AEM 617

Lecture 7

FARs / 14 CFR

Traditional Western Civilization is based on the rules of law.

In these U.S., the federal government regulates aviation in the Code of Federal Regulations (CFR) Title 14 "Aeronautics and Space"

"14 CFR part _ "

or unofficially,

"FARs" to be distinguished from Federal Acquisition Regulations

These rules specify all aviation requirements and actions allowed (from how to certify aircraft to how to pay the FAA for violation (14 CFR 13.16)). 3974 pages as of Jan 2016

Military Flight operations elsewhere. Different rules.

The FAA regulates <u>all</u> flight from 0' ft to ≈ 60 miles (The Kármán line) above the US. The upper limit is from the Outer Space Treaty of 1967.

The Kármán line is approximately where orbital velocity is below the speed necessary for aerodynamic lift of a vehicle. ≈ 100 km or 60 miles

Aside: Some of the pilots are saying, "But Class A ends at 60 kft". True, but above 60 kft, the airspace reverts to Class E. (i.e. under FAA control)

CHAPTER I—FEDERAL AVIATION ADMINISTRATION, DEPARTMENT OF TRANSPORTATION

SUBCHAPTER A—DEFINITIONS

SUBCHAPTER B—PROCEDURAL RULES

SUBCHAPTER C—AIRCRAFT

CHAPTER I—FEDERAL AVIATION ADMINISTRATION, DEPARTMENT OF TRANSPORTATION (CONTINUED)

SUBCHAPTER D—AIRMEN

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CHAPTER I—FEDERAL AVIATION ADMINISTRATION, DEPARTMENT OF TRANSPORTATION (CONTINUED)

SUBCHAPTER G—AIR CARRIERS AND OPERATORS FOR COMPENSATION OR HIRE: CERTIFICATION AND OPERATIONS

SUBCHAPTER H—SCHOOLS AND OTHER CERTIFICATED AGENCIES

CHAPTER II—OFFICE OF THE SECRETARY, DEPARTMENT OF TRANSPORTATION (AVIATION PROCEEDINGS)

EDITORIAL NOTE: Chapter II was transferred from the Civil Aeronautics Board to the Department of Transportation on January 1, 1985. For a document giving the disposition of CAB regulations once the Agency ceased to exist, see 50 FR 452, Jan. 4, 1985.

EDITORIAL NOTE: Nomenclature changes to chapter II appear by Docket No. DOT–OST–2008–0173, 73 FR 33327, June 12, 2008.

SUBCHAPTER A—ECONOMIC REGULATIONS

FAR 23 (aka 14 CFR 23)

Feb 1st 1965

Airworthyness Standards: Normal, Utility, Acrobatic and Commuter Aircraft

Describes the minimal certification requirements for civilian aircraft below 12500 lbs (except for commuter aircraft 19 K/lbs)

A brief overview

Flight
- Performance
- Controllability + Maneuverability
- Trim
- Stability
- Stalls
- Ground + Water operation
- High Speed

Structure
- Factor of Safety = 1.5
- Loads
- Control Surfaces + Loads
- Horz stab
- Vert
- Ailerons
- Ground loads
- Emergency landing loads
- Fatigue

Design + Construction
- Materials + processes
- Wing proof of strength
- Control Systems
- Landing Gear
- Cockpit + people "Accomodations" / Emergency Lighting
- Pressurization
- Fire protection

powerplant
- General
- Fuel System
- Oil
- Cooling
- Exhaust
- Fire

Equipment
- Instruments
- Electrical
- lights
- Ice, Oxygen

Operating Limits
- Airspeeds
- Flight Crew
- placards
- Flight Manual

Aircraft Catagories

Aircraft may be certified in any or all catagories if each req is met.

Normal: $W \leq 12500$ lbs

Bank angle $\leq 60°$, Stalls ok (no "whip" stalls

Passengers ≤ 9 + 1 pilot = 10 total

Ex: C-172, Piper ~~PA 34~~, B. Skipper, Learjet 23

Utility: $W \leq 12500$ lbs, 9 or ~~fewer~~ Passengers

Limited Aerobatics

- Spins (if approved!!)
- Bank up to 90°

Ex: lower weight A/C say 172

Acrobatic:

$W \leq 12500$ lbs, 9 or fewer

No attitude restrictions

Aircraft certified here are not certified in other catagory

Commuter:

Multi-engine

19 or fewer px.

$W \leq 19000$ lbs

Attitude limited to stalls, bank $\leq 60°$, normal flight.

Ex: Beechcraft 1900

Notice: Planes certified before 1965 were under the older CAR 3 rules. This may be one reason that light aircraft remain the same. The costs to recertify a 150 under 14 CFR 23 would be higher than the benefits.

Flight Performance

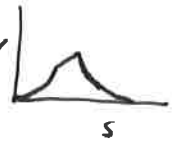
Stall Speeds: V_{S0} and $V_{S1} \leq 61$ kts (unless a special process)

Rotation Speed: $V_r \geq V_{S1}$ unless multiengine $V \geq V_1$

Decision Speed: V_1 pilot decides to continue or discontinue takeoff

Accelerate-stop distance (for $W > 6000$ lbs)

- Accel to V_{EF} where engine fails
- Accel to V_1
- Decel to stop

} reliable and safe $\Rightarrow$ 

Climb Gradients

Various regs based on weight and configuration $\approx 3.3\%$

Controllability

- A/C must be able to safely fly: T/O, Climb, level, descent, go-around, landing
- Must be able to transition without exceeding load limits
- Control forces limited to

Temp Application	Pitch	Roll	Yaw
stick	60 lbs	30 lbs	
yoke (2 hands)	75	50	
yoke (1 hand)	50	25	
rudder			150
prolonged			
	10	5	20

Implies Trim requirements

Set of transition maneuvers for testing control forces

Ex: landing config to go-around

M_{mo}/V_{mo} recovery

- Engine out multiengine

  bank and heading with time limit

- V_{mc} and V_{mcg} Minimum Controllable Airspeed (Air and ground)

  Critical to multiengine cert.

- Acrobatic Maneuvers

  Acrobatic aircraft must be able to perform acrobatic maneuvers safely....

- Load Limit Stick Forces

  For g-load (positive) max: wheel force $\geq \frac{W}{100}$ or 20 lbs but ≤ 50 lbs ok

  stick forces $\geq \frac{W}{140}$ or 15 lbs but ≤ 35 lbs ok

- Roll Rate

  +30 → -30 bank angle in 5 seconds for $W \leq 60000$ lbs

  in $\frac{W+500}{1300}$ for $W > 60000$ lbs

Stability

- Speed Stability in Climb, Cruise, Landing
  - Airspeed returns to ±10% of trim airspeed
  - 7.5% if commuter category
- Stick stability
  - Stable slope within specified range of trim speed
- Lateral and directional stability
  - Wings level sideslip
  - Rudder forces must not reverse
- Dynamic
  - Short period heavily damped
  - Dutch roll

    1/10 amplitude in 7 cycles < 18000ft and 13 cycles > 18000ft.

Stalls

- No reversed controls up to stall
- Must be a stall warning: Aero or a device

Spins.

Normal Category: Recovery in 1 turn. Must be impossible to obtain unrecoverable spin

Utility: Normal + Acrobatic

Acrobatic: Recover at any point in 1.5 turns, remain within loads, no disorientation or incapacitation of pilot !!

Misc:

Vibration + Buffeting: No buffeting up to M_{MO} in cruise, no damage up to M_D

High Speed:

1) Trim up to M_{MO} + Add upset + pilot reaction time
2) Must be below M_D, no exceptional pilot skill, no impairing buffet, no control reversal

Out of trim (if $M_D > 0.6$ and trimmable stab)

From M_D: { 3 seconds of trim ± / Max autopilot trim ± }

Must show positive stick force
Must test ≈ -1.0 g to 2.5 g
Must not exceed M_D / V_D

Structure

- The structure must support { limit loads without permanent deformation; ultimate loads for 3 seconds }
- Compliance w above must be shown for each critical load condition.

Flight Envelope

- Positive maneuvering limit

$n^+ \geq 2.1 + \frac{24000}{W+10000}$ for normal + commuter (but not necessary to > 3.8)

$n^+ \geq 4.4$ utility

$n^+ \geq 6.0$ acrobatic

- Negative

$n^- \geq 0.4 \cdot n^+$ normal + commuter + utility

$n \geq 0.5 \cdot n^+$ acrobatic

- Special Case

If the aircraft has special design features, relaxed n^+, n^-.

- Gust loads

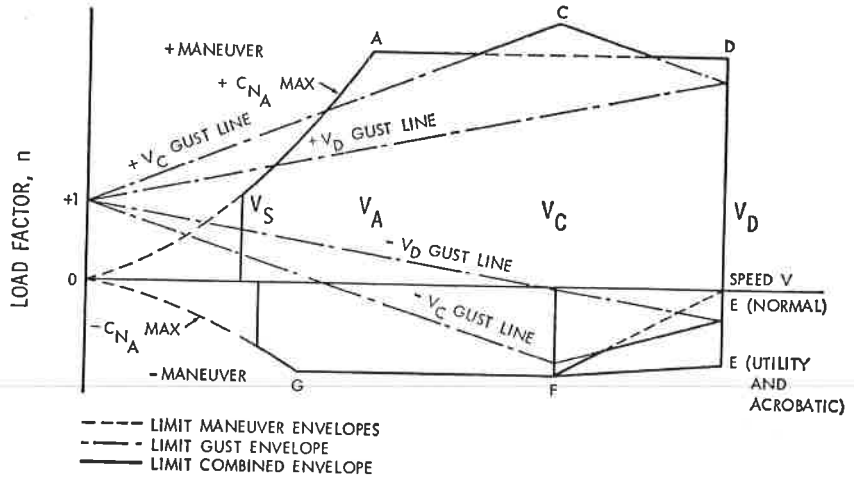
50 ft/s at V_C tapers to 25 between 20 KH to 50 KH

25 ft/s at V_D "

except 66 ft/s for commuter

Design Airspeeds

- Cruise $V_c \geq \$33\sqrt{\frac{W}{S}}$ (wing loading) or $\$36\sqrt{\frac{W}{S}}$ for acrobatic
- Dive $V_D \geq 1.25\, V_c$, $M_D \geq 1.25\, M_c$ many other criteria
- Maneuvering $V_A \geq V_S\sqrt{n}$
- Gust Intensity V_B



Q: Why does the maneuver envelope start at $n=0$, but the gust envelope starts at $n=1$

Gust Load Factors

"In the absence of a more rational analysis..." 14 CFR 23.341

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

$$K_g = \frac{0.88 \mu_g}{0.53 + \mu_g}$$

U_{de} = gust velocity [fps]

$\mu_g \equiv 2\left(\frac{W}{S}\right) \frac{1}{\rho} \frac{1}{\bar{C} a g}$ Airplane mass ratio

a = C_{N_α} in $\frac{1}{\text{radians}}$

g = gravity

$\bar{C}$ = chord

- Loads at Unsymetrical Flight Conditions
- Engine Torque + Side loads
- Pressurized Cabin

$P_{design} = \text{Max } \Delta p \cdot 1.33$

- Gyroscopic and Aero loads on engine mounts

$\dot{\psi} = 2.5 \text{ rad/s} \approx 140°/s$

$\dot{\phi} \approx 57°/\text{sec}$

$n = 2.5$

Max Thrust

- Control system

Max pilot Forces (if $W \leq 5000^{lb}$, otherwise multiply by >1.0 value)

Aileron		
	stick	67 lbs
	wheel	50.0 in-lbs
Elevator		
	stick	167 lbs
	wheel	200 lbs
Rudder		200 lbs

- Ground Gust Forces + Moments

- Aero Maneuvering Loads

- Landing Gear loads

- Emergency landing

Occupants must excape serious injury when

1) Safety belt used
2) 3.0g upward, 9.0 g forward, 1.5g side
3) LG up
4) turnover

Engines located <u>aft</u> of cabin must withstand 18g load and not enter the cabin

Example: Normal Category

$W = 2400\,lb$ $S = 180\,ft^2$ $C_{L_{max}} = 1.8$ $\bar{c} = 4\,ft$

1) Cruise $V_c \geq 33\sqrt{\frac{W}{S}} = 120\,kt$

2) Dive $V_D \geq 1.25 \cdot V_c = 150\,kt$

3) Maneuvering

V_S from $W = \underbrace{q}_{\frac{1}{2}\rho V^2} S C_{L_{max}} \Rightarrow V = \sqrt{\frac{2W}{S \cdot C_{L_{max}} \cdot \rho}}$

$= 79\,ft/s = 46\,kts$

$lbf \left| \frac{ft^2}{ft^2} \right| \frac{slug\,ft}{lbf\,s^2}$ ✓

$V_A \geq V_S \sqrt{n^+}$ Normal cat $n^+ \geq 2.1 + \frac{24000}{2400 + 10000} = 4$

$\geq 46\,kts \sqrt{4} = 93\,kts$

4) Negative g-load

$n^- \geq 0.4\, n^+ = 1.6$

5) Gust constant

$\mu_g \approx 13.9 \Rightarrow K_g \approx 0.84$

$n = 1 + \frac{0.84 \cdot U_{de} \cdot V \cdot 2\pi}{498 \cdot \frac{2400}{180}}$

$50\,ft/s$: $n = 1 + 0.0397\,V$

$25\,ft/s$: $n = 1 + 0.0198\,V$

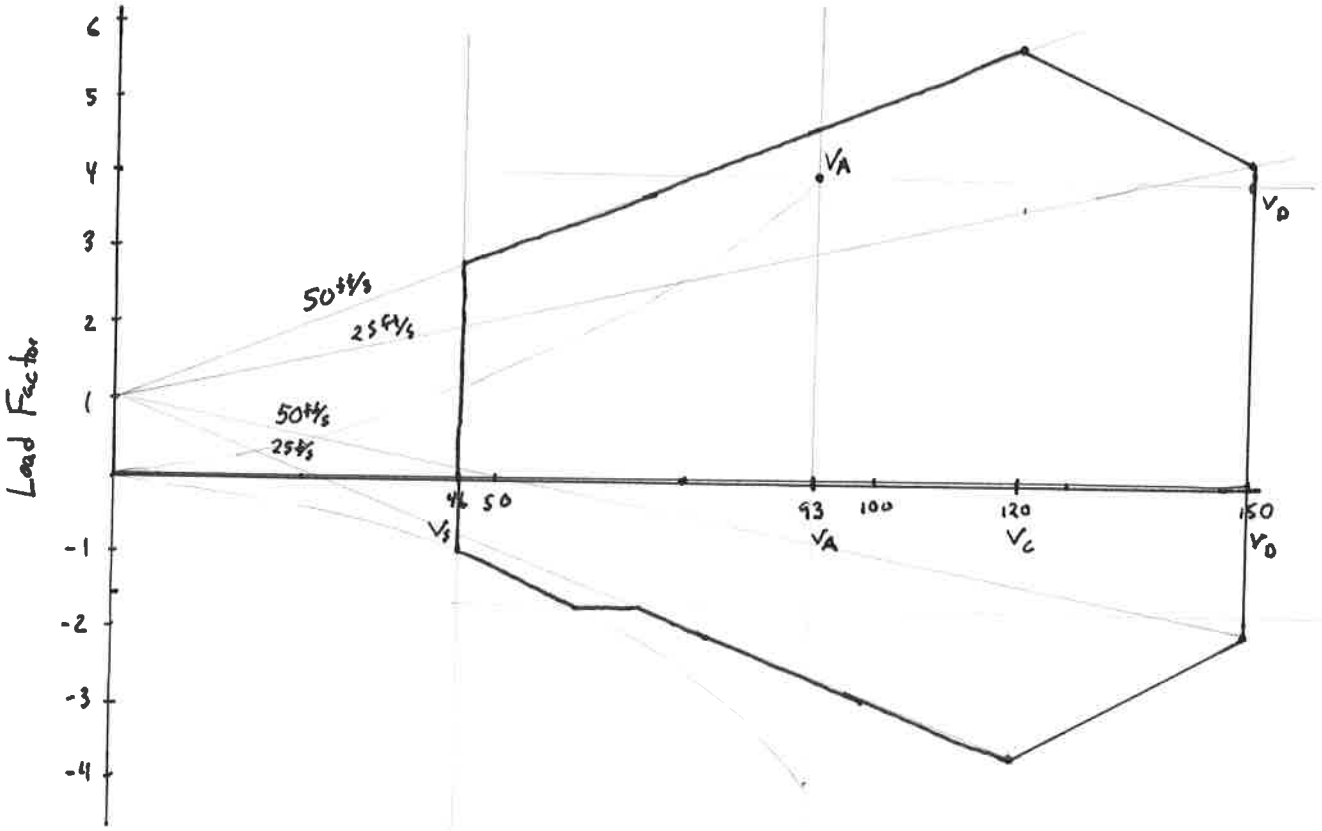
Intersection of $50\,ft/s$ with $n = 4$ at $V = 75.5\,kt$

$50\,ft/s$ at V_c: $n^+ = 5.77$

$n^- = 3.77$

$25\,ft/s$ at V_D: $n^+ = 3.98$

$n^- = 1.98$


Load Factor
6
5
4
3
2
1
-1
-2
-3
-4
50 ft/s
25 ft/s
50 ft/s
25 ft/s
V_A
V_D
V_S
50
93
100
120
150
V_A
V_C
V_D