

The FAA's Safety Continuum and Its New Rules for Small Airplanes

Aircraft Airworthiness and Sustainment (Australia) Conference
Brisbane, Queensland, Australia July 5, 2018

Marv Nuss

(913) 962-4683

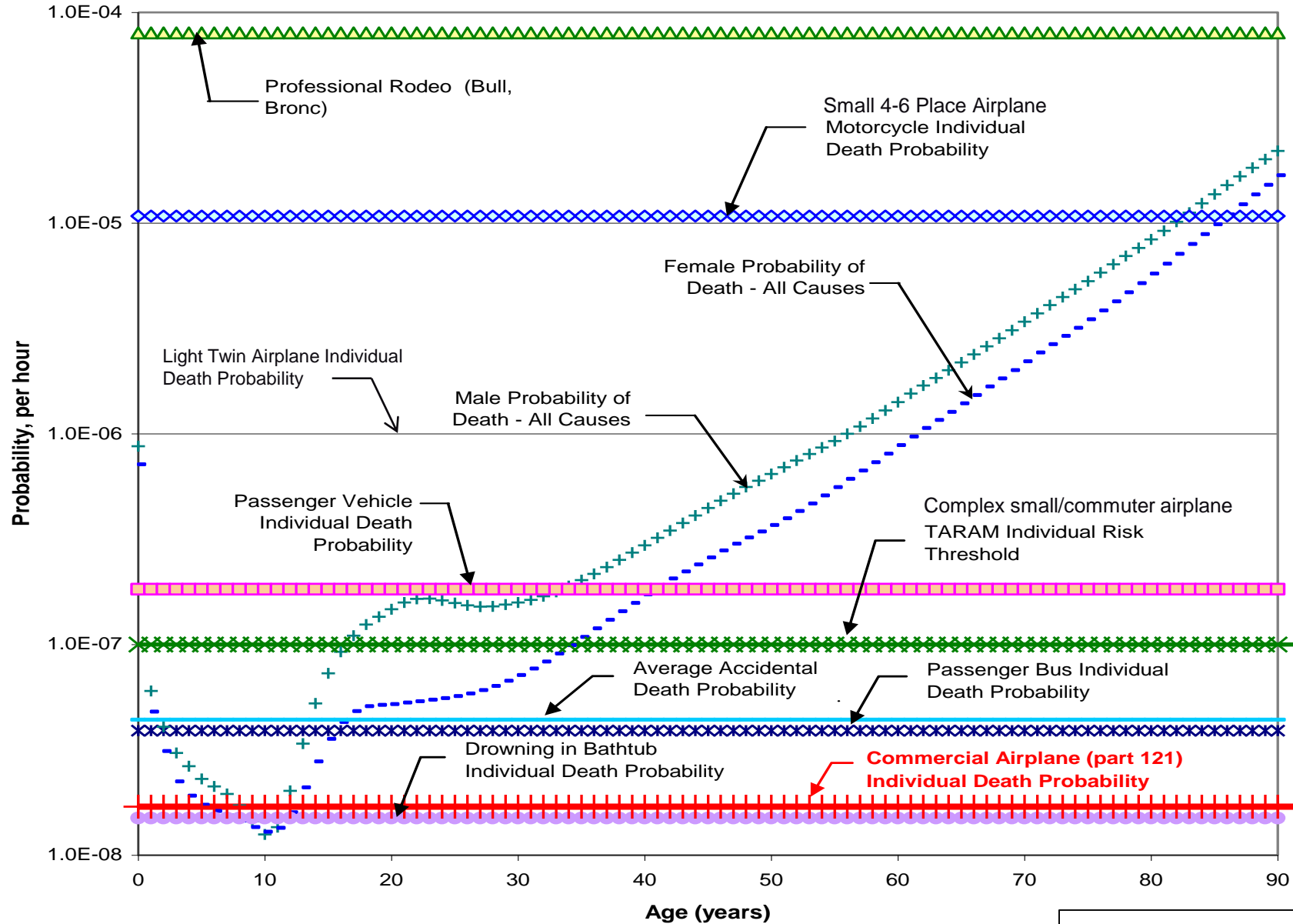
marv.nuss@marvnuss.com

www.marnvnuSS.com



- What is the FAA's Safety Continuum?
- How does it apply to small airplane certification?

Big Picture Perspective on Life Risk



Ref: FAA TARAM Handbook

➔ The FAA's Safety Continuum and Its New Rules for Small Airplanes, Australia AA&S, Brisbane July 2018 ➔

FAA's Safety Continuum for Pilots

Pilot certificate requirements

- Air Transport (ATP) + Type rating
 - 1st class medical certificate
 - Strict experience and proficiency requirements (12 mo.)
 - Mandatory retirement
- Air Transport
 - 1st class medical certificate
 - Strict experience and proficiency requirements (12 mo?)
- Commercial
 - 2nd class medical certificate
 - Experience and proficiency requirements

FAA's Safety Continuum for Pilots

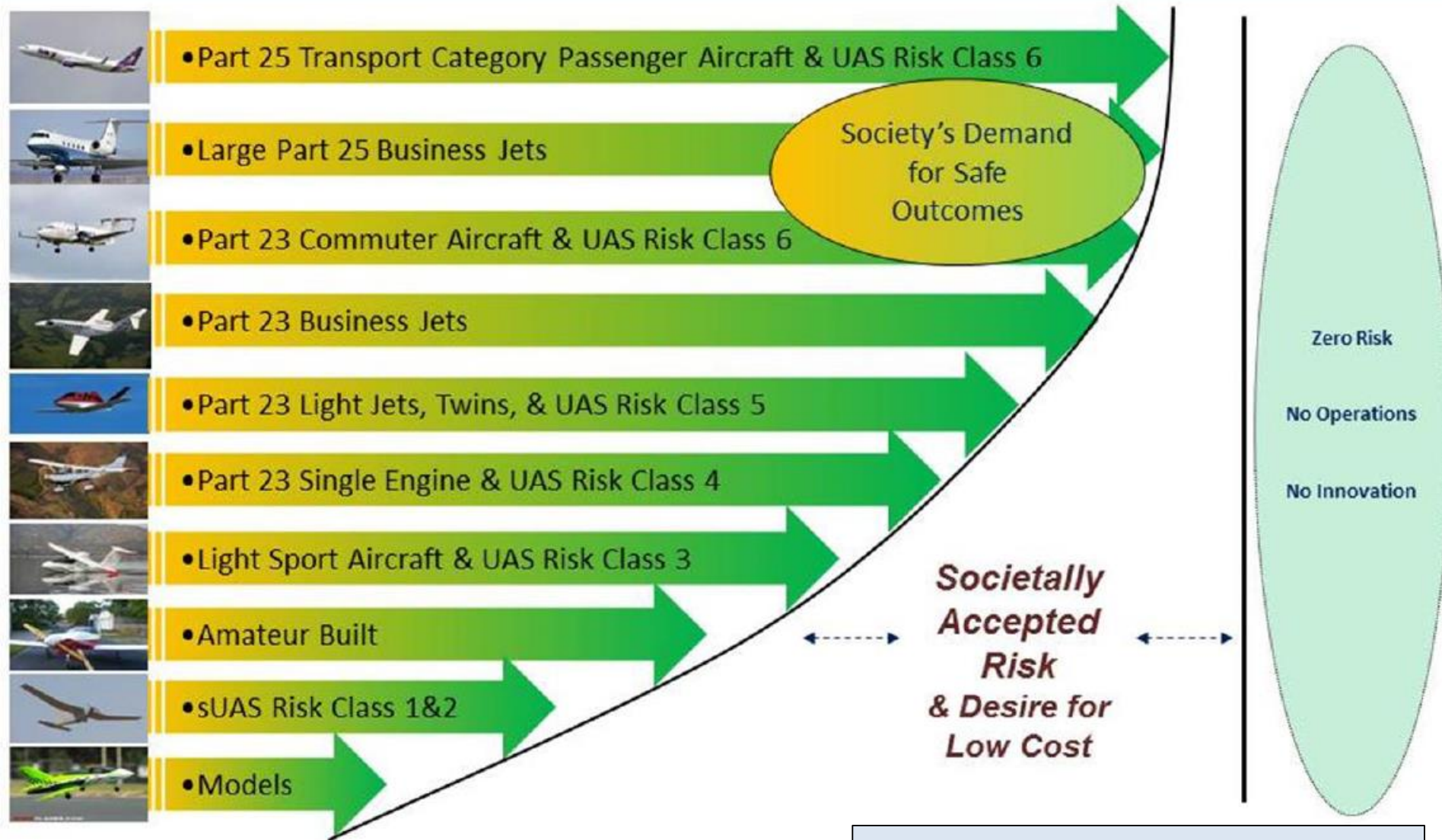
Pilot certificate requirements (Con't)

- Private
 - 3rd class medical once, then relaxed
 - 40 hours and biennial flight review
- Recreational
 - Drivers license
 - 40 hours and biennial flight review
- Sport
 - Drivers license
 - 40 hours and biennial flight review

FAA's Safety Continuum for Operations

- Part 121
 - Additional requirements for > 75,000 max weight
 - Additional requirements for > 30 seats
 - Additional requirements for > 19 seats
- Part 135
 - Strictest requirements for scheduled service
 - Less strict for on-demand and cargo
 - Additional requirements for > 10 seats
- Part 91
 - Strictest requirements for turbine engine aircraft
 - Stricter requirements for multi-engine aircraft
 - Stricter requirements for heavier aircraft

Safety Continuum



Courtesy FAA Small Airplane Directorate:
Lowell Foster, Steve Thompson

U.S. Aviation Fatal Accident Rates

Annual Average from 2005 through 2009

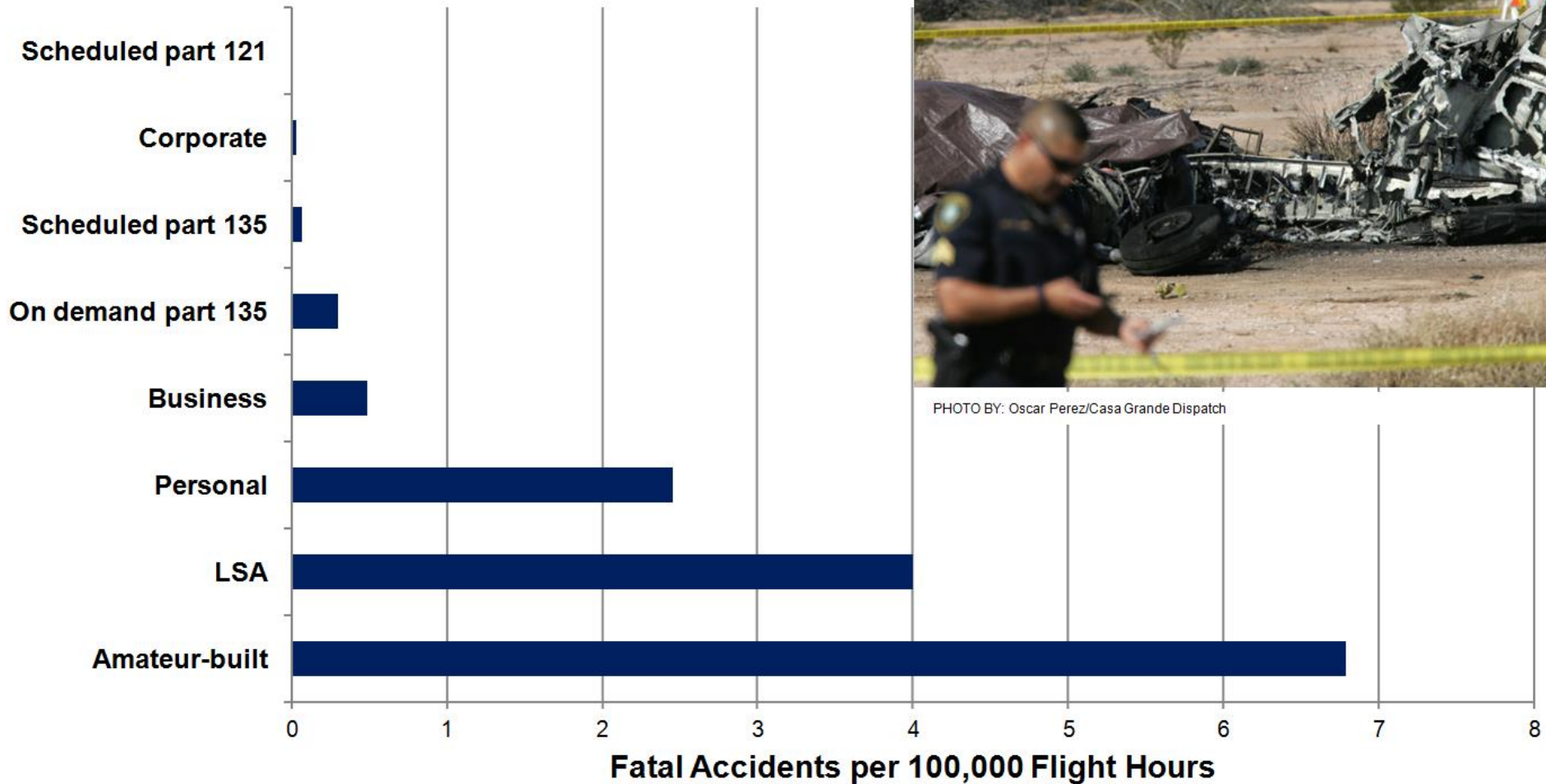
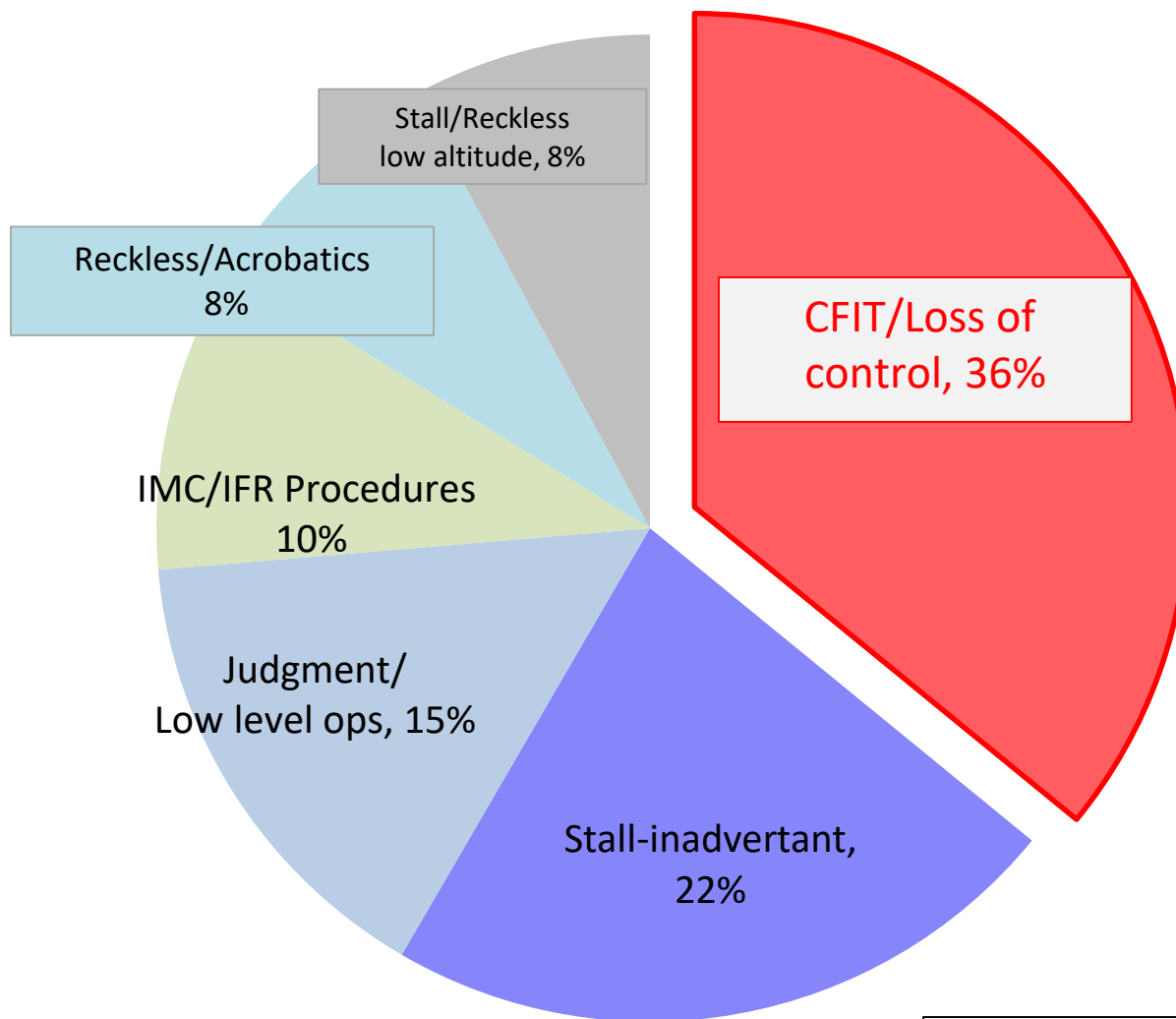


PHOTO BY: Oscar Perez/Casa Grande Dispatch

Courtesy FAA

Small Airplane Fatal Accident Causes 1980s-90s

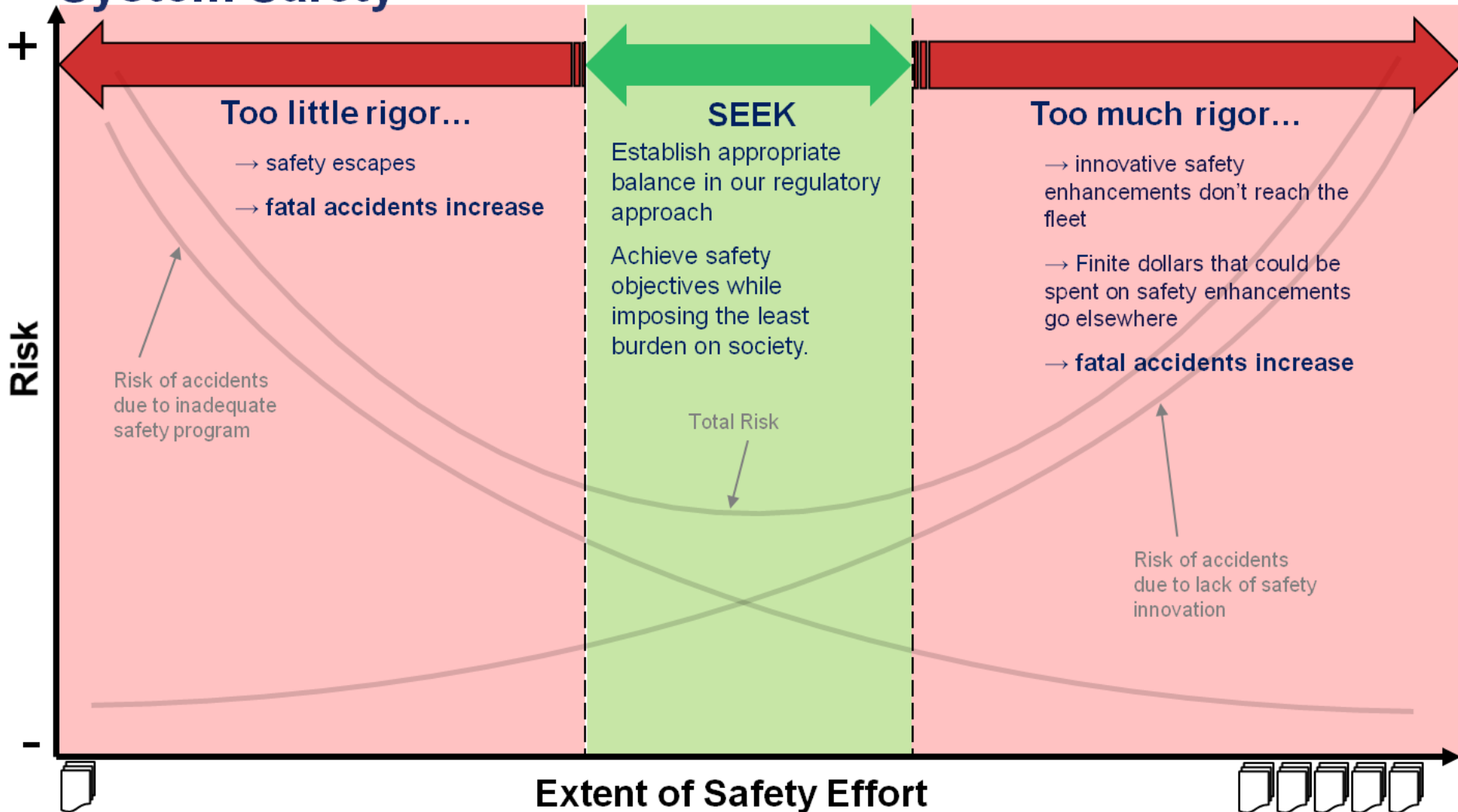


Data courtesy FAA Small Airplane Directorate

CFIT: Controlled Flight Into Terrain

Applying the Safety Continuum

System Safety



Courtesy FAA

→ The FAA's Safety Continuum and Its New Rules for Small Airplanes, Australia AA&S, Brisbane July 2018

1998 FAA White Paper

Multi-Tier Airworthiness Standards for Aircraft Certification

Considerations

⋮

Thus, the following considerations are made in this paper:

a) Compliance with transport level requirements may increase the cost for most GA aircraft, particularly for new technology CNS equipment. These costs

Recommendations

Based on these considerations, it is recommended that for general aviation and special classes of aircraft that do not carry passengers for hire:

a) Reliability and development assurance requirements may be tailored to aircraft type, depending on the operational environment and failure effects.

b) Certification criteria for new CNS equipment should be based on performance specifications, such as, accuracy, integrity, resolution, availability, reliability, and other performance specifications as deemed appropriate for the equipment.

c) As compared to aircraft carrying passengers for hire, a higher risk threshold may be allowed in defining certification criteria for private aviation.

Authors

Jim Treacy, ANM-103N
Mark Rumizen, ANE-110
Timothy Smyth, ACE-110
Tom Boudreau, ANE-110
Abbas Rizvi, AIR-101

Ann Azevedo, ANE-110
Jorge Castillo, ASW-110
Lowell Foster, ACE-110
Erv Dvorak, ACE-110

CNS: Communications, Navigation, Surveillance

Dated July 17, 1998.

Small Airplane Class Definitions

FAA established circa 1998-99

Class	Description
Class I	Single Reciprocating Engine Airplanes < 6,000 lbs.
	Restricted Category Agricultural Airplanes
	Sailplanes
	Normal Category Airships
	Manned Free Balloons
Class II	Multiple Reciprocating Engine Airplanes < 6,000 lbs.
	Single Turbine Engine Airplanes < 6,000 lbs.
	Multiple Turbine Engine Airplanes < 6,000 lbs.
Class III	Single Reciprocating Engine Airplanes > 6,000 lbs.
	Multiple Reciprocating Engine Airplanes > 6,000 lbs.
	Single Turbine Engine Airplanes > 6,000 lbs.
	Multiple Turbine Engine Airplanes > 6,000 lbs.
Class IV	Commuter Category Airplanes
Note:	Restricted category airplanes, other than agricultural airplanes, should be evaluated using the class definition most appropriate for their engine configuration and maximum weight.

Small Airplane AC 23.1309-1E

Design Failure Rate Maximums

Airplane Class	Failure Level			
	Minor	Major	Hazardous	Catastrophic
Class I	$<10^{-3}$	$<10^{-4}$	$<10^{-5}$	$<10^{-6}$
Class II	$<10^{-3}$	$<10^{-5}$	$<10^{-6}$	$<10^{-7}$
Class III	$<10^{-3}$	$<10^{-5}$	$<10^{-7}$	$<10^{-8}$
Class IV	$<10^{-3}$	$<10^{-5}$	$<10^{-7}$	$<10^{-9}$

- Values represent failure rate per flight hour
- Values are based on historical accident rates for each airplane class

FAA Advisory Circular 23.1309-1E: System Safety Analysis and Assessment for Part 23 Airplanes

Controlled Flight Into Terrain (CFIT)

GAJSC GA Accident Rate CY2001 – CY2010

Safety
Benefits of
a Balanced
Approach

2003:

- FAA approves installation of Chelton Flight Systems displays in multiple airplane models
- Cirrus begins deliveries with Avidyne displays
- Garmin introduces G1000

2002:

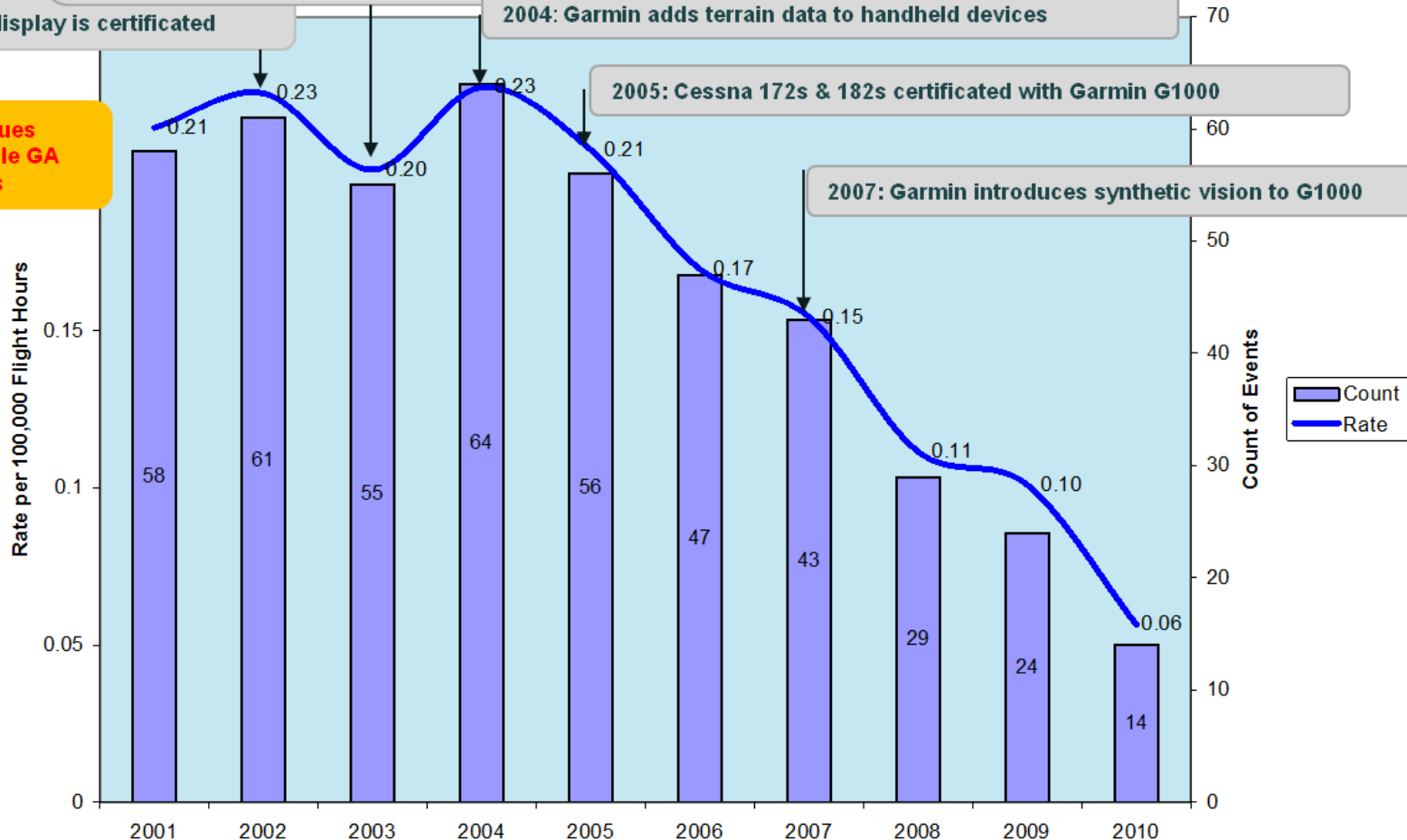
Avidyne display is certificated

2004: Garmin adds terrain data to handheld devices

2005: Cessna 172s & 182s certificated with Garmin G1000

2007: Garmin introduces synthetic vision to G1000

1999: FAA issues
policy to enable GA
glass displays



Courtesy FAA Small Airplane Directorate

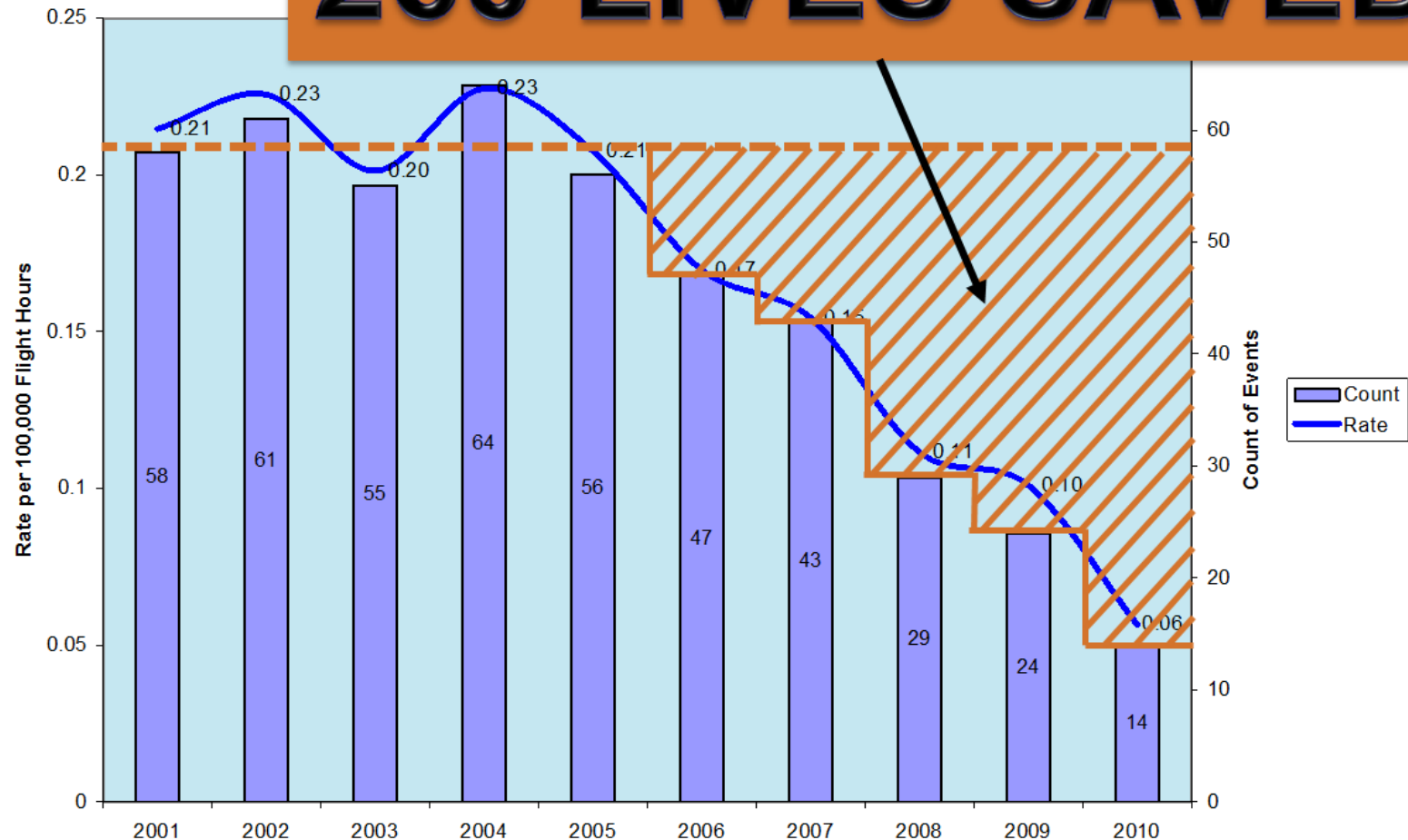
→ The FAA's Safety Continuum and Its New Rules for Small Airplane

Controlled Flight Into Terrain (CFIT)

GAJSC GA Accident Rate CY2001 – CY2010

Safety
Benefits of
a Balanced
Approach

260 LIVES SAVED



→ The FAA's Safety Continuum and Its New Rules for Small Airplane

Courtesy FAA Small Airplane Directorate

Cirrus SR-20 Equivalent Level of Safety (ELOS)

- SR-20 wing design prevents classic stall/spin situation
- §23.221 requires demonstration of quick spin recovery
- Since SR-20 can't spin, demonstration is impossible
- SR-20 included a General Aviation Recovery Device (GARD) in its design (ballistic recovery parachute) to provide an ELOS to the spin requirement



FAA's Safety Continuum

FAA perspective prior to new part 23 rules

- Before rewrite, several rules in Part 23 and Part 25 were identical
- But how compliance was shown may be *different* because the products and how they are used are *different*
- Using a Part 25 approach to showing compliance on a Part 23 airplane can result in a higher cost burden to the applicant and may result in a lower level of safety. *How is this possible?*
 - Because there are assumptions built into the rules as well as the accepted means of compliance
 - Without understanding the assumptions, one cannot adequately evaluate the level of safety

Courtesy FAA Small Airplane Directorate:
Lowell Foster, Steve Thompson

FAA's Safety Continuum

- The Continuum allows for FAA to accept:
 - Higher rigor compliance showing and small error margins
 - Lower rigor, *simpler* compliance showing and larger error margins
- Historically Part 23 has allowed simpler compliance with larger margins compared to Part 25, which needed the more complex compliance showings because they couldn't accept the weight penalties associated with larger margins.

Courtesy FAA Small Airplane Directorate:
Lowell Foster, Steve Thompson

FAA's Safety Continuum

- Applicants wanting the absolute smallest margins for error will have to use a high level of rigor in showing of compliance based on which level the airplane will be certificated to.
- Applicants have the option of choosing lower or higher rigor levels in their showing of compliance.
- But as airplanes get larger, typically the applicants are more reluctant to give up utility for simplified compliance showing options.

Courtesy FAA Small Airplane Directorate:
Lowell Foster, Steve Thompson

Example of the Safety Continuum

From GARMIN aviation products website, April 5, 2017



G5 Electronic Flight
Instrument for
Experimental/LSA Aircraft
\$1,199.00 USD



G5 Electronic Flight
Instrument for Certificated
Aircraft
\$2,149.00 USD and Up

Small Airplane Revitalization Act of 2013

Public Law 113–53
113th Congress

An Act

Nov. 27, 2013
[H.R. 1848]

To ensure that the Federal Aviation Administration advances the safety of small airplanes, and the continued development of the general aviation industry, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

SECTION 1. SHORT TITLE.

This Act may be cited as the “Small Airplane Revitalization Act of 2013”.

SEC. 2. FINDINGS.

Congress makes the following findings:

(1) A healthy small aircraft industry is integral to economic growth and to maintaining an effective transportation infrastructure for communities and countries around the world.

(2) Small airplanes comprise nearly 90 percent of general aviation aircraft certified by the Federal Aviation Administration.

(3) General aviation provides for the cultivation of a workforce of engineers, manufacturing and maintenance professionals, and pilots who secure the economic success and defense of the United States.

(4) General aviation contributes to well-paying jobs in the manufacturing and technology sectors in the United States and products produced by those sectors are exported in great numbers.

(5) Technology developed and proven in general aviation aids in the success and safety of all sectors of aviation and scientific competence.

(6) The average small airplane in the United States is now 40 years old and the regulatory barriers to bringing new designs to the market are resulting in a lack of innovation and investment in small airplane design.

(7) Since 2003, the United States lost 10,000 active private pilots per year on average, partially due to a lack of cost-effective, new small airplanes.

(8) General aviation safety can be improved by modernizing and revamping the regulations relating to small airplanes to clear the path for technology adoption and cost-effective means to retrofit the existing fleet with new safety technologies.

(8) General aviation safety can be improved by modernizing and revamping the regulations relating to small airplanes to clear the path for technology adoption and cost-effective means to retrofit the existing fleet with new safety technologies.

Small Airplane Revitalization Act of 2013.
49 USC 44704 note.

Small Airplane Revitalization Act of 2013

(con't)

PUBLIC LAW 113-53—NOV. 27, 2013

127 STAT. 585

SEC. 3. SAFETY AND REGULATORY IMPROVEMENTS FOR GENERAL AVIATION.

(a) IN GENERAL.—Not later than December 15, 2015, the Administrator of the Federal Aviation Administration shall issue a final rule— Deadline.

(1) to advance the safety and continued development of small airplanes by reorganizing the certification requirements for such airplanes under part 23 to streamline the approval of safety advancements; and

(2) that meets the objectives described in subsection (b).

(b) OBJECTIVES DESCRIBED.—The objectives described in this subsection are based on the recommendations of the Part 23 Reorganization Aviation Rulemaking Committee:

(1) The establishment of a regulatory regime for small airplanes that will improve safety and reduce the regulatory cost burden for the Federal Aviation Administration and the aviation industry.

(2) The establishment of broad, outcome-driven safety objectives that will spur innovation and technology adoption.

(3) The replacement of current, prescriptive requirements under part 23 with performance-based regulations.

(4) The use of consensus standards accepted by the Federal Aviation Administration to clarify how the safety objectives of part 23 may be met using specific designs and technologies.

(c) CONSENSUS-BASED STANDARDS.—In prescribing regulations under this section, the Administrator shall use consensus standards, as described in section 12(d) of the National Technology Transfer and Advancement Act of 1996 (15 U.S.C. 272 note), to the extent practicable while continuing traditional methods for meeting part 23.

Part 23 -- Airworthiness standards: Normal category airplanes

New Part 23 Regulatory Approach

- Replaces prescriptive regulations with performance-based regulations
- Establishes 4 risk levels for airplanes with up to 19 passengers and a maximum take-off weight of 19,000 pounds.
- Moves the prescriptive design specific requirements of Part 23 amendment 23-63 to FAA-accepted consensus-based methods of compliance specified in ASTM standards

Note: New rules maintain the same level of safety as prior rules --

with two exceptions:

- *Stall/spin*
- *Icing*

Small Airplane Certification Levels and Performance Definitions

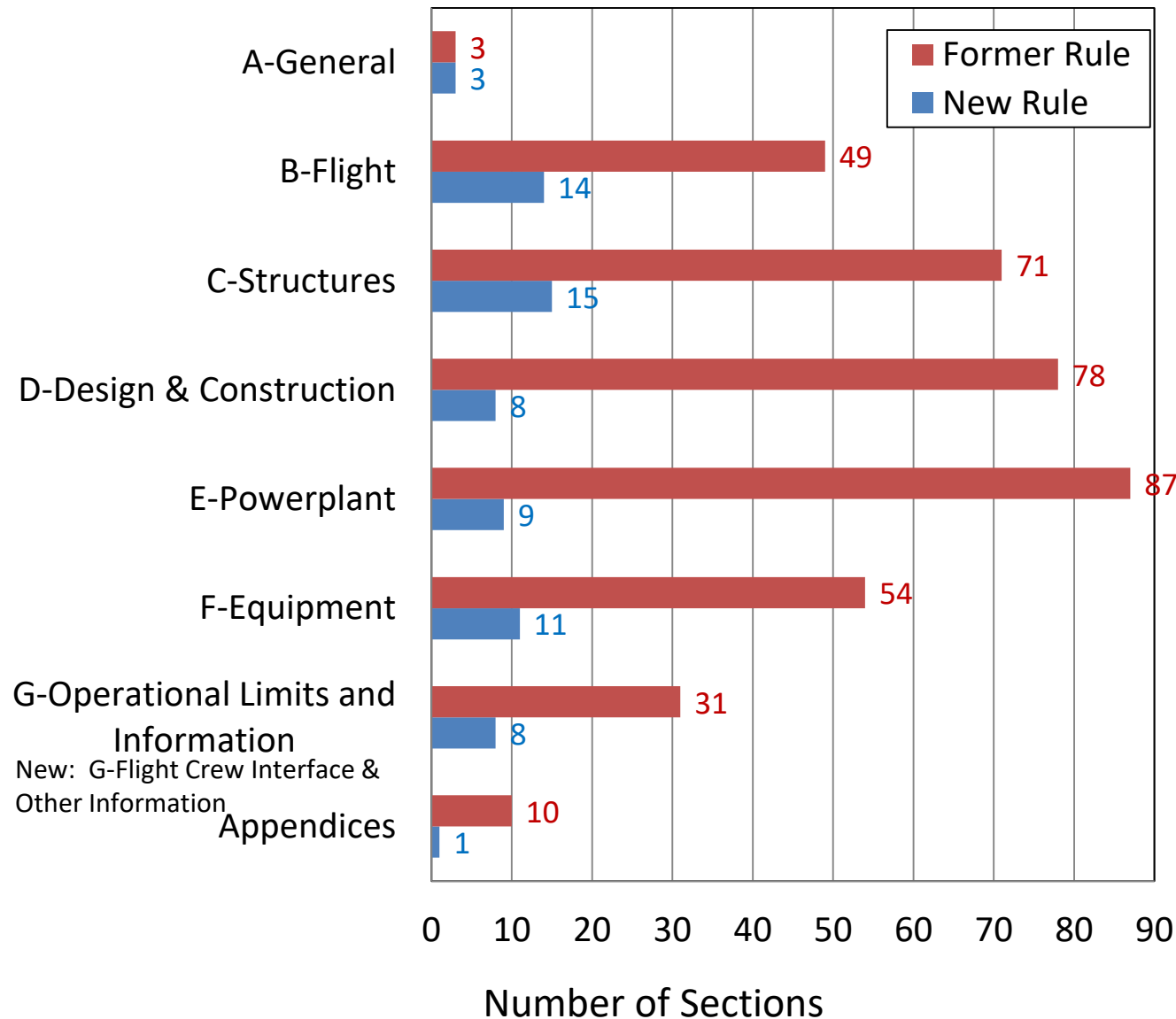
§23.2005(b) Certification Level	Maximum Seating Configuration (MTOGW = 19,000 lbs.)
Level 1	0 to 1 passengers
Level 2	2 to 6 passengers
Level 3	7 to 9 passengers
Level 4	10 to 19 passengers
§23.2005(c) Performance Level	Speed Criteria
Low Speed	V_{NO} and $V_{MO} \leq 250$ Knots Calibrated Airspeed (KCAS) and $M_{MO} \leq 0.6$
High Speed	V_{NO} or $V_{MO} > 250$ KCAS or $M_{MO} > 0.6$
Note: Levels per §23.2005, amendment 23-64	

Small Airplane Certification and Performance Levels

§23.2005(c) Performance Level	§23.2005(b) Certification Level Maximum Seating Configuration (MTOGW = 19,000 lbs.)			
Speed Criteria	Level 1 0-1 Pax	Level 2 2-6 Pax	Level 3 7-9 Pax	Level 4 10-19 Pax
Low Speed $V_{NO}/V_{MO} \leq 250 \text{ Kts}$ $M_{MO} \leq 0.6$	Piston Trainer (Cessna 152) 19,000 lb. ag plane	Typical personal A/C (Cessna 172, Cirrus SR22, etc.)	Medium twins (Cessna 402)	Slow Commuter (de Havilland Canada DHC-6 Twin Otter)
High Speed $V_{NO}/V_{MO} > 250 \text{ Kts}$ $M_{MO} > 0.6$	Fast single seat jet	VLJ: (Cirrus, Honda Jets, etc.)	Cessna CJ, Beech Premier jets; PC-12	Commuter (Beech 1900)

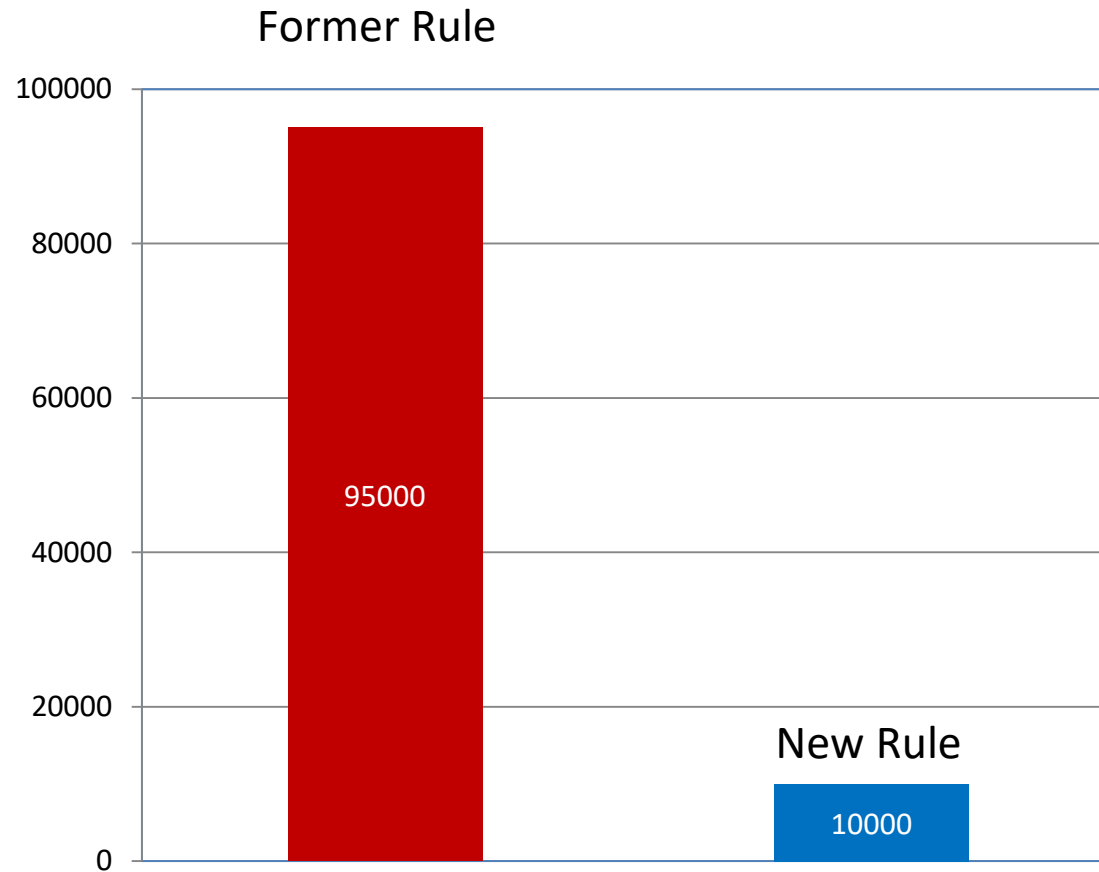
Comparison of Part 23 Subparts

Comparison of Sections in Each Sub-part



Part 23 Comparison

Part 23 Word Count



Former Part 23 Maneuver Loads

Small airplanes (§23.337)

amendment 23-63

- Normal and commuter category
 - Positive limit $N_z = 2.1 + 24,000/(W+10,000)$
 - ◆ Need not be more than 3.8g
 - Negative limit $N_z = -0.4 \times \text{Positive } N_z$
 $(-N_z = -1.52g \text{ if } +N_z = 3.8g)$
- Utility category
 - Positive limit $N_z = 4.4g$
 - Negative limit $N_z = -1.76g$
- Acrobatic category
 - Positive limit $N_z = 6.0g$
 - Negative limit $N_z = -3.0g$

Means of compliance to
rules of amendment 23-63
remain acceptable

N_z = Load factor
W = max takeoff weight

New Part 23 Design Loads

Amendment 23-64

§23.2210 Structural design loads.

(a) The applicant must:

- (1) Determine the applicable structural design loads resulting from likely externally or internally applied pressures, forces, or moments that may occur in flight, ground and water operations, ground and water handling, and while the airplane is parked or moored.
- (2) Determine the loads required by paragraph (a)(1) of this section at all critical combinations of parameters, on and within the boundaries of the structural design envelope.

(b) The magnitude and distribution of the applicable structural design loads required by this section must be based on physical principles.

Note that there are no categories or specific load factors specified

Former Part 23 Gust Loads

Small airplanes (§23.341)

amendment 23-63

$$n = 1 + \frac{K_g \cdot U_{de} \cdot V \cdot a}{498 \cdot (W/S)}$$

$$K_g = 0.88 \mu_g / (5.3 + \mu_g)$$

$$\mu_g = 2(W/S) / (\rho \cdot C \cdot a \cdot g)$$

U_{de} = Derived gust velocities per §23.333

$$U_{de} = 50 \text{ ft/sec @ } V_c, 25 \text{ ft/sec @ } V_d$$

ρ = air density (0.002378 slugs/ft³)

W/S = wing loading (lbs/ft²)

C = Mean chord (ft)

g = acceleration of gravity (32.2 ft/sec²)

V = Equivalent airspeed (kts)

a = lift curve slope (C_L /rad)

Means of compliance to rules of amendment 23-63 remain acceptable

New Small Airplane Design Loads

Amendment 23-64

For Gust loads:

§23.2215 Flight load conditions.

The applicant must determine the structural design loads resulting from the following flight conditions:

- (a) Atmospheric gusts where the magnitude and gradient of these gusts are based on measured gust statistics.
- (b) Symmetric and asymmetric maneuvers.
- (c) Asymmetric thrust resulting from the failure of a powerplant unit.

Note that there is no prescriptive equation

§23.2240 Structural durability.

- (a) The applicant must develop and implement inspections or other procedures to prevent structural failures due to foreseeable causes of strength degradation, which could result in serious or fatal injuries, or extended periods of operation with reduced safety margins. ...
- (b) For Level 4 airplanes, the procedures developed for compliance with paragraph (a) of this section must be capable of detecting structural damage before the damage could result in structural failure.
- (c) ...

Replaces §§ 23.571, .572, .573, .574, .575, and .627 -- word count = 1436

New rule (Amendment 23-64) §23.2240 -- word count = 209

Emergency Conditions

Amendment 23-63

§23.561 Emergency landing conditions

456 words

§23.562 Emergency landing dynamic conditions

1019 words

and these equations:

$$HIC = \left\{ (t_2 - t_1) \left[\frac{1}{(t_2 - t_1)} \int_{t_1}^{t_2} a(t) dt \right]^{2.5} \right\}_{Max}$$

$$g\rho = 19.0(V_{S0}/61)^2 \text{ or } g\rho = 15.0(V_{S0}/61)^2$$

$$t_r = \frac{31}{32.2(g\rho)} = \frac{.96}{g\rho}$$

Amendment 23-64

§23.2270 Emergency conditions

279 words

no equations

Part 23 -- Airworthiness standards: Normal category airplanes

New Part 23 Compliance Approach

- Consensus-based standards become means of compliance
- Standards being developed by industry-led ASTM committees
 - **Committee F44 on General Aviation Aircraft**
 - 230 members, 9 subcommittees
 - ◆ Textron, Cirrus, Diamond, Flight Design, Embry Riddle, Pipistrel, Garmin, AOPA, NASA, AEA, etc.
 - Multinational effort
 - ◆ FAA, EASA, TCCA, CAAC, ANAC, NZ-CAA, CASA
- FAA must accept the standards as described in AC 23.2010-1,
“FAA Accepted Means of Compliance Process for 14 CFR Part 23”
 - Acceptance may include exceptions, but CAAs are striving to minimize these through F44 collaboration

CAA: Civil Aviation Authority

Part 23 -- Airworthiness standards: Normal category airplanes

New Part 23 Compliance Approach (Con't)

- First stage incorporated existing standards
 - Part 23 amendment 63
 - ◆ Prescriptive aspects of rules (examples on prior slides)
 - EASA Certification Specification (CS) CS-23
 - EASA requirements for VLA
 - Other “non-contentious” improvements
- Second stage in progress
 - Developing new innovative approaches
 - FAA published new MOC for some rules
 - ◆ Federal Register May 11, 2018, page 21850
 - ◆ New standards also available in ASTM Volume 15.11

MOC: Means of Compliance
VLA: Very Light Aircraft

Part 23 -- Airworthiness standards:

Normal category airplanes

New Part 23 Compliance Approach

Example: Accepted compliance to 23.2240, Structural durability:

- ASTM F3264-18 - Standard Specification for Normal Category Aeroplanes Certification, Section 6, Structures
 - F3115/F3115M Specification for Structural Durability for Small Airplanes
- FAA 4.4.1: “For metallic (***aluminum***), ***unpressurized, non-aerobatic, low-speed, level 1 airplanes***, applicants can ***demonstrate a 10,000 hour safe-life*** by limiting the ‘***1g***’ ***gross stress***, at maximum takeoff weight, to ***no more than 5.5 ksi***. The applicant must show effective ***stress concentration factors of 4 or less in highly loaded joints*** and use materials or material systems for which the physical and mechanical properties are well established.”
- Emphasis added
- ***Probable*** compliance for Level 4, high speed:
 - Damage tolerance and full scale fatigue test
(Same as Part 25)

Notable Final Rule Preamble Passage

“...all engines and propellers require a separate TC except for those engines and propellers installed in airplanes that can be certificated as level 1 low speed.”

“For the approval of ***electric aircraft engines, part 33 airworthiness standards will be developed*** to address those products as they are presented to the FAA for type certification. Currently those standards do not exist in part 33, therefore, ***special conditions will likely be used to establish standards for the issuance of a TC before those standards have been promulgated.***”

“FAA retains the term “fuel” in the regulation, but notes the term ***“fuel” in this subpart includes any form of energy*** used by an engine or powerplant installation, such as provided by carbon-based fuels or electrical potential. ***Fuel systems will also include the means of energy storage*** for the power provided (i.e., batteries that provide power to an electric motor) or devices that generate power for propulsion (i.e., solar panels or fuel cells).”

Emphasis added

Notable Final Rule Preamble Passage

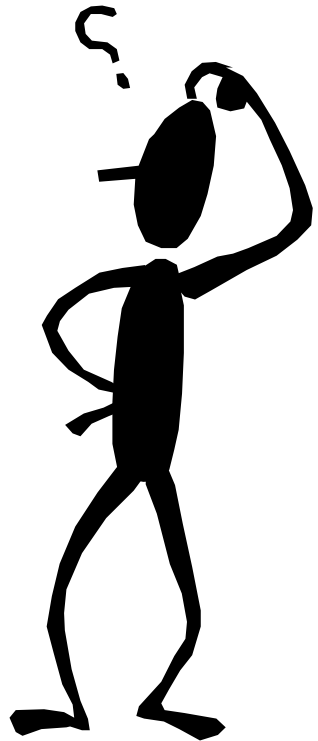
“The FAA promulgates this action to amend the airworthiness standards for new part 23 type certificated airplanes to ***reflect the current needs of the small airplane industry, accommodate future trends, address emerging technologies, and enable the creation of new part 23 manufacturers and new type certificated airplanes.*** The rule’s changes to part 23 are necessary to ***eliminate the current workload of exemptions, special conditions, and equivalent levels of safety*** findings necessary to certificate new part 23 airplanes. These part 23 changes will also ***promote safety by enacting new regulations for controllability and stall standards and promote the introduction of new technologies in part 23 airplanes.***”

Emphasis added

Summary

- FAA's safety continuum is not “new”
- FAA uses the continuum concept to manage risk
 - Allocation of resources
 - Use of delegations
 - Design standards
 - Continued operational safety actions
- FAA's new Part 23 rules embrace this approach
 - Flexibility to accept innovative approaches to improve safety without excessive compliance rigor

Thank you for your attention and interest



Questions?

Marv Nuss
(913) 962-4683
marv.nuss@marvnuss.com
www.marnvnuSS.com

