A Regulatory Perspective on Advanced Transportation Systems

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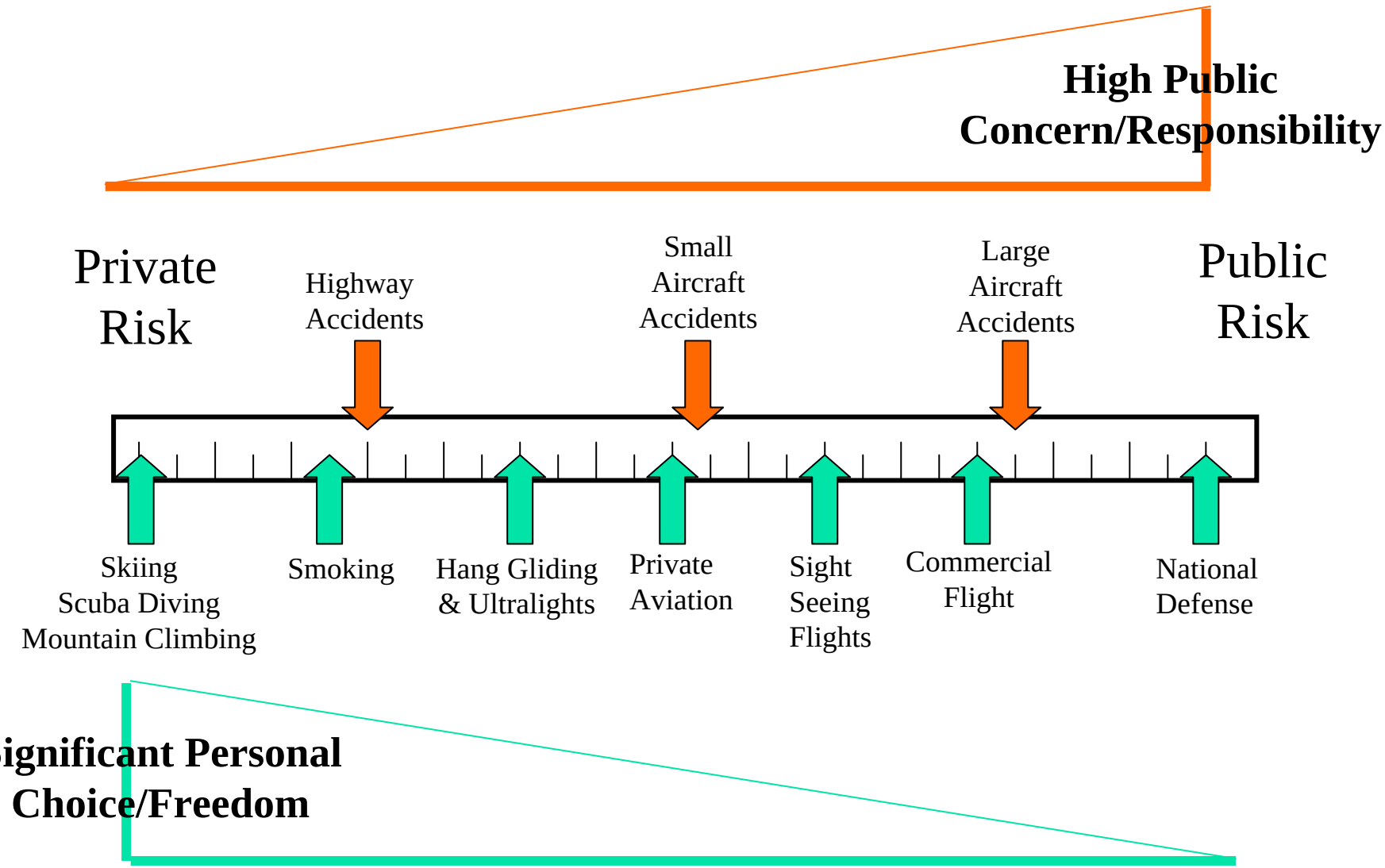
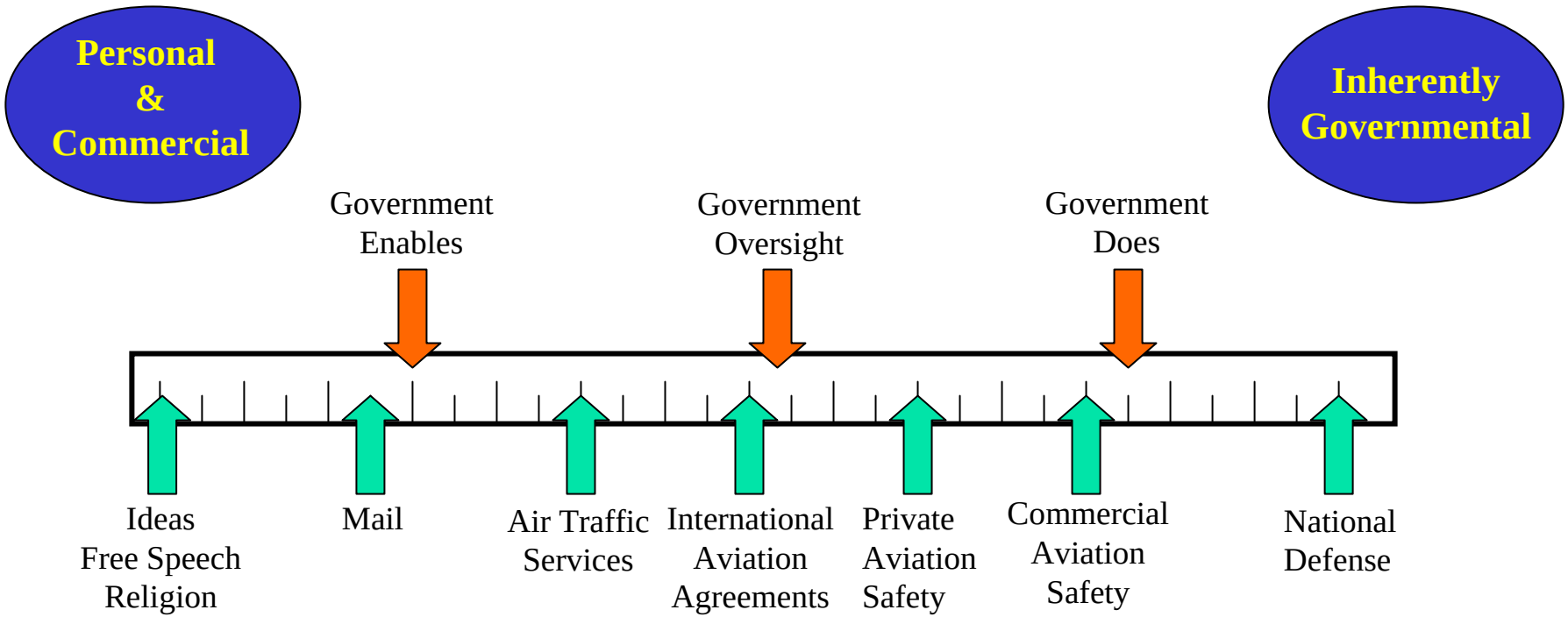
Outline

- Primer on Aviation Regulations
- Considerations for advanced transportation systems

“Personal” vs. “Public” Risk Assumption

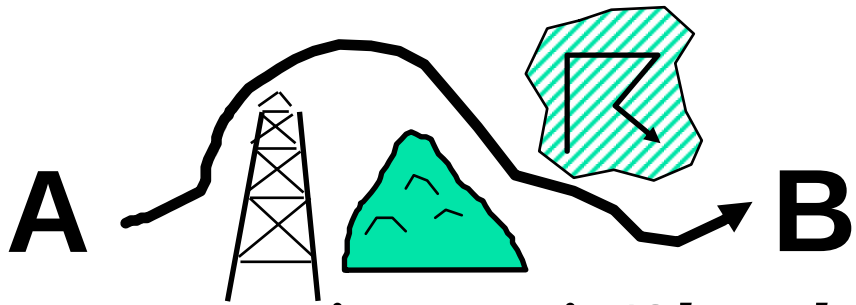


Governmental Role



Operations

Get from A to B, or back to A



Miss Terrain/Obstacles

$AC_{\#1}$ $AC_{\#2}$

Safe Aircraft to Aircraft Separation

Fundamental Governmental Aviation Responsibilities

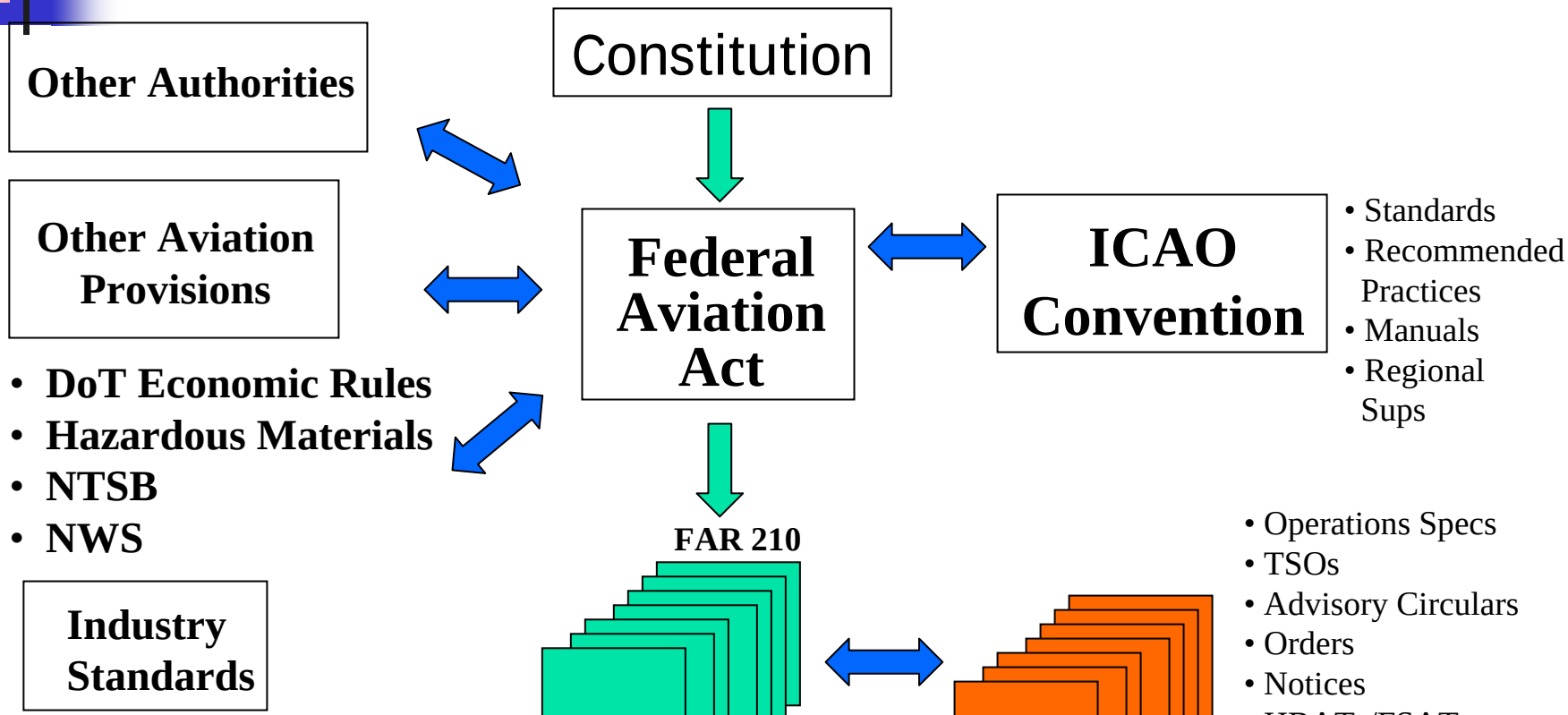
- Assure that aircraft don't fall on the public
- Assure the "highest level of safety" for public transportation;
- Assure at least a basic level of safety for other "certificated aircraft" passengers
- Assure that aircraft can satisfy safety related inter-aircraft responsibilities for mutual separation

In part, these functions are accomplished via some type of "certification"

Means to Accomplish Governmental Responsibility

- Certifying “stuff”-- air vehicles and supporting ground elements - if, and as necessary
- Establishing operating rules--”rules of the road”
- Providing or empowering certain capabilities (e.g., certain services, facilities, or capabilities agreed to by the aviation system users, or by the public)

Basis for Government 'Certification'



Federal Aviation Regulations (FARs)

Title 14 - Code of Federal Regulations, Aeronautics and Space
Chapter I - FAA, Department of Transportation

Subchapter A - Definitions
Part 1 - Definitions and Abbreviations
Subchapter B - Procedural Rules
Part 11 - General Rulemaking Procedures
Part 13 - Investigative and Enforcement Procedures
Part 14 - Rules Impl. the Equal Access to Justice Act of 1980
Part 15 - Adm Claims Under Federal Tort Claims Act
Part 16 - Rules for Fed-Assisted Airport Enforcement
Part 17 - Procedures for Protests and Contracts Disputes

FARs - (Cont.)

Subchapter C - Aircraft
Part 21 - Certification Procedures for Products and Parts
Part 23 – Airworthiness Stds: Norm, Utility, Acrobatic, Category Airplanes
Part 25 - Airworthiness Standards: Transport Category Airplanes
Part 27 - AW Standards: Normal Category Rotorcraft
Part 29 - AW Standards: Transport Category Rotorcraft
Part 31 - AW Standards: Manned Free Balloons
Part 33 - AW Standards: Aircraft Engines
Part 34 - Fuel Vent & Exhaust Emission Reqts for Turbine Powered Airplanes
Part 35 - Airworthiness Standards: Propellers
Part 36 - Noise Standards: Aircraft Type and AW Cert
Part 39 - Airworthiness Directives
Part 43 - Maint, Prev MX, Rebuilding, and Alteration
Part 45 - Identification and Registration Marking
Part 47 - Aircraft Registration
Part 49 - Recording of Aircraft Titles and Security Docs

FARs - (Cont.)

Subchapter D - Airmen

Part 61 - Cert: Pilots, Flight Instrs, and Ground Instrs

Part 63 - Certification: Flight Crewmembers other than Pilots

Part 65 - Cert: Airmen Other Than Flight Crewmembers

Part 67 - Medical Stds and Certification

Subchapter E - Airspace

Part 71 - Class A, B, C, D, E Airspace; Airways; etc

Part 73 - Special Use Airspace

Part 77 - Objects Affecting Navigable Airspace

Subchapter F - Air Traffic and General Operating Rules

Part 91 - General Operating and Flight Rules

Part 93 - Special Air Traffic Rules and Apt Traffic Patterns

Part 95 - IFR Altitudes

Part 97 - Standard Instrument Approach Procedures

Part 99 - Security Control of Air Traffic

FARs - (Cont.)

Part 101 - Moored Bal, Kites, UnM Rkts and UnM Free Bal
Part 103 - Ultralight Vehicles
Part 105 - Parachute Jumping
Part 107 - Airport Security
Part 108 - Airplane Operator Security
Part 109 - Indirect Air Carrier Security

Subchapter G - Air Car and Ops for Comp or Hire: Cert and Ops

Part 119 - Cert: Air Carriers and Commercial Operators
Part 121 - Operating Reqts: Domestic, Flag, and Sup Ops
Part 125 - Cert and Ops: AC 20 PAX or more or 6,000#
Part 127 - Removed.
Part 129 - Ops: Foreign Ops & U.S.-Reg AC in Common Carriage
Part 133 - Rotorcraft External Load Operations
Part 135 - Ops Reqts: Commuter and On Demand

FARs - (Cont.)

Part 137 - Agricultural Aircraft Operations

Part 139 - Cert and Ops: Land Apts Serv Air Carriers

Subchapter H - Schools and Other Certified Agencies

Part 141 - Pilot Schools

Part 142 - Training Centers

Part 143 - Removed - "Ground Instructors."

Part 145 - Repair Stations

Part 147 - Aviation Maintenance Technician Schools

Subchapter I - Airports

Part 150 - Airport Noise Compatibility Planning

Part 151 - Federal Aid to Airports

Part 152 - Airport Aid Program

Part 155 - Release of Apt Property from Disp Restrictions

Part 156 - State Block Grant Pilot Program

Part 157 - Notice of Const, Alter, Activ, and Deact of Aprts

FARs - (Cont.)

Part 158 - Passenger Facility Charges (PFCs)
Part 159 - Removed - National Capital Airports.
Part 161 - Notice/Apprvl of Apt Noise and Access Restrs
Part 169 - Exp of Fedl Funds Nonmil Apts or Nav Facil
Subchapter J - Navigational Facilities
Part 170 - Estab and Disct Crit for ATC Serv and Nav Facil
Part 171 - Non-Federal Navigation Facilities
Subchapter K - Administrative Regulations
Part 183 - Representatives of the Administrator
Part 185 - Testimony by Employees and Records in Legal
Part 187 - Fees
Part 189 - Use of FAA Communications System
Part 191 - Withholding Security Info from Disclosure
Subchapter L, M - [Reserved]
Subchapter N - War Risk Insurance
Part 198 - Aviation Insurance

Requirements, Guidance & Standards

Industry generated standards

Recommended Practices

Acceptable ways to show compliance

Advisory Material

Regulatory requirements

Aviation Regulations

Other Key Criteria/ Authorities

- ICAO (International Civil Aviation Organization)

Chicago Convention (‘44 - Treaty)

- Annex 1 - Licenses
- Annex 2 - Rules of the Air
- Annex 6 - Flight Operations
- Annex 10 - Navigation Facilities
- Procedures for Air Navigation -Ops, PANS-RAC,...
- Manuals (...All Weather Operations DOC9365-AN/910)
- Regional Supplements (Pacific - Doc 7030)

Joint Aviation Authorities/European Aviation Safety Agency/Eurocontrol (Europe)

Other Authorities or ATS Entities - 185+ Worldwide

Role of Regulations

- Minimum standards
- Protection (e.g., data disclosure)
- Incentives

Certification

- Approval and Authorization of:
  - Operations
  - Procedures
  - People
  - Processes
  - Aircraft
  - Facilities
  - Equipment

Rules – Some Key Differences

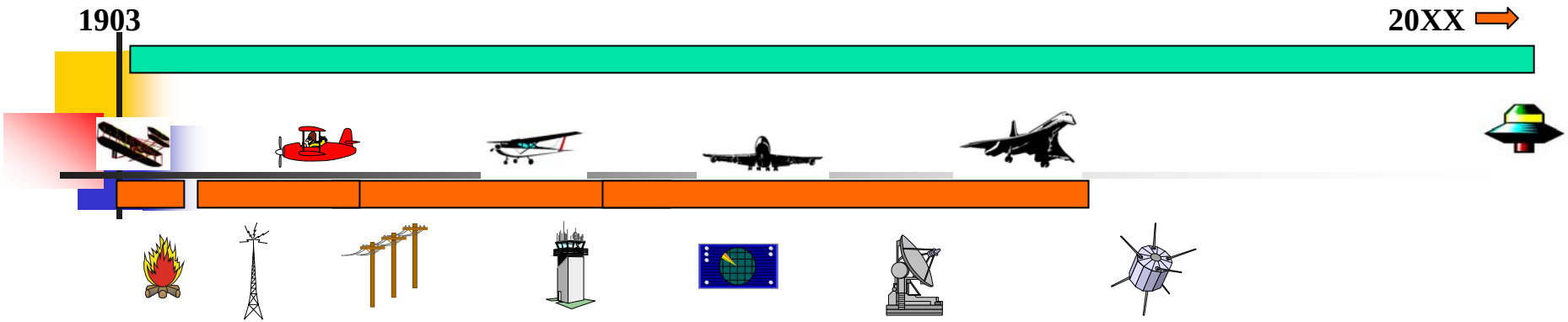
- Airworthiness certification (23, 25, 27, 29...) – Type certificates, Supplemental TCs, etc
  - Point in time
- Operations certification (91, 121, 135...)
  - Continuous applicability

Communication, Navigation, and Surveillance Rules Are Operating Rules

CNS Regulatory Basis

COM	NAVIGATION		SURV
91.123...	91.113...	121.345...	91.215
91.127...	91.175	121.349...	91.219
91.183...	91.189…	121.355...	91.221
91.205	91.205	121.389...	91.411
121.99	91.511...	121.445...	91.413
121.101	91.703...	121.567...	121.345...
121.119	97.1…	121.607...	121.356
121.345...	121.91...	121.651...	
121.607	121.189..	121 Append E/F/G…	
	121.305...	*Continuous Applicability*	

The Evolution of Aviation



Regulation:
- Safety
- Infrastructure
- National Viability

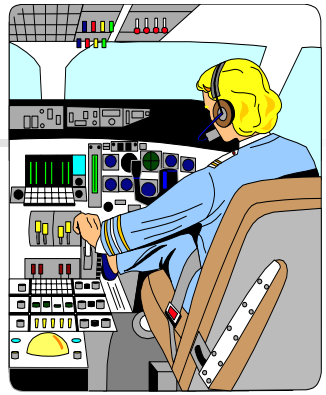
Operations:
- Business
- Pleasure
- Strategic

Change:
- Why?
- How Much?
- Justification!

Vision

Consensus

Operational Approval



Air Traffic Services Requirements

Aircraft Airworthiness Requirements

Aviation Services

Outline

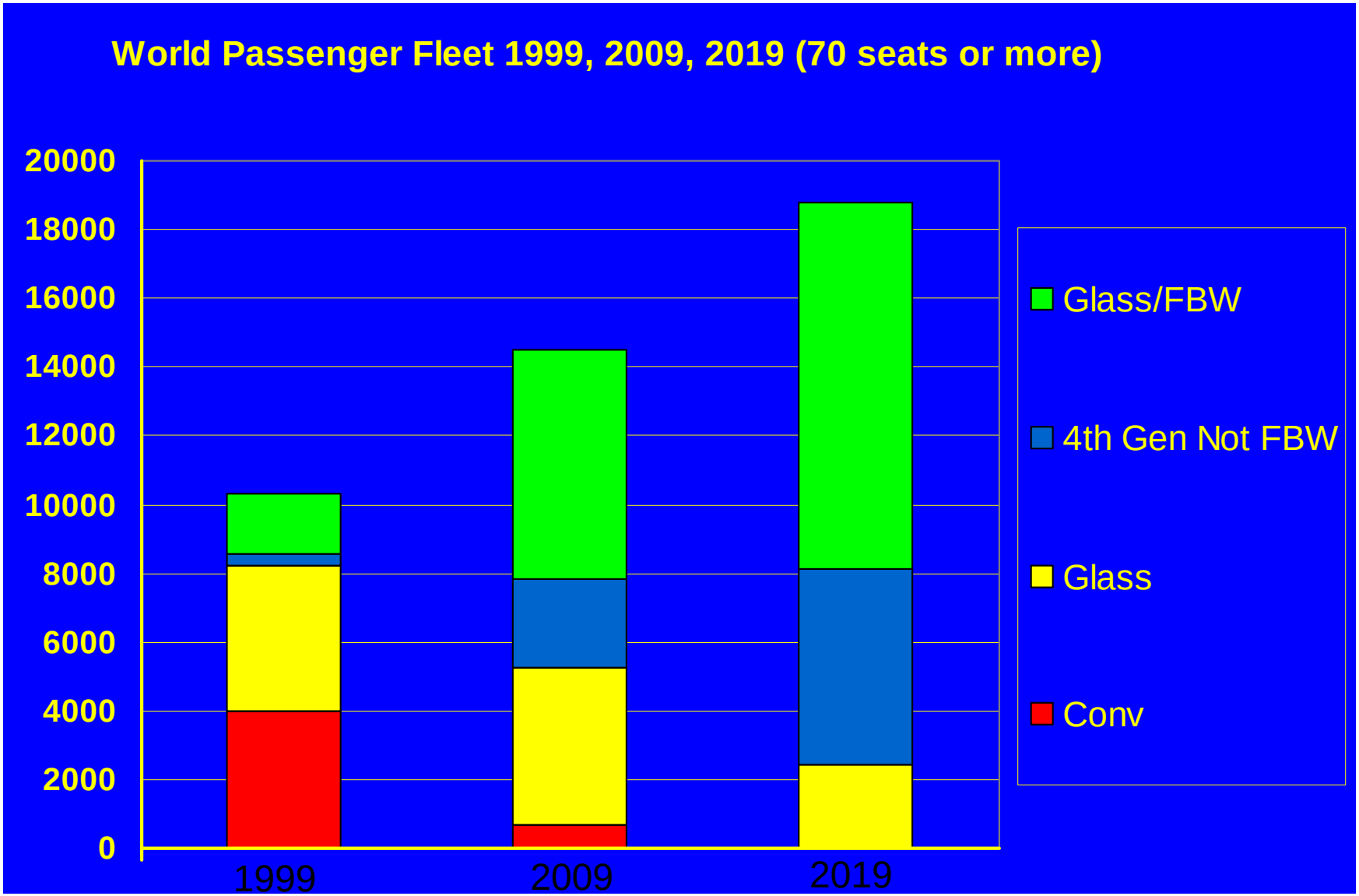
- Primer on Aviation Regulations
- Considerations for advanced transportation systems

Perspective

- Two thirds to three quarters of all accidents have human error cited as a primary factor
- Changes in technology will not alter this fact
- Changes in “technology” are coming fast and furious
- Every change brings risk

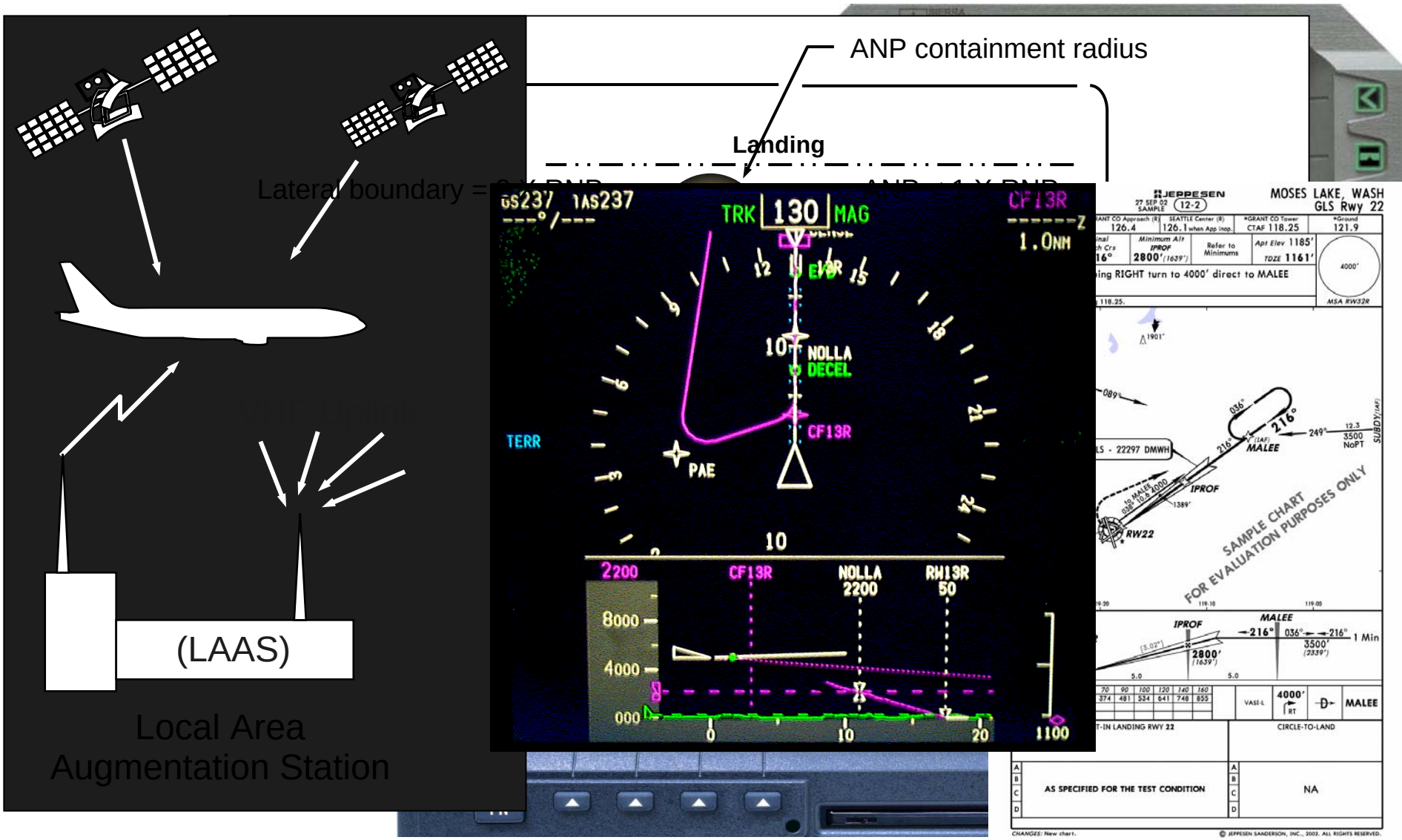
We will continue to rely on the human for safety, efficiency, and effectiveness

World Passenger Fleet Evolution



Courtesy: Airbus

Technology


ANP containment radius
Landing
Lateral boundary =
(LAAS)
Local Area
Augmentation Station
TRK 130 MAG
CF13R
1.0NM
NOLLA
DECEL
CF13R
TERR
PAE
2200
CF13R
NOLLA
2200
RW13R
50
8000
4000
000
1100
JEPPESEN
MOSES LAKE, WASH
GLS Rwy 22
MALEE
IPROF
SAMPLE CHART
FOR EVALUATION PURPOSES ONLY
AS SPECIFIED FOR THE TEST CONDITION
NA

“Technologies” (Partial list)

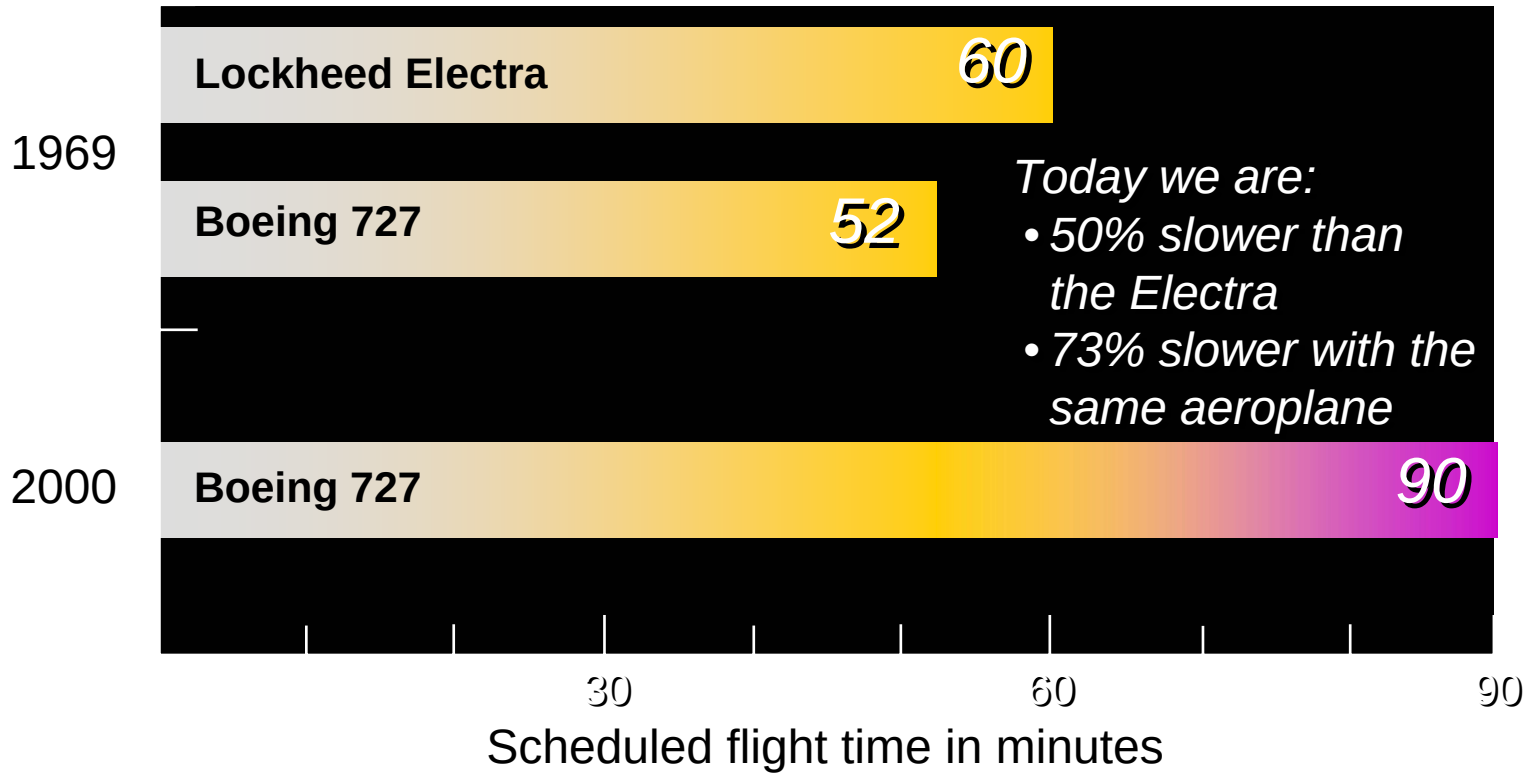
- Global Positioning System (GPS) Landing Systems (GLS)
- Ground-based/Space-based Augmentation Systems
- Data link communication
- RNP (Req’d Nav Perf)
- RCP (Req’d Comm Perf)
- RMP (Req’d Monitoring Perf)
- RNAV (Area Navigation)
- VNAV (Vertical Nav)
- ADS-B (Automatic Dependent Surveillance – Broadcast)
- Electronic Flight Bags
- Head-up Displays
- Head-mounted displays
- Microjets
- Enhanced Vision
- Synthetic Vision
- Weather displays
- Alerting for runway awareness
- RVSM (Reduced Vertical Separation)
- Turbulence detection systems
- Vertical Situation Displays
- Surface map displays
- Highway-in-the-sky displays
- Traffic displays
- Graphical flight planning
- Cursor control devices
- Multifunction controls
- Electronic checklists
- Electronic charts
- Electronic manuals
- Multifunction displays
- Night vision goggles
- Wireless technologies
- Security displays
- Unoccupied air vehicles

But Consider

- Every new system or technology brings additional tasks/decisions
- Maintaining current level of safety requires an effort
- Integration is critical – considering “stuff” (equipment, training, procedures) in isolation is not sufficient
- Technology advances and implementation don’t guarantee operational or safety benefit

Technology Advances do not Ensure Operational Capability

Washington D.C. (DCA) to New York (LGA)



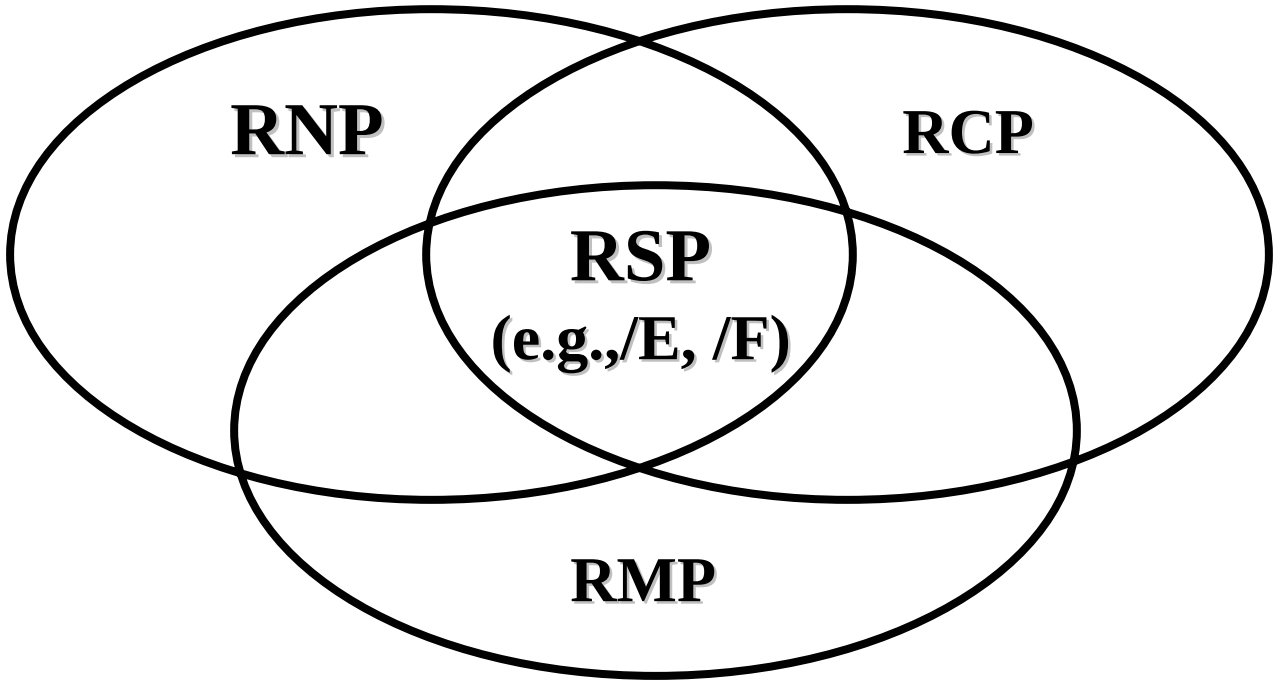
Courtesy Boeing

New Operational Concepts and Capabilities - examples

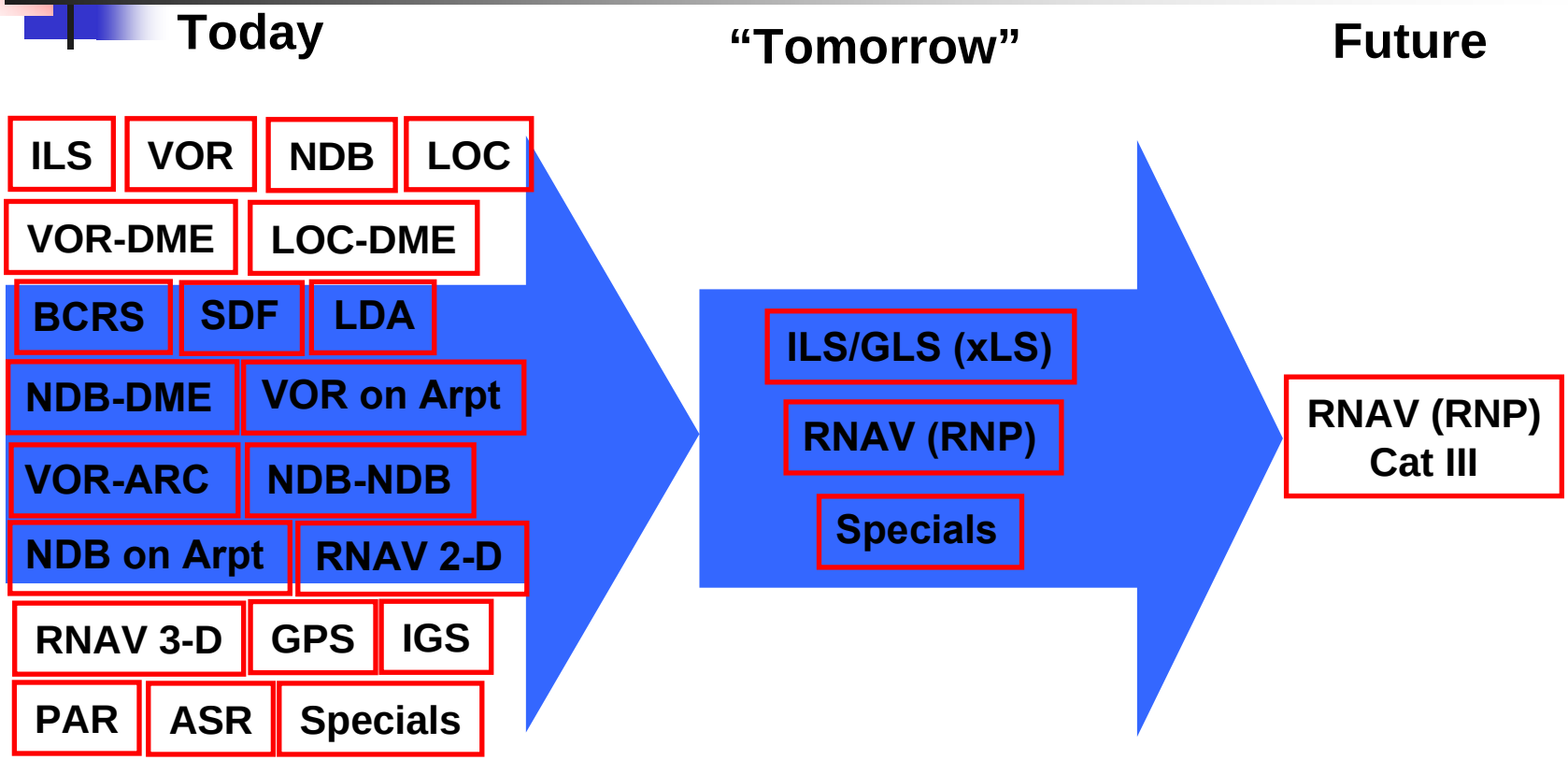
- Self separation
- RNP RNAV
- Closely spaced runway operation
- Communications
- ATM (conflict probe concept)
- ...

Goal: Performance-Based Airspace System

Required Navigation, Communication, Monitoring and System Performance



Goal - Allows Fewer Approach Types for an Operator



Opportunity for decreased training costs

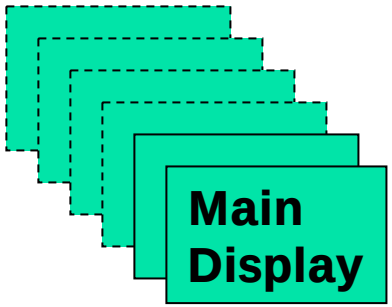
Application of RNP enables simplified and fewer approach types, enabling safety with reduced training costs.

Considerations

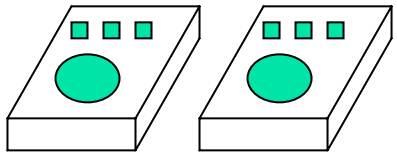
- Aviation is international
- Many manufacturers (airframe, avionics)
- One aircraft - many Air Traffic Mgt Systems
- One ATM – many aircraft capabilities
- Humans are a key element of safety in achieving certification “credit” in both airworthiness and operating rules

  e.g., autoland assumes pilot monitoring to permit disengagement as necessary

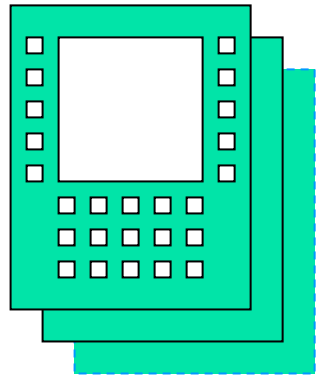
The new “Standard” Avionics Suite



- 2, 3, 4, 5, or 6 LCDs
- 8x8, 8x10, or 10x13



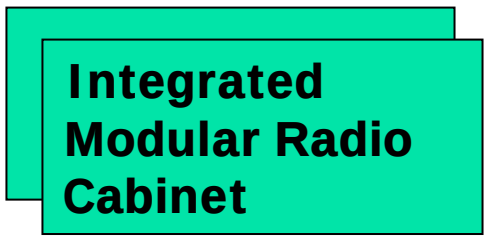
- **2 Cursor Control Devices (CCDs)**
- **Trackball, joystick, touchpad, or 2-axis button**
- **Multifunction knob**

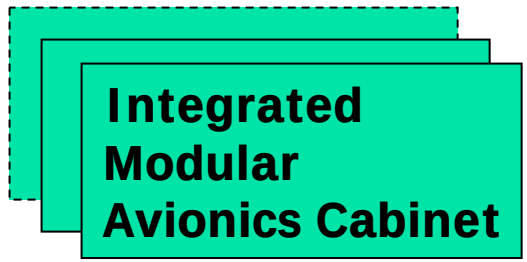


- **2 or 3 MCDUs (or multifunction keyboards)**

In the flight deck

In the electronics bay

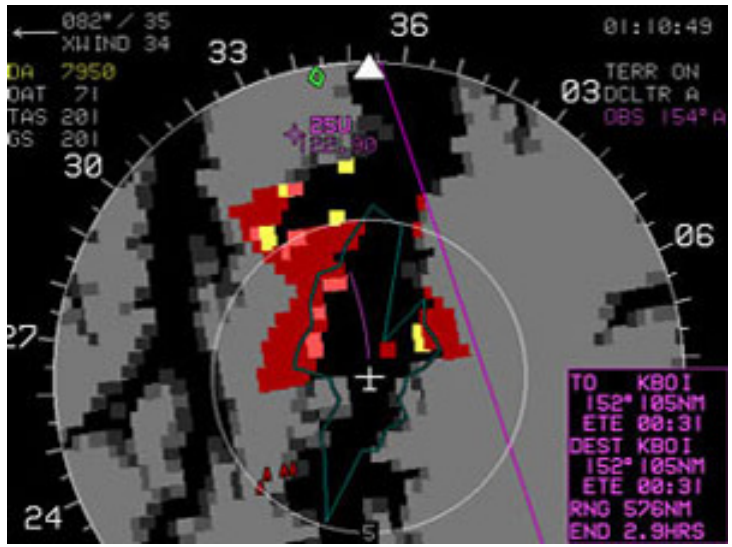


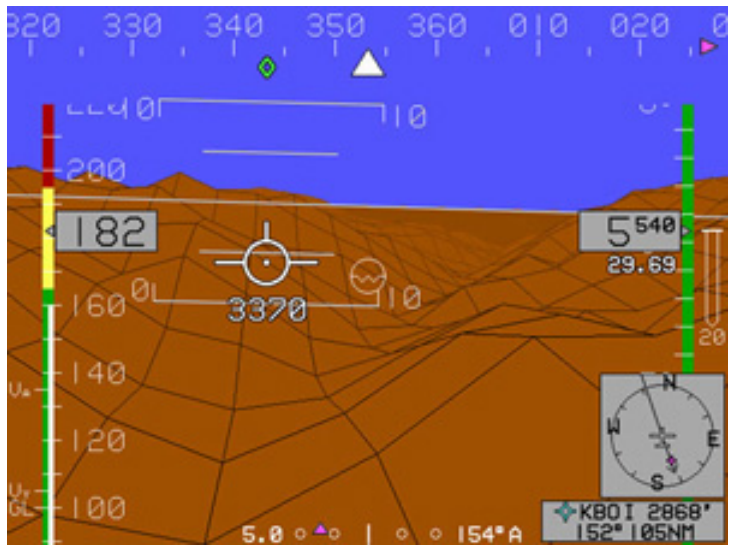


Dassault Falconjet

Electronic Flight Bag With Multiple-Hosted Applications

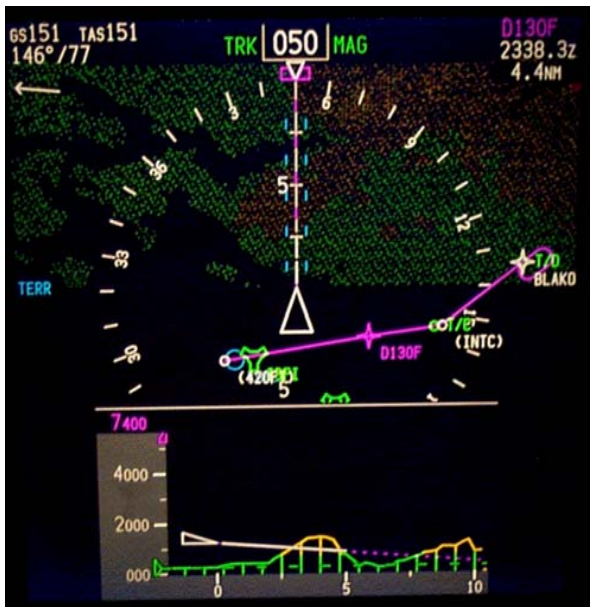
Capstone Phase II



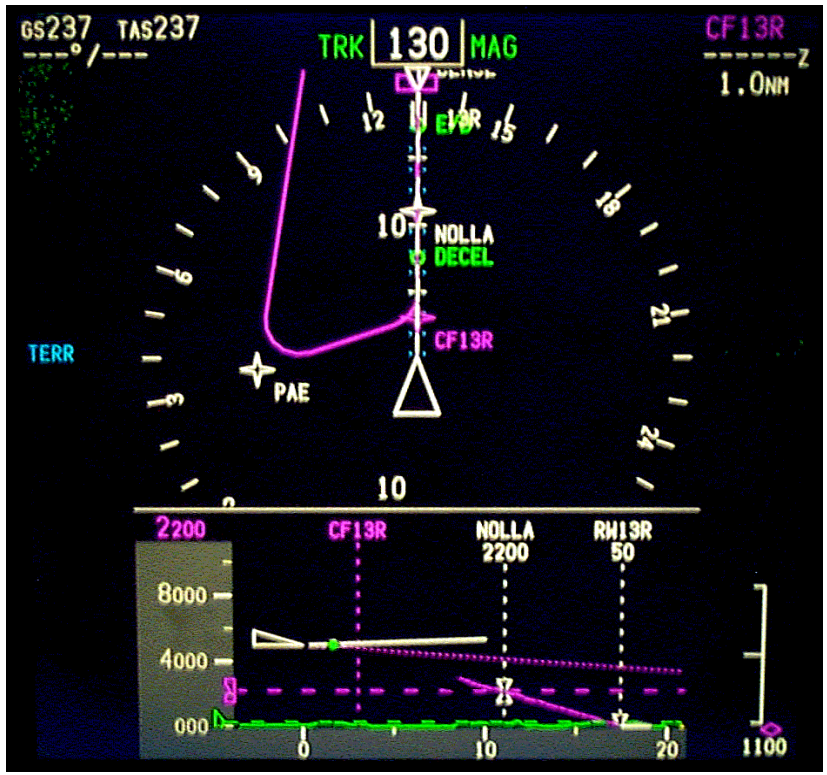


Boeing
Vertical Situation Display (VSD)

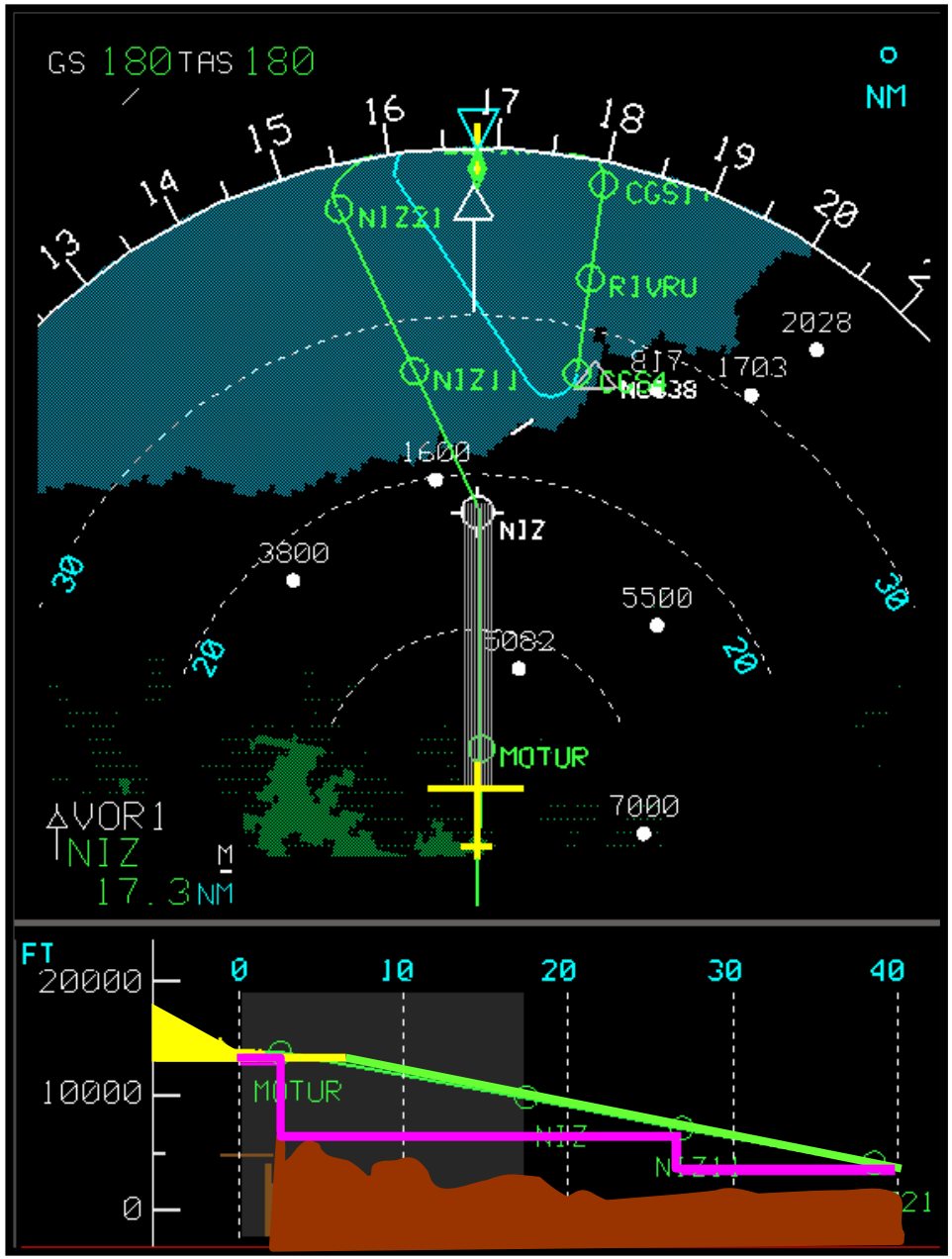
Controlled Flight Into Terrain (CFIT)



Landing



A380 Vertical Display



New 25.1329 Rule – Flight Guidance Systems (FGS)
(includes autopilot, flight director, autothrust)

25.1329 (a)

(a) Quick disengagement controls for the autopilot and autothrust functions must be provided for each pilot. The autopilot quick disengagement controls must be located on both control wheels (or equivalent). The autothrust quick disengagement controls must be located on the thrust control levers. Quick disengagement controls must be readily accessible to each pilot while operating the control wheel (or equivalent) and thrust control levers.

Autopilot / Autothrust Disengagement

New 25.1329 Rule

25.1329 (b)

b) The effects of a failure of the system to disengage the autopilot or autothrust functions when manually commanded by the pilot must be assessed in accordance with the requirements of §/JAR 25.1309

Failure to Disengage

New 25.1329 Rule

25.1329 (c)

(c) Engagement or switching of the flight guidance system, a mode, or a sensor must not produce a significant transient response affecting the control or flight path of the airplane.

FGS Engagement & Switching Transients

New 25.1329 Rule

25.1329 (d)

(d) Under normal conditions, the disengagement of any automatic control functions of a flight guidance system must not produce any significant transient response affecting the control or flight path of the airplane, nor require a significant force to be applied by the pilot to maintain the desired flight path.

Autopilot / Autothrottle Disengagement Transients

New 25.1329 Rule

25.1329 (e)

(e) Under other than normal conditions, transients affecting the control or flight path of the airplane resulting from the disengagement of any automatic control functions of a flight guidance system must not require exceptional piloting skill or strength to remain within, or recover to, the normal flight envelope.

Non-normal Conditions

New 25.1329 Rule

25.1329 (f)

(f) Command reference controls (e.g., heading select, vertical speed) must operate consistently with the criteria specified in §/JAR 25.777(b) and 25.779(a) for cockpit controls. The function and direction of motion of each control must be plainly indicated on, or adjacent to, each control if necessary to prevent inappropriate use or confusion.

Cockpit Controls

New 25.1329 Rule

25.1329 (g)

(g) Under any condition of flight appropriate to its use, the Flight Guidance System must not:

- produce unacceptable loads on the airplane (in accordance with §/JAR 25.302), or
- create hazardous deviations in the flight path.

This applies to both fault-free operation and in the event of a malfunction, and assumes that the pilot begins corrective action within a reasonable period of time

New 25.1329 Rule

25.1329 (h)

(h) When the flight guidance system is in use, a means must be provided to avoid excursions beyond an acceptable margin from the speed range of the normal flight envelope. If the aircraft experiences an excursion outside this range, the flight guidance system must not provide guidance or control to an unsafe speed.

Speed Protection

New 25.1329 Rule

25.1329 (i)

(i) The FGS functions, controls, indications, and alerts must be designed to minimize flight crew errors and confusion concerning the behavior and operation of the FGS. Means must be provided to indicate the current mode of operation, including any armed modes, transitions, and reversions. Selector switch position is not an acceptable means of indication. The controls and indications must be grouped and presented in a logical and consistent manner. The indications must be visible to each pilot under all expected lighting conditions.

Crew Awareness

New 25.1329 Rule

25.1329 (j)

(j) Following disengagement of the autopilot, a visual and aural warning must be provided to each pilot and be timely and distinct from all other cockpit warnings.

Autopilot Alerts

New 25.1329 Rule

25.1329 (k)

(k) Following disengagement of the autothrust function, a caution must be provided to each pilot.

Autothrust Alerts

New 25.1329 Rule

25.1329 (l)

(l) The autopilot must not create an unsafe condition when the flight crew applies an override force to the flight controls

Autopilot Override

New 25.1329 Rule

25.1329 (m)

(m) During autothrust operation, it must be possible for the flight crew to move the thrust levers without requiring excessive force. The autothrust response to flight crew override must not create an unsafe condition.

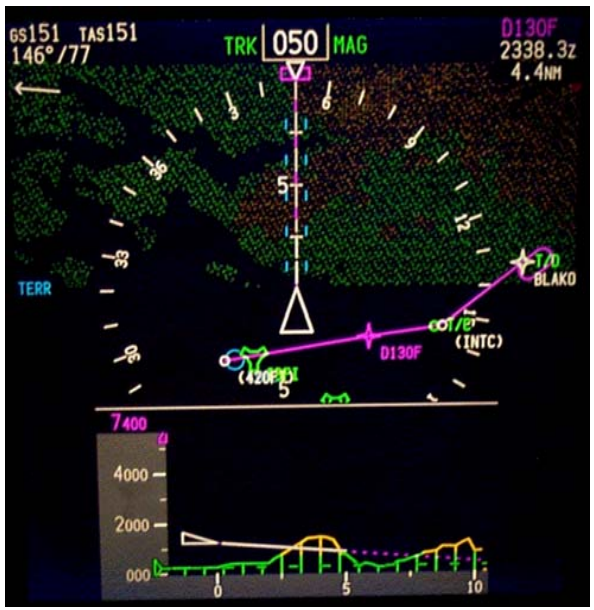
Autothrust Override

Operating Rules - Autoflight

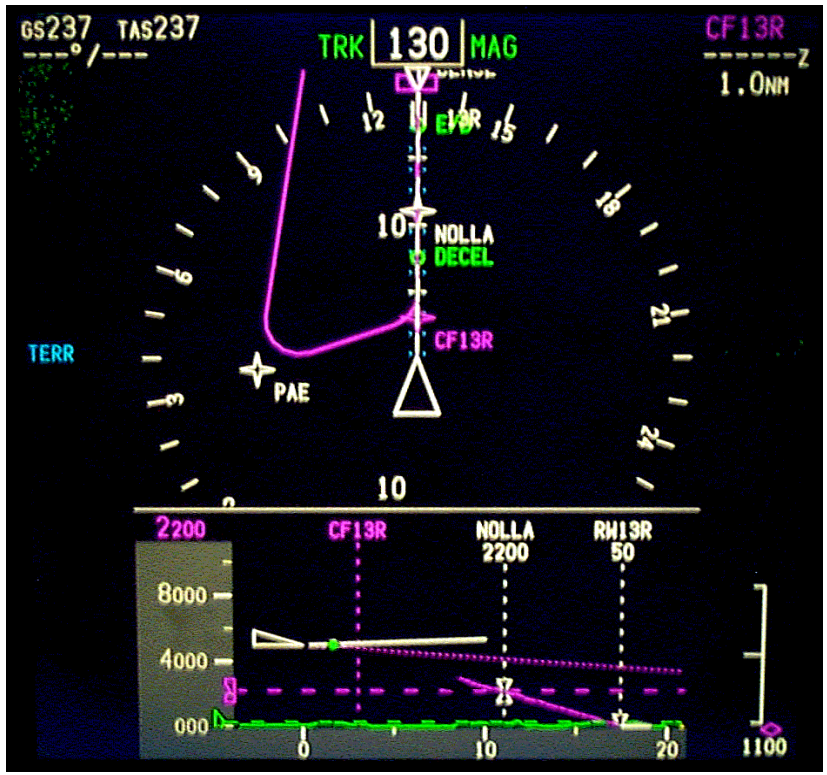
- 14 CFR Part 121.579 – minimum use height
- Handbook Bulletin on use of autopilot in icing
- Use of autopilot/autoland in low visibility conditions
- Order 8400.13A – describes how to get lower minima using a HUD

Boeing
Vertical Situation Display (VSD)

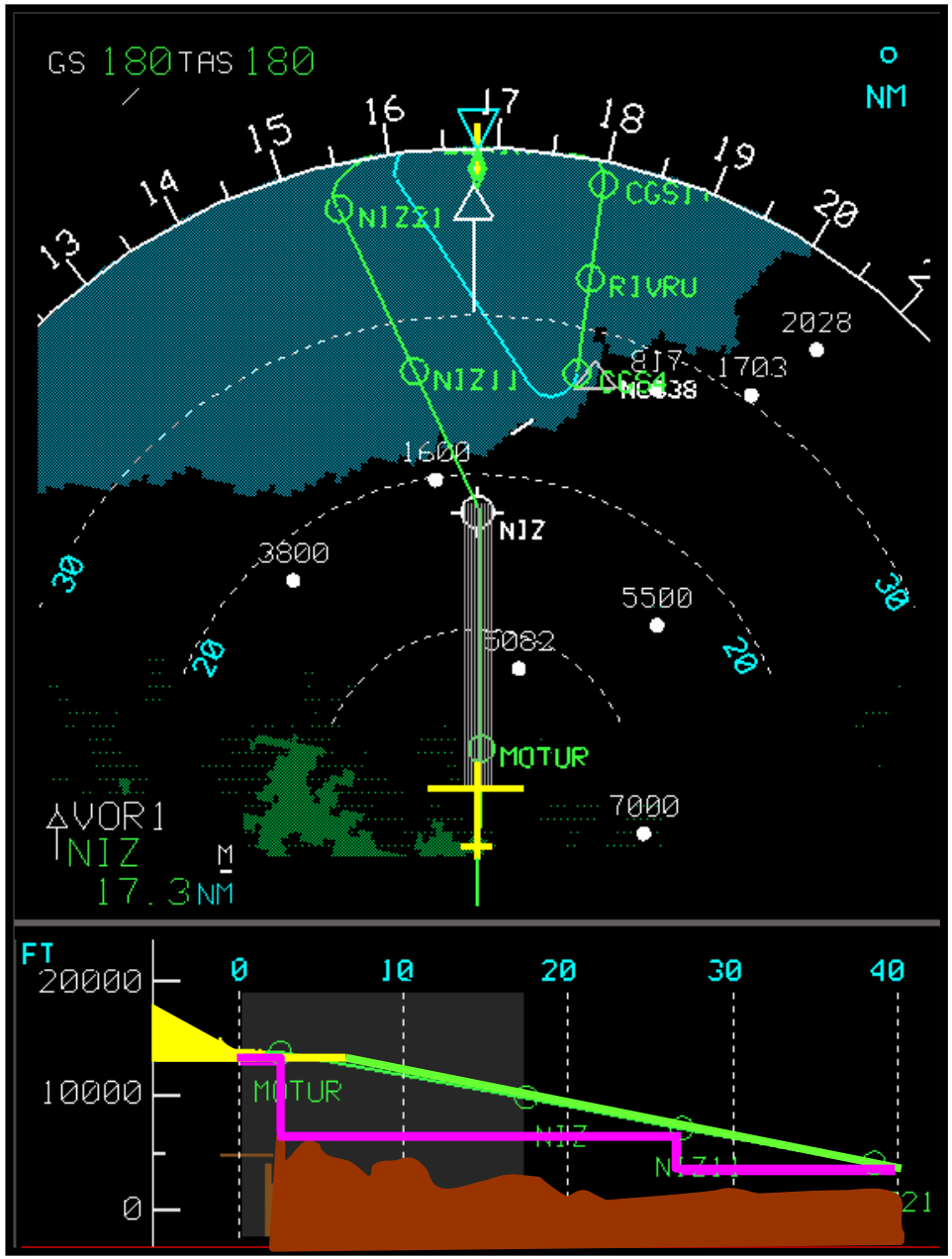
Controlled Flight Into Terrain (CFIT)



Landing



A380 Vertical Display



Closing Thoughts

- Aviation is global
- Operational requirements first, then technology
- Major changes to regulatory assumptions involve significant risk to the applicant
- Appropriately addressing the human is a key to success
- The transition is a major challenge
- The “Technical 10%” rule