EGNOS AND SBAS: AN AVIONICS PERSPECTIVE

EUROPEAN SPACE WEEK – SAFETY OF LIFE SESSION

JP RIVET, DIRECTOR, MARKETING, AVIONICS

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ABOUT COLLINS AEROSPACE

Collins Aerospace, a unit of United Technologies Corp. (NYSE: UTX), is a leader in technologically advanced and intelligent solutions for the global aerospace and defense industry.

Created in 2018 by bringing together UTC Aerospace Systems and Rockwell Collins, Collins Aerospace has the capabilities, comprehensive portfolio and expertise to solve customers' toughest challenges and to meet the demands of a rapidly evolving global market.

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BY THE NUMBERS

GLOBAL PRESENCE

70,000
employees

16,000+
engineering workforce

Nearly
300
sites globally

ANNUAL REVENUE

$23 billion
net sales*

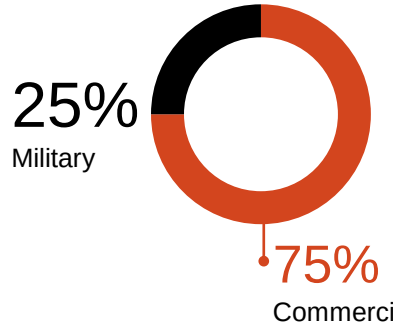
** 2017 pro-forma*

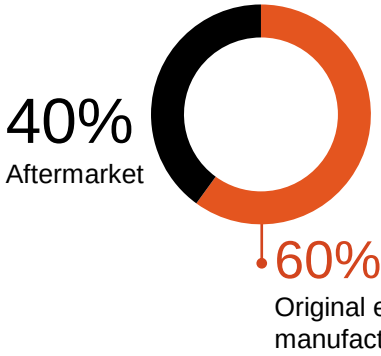
INVESTED IN INNOVATION

$3.1 billion
research and development investment**

** * 2017 pro forma, customer and company-funded*

BROAD AVIATION AND MILITARY PORTFOLIO





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COLLINS HISTORY IN GNSS

EGNOS SOL SESSION

- July 19th, 1977 – First GPS signal from first Global Positioning System (GPS) satellite known as NTS-2 decoded at the heritage Rockwell Collins facility in Cedar Rapids

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COLLINS HISTORY IN GNSS

EGNOS SOL SESSION

- May 25, 1983 – First GPS guided transatlantic flight

- 1995 – First TSO for a Multi Mode Receiver

- 2006 – First SBAS – GPS-4000S
  - Participation in GIANT to deploy PBN LPV operations in Europe

- 2018 – business jet aircraft and new generation aircraft such as A220 and A350XWB use LPV for approaches using Collins SBAS

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SBAS HISTORY TO DATE

EGNOS SOL SESSION

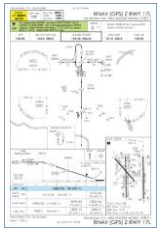
WAAS IOC Commissioning July, **2003**

First LPV-200, LPV Approaches Surpass ILS in US September, **2008**

GAGAN Operational December, **2013**

Decommissioning of ILS in favor of LPV

Multi-Constellation Provides SBAS-Like Performance Worldwide



First LPV Approach September, **2003**

EGNOS SoL Operational March **2011**

A350 Enters Service with SBAS January, **2015**

Emerging SBAS Mandates

Increased adoption of LPV

SBAS is exceeding expectations

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CUSTOMER DEMAND AND DEVELOPMENT

EGNOS SOL SESSION

GLU-920

GLU-920

GLU-925

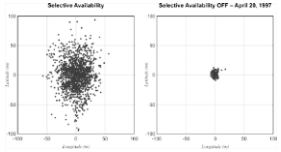
GPS-4000S

GLU-925S

GLU-2100

OEMs Required GPS and Increased Integration

Selective Availability Turned Off



GPS Landing System Emerges

SBAS Benefits Begin to Surface

Increased Integration and SBAS for ADS-B

MF/MC GLS Cat II/III LPV

Longstanding commitment to GNSS innovation

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BUSINESS AVIATION - AIRSPACE MODERNIZATION PACKAGES

EGNOS SOL SESSION

Airspace access and efficiency

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COMMERCIAL AVIATION – MANDATE DRIVEN

EGNOS SOL SESSION

- Next Generation MMR product with SBAS EIS June 2018 on B737MAX
- Certifications across all production platforms in 2018 and 2019
- Comprehensive portfolio of STC's that address almost all aircraft types
  - Next generation MMR or standalone 2 MCU GPS

Airspace access

SBAS AS PART OF THE WIDER SYSTEM

EGNOS SOL SESSION

- SBAS will often be implemented in the aircraft to support airspace modernization and mandates
- Vital as a source of position for ADS-B Out
  - FAA Mandate has driven equippage on US based aircraft, including those flying into Europe -
    - LPV not systematically a part of the upgrade – SBAS only
  - GAGAN Mandate will lead to increased SBAS equippage with a roadmap to LPV
- Airspace Modernization upgrade packages provide a comprehensive upgrade on many business jet aircraft
- When LPV becomes a linefit option on commercial platforms, we expect high take up, especially on single aisle platforms

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CHALLENGES

EGNOS SOL SESSION

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CHALLENGES – LPV RETROFIT

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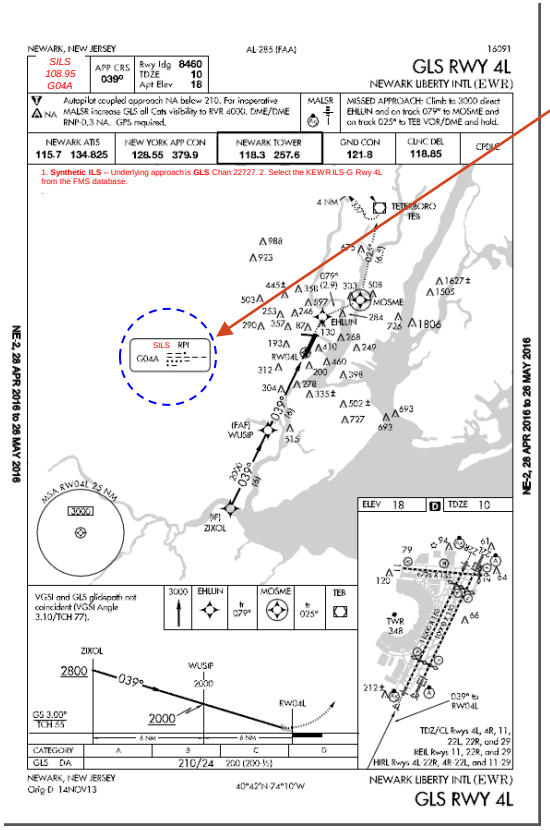
- Some architectures can introduce high cost for implementation of LPV
- Retrofit of LPV is problematic
  - Impacts Displays, Tuning, Autopilot
  - Very Costly – detracts from the business case to implement for OEM and operators alike
- Synthetic ILS (SILS) developed to address retrofit issues
- Make GLS or LPV look identical to ILS for all aircraft systems except MMR
  - Operationally equivalent to ILS
  - Reduced cost of implementation with limited changes
  - Minimal crew training
- SILS is patented by Boeing
  - Boeing SB required for implementation – Next Generation MMR capability

HOW SILS WORKS

EGNOS SOL SESSION

- Synthetic ILS



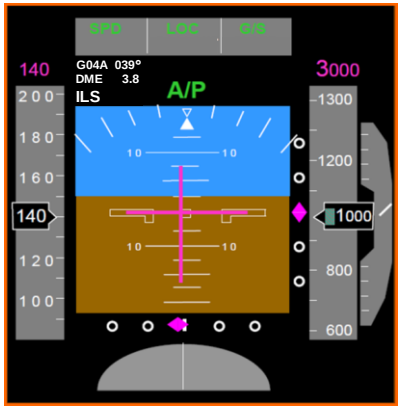
Specially assigned ILS frequency is the published SILS identifier

Pilot selects ILS approach on CDU (or control panel)

or

Label 033 goes to MMR with SILS frequency

PFD shows approach Ident & Guidance, ILS mode



- Standard procedure flown (not “special” procedure)
- Approach chart looks identical to Approved Operation chart except:
  - ILS tuning frequency instead of Channel number
  - Note indicating the underlying approach is Synthetic ILS

HOW SILS WORKS

EGNOS SOL SESSION

- GLU-2100 evaluates Tuning Input based on Internal Database
  - Tuned Frequency could equate to “Real” ILS Frequency
  - Tuned Frequency could equate to “SILS” Mode
  - Current Location is used to Evaluate

- GLU-2100 selects ILS or SILS based on Tuning Input Evaluation
  - If ILS, Normal ILS Operation
  - If SILS, GLU-2100 Tunes GLS/LPV Channel per Internal Database
  - Outputs are ILS Look-a-like regardless of mode

Increased operational capability with minimal aircraft modification

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OPPORTUNITES

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HGS CAPABILITIES

EGNOS SOL SESSION

HGS provides additional capabilities on existing infrastructures

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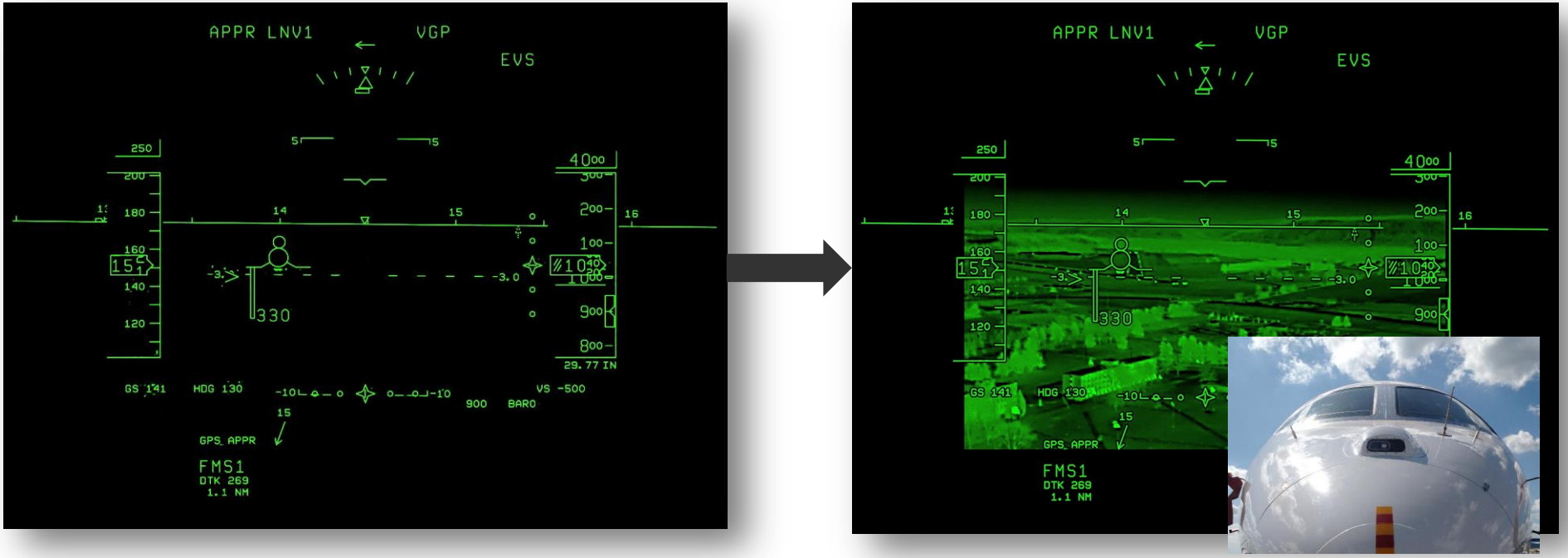
EFVS INTRODUCTION

EGNOS SOL SESSION



A “visual-equivalent” view via sensors exceeding human vision

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NEW EFVS REGULATIONS (CFR 91.176)

EGNOS SOL SESSION

- Expanded Minima
  - Utilize EFVS to 100’ (CFR 91.176B or “EFVS Approach System”)
  - Utilize EFVS to landing (CFR 91.176A or “EFVS Landing System”)
  - “Vertically Guided” approach required (ILS, GLS, LPV, RNP)

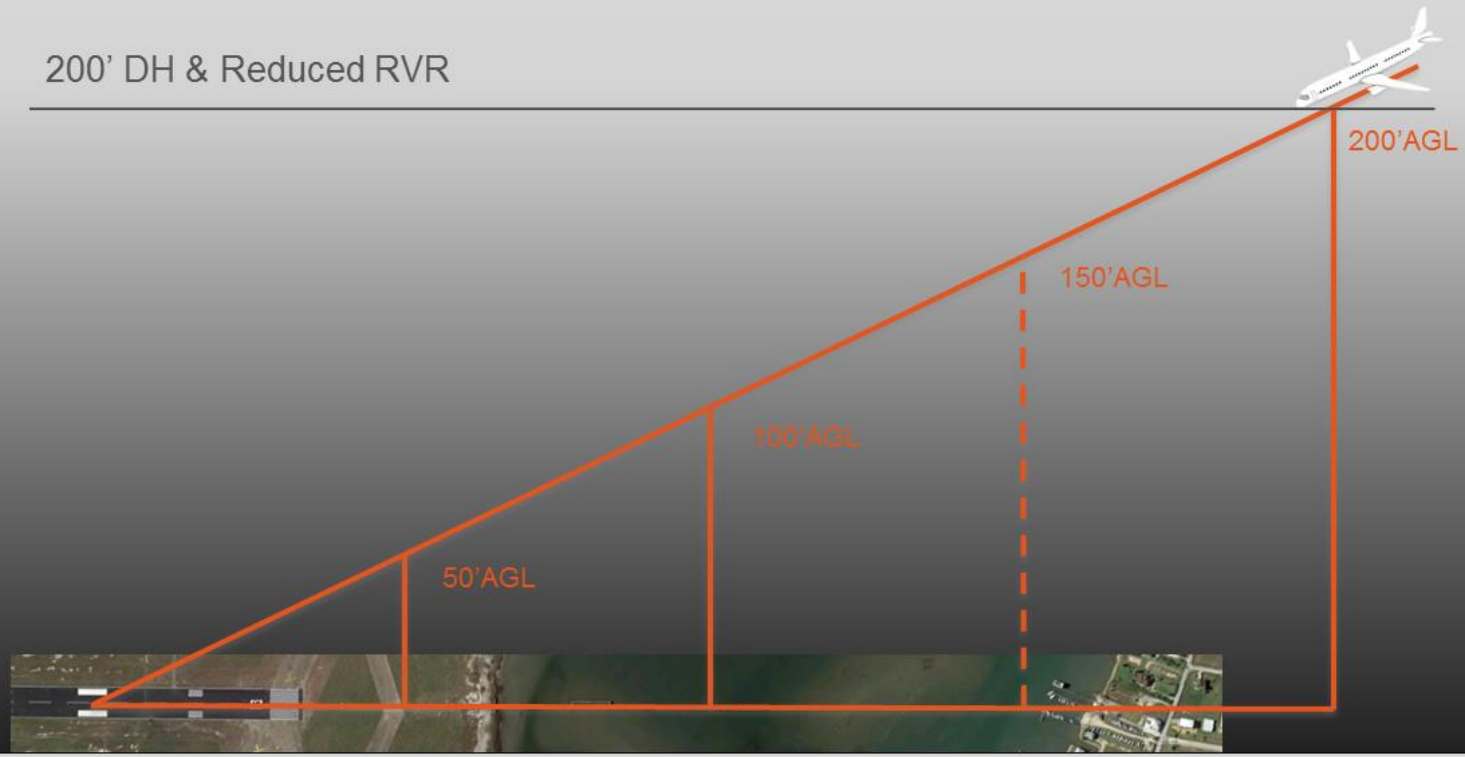
- Additional operations
  - Adds applicability to Part 121, 125 and 135 operators
  - Allows dispatch under IFR
  - Initiate an approach when WX is at or below minimum IAP visibility

- Establishment of training and usage requirements
  - Requires pilot usage within last 6 months for lower minima

EFVS LANDING SYSTEM – 91.176A ("EFVS II")

EGNOS SOL SESSION

Equipment: Requires Dual HGS & EVS Sensor



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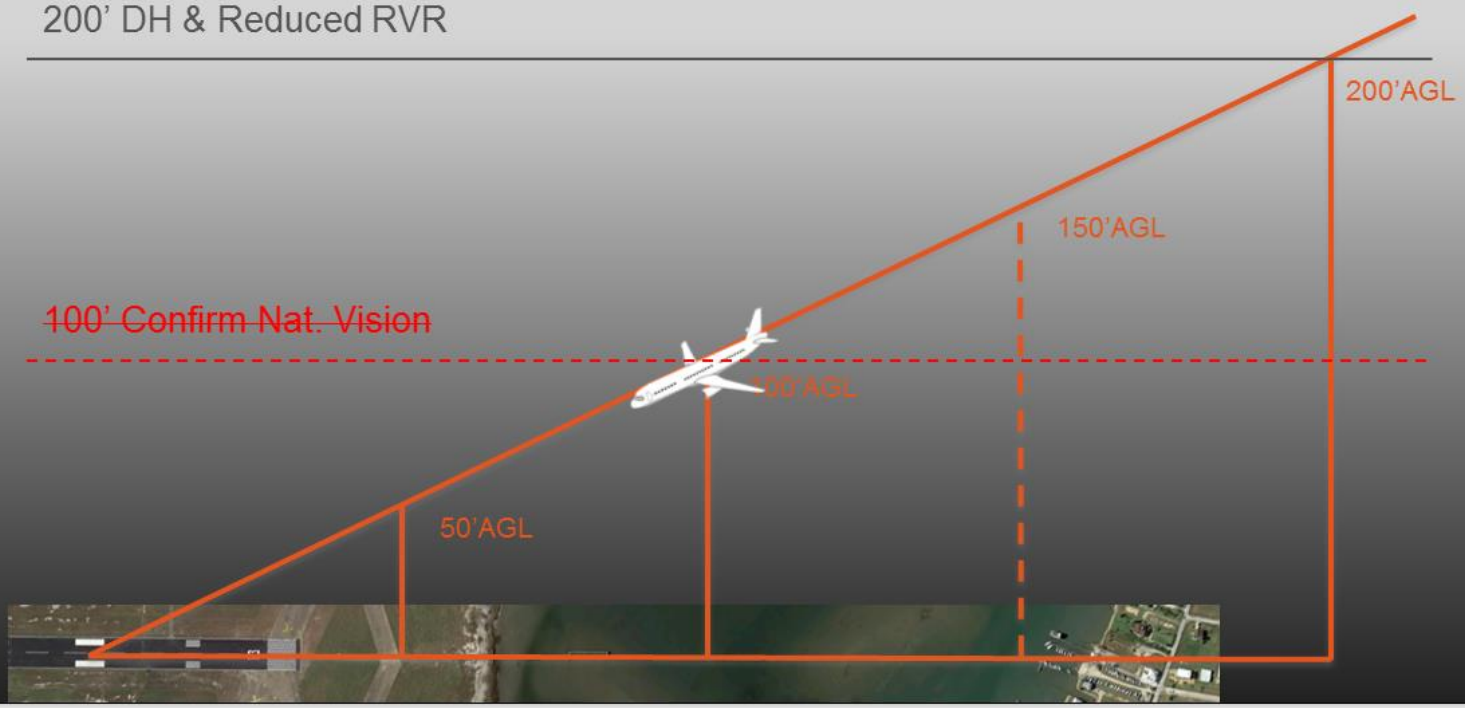

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EFVS LANDING SYSTEM – 91.176A ("EFVS II")

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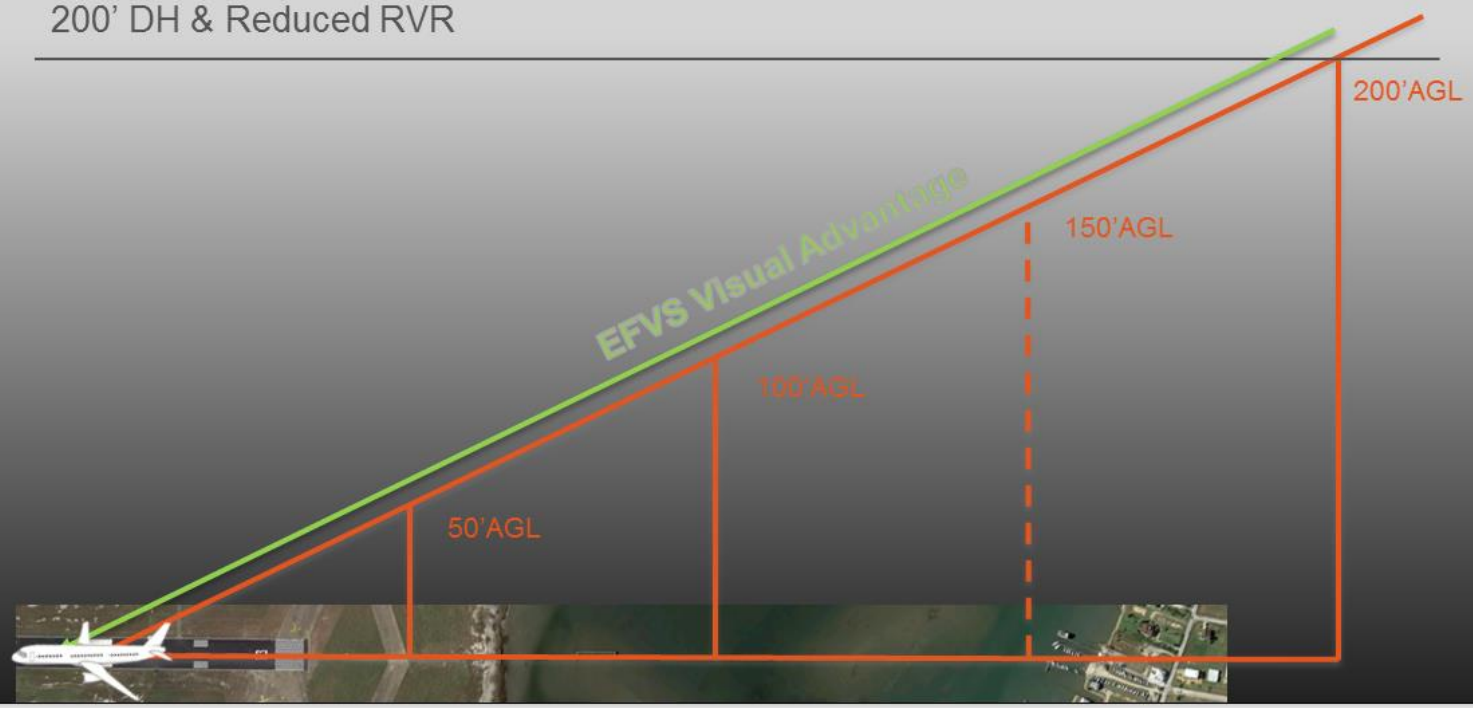

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EFVS CAPABILITIES

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FUTURE GROWTH?

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Boeing 737 MAX

A320/A330NEO

Boeing 747-8

Boeing 777X

Bombardier
Global 7500

Airbus A220

Airbus 350

Bombardier
Global 5500/6500

Bombardier
Challengers

Mitsubishi
MRJ

Embraer
Legacy 500/450

G280

All our future positions are EGNOS-enabled

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THANK YOU

- Questions?

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