A Brief History of Design Solutions to Loss-of-Control

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Hyperlinks in text and photos, included in PDF

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Dedicated to designers Weick, Thorp, and Thurston,

and Ahunt and Rlandmann for devotion to aviation on Wikipedia

At the edges of controlled flight, and beyond, design the flight controls to respond according to intuition.

- Roll? – Absolutely. No reversal.
- Yaw? – Absolutely. No dramatic roll effect from yaw control.
- Pitch? – Not so much. But, at least, no dramatic surprises.

Design in a Governor effect – restraining the pilot's ability:

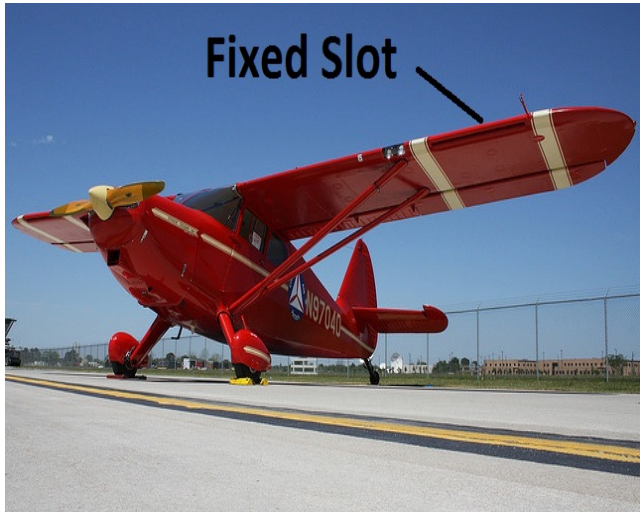
- Always, or
- Conditionally, or
- Never

Roll control – Enhanced aileron effectiveness

Automatic – no pilot action required

- 1934 Touring Airplane Competition led to production of Bf-108, Handley-Page slats, (600 produced, then 35,000 as Me-109)

1947 Stinson 108, Slot and conditional elevator limit (5200 produced)
1947 Antonov 2 begins production to 18,000+



Proved by 1929 Guggenheim Prize Winner

Free ailerons,
Automatic Slats,
Fowler flaps

More Slats and Slots

1954 Helio Courier – Slats + interceptors (600)

1959 Morane-Saulnier 880, 890 series Rallyes (3000)

also Do-27 (600+)

Also, standard wing-leveler

Government + NGO research

1978 NASA full-scale tests begin on AA-1X Yankee

1981 GAMA Workshop on GA Stall/Spins

1982 GAMA proposes spin resistant alternative to 23.221

1982-1983 Evaluations by industry and FAA test pilots

1985 GAMA formal submission to FAA

1986-1987 Continued testing on AA-1X and C-23X

1989 NPRM 89-5

1991 Amendment 23-42

2000 SAE publishes NASA report, still not public domain today

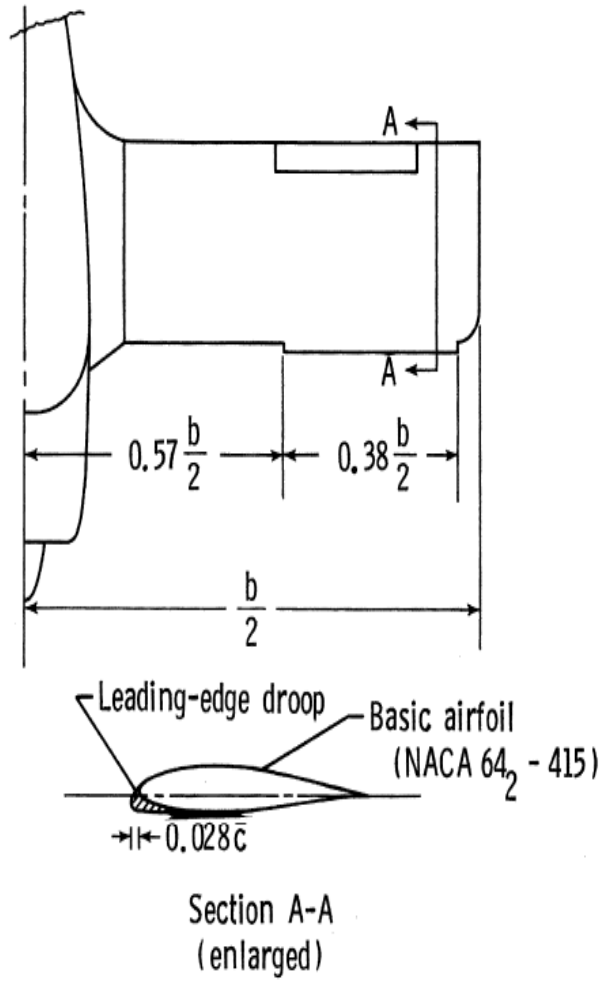


Figure 7. Wing leading-edge modification.

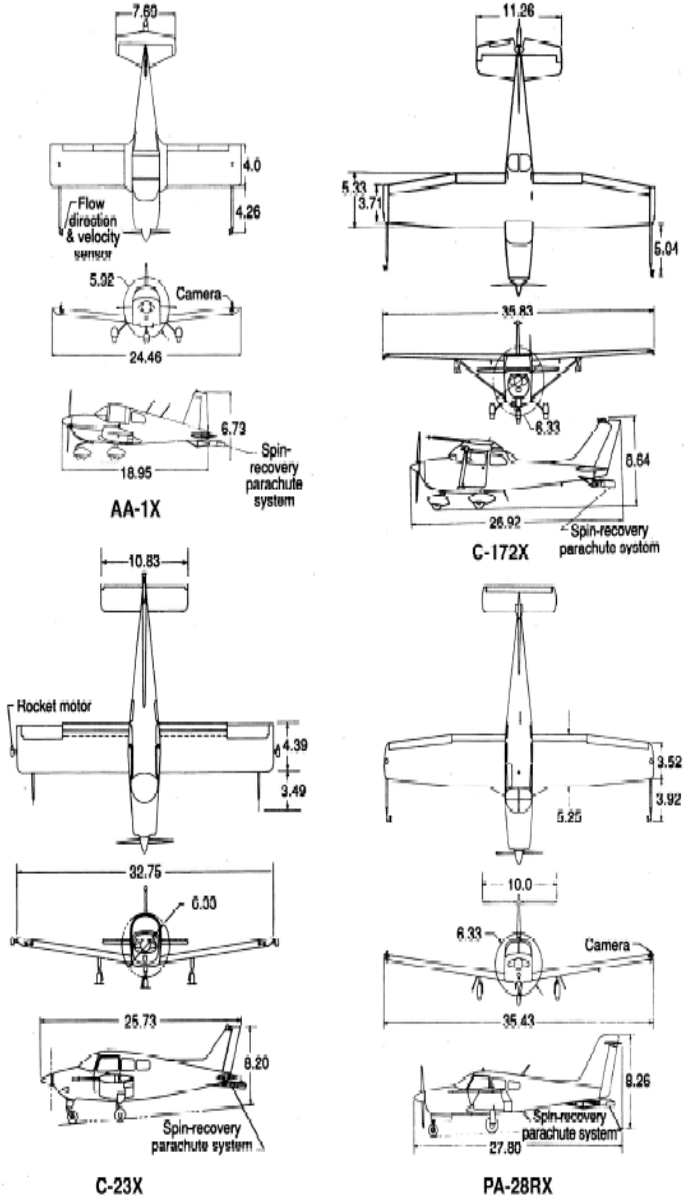


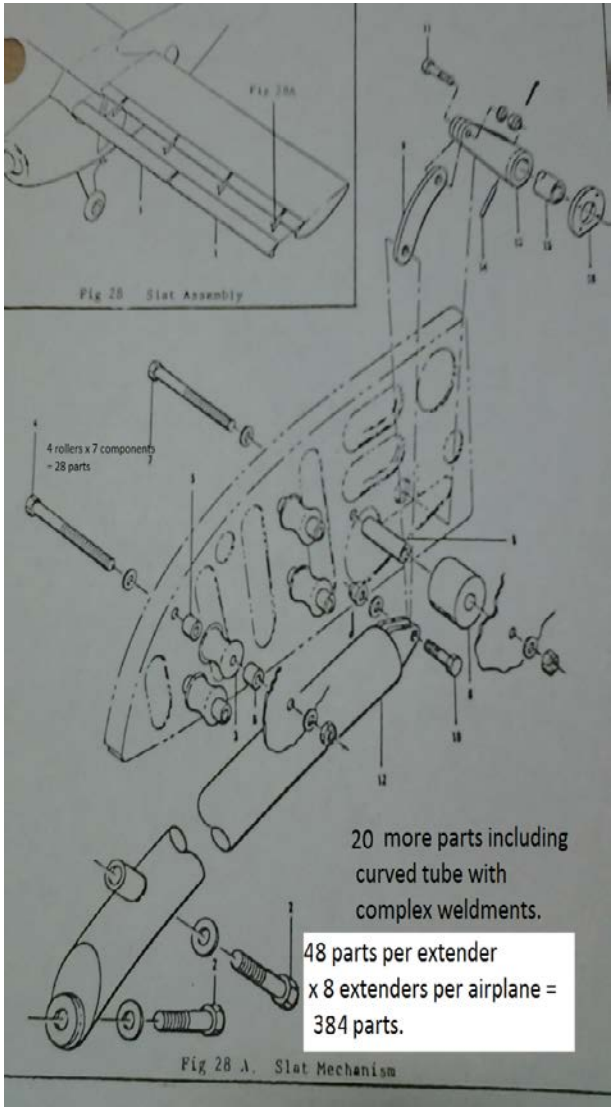
Figure 8. Research airplane configurations.

	Number of spins / Attempts	
	Basic airplane	Modified airplane
AA-1X (Yankee)	$\frac{185}{193} = 96\%$	$\frac{0}{31} = 0\%$
C-23X (Sundowner)	$\frac{127}{129} = 98\%$	$\frac{7}{134} = 5\%$
PA-28RX (Arrow)	$\frac{173}{209} = 83\%$	$\frac{13}{244} = 5\%$
C-172X (Skyhawk)	$\frac{97}{164} = 59\%$	$\frac{0}{36} = 0\%$

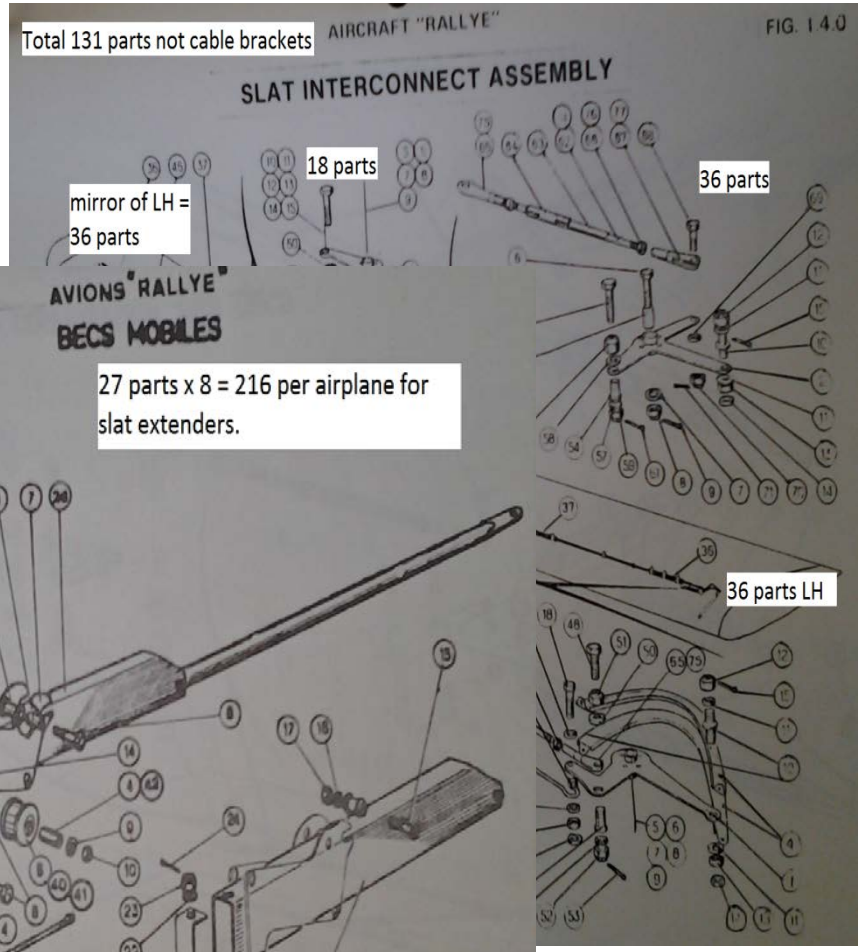
Figure 28. Frequency of spin entry following application of prospin control inputs.

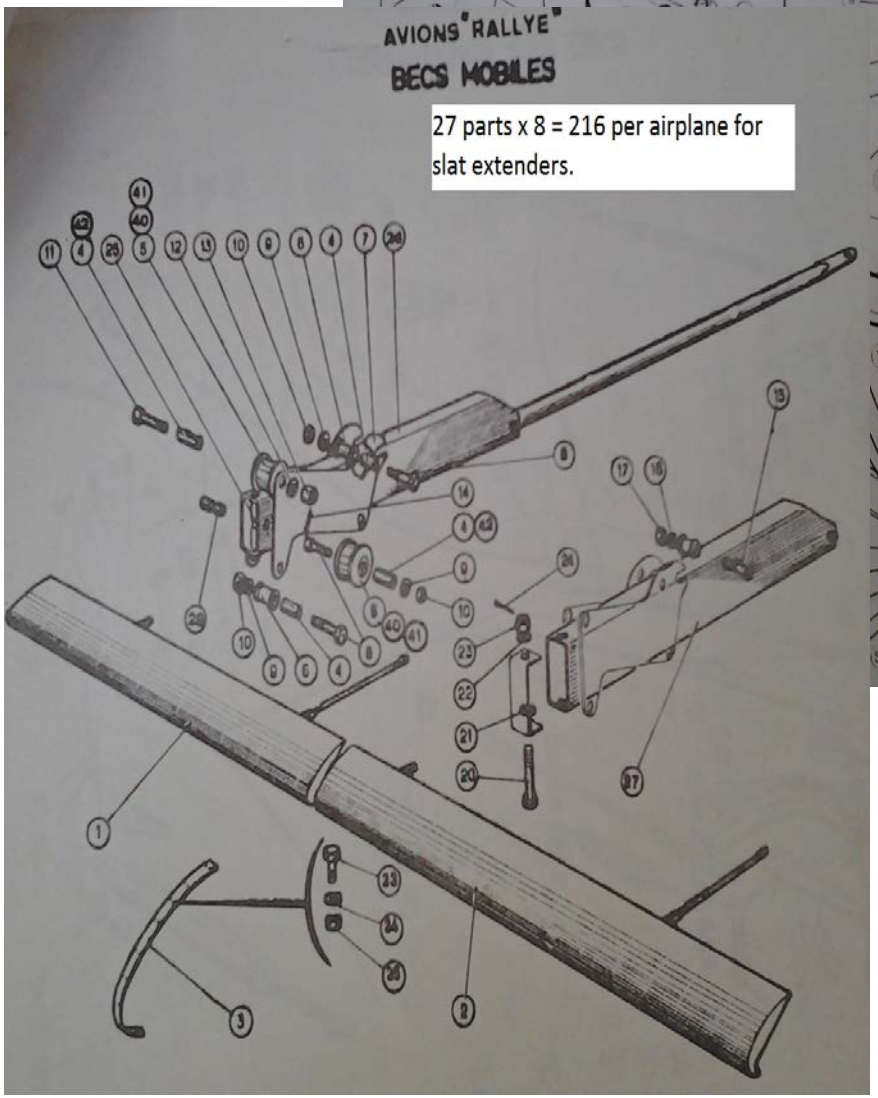
Restraints on NASA proposal/tests/results

- Original proposal included moving leading-edge devices. Too complex? Too expensive? Nothing new (Bf-108, An-2, Helio, Rallye)?
- Results apply to wing aspect ratio of 7 or less.
- “Not spin” includes steep spiral, which is little safety improvement over a spin, when low.



384 parts for Helio

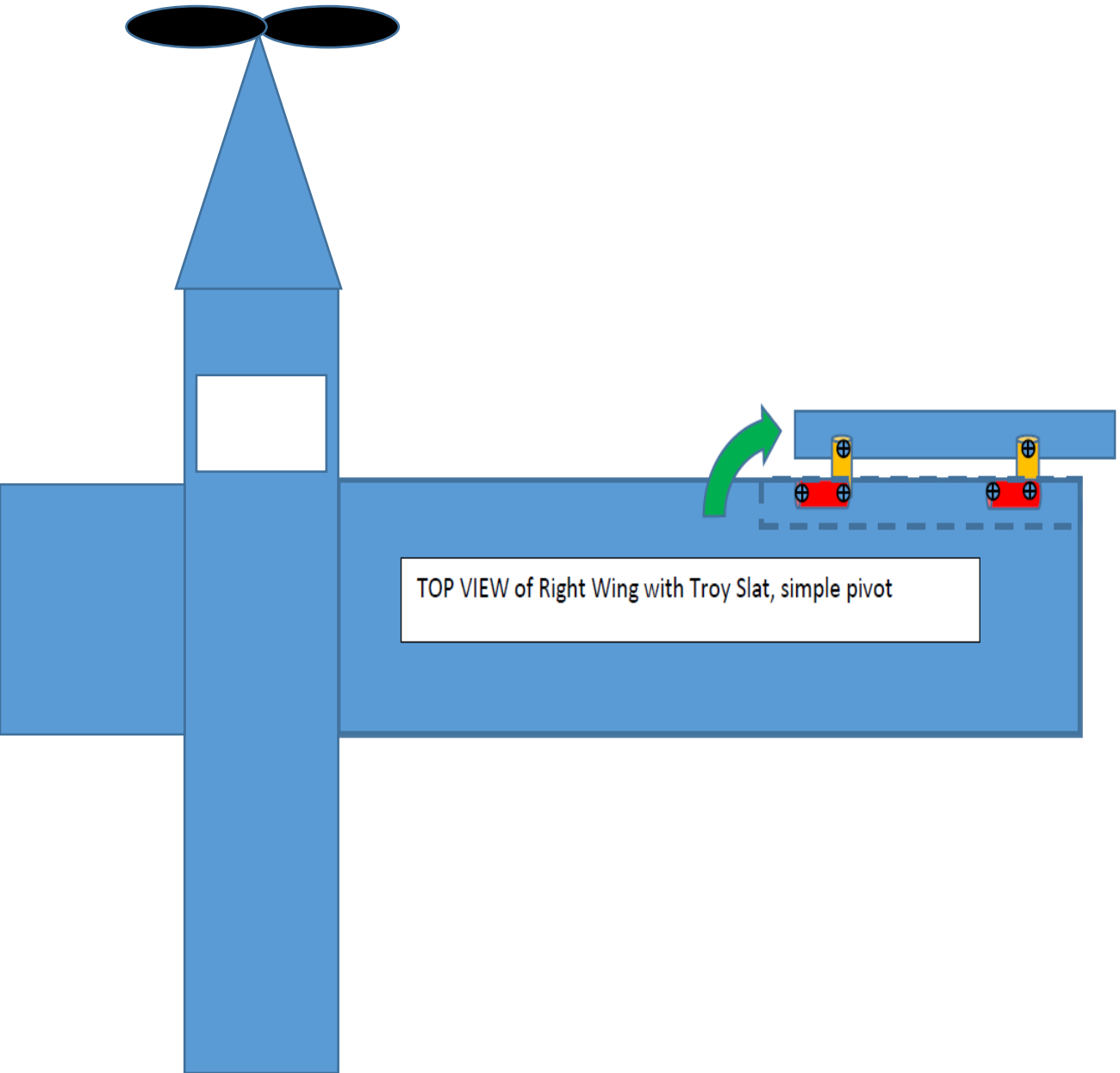




347 parts for Rallye

Popular new Light Sport, 2012, now +15/month

Just Aircraft SuperSTOL

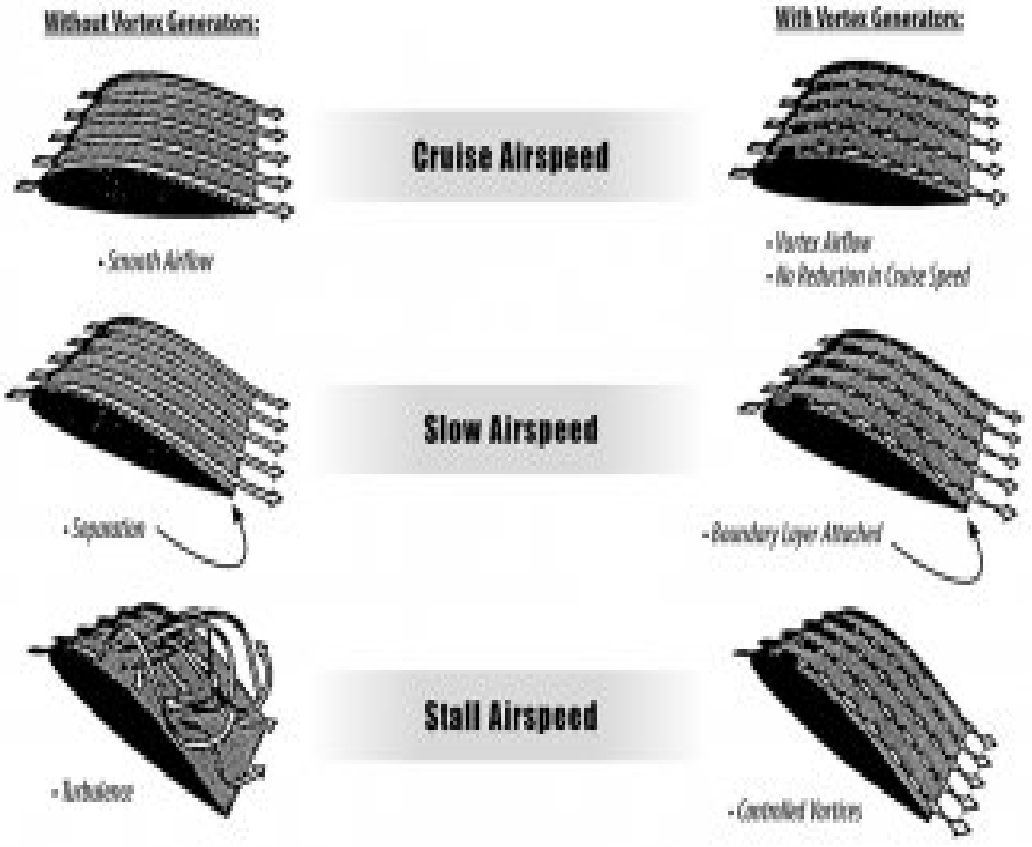

TOP VIEW of Right Wing with Troy Slat, simple pivot

For one pair of slats, about 40 parts for mounting.

STC – Supplemental Type Certificate (modifications to TC aircraft)

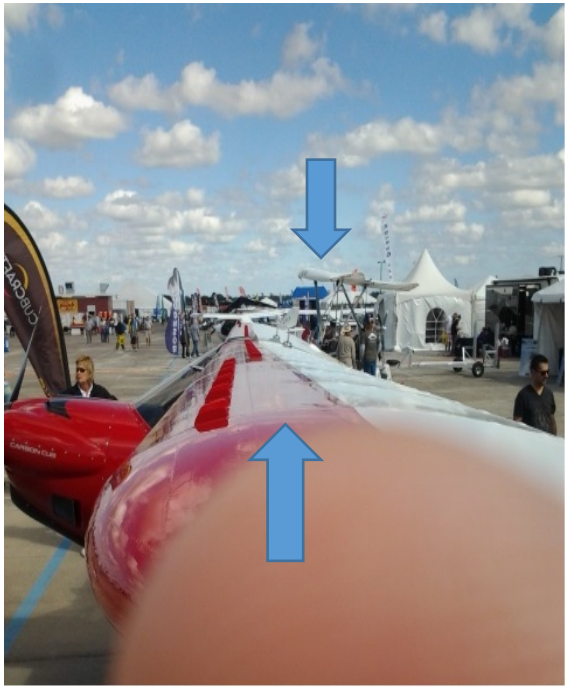
1937 Maxwell flaps researched by NACA, used in STC today

Other aileron enhancements
1989 – Vortex Generator STCs start



Micro and not-so-micro VG

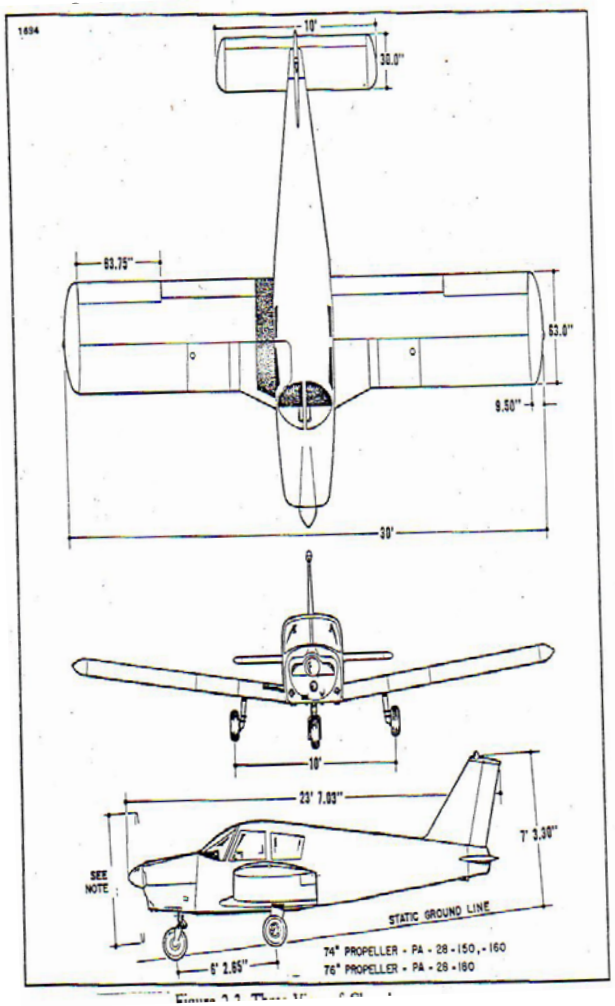
¢¢¢, but only +4 degrees AOA

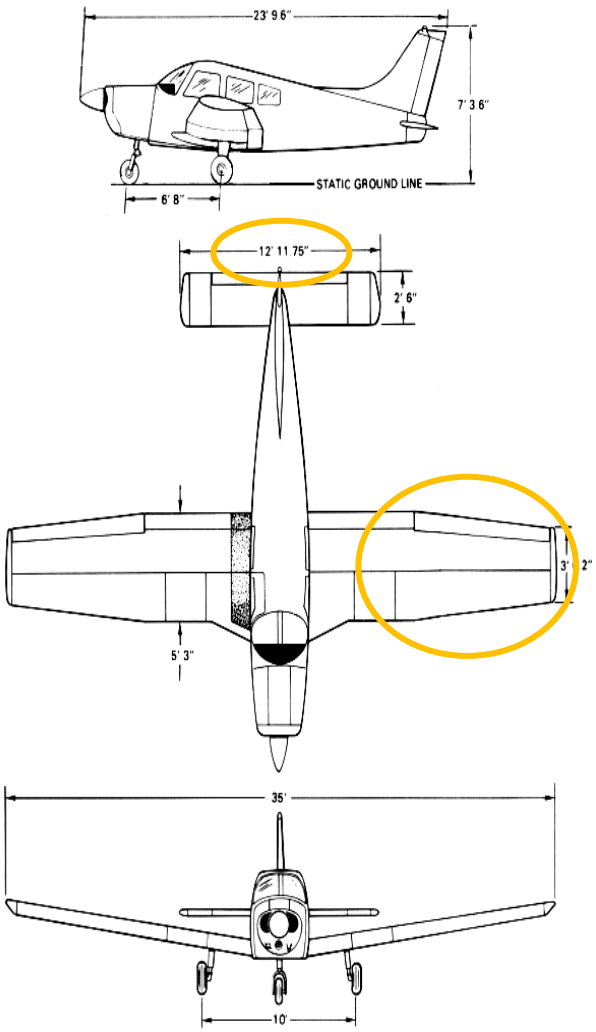


Elevator limiting to very modest AOA -
1939 safety plane started production – Ercoupe, et al.

+Full-authority rudder limiting (NO pilot rudder control),
Full-authority pitch limited at elevator (5600 total, not all two-control)

1961 Piper Cherokee PA-28, then





1976 – Amateur-built canards start appearing

The latest Velocity kit aircraft

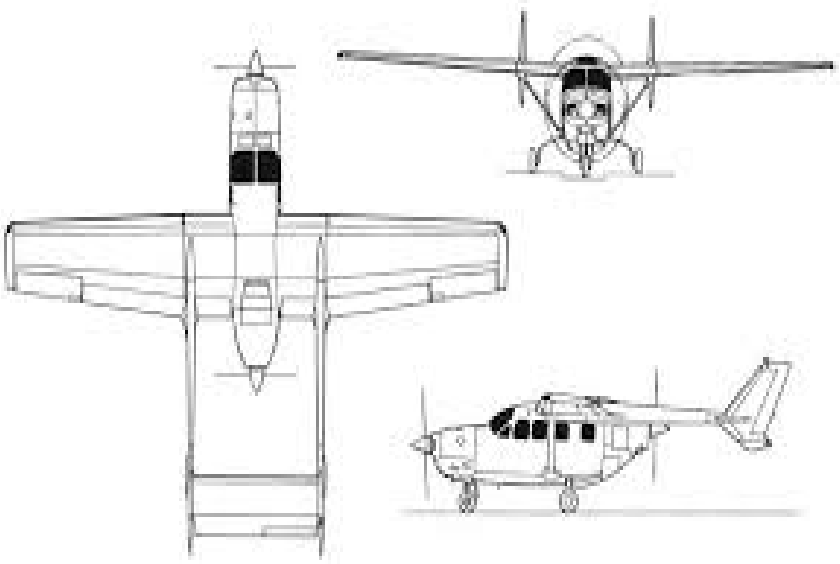
1958? Robertson Mods to Cessna begin

WREN 460

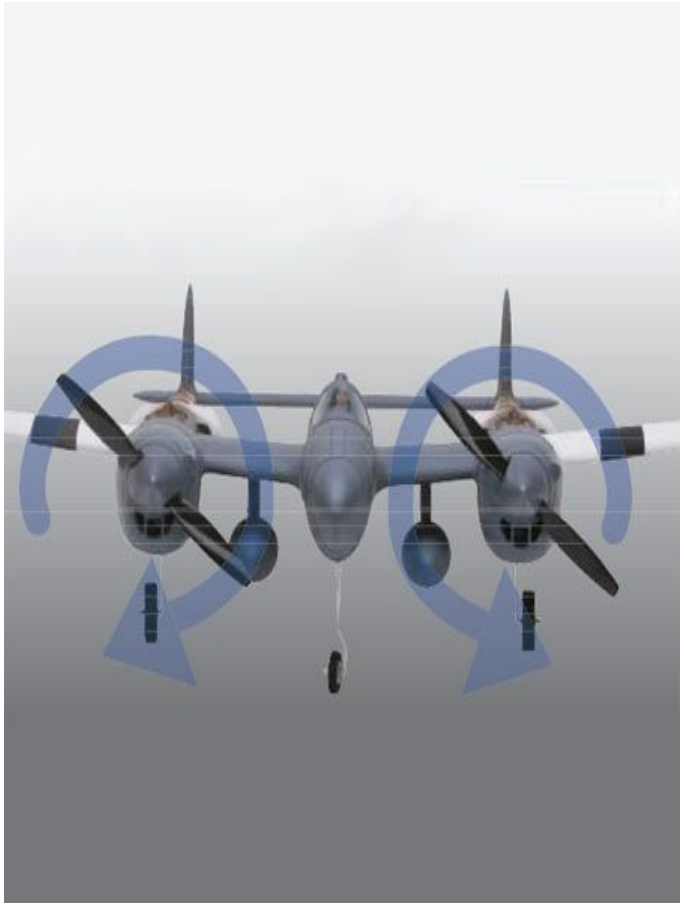
Now [Peterson Performance]

1965-1977 Mooney delivers all M20 with ‘always on’ wing-leveler

1961 – Center-line-thrust twin Cessna 336, 337

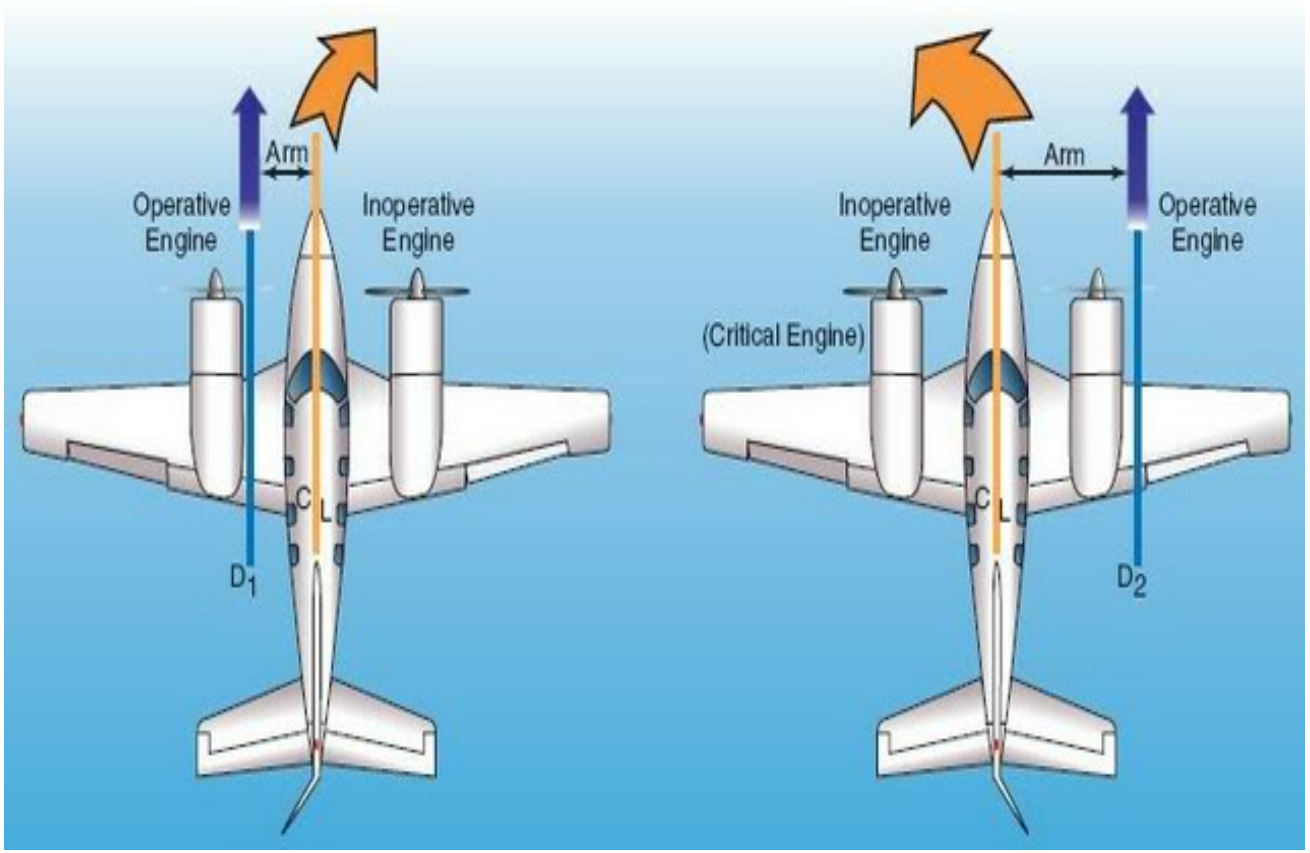


1978 Piper PA-44 Seminole has counter-rotating engines (Lockheed P-38 also)



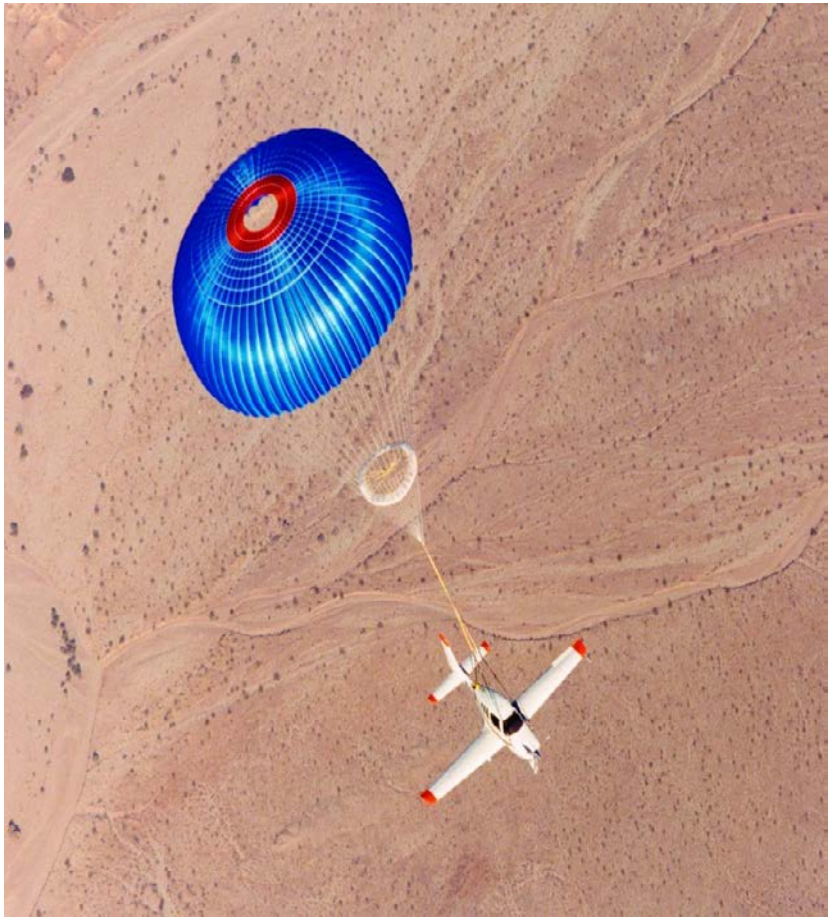
(Best graphic is P-38.)

VGs applied to engine-out Asymmetric twin



1982 – Precise Flight Speed Brakes introduced

1998 – Type Certificate includes ballistic parachute for LOC



1998 – Lancair –> Columbia –> Corvallis gets TC with active rudder limiter and wing cuffs.

Year 2000 – Diamond DA40 introduced

Summary

- Make wings and ailerons capable of very high Angle of Attack, higher than elevator's ability to stall the wing. (1929 – 86 years ago)
- Limit the elevator to some small maximum Angle of Attack, conditionally or permanently. (1939, 1947)
- Empower only the aileron through boundary layer enhancement, to an AOA greater than the elevator ability to stall the ailerons. Or/and, conditionally spoil the elevator (NASA TM 83208).
- Limit the pilot's ability to cross-control by blocking the rudder or giving him no rudder control : connecting it to aileron control.

Other LOC solutions – Center-line thrust, wing-leveler

Consensus Industry Committee for Certification

- **Federal law - National Technology Transfer and Advancement Act of 1995 (Public Law 104-113), signed into law on March 7, 1996, and OMB Circular A-119**
- **Historical aviation industry standards not formally administered by industry committee, rather by often obsolete military standards**
- **Choice of an administration service to organize meetings and maintain the data**
  - ***Not industry specific as is SAE – the Society of Automotive Engineers***
  - ***Generic – ASTM – now international but originally the American Society for Testing and Materials (I happen to be a vociferous critic of their information handling technology, but that is a battle for another day)***
  - ***Could be any of many organizations.***