Synthetic & Enhanced Vision – Operational Benefits, Affordability and Availability

Tom Horne – Experimental Test Pilot

Mike Mena – Director, Advanced Cockpit Programs

Gulfstream Aerospace Corporation

Overview

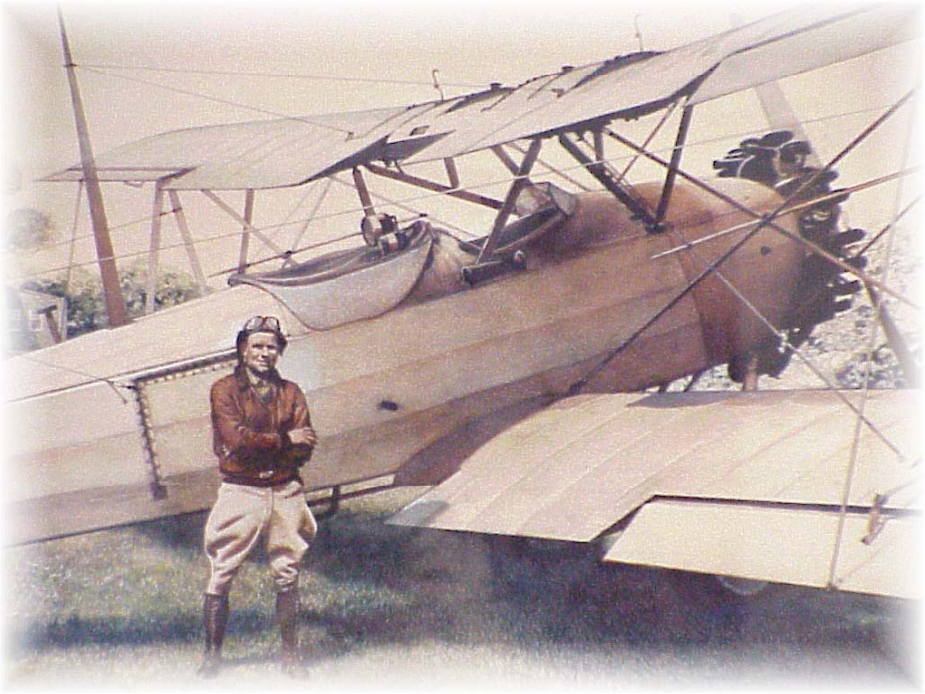
- *Instrument Flying in the Past*
- *Where we are Today*
- *The Changing Environment*
- *Enhanced Flight Vision System*
- *Synthetic Vision System*
- *Affordability and Availability*
- *Performance Measures*
- *Summary*
- *Questions*

Gulfstream

Blind Flying Goals of 1926

Guggenheim Foundation for Aeronautical Research – Study Directives:

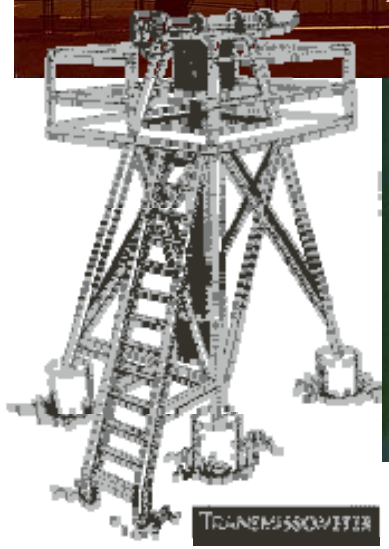
- **“The dissipation of fog”**
- **“The development of means whereby flying fields may be located from the air regardless of fog”**
- **“The development of instruments to show accurately the height of airplanes above the ground”**
- **“Improvement and perfection of instruments allowing airplanes to fly properly in fog”**
- **“Penetration of fog by light rays”**

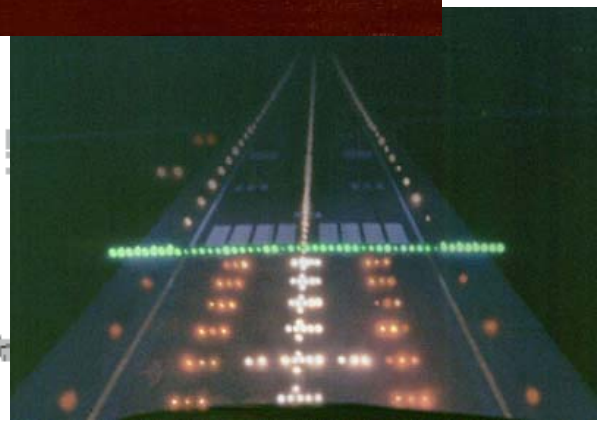


James Doolittle and the First Blind Flying Cockpit of 1929

Today's CATII And CATIII Infrastructure

- **Airport Light Structures**
- **Transmissometers at touchdown, mid field and rollout**
- **Surveyed Approach and Missed Approach Terrain**
- **Safety areas**
- **Guidance monitoring and integrity**
- **Specified runway dimensions, markings**





Highly Effective, Reliable and Safe, <u>But Costly to Maintain – Limited to Major Airports</u>

Considerations for Enhanced and Synthetic Vision Systems

- **Business Aviation Aircraft Require Flexibility and World Wide Access**
- **World Wide Airport Infrastructure is not CATIII**
- **Guidance Based Systems requires CATIII light structure**
- **Aircraft System Certification Extensive**
- **Crew Training Required Every 6 Months**

A Simpler Approach was Required

The Coming Airspace

- **USA's Next Gen, New Airspace Design**
  - **A 20 year initiative to modernize the US Air Transportation System**
  - **Identified the development of Eight Key Capabilities, one being *Equivalent Visual Operations***
- **Goal is to reduce airport infrastructure and increase access to airports**
- **Equipment will make a difference in access by users to airports**
- **The Challenge:**
  - **Development of vision based technologies that can be certified, are affordable and effective**

Gulfstream®

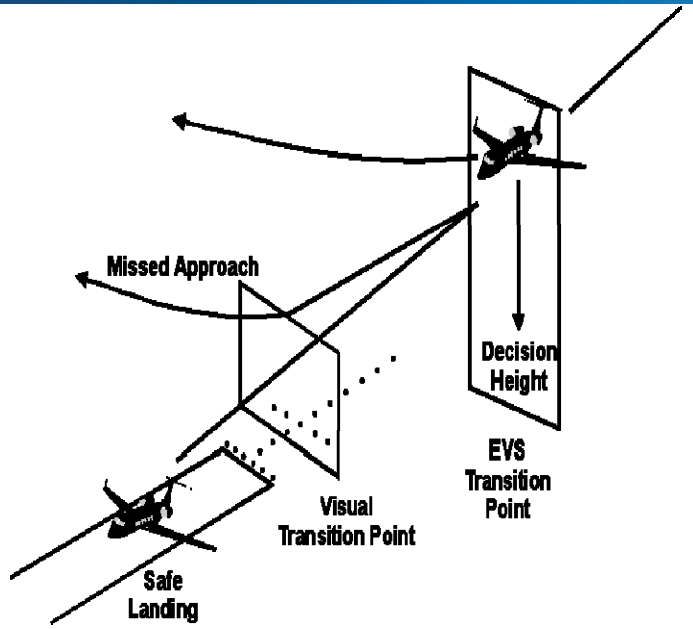
EVS II

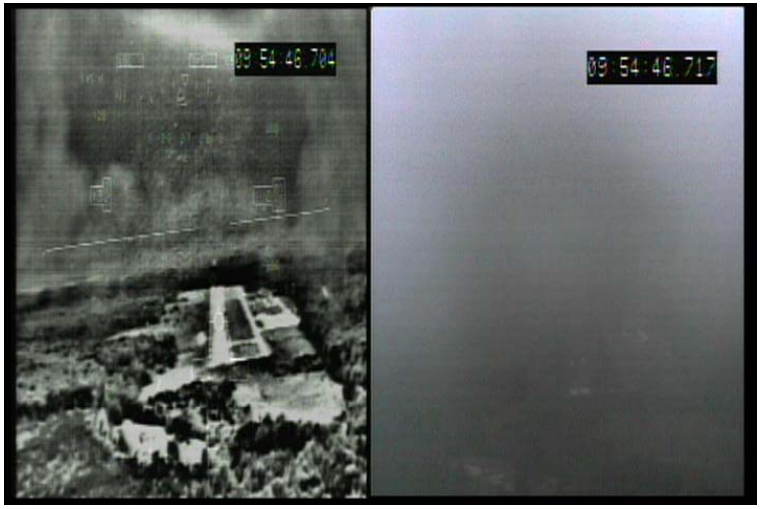
Enhanced Vision System

Enhanced Flight Visibility System (EFVS) Definitions and Operations

- **FAA EFVS Definition (FAR Part 1)** ***An electronic means*** **to provide a display of the forward external scene topography……*through the use of imaging sensors*, such as a forward looking infrared, millimeter wave radiometry, millimeter wave radar, and low light level image intensifying sensor.**
- **Operational Capability -- FAR 91.175 (l), (2)**
  - **"The pilot determines that the enhanced flight visibility observed by use of a certified enhanced flight vision system is not less than the visibility prescribed in the standard instrument approach procedure being used"**

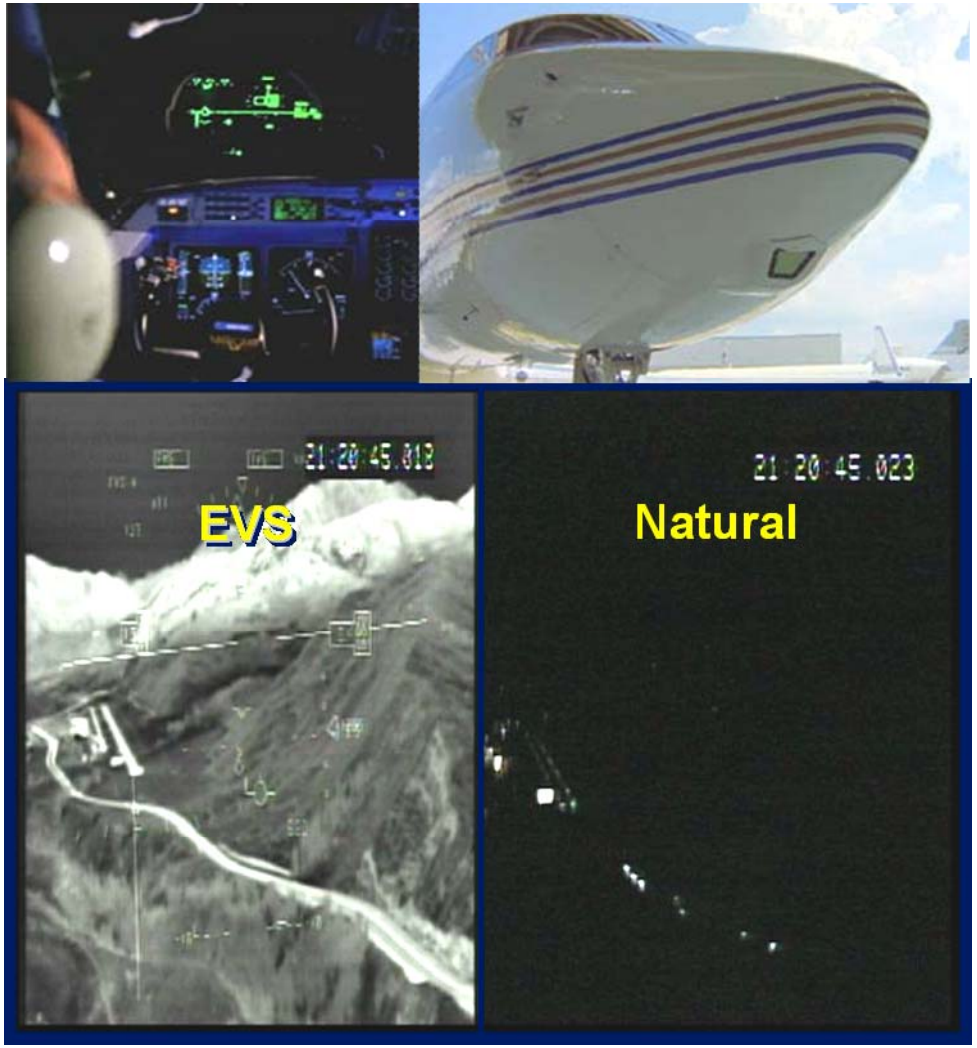
Lower Minimums Effectively Achieved





Gulfstream's Enhanced Vision System (EVS)

- **Head-Up Display (HUD)**
  - **Displays flight guidance symbology**
  - **Synthetic runway displayed on ILS approaches**
- **EVS Sensor – Supplied by Kollsman**
  - **Cryo-cooled Infrared device**
- **EVS Image Superimposed on HUD**
  - **Image is conformal to outside environment**
- **Certified in 2001 and 2007**
  - **New FAA Regulation for EVS and official definition of EVS**
- **Provides improved pilot situational awareness in low visibility and night conditions**



A Fully Qualified EFVS

EFVS Uses

Low Visibility

Night Operations

EFVS provides the ability to see at night and in low visibility

Gulfstream EVS – Approach to Asheville, NC
13 August, 2007

AVL EVS II DVD.mpg

Gulfstream®

SV-PFD

Synthetic Vision PFD

Tom Horne

SV-PFD Operational Benefits

- **Enhance aircrew awareness for improved safety**
  - **Night ops**
  - **Instrument conditions**
  - **Mountainous terrain**
  - **Instrument approach**
  - **Landing runway identification**
  - **Unusual attitude awareness**
- **Symbology improvements**
- **Possible future operational credits**

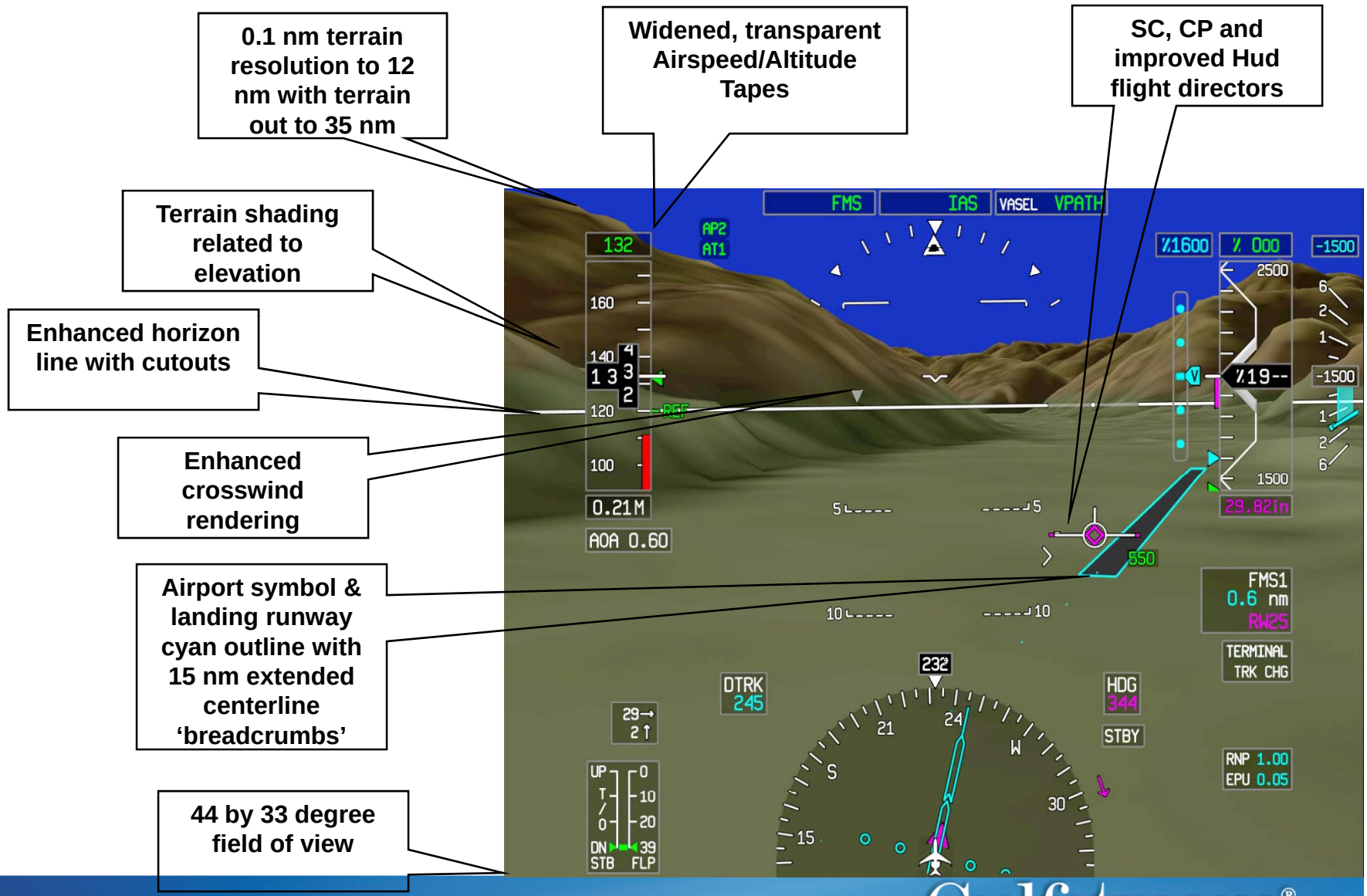
General Aviation Fatal Accident Statistics 2005

Accident Cause	% of total
Loss of Control (Takeoff)	24%
Approach & Landing	19%
Controlled Flight into Terrain	19%
Loss of Control (in flight)	18%
Loss of Control (Maneuvering)	11%
Midair	1%
Other	8%

SVS potentially helps up to 91% of fatal GA accident causes

Gulfstream

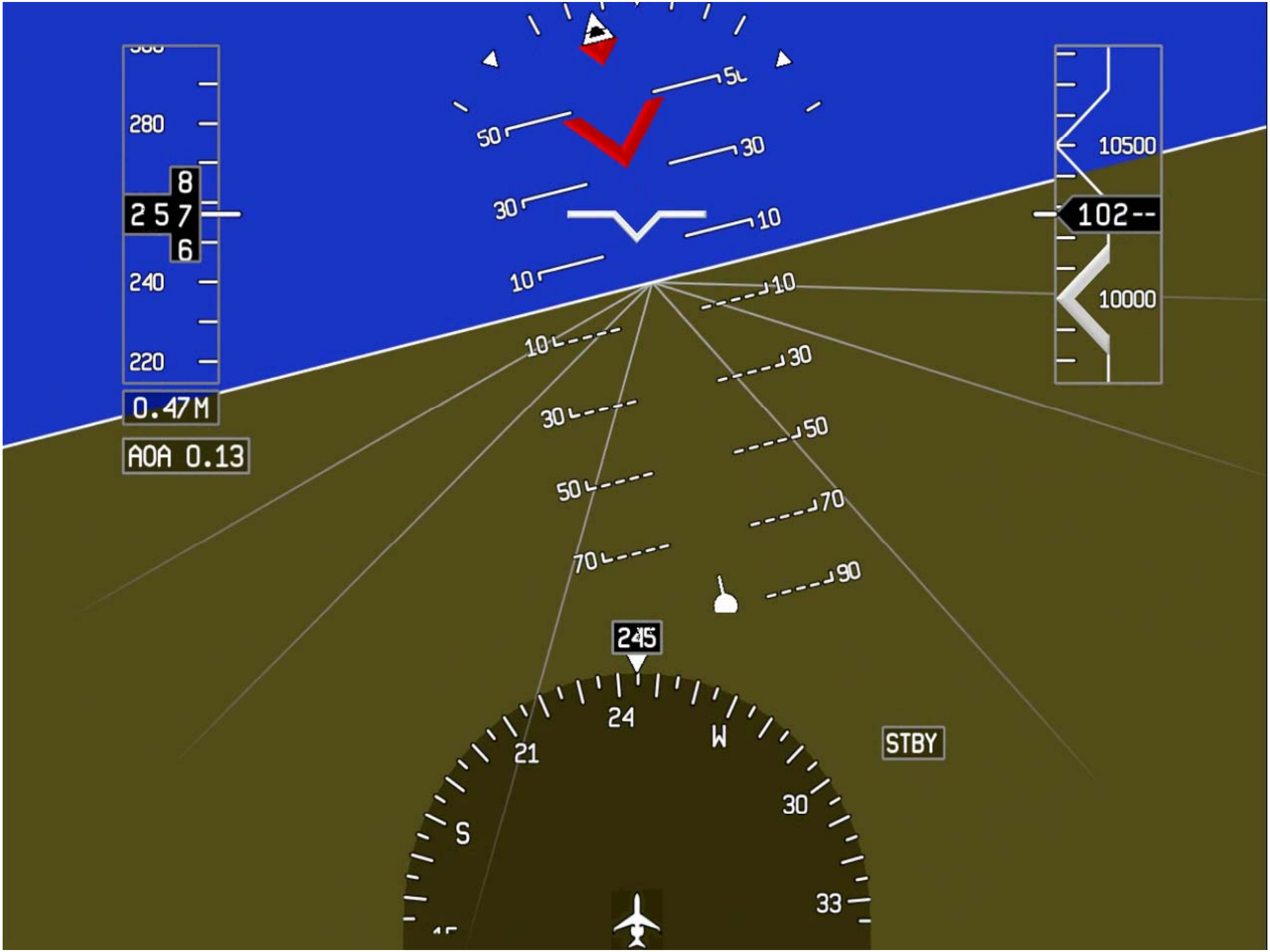
SV-PFD Features



Gulfstream®

SVS Operational Benefits

- ***Terrain***
  - ***Provides "Day, VFR" flight conditions***
- ***Flight Directors***
  - ***Allows standard or HUD type and improved precision***
- ***Crosswinds***
  - ***Ability to follow flight path in high crosswinds***
- ***Pitch/Roll***
  - ***Enhanced precision, like HUD***
  - ***Unusual attitude awareness***


280
257
240
220
0.47M
AOA 0.13
50
30
10
10500
10200
10000
245
24
21
W
S
30
33
STBY

SVS Operational Benefits

- *Landing Runway awareness*
  - *Highlight runway selected for approach*
  - *Show other runways*
- *Approach path deviation* awareness
  - *Glidepath and distance to runway awareness*
  - *Provides a "Time to go" intuitive cue*
- *Obstacle Awareness*

Gulfstream


200
300
280
240
F10
0.41M
AOA 0.29
1460
1800
1500
1000
29.96in
FMS1
4.0 nm
RW27
TERMINAL
MSG
243
DTRK
276
HDG
239
STBY
RNP 1.00
EPU 0.05
UP
DN
T
O
0
10
20
39
21
24
W
S
30
33

“One peek is worth a thousand cross checks”

Gulfstream®

Provides crews intuitive awareness to help prevent accidents

Affordability and Availability

Future Considerations

Mike Mena

Affordability – Enhanced Flight Vision Systems

- EFVS = HUD + EVS
- FAR Part 25
- Gulfstream EVS – Certified in 2001
  - Approximate Range: $800,000 to $1,200,000
- Bombardier EVS – Certified in 2006
- Dassault EVS – Certified in 2007
- FedEx MD-10 EVS – Certified in 2008
- Boeing BBJ EVS – Will Certify in 2008

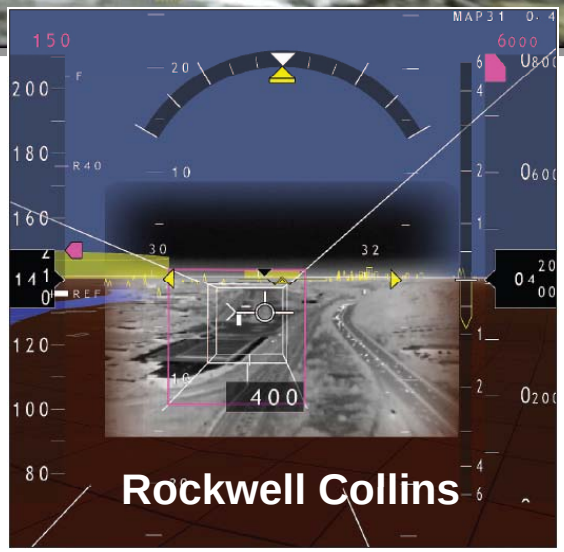
Affordability – Synthetic Vision Systems

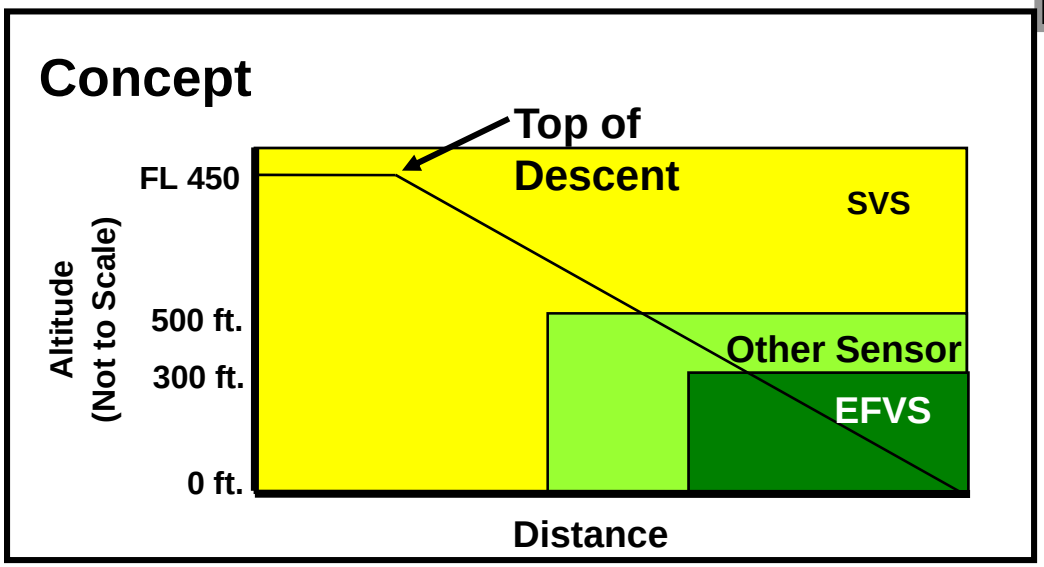
- **Range: $30,000 to $300,000**
- **Systems:**
  - **Chelton Flight System's 3D Synthetic Vision System**
    - **FAR Part 23 Supplemental Type Certificate**
  - **Garmin G-1000® Synthetic Vision System**
    - **FAR Part 23 Supplemental Type Certificate**
  - **Gulfstream SV-PFD**
    - **Based on Honeywell's Integrated Primary Flight Display (IPFD)**
    - **FAR Part 25 Amended Type Certificate for G350/G450/G500/G550**
  - **Universal's Vision-1™ System**
    - **FAR Part 23 and 25 Supplemental Type Certificates**

Pricing Appropriate Based on Model of Aircraft

The Future – Equivalent Visual Operations and Fusion of EFVS and SVS

- Equivalent Vision Operations – VFR-Like Tempo in Weather – The FAA's Next Gen Plan
- New FAA Regulations being developed to promote operational capabilities with Equivalent Vision
- Integration of EFVS and SVS with Fusion is the next logical progression
- Fusion will apply to EFVS and SVS with Head Up and Head Down Displays





Gulfstream®

EFVS and SVS Performance Can be Measured

- FAA regulations provide design criteria and performance measures
  - FAR 91.175
  - FAR 91.16
  - AC-120-28
- Performance measures include navigation performance, flight path accuracy

NEW EASA Operational and Airworthiness Criteria Under Development

Summary – The Value of Vision Based Technology

- **Reduces reliance on airport infrastructure**
- **Improves safety**
- **The new airspace requires it**
- **Opens the door for greater airport use**
- **Is expandable**

EFVS and SVS solutions are affordable and available to the Business Aviation Market

Vision Based Technology

Gulfstream

A GENERAL DYNAMICS COMPANY