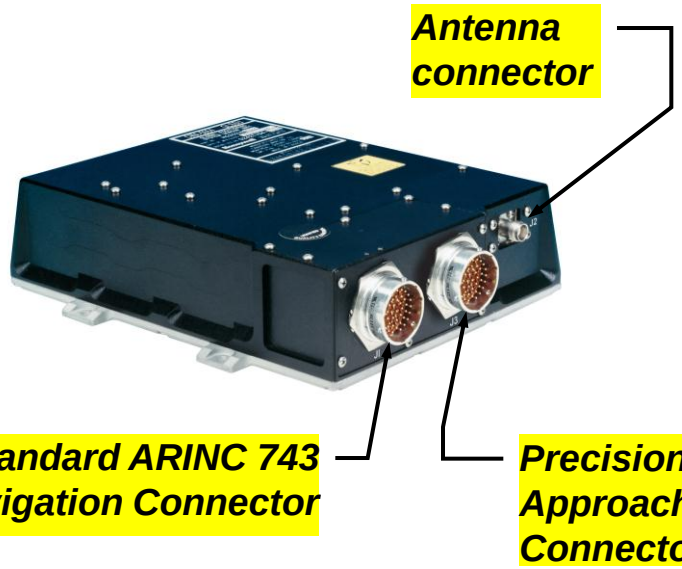
- **GLSSU developed by CMC Electronics as an alternative to MMR**
  - ***ARINC 743B Alternate Form Factor***
  - ***Today: SBAS + LPV***
  - ***Tomorrow: SBAS + LPV & GBAS + GLS in one receiver: GLSSU***
    - ✓ **External VDB receiver, same foot-print**

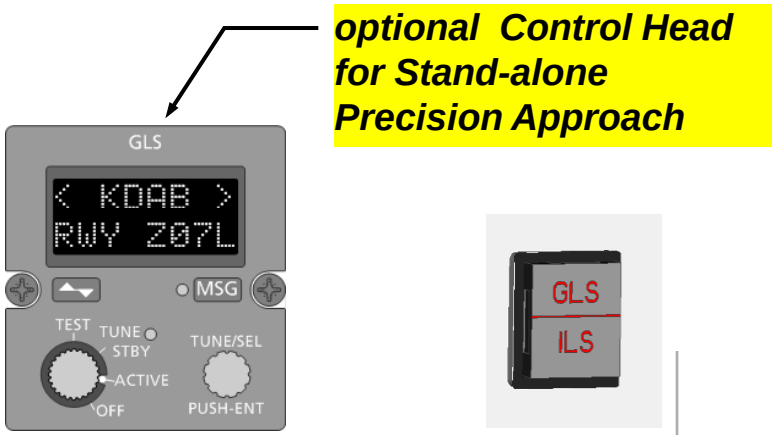
- **Example: classic B-757 Retrofit**
  - ***No GPS***
  - ***VOR/DME & INS navigation***
  - ***ILS approach***

# A Practical Example of an ARINC 743B SBAS/GBAS receiver

- **GLSSU dual purpose:**
  - ***SBAS Navigation***
    - ***RNP0.1 performance***
    - ***ADS-B in terminal area***
    - ***Primary Mean Nav***
    - ***SA Aware built-in***
  - ***SBAS LPV + GBAS GLS***

- **Complete GLSSU system:**
  - ***Built-in High integrity switch for ILS-GLS signal source selection***
  - ***External VDB receiver for GBAS***
  - ***<u>Optional</u> control head***
  - ***Addition of guidance mode ILS-GLS/LPV selector***
  - ***Active antenna, TSO C-190, required for LPV or GLS***



# CMA-5024 IntegriFlight™ GLSSU SBAS/LPV

- **GPS Landing + GLSSU in single unit**
  - ***Certified (2008) to highest standards TSO-C145c Beta-3 & TSO-C146c Delta-4***
    - ✓ **No "Waivers" of any sort**
    - ✓ **Primary Means of Navigation**
    - ✓ **Supports RNP0.1 certification**
    - ✓ **Supports ADS-B requirements, NAC_V=2**
    - ✓ **Built-In WAAS LPV + FAS Database**
    - ✓ **Built-in High Integrity Switch ILS/GLS switch**
  - ***SA-Aware world-wide***
  - ***ARINC 743A-4/5 & 743B compliant***
  - ***Unmatched 40,000MTBF***
  - ***Aircraft Personality Data (APD) provision to configure interface to specific airframe type.***
  - ***Upgradable to LAAS, external VDB required***
  - ***CAT-IIIb ready: All-in-view 24-Channel Narrow Correlator technology***

**CMA-5024 GLSSU**


**CMA-5025 Control Panel**

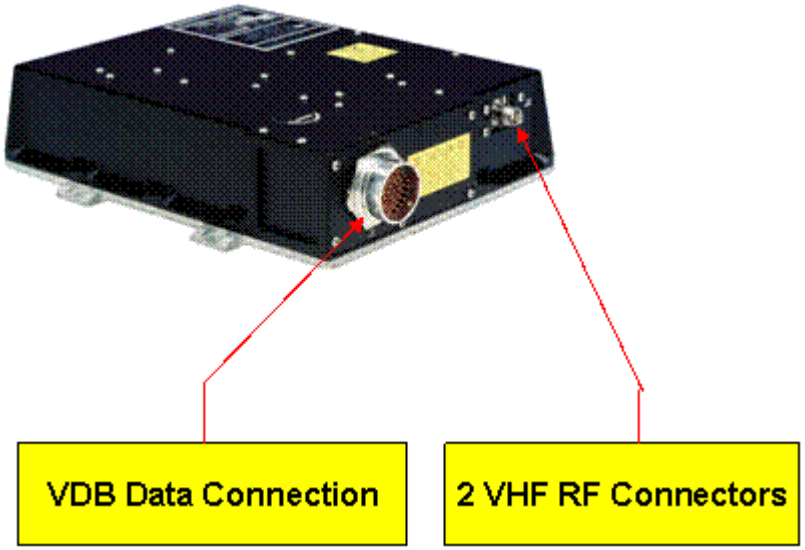
# CMA-5025 IntegriFlight™ Control Panel - Overview

- TSO-C146c Delta-4
- Smallest “standard” form factor
  - *2.25” X 2.5” X 4.5”*
- Connects to GLSSU:
  - *Controls and selects WAAS LPV ICAO tuning range from (40000 to 99999)*
  - *Controls and selects LAAS GLS ICAO tuning range from (20000 to 39999)*
- 20,000 hour MTBF


- Left and Right CMA-5025 connect to Left and Right CMA-5024s
- GLSSUs crosstalk tuning at all times, all GLSSUs tuned to same approach
- Both CMA-5025s will display same active approach (GLSSUs will cross-talk the tuning among themselves and to the opposite control panel)
- Either side can select tuning, opposite control panel will display same selected approach, all GLSSUs will tune to same selected approach.

# CMA-5010 IntegriFlight™ VDB Receiver - Overview

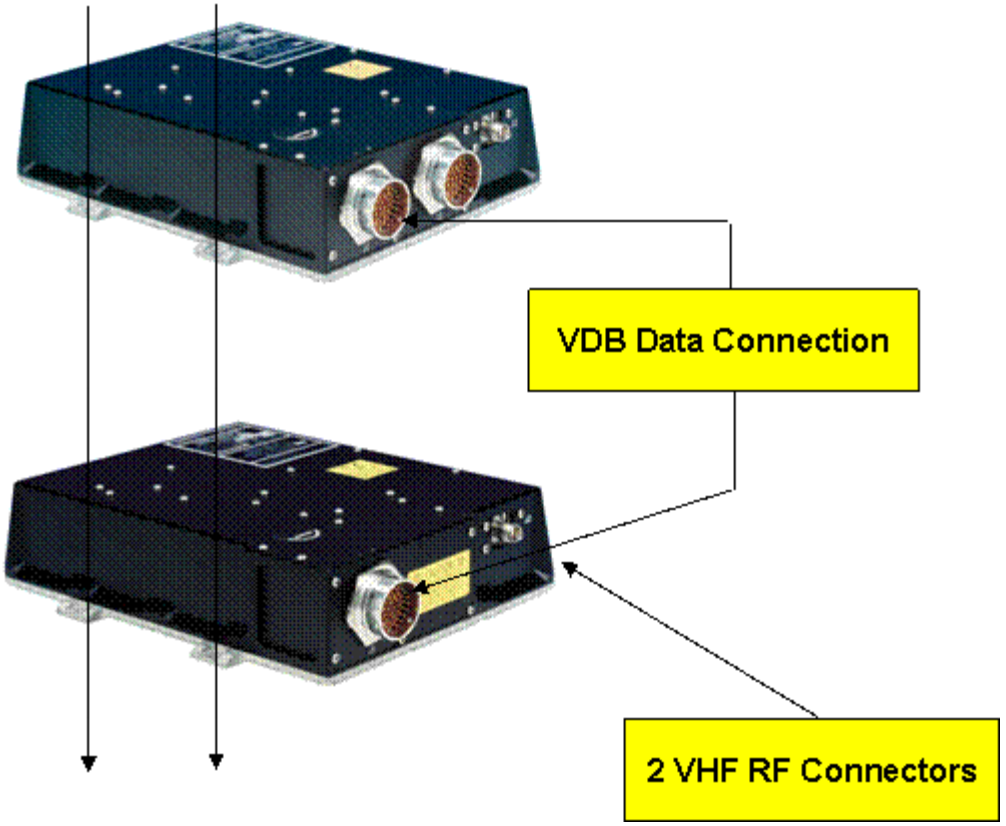
- **Dedicated VBD Receiver (planned)**
  - *RTCA/DO-253C*
  - *ARINC 755 I/O compliant*
- **3 Connectors:**
  - *Data and Power Connector Connected only to GLSSU*
  - *2 RF Connectors: (In and Out) Configurable RF ILS/VDB switch, 3dB power split or active RF*
- **Controlled only by GLSSU and ILS/GLS Approach Select Switch**
- **> 40,000 hour MTBF target**
- **An "Add-Below" to existing GLSSU**
  - *Identical "footprint" to GLSSU*
  - *Slim deck height, approx 1 inch*




**CMA-5010**
**VDB Receiver**
**Representative Unit**

# CMA-5010 IntegriFlight™ VDB Receiver - Overview

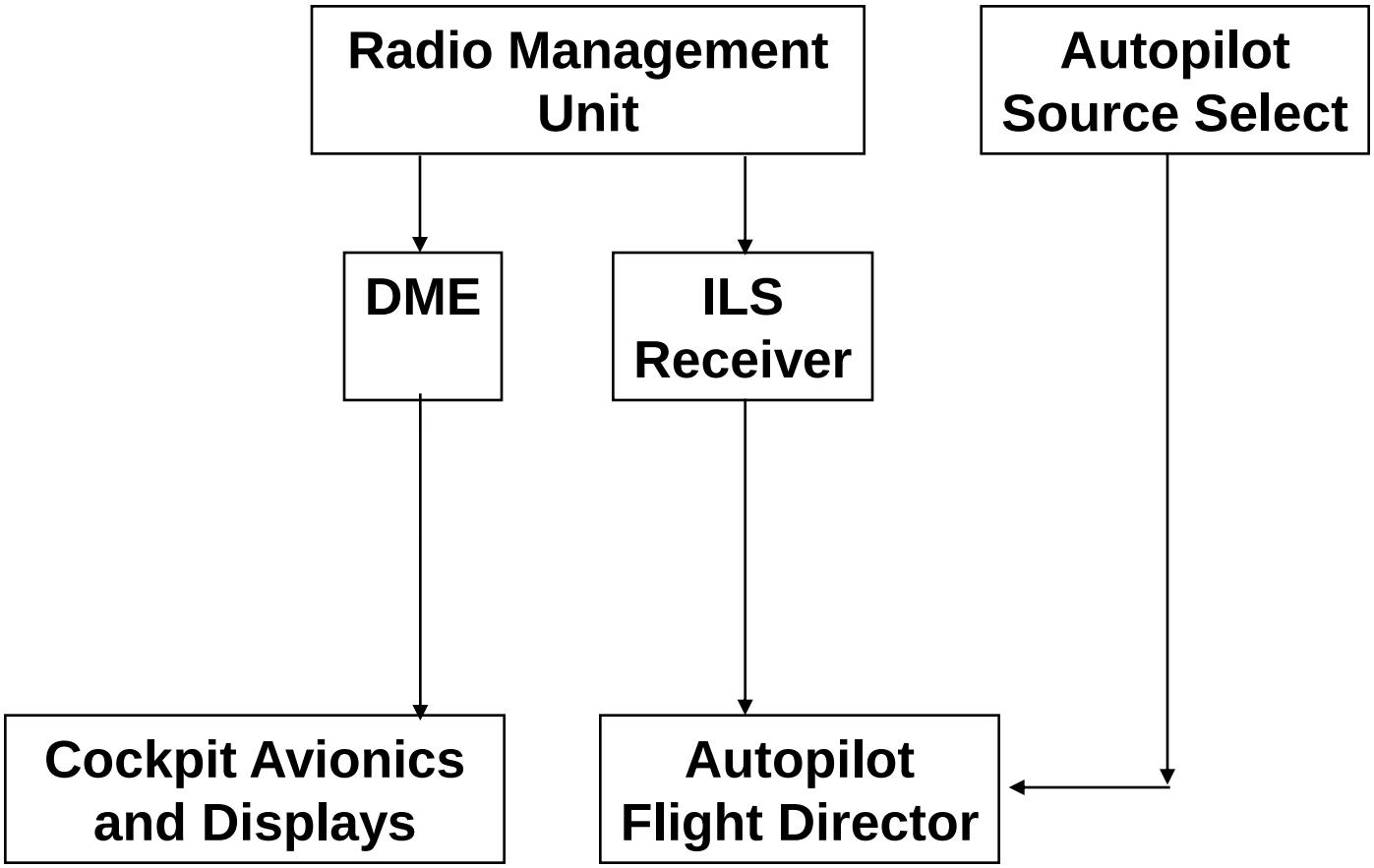
**CMA-5024**
**GLSSU**



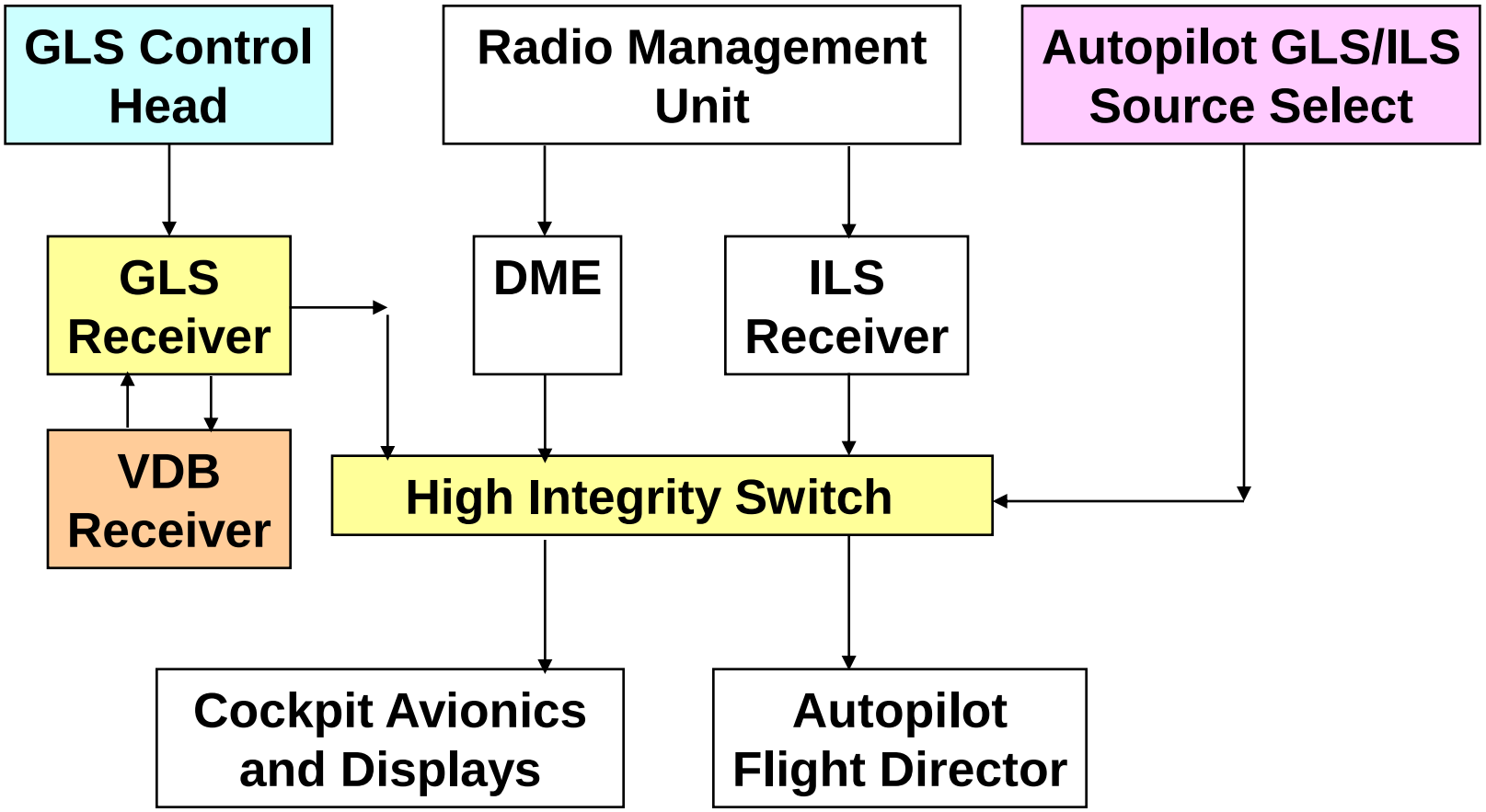

**CMA-5010**
**VDB Receiver**
**Representative Unit**

**Mounting**
**Bolts**

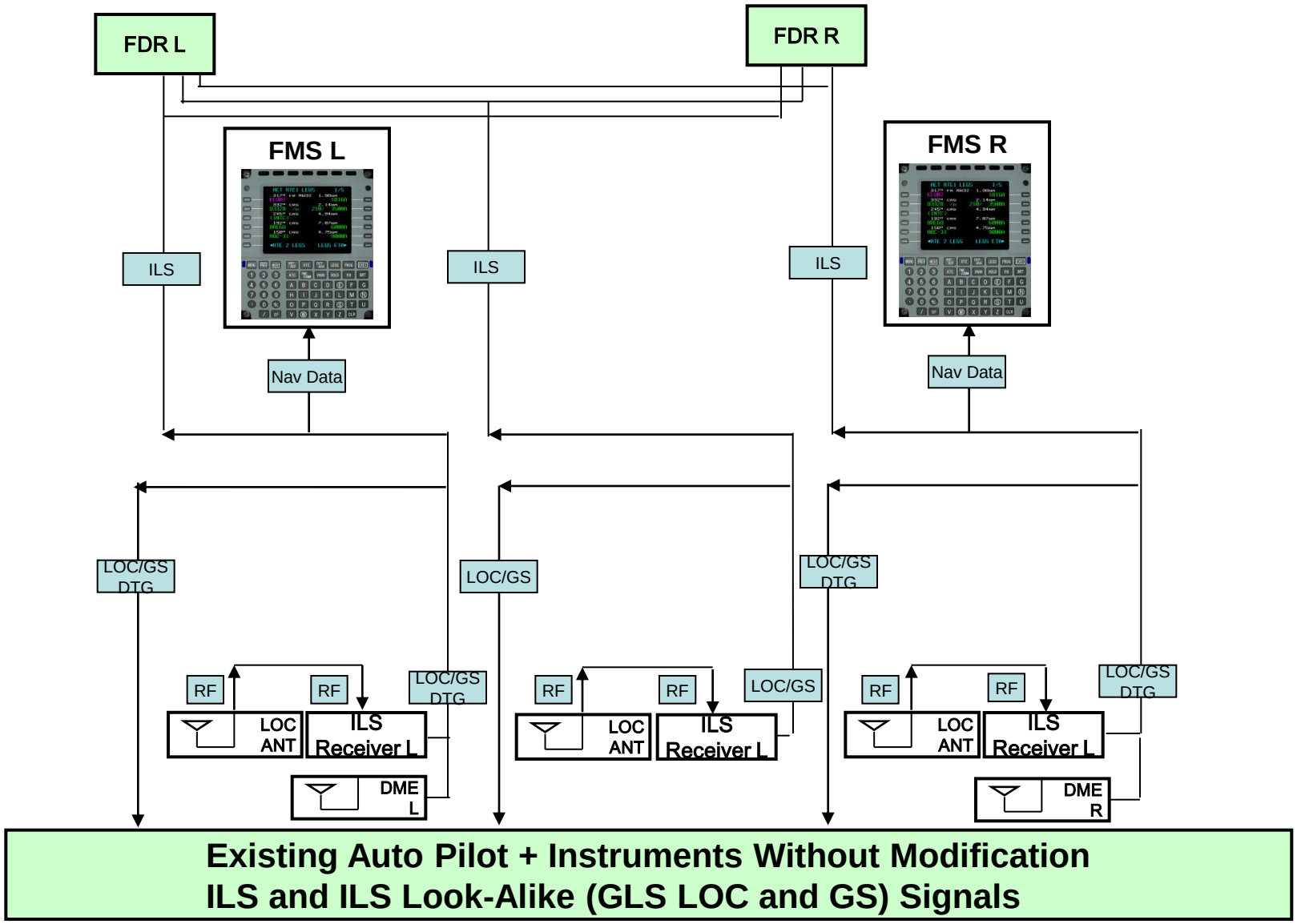
# ILS / DME Top Level Diagram



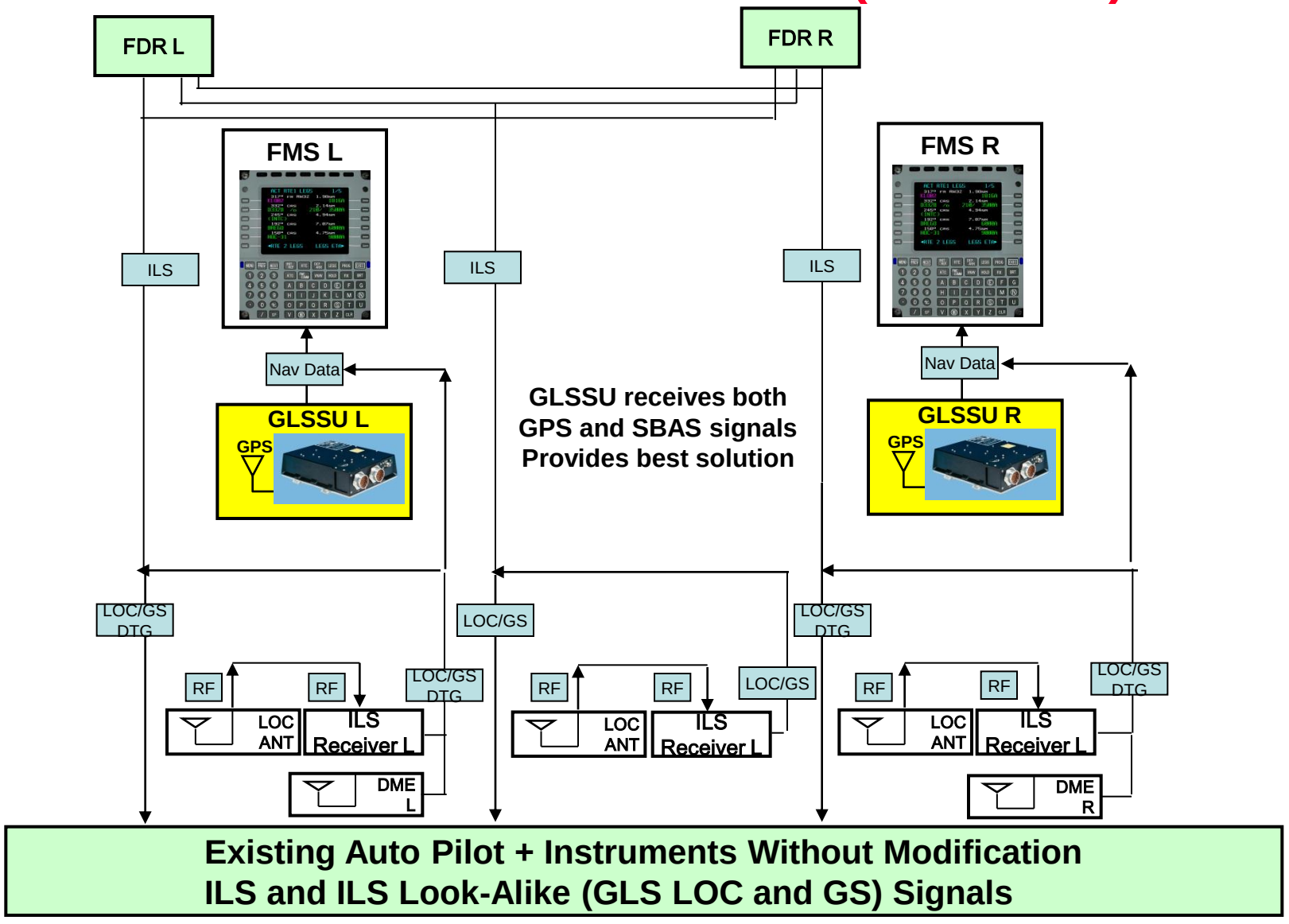
# ILS/DME + GLS Approach Top Level Diagram



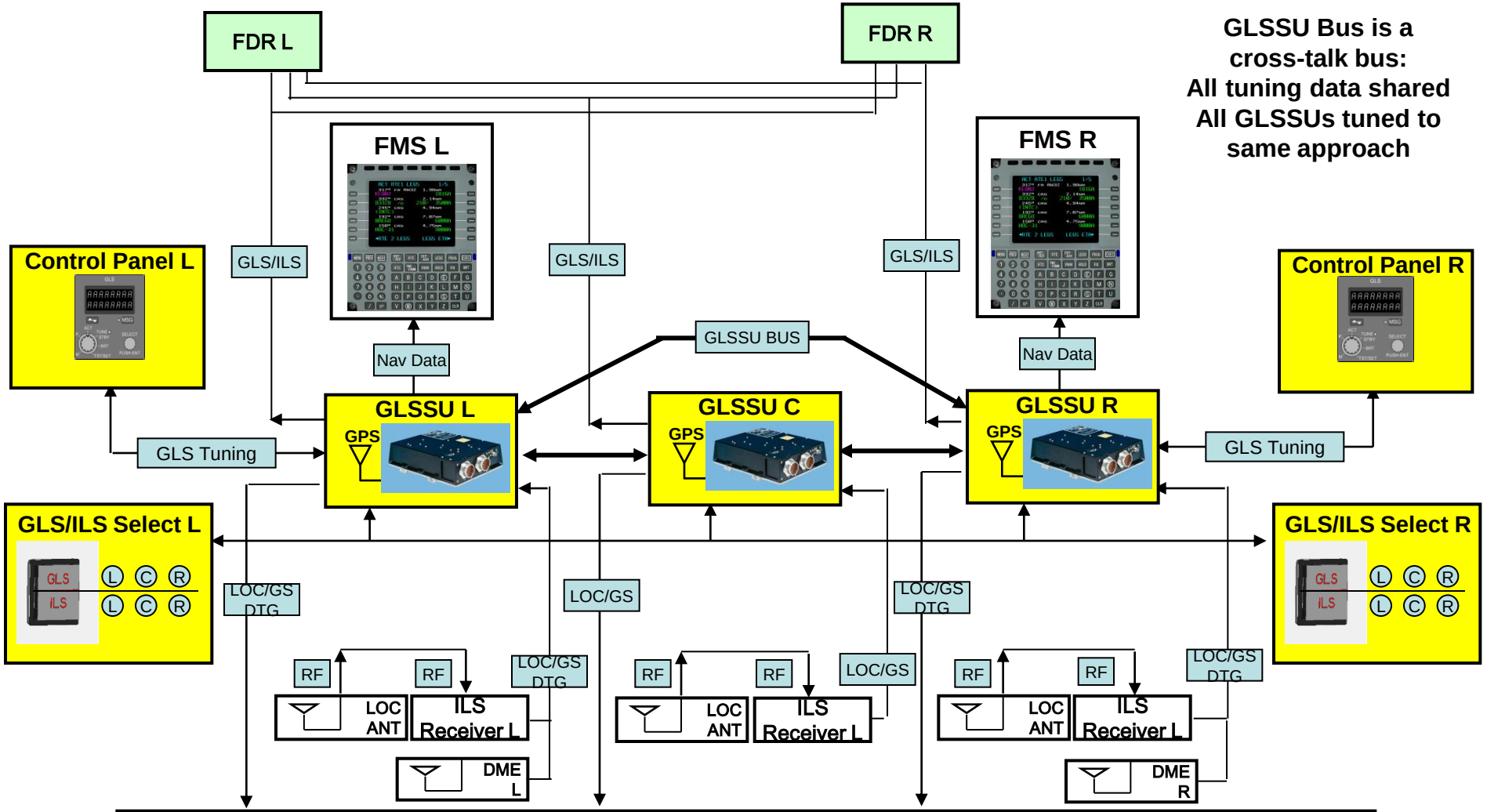
# Architecture in a classic 757 NO GPS



# Architecture in a classic 757 + SBAS (SA-Aware)



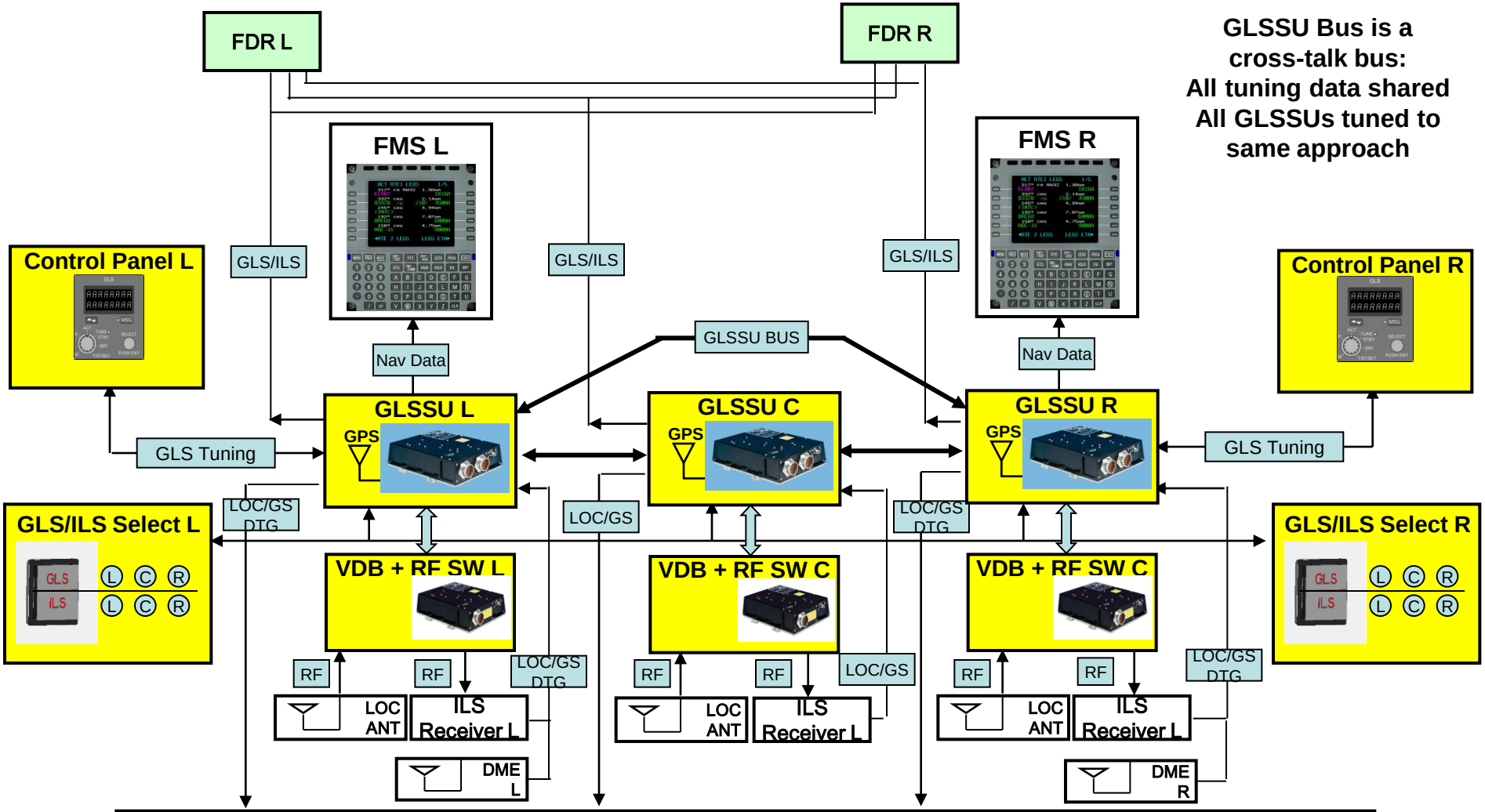
# Architecture in a classic 757 + SBAS + LPV




**GLSSU Bus is a cross-talk bus:**
**All tuning data shared**
**All GLSSUs tuned to same approach**

**Existing Auto Pilot + Instruments Without Modification**
**ILS and ILS Look-Alike (GLS LOC and GS) Signals**

# Architecture in a classic 757 + SBAS + LPV + GBAS + GLS



# Concluding Remarks

- **SBAS and GBAS in one receiver as a simple retrofit solution for classic aircraft is possible.**
- **GLSSU with SBAS available today**
- **GLSSU with GBAS coming soon.**

- **To consider future standards:**
  - **Radio box with classical radios (ILS, VOR, etc) in one box, but NO GPS**
  - **Separate GNSS box**
    - ✓ **GPS, SBAS, GLS today**
    - ✓ **Coming: GPS L1 & L5, Galileo, and still newer things on drawing boards**
    - ✓ **The GNSS receiver will undergo changes for decades to come. Does it make sense to integrate it with ILS, VOR, etc…?**

# On the Button Accuracy

## The Precision Upgrade Solution for Existing Aircraft

**IntegriFlight® SBAS/WAAS GPS Receiver**

- Worldwide Primary Means Navigation
- Meets or exceeds ADS-B requirements
- Navigation solution supports RNP0.1
- Fully coupled autopilot LPV guidance
- Growth to LAAS/GBAS

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