Use of Supplemental Oxygen

TIME TO INCREASE PUBLIC SAFETY

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Why it's an industry issue!

- Adoption of SMS, threat & error management
- Focus on professionalism
- Business aircraft flying higher for longer periods
- Use of emergency equipment for normal flight operations

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Agenda

- Operational hazards of complying with FAR 91.211
  – Rick Miller, Merck
- Aircraft certification technical review
  – John Salamankas, Gulfstream
- History of FAR 91.211
  – Doug Carr, NBAA

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Background
The Rules

- 14 CFR 91.211
- EU-OPS 1
- EASA-OPS
- ICAO Annex 6

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FAR 91.211 (b)(1)(ii)

- Clearly written/understood
- Commonly/intentionally ignored

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EU-OPS 1

- Based on Cabin Altitude

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EASA-OPS

- Will soon replace EU-OPS
- No change to EU-OPS 1 O_2 Mask Usage

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ICAO Annex 6

- The Same O2 Mask Usage Rules as EU-OPS 1

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Safety Management

- Identification of the Hazard(s)
- Risk assessment
  - Severity of the hazard
  - Probability of an occurrence
  - Tolerability of its effects
- Eliminate, Mitigate, or Accept

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FAR 91.211(b)(1)(ii)
The Hazard

- Hypoxia due to Depressurization
- Explosive, Rapid, or Slow
- Rapid Depressurization Above 41,000 ft.
  - 9 – 12 seconds EPT

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FAR 91.211(b)(1)(ii) Non-Compliance

- Why are otherwise compliant and disciplined professional pilots choosing to ignore FAR 91.211?
- Why are the compliant pilots frustrated with the current regulation?
- Why aren't the FAA and NTSB addressing this situation?

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Risk Assessment

- Severity of the Hazard
- Probability of an Occurrence
- Tolerability of Its Effects

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FAR 91.211(b)(1)(ii) Severity of the Hazard

- Unmitigated Depressurization Event is Categorized as Catastrophic

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FAR 91.211(b)(1)(ii) Probability

- Unlikely or Highly Unlikely
  - Based on an explosive or rapid decompression event

FAR 91.211(b)(1)(ii) Tolerability of Its Effects

- Highly Unlikely/Catastrophic
  - = Acceptable Risk
- Unlikely/Catastrophic
  - = Acceptable with Mitigation Risk

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Hazards Caused by FAR 91.211 Compliance

- Fatigue
- CRM Interference
- Vision Interference
- Oxygen Depletion
- Oxygen Toxicity
- Unsanitary Health Risks
- Untimely Wear
- Quick-donning Feature Negated

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Compliance Hazards
Fatigue

- Mask not made for long duration use
- Comfort feature marginally effective

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Compliance Hazards
CRM Interference

- Impaired communication
- Pilot Wearing Mask is Effectively Isolated

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Compliance Hazards
Vision Interference

- Mask interferes with glasses

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Compliance Hazards
Oxygen Depletion

- Oxygen is consumed in NORMAL setting
- Translation from psi to time/distance
- Replenishment challenges at foreign locations

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Compliance Hazards
Oxygen Toxicity

- More time now spent breathing oxygen
- Bronchial irritation

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Compliance Hazards
Unsanitary Health Risks

- Difficult to effectively clean
- Hose cannot be cleaned

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Compliance Hazards
Untimely Wear

- Designed for emergency use

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Compliance Hazards
Quick-donning Negated

- Not easily re-stowed after routine use
- Unsecured mask technique

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Mitigation

- Requires Understanding
- Reduces Probability and/or Severity
- Is not considered permanent

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Mitigation Options

- Ignore FAR 91.211
- Change FAR 91.211
- Modify Oxygen System
- Petition for Exemption

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Mitigation Options
Ignore FAR 91.211

- Poor airmanship
- Normalization of deviance culture

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Mitigation Options
Change FAR 91.211

- Highly challenging option
- Harmonize with ICAO Annex 6
- Possibility to include additional mitigation
  - Training requirements
  - Equipment requirements

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Mitigation Options
Modify Oxygen System

- Fitted military style masks
- Segregated emergency system

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Mitigation Options
Petition for Exemption

- Common prior to 1986
- No successful exemptions in 28 years
- No applications based on SMS risk analysis

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Transport Aircraft Certification to 51,000

- John Salamankas
  - Chief Production Test Pilot
  - Gulfstream Aerospace

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Overview

- Presenter
- Purpose
- Certification
- Production
- Continued Operational Safety
- Perspective

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Purpose

- Requirements to certify up to 51,000 feet
- Same as to lower altitudes
- Except
  - Gets harder to comply
  - “Special Conditions”
- FAR’s 91, 43, and 135 govern most corporate jets
- FAR’s 21 and 25 define certification and production requirements
  - Widely unknown in the operational world
  - Useful and important to us today

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Certification

- FAR 25 - Airworthiness Standards: Transport Category Airplanes
- Assures safety through rigorous design, construction, and test requirements
- Certification process
  - Notification to FAA
  - Certification Basis established
  - Manufacturer's testing

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Certification

- TIA – Type inspection Authorization
- FAA Flight Test
- Reports
- Type Certificate

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Certification

- Safety Analysis required all for systems and components (AC 25.1309)
- MINOR (Nonessential)
  - Failure would not significantly reduce safety
  - Involve crew actions well within their capabilities
  - May be probable (1.E-5 or greater)

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Certification

- MAJOR (Essential)
  - Would reduce capability of the airplane, or the ability of crew to cope with condition
    - Significant reduction in safety margins
    - Significant increase in crew workload
    - Physical stress, discomfort to occupants
    - Crew may not be relied on to perform tasks accurately or completely
  - Must be improbable (1.E-5 and 1.E-9)

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Certification

- CATASTROPHIC (Critical)
  - Failure condition which would prevent continued safe flight and landing
  - Must be extremely improbable (1.E-9 or less)

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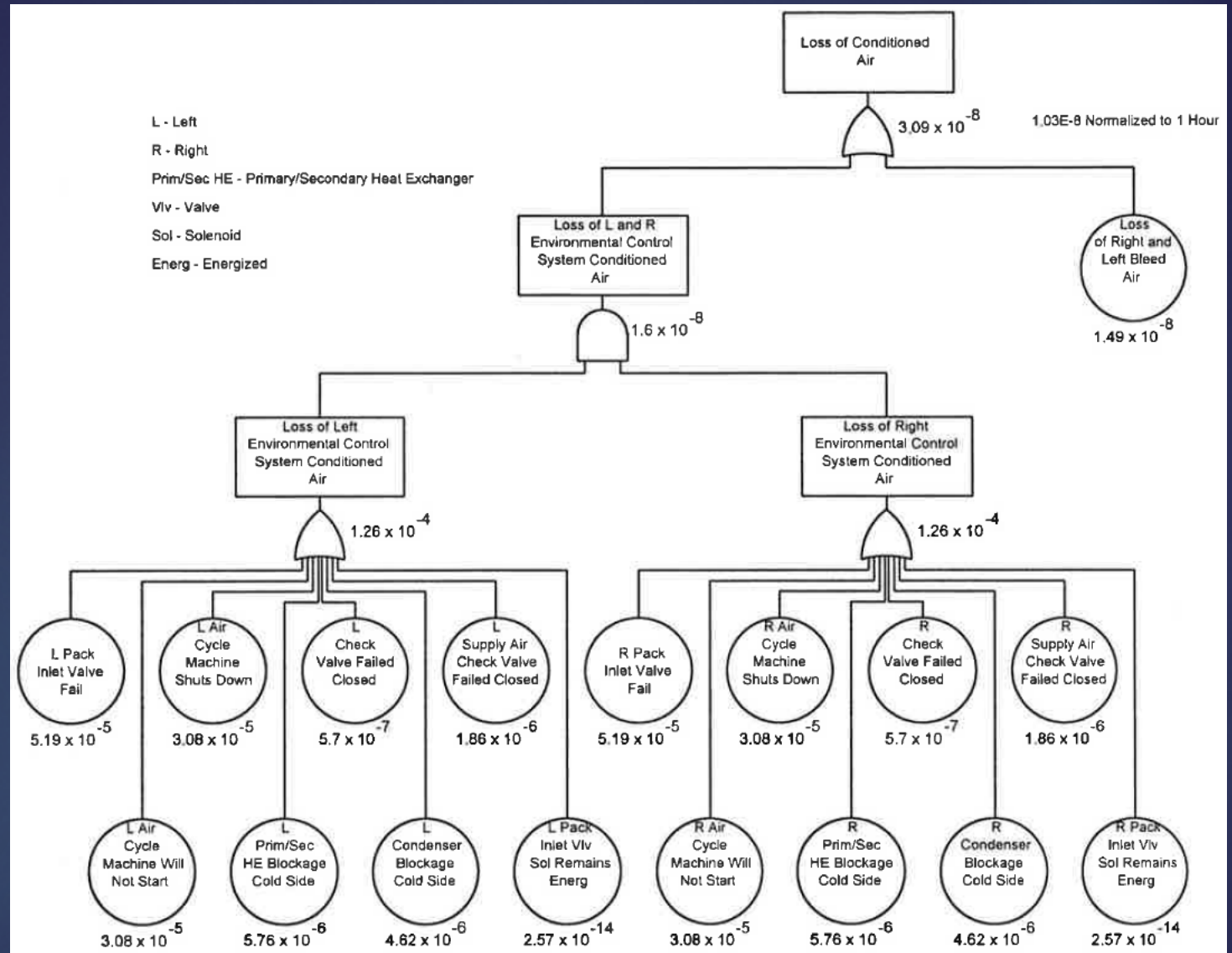

Fault Tree 3.1 Loss of Conditioned air

Certification

- Tests are thorough and demanding
- Demonstrate satisfactory system operation throughout the flight envelope
  - Includes failure conditions
- Flying qualities require demonstrations outside the approved flight envelope
  - Flutter requires 53,000 ft, 400 knots
  - Vmc

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Certification

- Examples of required demonstrations
  - Natural icing and stalls
  - Smoke evacuation
  - Maximum brake energy
  - Electrical loads/component cooling
  - Hot weather/fuel
  - Quick relights
  - Use of rudder

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Certification

- 25.365 Pressurized Compartment Loads
  - Structure withstand pressure differential loads of 1.33 x max pressure relief valve setting for operation up to 45,000 ft.
  - 1.67 x max relief valve setting for approval above 45,000 ft. up to 51,000 ft.
  - At any altitude, structure withstand penetration by a portion of a disintegrating engine

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Certification

- 25.571 Damage – tolerance and fatigue evaluation of structure
  - Strength, detail design, and fabrication must show catastrophic failure due to fatigue, corrosion, manufacturing defects, or accidental damage will be avoided throughout the operational life of the airplane

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Certification

- 25.775 Windshields and windows
  - Design in pressurized airplanes must be based on factors peculiar to high altitude operation
    - Continuous and cyclic pressurization loadings
    - Effects of temperatures and temperature differentials

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Certification

- 25.841 Pressurized cabins
  - Certification above 25,000 ft.
    - Any probable pressurization failure cannot expose occupants to cabin altitudes above 15,000 ft.
    - Decompression from any failure not shown to be extremely improbable cannot expose occupants
      - 25,000 ft. for more than 2 minutes
      - 40,000 ft. for any duration
  - Dual redundant systems and warnings

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Certification

- 25.1438 Pressurization and pneumatic systems
  - Pressurization system elements must be burst pressure tested to 2.0 x max normal operating pressure
  - Pneumatic system elements 3.0 x normal pressure

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Certification

- 25.1441 Oxygen equipment and supply
  - Oxygen equipment and flow rate must be approved if requesting certification above 40,000 ft.
- 25.1443 Minimum mass flow of supplemental oxygen
  - Cabin altitude based requirements for crew and passenger system

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Production

- FAR 21 Certification procedures for products and parts
  - Design approvals
  - Production approvals
  - Airworthiness certificates
  - Procedural requirements

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Production

- 21.16 Special conditions
  - If the FAA finds airworthiness regulations do not contain adequate or appropriate safety standards because of a novel or unusual design feature they may prescribe special conditions for the product
  - Contain safety standards necessary to establish a level of safety equivalent to that established in the regulations

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Production

- Special Condition: Gulfstream V, High Altitude Operation
  - Pressure vessel integrity
  - Ventilation
  - Air conditioning
  - Pressurization
    - Dual engine out emergency descent
      - 17 second recognition time from cabin altitude warning
  - Oxygen equipment

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Production

- 21.123 Production under type certificate
- 21.127 Tests: aircraft
- 21.135 Organization
- 21.137 Quality system
  - Data control
  - Document control
  - Supplier control
  - Manufacturing process control

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Continued Operational Safety

- FAR 21.3 Reporting of failures malfunctions, and defects
  - Type certificate holder must report certain failures, malfunctions, and defects after the product leaves its quality system
  - “21.3 plus” includes cabin altitude above 14,000 ft. or mask deployment.

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Perspective

- Evolutionary increase in safety
  - Knowledge
  - Manufacturing technology
  - Materials
- Airworthiness standards part of evolution
  - Constantly raising the bar
- Technology and automation used to reduce risk
  - Emergency Descent Mode of autopilot

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Perspective

- Certification rules have made modern jet transports safer than ever
- Operating rules should recognize the improvement

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FAR 91.211 – A Quick History

- CAB first proposed supplemental oxygen requirements for Part 91 in 1967
- Rule was codified as Part 91.32 on June 17, 1970
- Commercial operations faced supplemental oxygen requirements beginning in the 1950's and perhaps earlier
- Initial commercial requirements were based on *cabin* altitude, not *aircraft* altitude

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FAR 91.211 – A Quick History

- August, 1982 FAA proposal would have allowed operations above FL350 for aircraft with cabin pressure volume in excess of 20,000 cubit feet
- In 1986, FAA withdrew proposal based on “unsupportable assumptions”
- November, 1989 FAA proposed to codify certification criteria for aircraft operating up to 51,000 ft
- FAA issued final rule in June, 1996

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Additional Regulatory Perspectives ICAO Annex 6, Part 2

- 2.2.3.8 Oxygen supply
- The pilot-in-command shall ensure that breathing oxygen is available to crew members and passengers in sufficient quantities for all flights at such altitudes where a lack of oxygen might result in impairment of the faculties of crew members or harmfully affect passengers.

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Additional Regulatory Perspectives ICAO Annex 6, Part 2, Att. 2.A

- 2. Use of oxygen
- 2.1 All flight crew members, when engaged in performing duties essential to the safe operation of an aeroplane in flight, should use breathing oxygen continuously whenever the circumstances prevail for which its supply has been indicated to be necessary in 1.1 or 1.2.
- 2.2 All flight crew members of pressurized aeroplanes operating above an altitude where the atmospheric pressure is less than 376 hPa should have available at the flight duty station a quick donning type of mask which will readily supply oxygen upon demand.

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Additional Regulatory Perspectives EASA Part NCC

- NCC.OP.210 Use of supplemental oxygen
- The pilot-in-command shall ensure that flight crew members engaged in performing duties essential to the safe operation of an aircraft in flight use supplemental oxygen continuously whenever the cabin altitude exceeds 10 000 ft for a period of more than 30 minutes and whenever the cabin altitude exceeds 13 000 ft.

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Additional Regulatory Perspectives EASA Part NCC

- NCC.IDE.A.195 Supplemental oxygen — pressurised aeroplanes
- (a) Pressurised aeroplanes operated at flight altitudes for which the oxygen supply is required in accordance with (b) shall be equipped with oxygen storage and dispensing apparatus capable of storing and dispensing the required oxygen supplies.
- (b) Pressurised aeroplanes operated above flight altitudes at which the pressure altitude in the passenger compartments is above 10 000 ft shall carry enough breathing oxygen to supply:
- (1) all crew members and at least:
- (i) 30 % of the passengers, for any period when, in the event of loss of pressurisation and taking into account the circumstances of the flight, the pressure altitude in the passenger compartment will be between 14 000 ft and 15 000 ft; and
- (ii) 10 % of the passengers for the remainder of the flight time when the pressure altitude in the passenger compartment will be between 10 000 ft and 14 000 ft, after the initial 30 minutes at these altitudes;
- (2) all the occupants of the passenger compartment for no less than 10 minutes, in the case of aeroplanes operated at pressure altitudes above 25 000 ft, or operated below that altitude, but under conditions that will not allow them to descend safely to a pressure altitude of 13 000 ft within 4 minutes.
- (c) Pressurised aeroplanes operated at flight altitudes above 25 000 ft shall, in addition, be equipped with:
- (1) a device to provide a warning indication to the flight crew of any loss of pressurisation; and
- (2) quick donning masks for flight crew members;

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Thank you!

NBAA

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