Small Airplane Approach for Enhancing Safety Through Technology
Objectives

• Communicate Our Experiences
• Managing Risk & Incremental Improvement
• Discuss How Our Experience Might Benefit the Rotorcraft Community
90’s - Fixed Wing GA Fatal Accidents

- 1 Per Day, At Least……Flat For Years
- Recurrent Root Causes
- Better Information Would Benefit Safety
- Needed a New Approach
90’s Attitudes Toward Change

• Stagnation = situation unchanged for essentially 30+ years

• Few examples of “new technology” - Little innovation or new product development

• Companies & FAA entrenched in S-curve - Hindering technology potential
Technology Implementation

• Typically follows an S-curve* for wide spread acceptance and use


• S-curve mentality forced small airplanes to wait until older/used equipment was cheap
90’s Reality Check for Part 23

• Typical “IFR” Panel
  – Single ADI Failure = Partial Panel
  – Typical, even on new Aircraft into 1990’s

• Primary Attitude (Vacuum Driven)
  – Single source of attitude acceptable for 91 IFR Ops (Yet, failure in hundreds of hours, ie. 10E-2)
  – Ironically, waiting on systems to meet “acceptable level of safety for aviation products”, ie 10E-9
90’s Technology Potential

- NASA studies showed display concepts could enhance safety
  - Wide format attitude displays
  - Moving GPS maps with weather, terrain, traffic
  - Could reduce accidents due to “pilot error”
Response - Planned Evolution

• Worked to improve GA safety through **Purposeful Architectural Change**

• Goal to Maintain at least same level of safety, but implement incremental change

• Had to address “Single Level Of Safety” Mentality
Addressing Barriers

• Natural Desire for 100% Safety Assurance & Zero Risk
• Lack of Familiarity With Technology
• Assumptions Regarding Pilot Skill & Response to Failures
• Focus on Theoretical Design Targets Instead of Functional Performance & Failure Mitigation
Where Did $10^{-9}$ Come From?

• **Transport Category Airplanes**
  – Fatal Accident Rate At Time Of Rule $10^{-6}$
  – Data Showed ~10% Caused By System Failures $10^{-1}$
  – Assume 100 Catastrophic Failure Conditions $10^{-2}$
  – Results In Probability $10^{-9}$

• **Small Single-engine Airplanes**
  – Fatal Accident Rate At Time Of Rule (IN IMC) $10^{-4}$
  – ~10% Caused By System Failures $10^{-1}$
  – Assume 10 Catastrophic Failure Conditions $10^{-1}$
  – Results In Probability $10^{-6}$

• **Goal:** Rate Should **NOT INCREASE**
# Analyzing Risk Exposure Factors

<table>
<thead>
<tr>
<th>Aircraft/Ops</th>
<th>Passengers</th>
<th>Complex Parts/Systems</th>
<th>Annual Hours Flown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small Single /Recreational</td>
<td>1’s</td>
<td>10’s</td>
<td>10’s</td>
</tr>
<tr>
<td>Large Twin /Business Use</td>
<td>10’s</td>
<td>100’s</td>
<td>100’s</td>
</tr>
<tr>
<td>Airliner /Commercial</td>
<td>100’s</td>
<td>1000’s</td>
<td>1000’s</td>
</tr>
</tbody>
</table>

- A Single Level of Safety for all Segments of Aviation Doesn’t Consider Specific Risk Exposure
Logical System Analysis Targets

<table>
<thead>
<tr>
<th>Aircraft/Ops</th>
<th>Passengers</th>
<th>Complex Parts/Systems</th>
<th>Annual Hours Flown</th>
<th>Theoretical Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small Single/Recreational</td>
<td>1’s</td>
<td>10’s</td>
<td>10’s</td>
<td>10E-6</td>
</tr>
<tr>
<td>Large Twin/Business Use</td>
<td>10’s</td>
<td>100’s</td>
<td>100’s</td>
<td>10E-8</td>
</tr>
<tr>
<td>Airliner/Commercial</td>
<td>100’s</td>
<td>1000’s</td>
<td>1000’s</td>
<td>10E-9</td>
</tr>
</tbody>
</table>

- Created Tiered Approach to Theoretical Probability of Catastrophic Failure
- Not a “reduction” in Safety, but **Appropriate** Safety
Actual Safety Data

- Shows Relative Trend Between Segments of Part 23
- Indicates One Level of Safety Not A Realistic Goal

General Aviation Safety Comparison

- Corporate (Part 23): 0.034
- Business (Part 23): 0.46
- Personal (Part 23): 1.54
- LSA: 4
- Amateur Built (Exp): 7.91

Fatal Accidents per 100,000 Fleet Hours Log Scale
Tiered Safety Targets

- Part 23 Established Continuum of Safety
- Relative Safety Expectation

Safety efforts seek to move all to the left, not just one segment.
Result – Avionics Revolution

• Kept what is still certifiable for IFR, and added glass
  – Mitigated the main risk of introducing glass – loss of function
• Appropriate Design Targets Allowed Affordable Products
Success of New Technology

- More glass in GA than in the Transport fleet!
- New pilots training on glass
- 7000+ airplanes equipped with synthetic vision
- Large % of GA has “latest technology”
Take Away Items

• We manage risk, intent of SMS
  – Today’s “processes” involve risk
  – Tomorrow’s will also involve risk
  – Over time, intent is to reduce the overall risk and save lives = risk management in action

• Focus on incremental change, not radical change – move one “yard” at a time

• Can’t assume zero risk is the only acceptable option – does not exist
On The Horizon...

- UAS technology used in Part 23: key sensors, control & navigation concepts
- Auto-land systems already in place in UAS & “optionally piloted” vehicles
- Point and click navigation & flight planning
- Concepts to enhance GA safety
For More Information:

Wes Ryan, ACE-114
wes.ryan@faa.gov
Phone: 816-329-4127
Supporting Information
Failure Condition ≠ Failure ≠ Failure Mode

• **Failure Condition**: A condition with an effect on the aircraft and its occupants, both direct and consequential, caused or contributed to by one or more failures, considering relevant adverse operation or environmental conditions.
  – Result of the failure, not the failure itself
  – Result from one failure or combination of failures

• **Failure**: The inability of an item to perform its intended function.
  – More component oriented.
  – Often viewed as single point cause

• **Failure Mode**: The way in which the failure of an item occurs.
PROBABILITY VS. RELIABILITY

• Probability is not the same as reliability
• “RELIABILITY” and “PROBABILITY” are quite different
• 23.1309 has nothing to do with “RELIABILITY”
  – 23.1309 regulates the probability of a particular event
  – 23.1309 does not regulate reliability
• Term and concept of “RELIABILITY” is not appropriate in this context
• Can and has caused huge misunderstandings
Failure ≠ Error

- **Failure**: The inability of an item to perform its intended function.
  - More component oriented.
  - Often viewed as single point cause

- **Error**:
  - 1. An occurrence arising as a result of an incorrect action or decision by personnel operating or maintaining a system.
  - 2. A mistake in requirements design, or implementation.
Graphical Summary

- Early Aircraft
- Transport Aircraft
- Electronics
- Digital Systems
- Integrated Systems
- Statistical Analysis
- Current Civil Cert Requirements

Cost & Complexity vs. Time & Expectations

Certification Complexity
Graphical Summary

- Cost & Complexity
- Time & Safety Level

- Early Aircraft
- Transport Aircraft
- Electronics
- Digital Systems
- Appropriate Requirements
- Integrated Systems
- Statistical Analysis
- Current Civil Cert Requirements

Moving from 10E-9 for Small Aircraft and Applying Appropriate, Clear Standards Led to GA Glass Revolution
2003 Relative Comparison

Accident Rate per Aircraft Type, 2003 (per 100,000 Flight Hours)

- All Aircraft: Total 1.35, Fatal 6.75
- Single-engine Piston Airplane: Total 1.41, Fatal 7.91
- Multi-engine Piston Airplane: Total 2.27, Fatal 5.58
- Turboprop Airplane: Total 1.48, Fatal 4.50
- Jet Airplane: Total 0.97, Fatal 0.56
- Amateur-built: Total 1.62, Fatal 10.66
- Rotorcraft: Total 5.50, Fatal 19.45
- Gliders: Total 5.07, Fatal 14.73
- Lighter-than-air: Total 0.00, Fatal 0.00
Potential for Rotorcraft

• Compare current equipment failure rates to actual accident data
  – Chance of fatal accident – Similar to, but worse than Part 23 single engine aircraft
  – May justify adopting a similar managed risk approach to safety enhancing technology

• Current chance of fatal accident around 10E-6

• May not make sense to enforce a 10E-9 mentality on Rotorcraft Equipment
Future Challenges for GA

- Future small jets / single-engine jets need a different approach to certification and pilot training
- Electric power coming
  - LSA developing standards
  - Cessna working on electric C-172
- Autonomous operation from takeoff to landing
Further Horizon...

• Fused image on PFD – use synthetic until IR or radar image is strong enough to replace it. Real-time integrity validation

• Enhanced or smart 4D guidance (Pathway or other scheme) is matched to RNP and NextGen operations – includes time element