Radio Navigation Aids
Flight Test Seminar

FLIGHT INSPECTION IN THE NEW MILLENNIUM

Change, Challenge, and Opportunity

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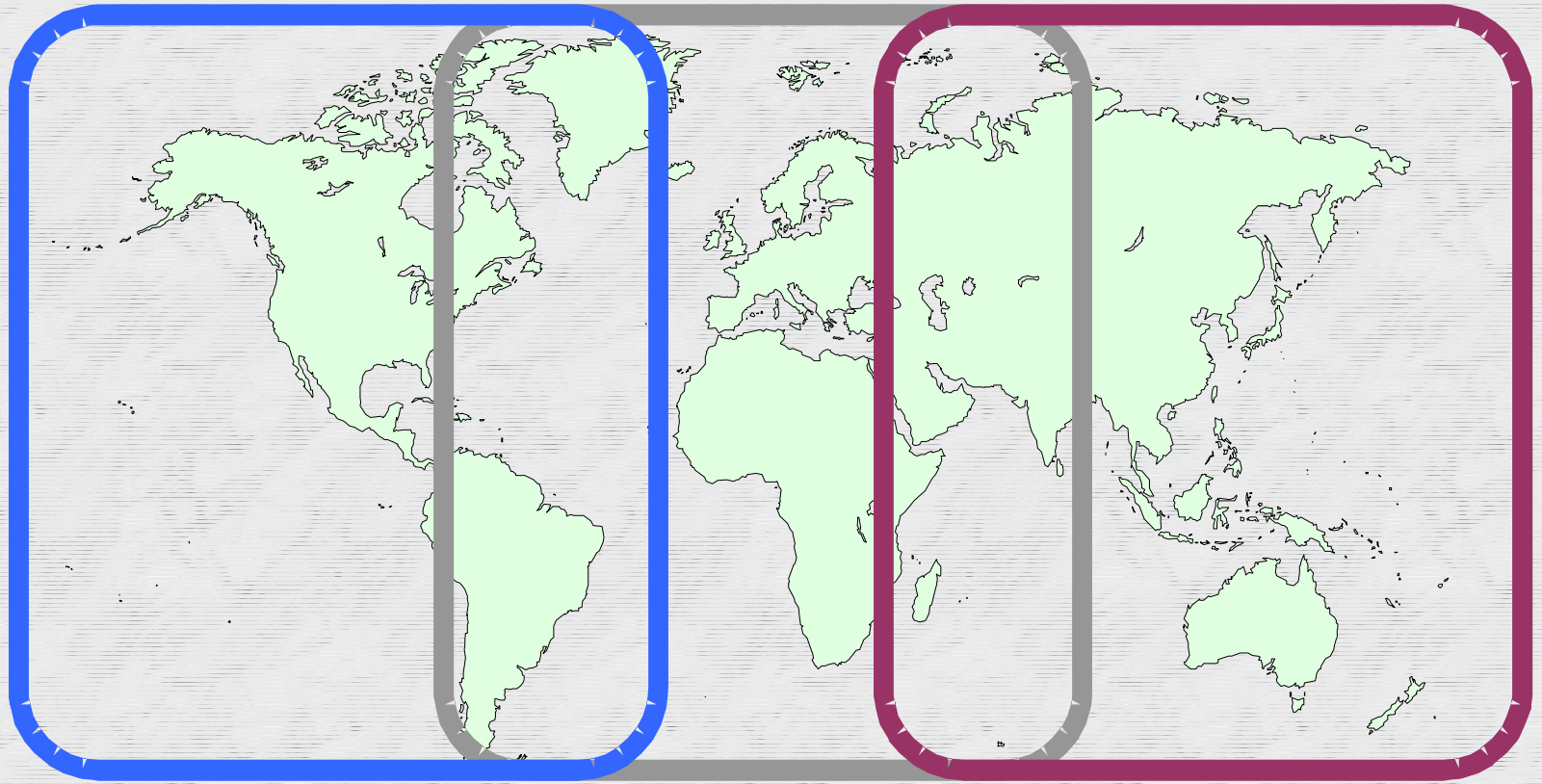
CHANGES

- Global Positioning system (GPS)
  - Concept and configuration developed in 1970s
  - 10 Block I SVs launched 1978-1985
  - Block II SVs began in 1985
  - Full Operational Capability in April 1995
- GLObal Navigation Satellite System (GLONASS)
  - Developed virtually at same time as GPS
  - First SV in orbit December 1982
  - Full development slowed by political and economic changes
- Galileo
  - European Union member states have agreed to build and operate
  - Currently in Program Definition Phase
  - Deployment to begin in 2006
  - Full Operational Capability in 2008

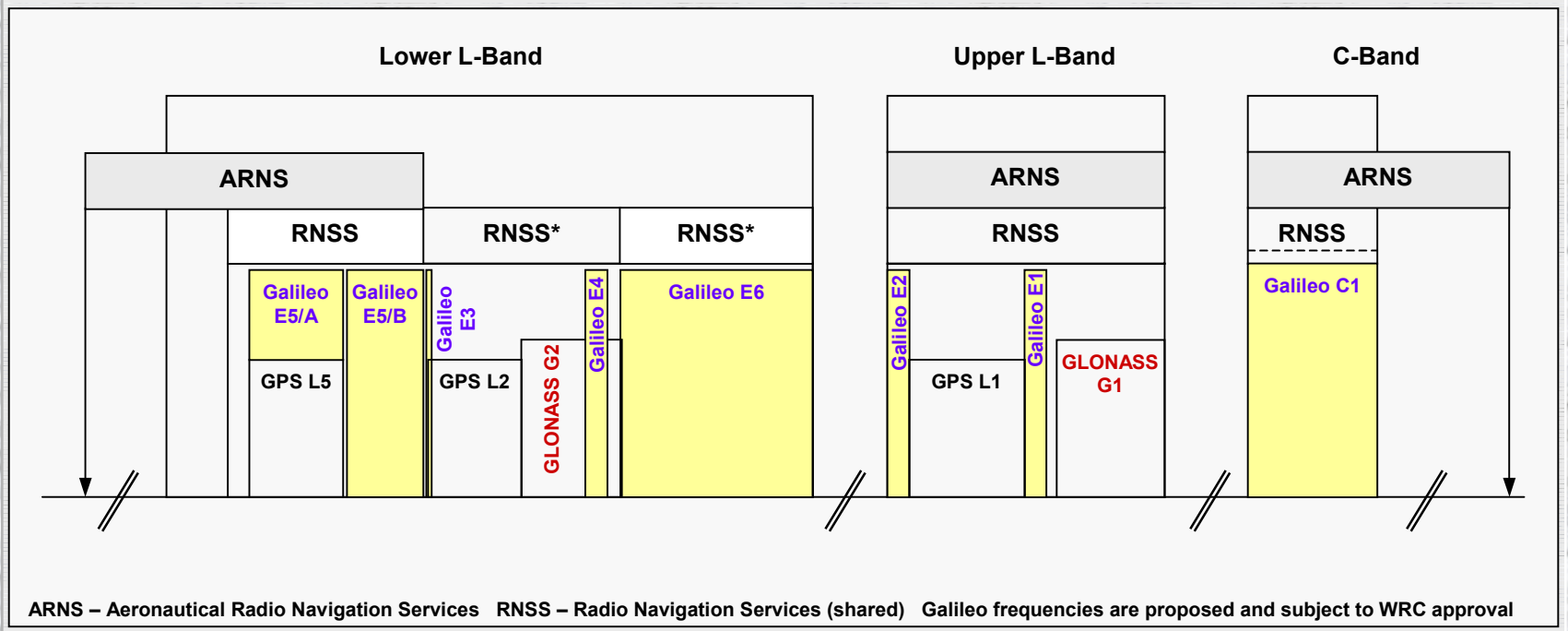
GLOBAL SYSTEMS

- **ICAO Global Systems**
  - CNS/ATM concept adopted in 1981
  - GNSS-1 based on GPS and GLONASS
  - GNSS-2 will include Galileo and new local augmentation systems
  - Each system provides 3-dimensional position, navigation, timing, and synchronization for safety, security, science, engineering and related applications
  - Each system has been established with an open architecture
  - New systems will provide interoperability/compatibility
- **Benefits of multiple independent constellations**
  - Sole-means positioning and navigation
  - Mitigates common-mode failures
  - Frequency diversity reduces interference susceptibility
  - Each system can support local and regional augmentation

GLOBAL SYSTEMS



ANTICIPATED GNSS SPECTRUM



AUGMENTATION SYSTEMS

- **ABAS – Aircraft-based Augmentation System**
  - Integrates GNSS information with information available onboard the aircraft
  - FDE
  - AAIM
  - RAIM
- **SBAS – Space-based Augmentation System**
  - Wide-area coverage
  - Aircraft receives augmentation information from satellite-based transmitter
  - Ground infrastructure – monitoring and processing
  - SBAS satellites – data relay from ground to aircraft
  - Aircraft receiver – determine tropospheric delay and apply correction data to improve performance
  - WAAS, MSAS, EGNOS

AUGMENTATION SYSTEMS

- GBAS – Ground-based Augmentation System
  - Aircraft within the coverage area will receive augmentation data from a ground-based VHF transmitter
  - Ground subsystem – provides approach data, corrections and integrity information for in-view satellites
  - Aircraft avionics – receives approach information and applies corrections
  - GBAS will provide precision landing minima to the Category III level
  - LAAS, UDS (WADS, RADS, and LADS)
- Eurofix
  - Integrated DGNSS and Loran-C
  - Corrections provided by additional modulation of Loran-C
  - DGNSS reference stations located at Loran-C facility
  - Loran-C remains independent

ADDITIONAL CHANGES

- **Surveillance**
  - Satellite-based PVT used for air traffic control and air-to-air situational awareness
  - Collision avoidance
  - Closely-spaced parallel approaches
  - ADS
- **Non-Changes**
  - Maintain and flight inspect traditional systems for 10 - 15 years
  - Advances in hardware and software have improved ground-based system reliability
  - Avionics Improvements (FMS, IRU, LNAV, VNAV, barometric altimetry, and RNP)

CHALLENGES

- **Role of Flight Inspection for GNSS**
  - Learning curve for satellite-based procedures in the U.S.
  - ICAO SARPs
  - TSE = NSE + FTE
  - NSE dependent on Control and User Segments
  - No Flight Inspection analysis of Signal-in-Space
  - FTE removed by AFIS
- **Augmentations – SBAS and GBAS**
  - Little effect on error allocation
  - Provide improvements in accuracy and integrity
- **Performance Monitoring**
  - Recommended by SARPs
  - Regions using GNSS provided by another State
  - Aid to accident/incident investigations
  - Anomaly analysis

GNSS FLIGHT INSPECTION ROLE

- **Ground-based Navigation Systems**
  - Signals generated in ground transmitter and radiated through elaborate phasing and antenna circuits
  - Monitoring accomplished using integral and near-field sensors
  - Guidance is based on modulation schemes recovered by the avionics relative to the aircraft position in the radiation pattern
- **GNSS Navigation**
  - Guidance is generated in the aircraft avionics based on satellite ranging and augmentation data
  - Avionics algorithms (DO-178B) determine real-time position, guidance, scaling, distance information, FDE, and integrity monitoring
  - Avionics are certified (TSO) through compliance with a comprehensive test and evaluation process

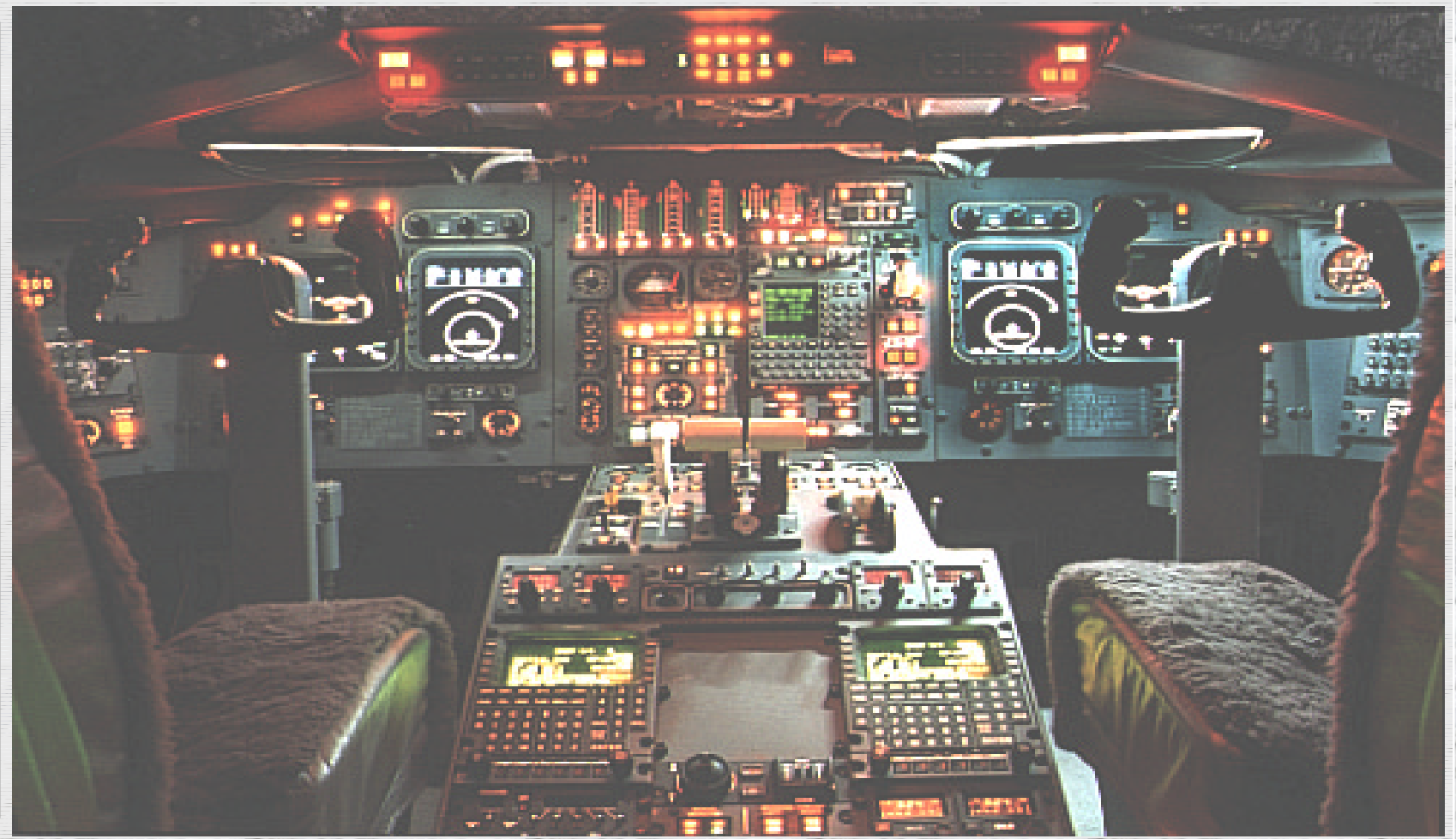
GNSS FLIGHT INSPECTION ROLE

- Flight Procedure Design Validation
  - Procedure accuracy dependent on geographic coordinates
  - ICAO Doc 9674, WGS-84 Manual provides guidance
  - Obstacle validation
  - Human factors
- New Approach Chart Design
  - Multiple Approach Minima (DA, MDA)
  - LNAV, VNAV, RNP
- GBAS Data Broadcast Coverage Analysis
  - Coverage and Signal Strength
- GNSS Interference Detection and Localization
  - Coordinated response
  - Multiple platforms (aircraft, ground vehicle, hand-held, and fixed monitoring)

OPPORTUNITIES

- **Flight Inspection Aircraft**
  - Cost Effective (determined by mission requirements)
  - Increased use of FMS (dual system)
  - IRU
  - Air-Ground Data Link for flight information and download of flight inspection data
- **Flight Inspection System**
  - Decreased size, weight and power requirements
  - Increased use of DSP and Sampling receivers
  - Use of RNP/ANP
  - Analysis software

FLIGHT INSPECTION AIRCRAFT



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  - Cost Effective (determined by mission requirements)
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- **Flight Inspection System**
  - Decreased size, weight and power requirements
  - Utilize modular - portable system
  - Increased use of DSP and Sampling receivers
  - Use of RNP/ANP
  - Analysis software

Automated Flight Inspection Systems