

AEM 617

Lecture 7

FARs / 14 CFR

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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 \_ "

" FARs " <sup>or unofficially</sup> to be distinguished from Federal Acquisition Regulations  
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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 all flight from 0' ft to  $\approx 60$  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.  $\approx 100$  km or 60 miles

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

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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.

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# FAR 23 (aka 14 CFR 23)

Feb 1<sup>st</sup> 1965

Airworthiness Standards: Normal, Utility, Acrobatic and Commuter Aircraft

Describes the minimal certification requirements for civilian aircraft below 12500<sup>lbs</sup> (except for commuter aircraft 19<sup>klbs</sup>)

## 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
- Horiz stab
- Vert
- Ailerons
- Ground loads
- Emergency landing loads
- Fatigue

### Design + Construction

- Materials + Processes
- Wing proof of strength
- Control Systems
- Landing Gear
- Cockpit + people "Accommodations" / Emergency Lighting
- Pressurization
- Fire Protection

### Powerplant

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

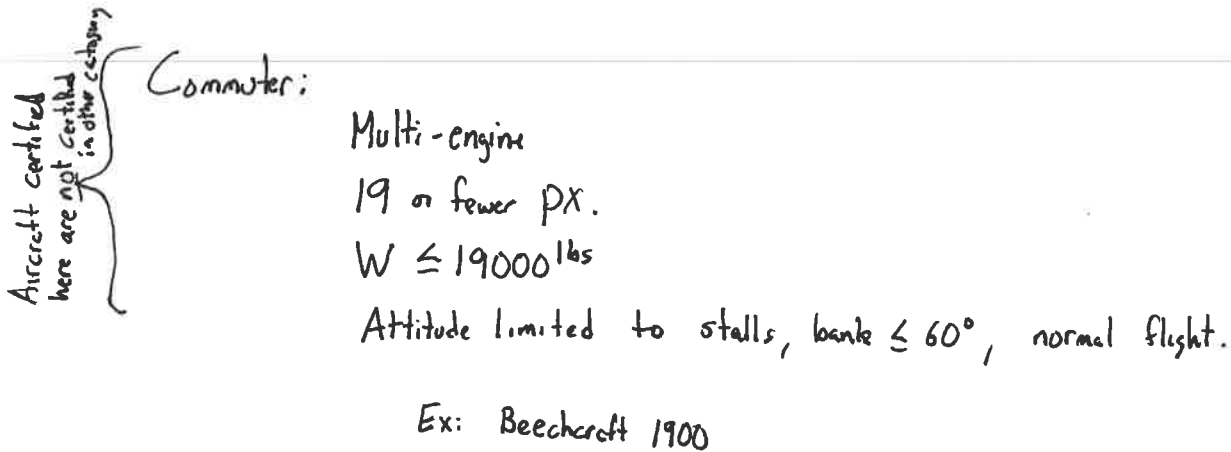
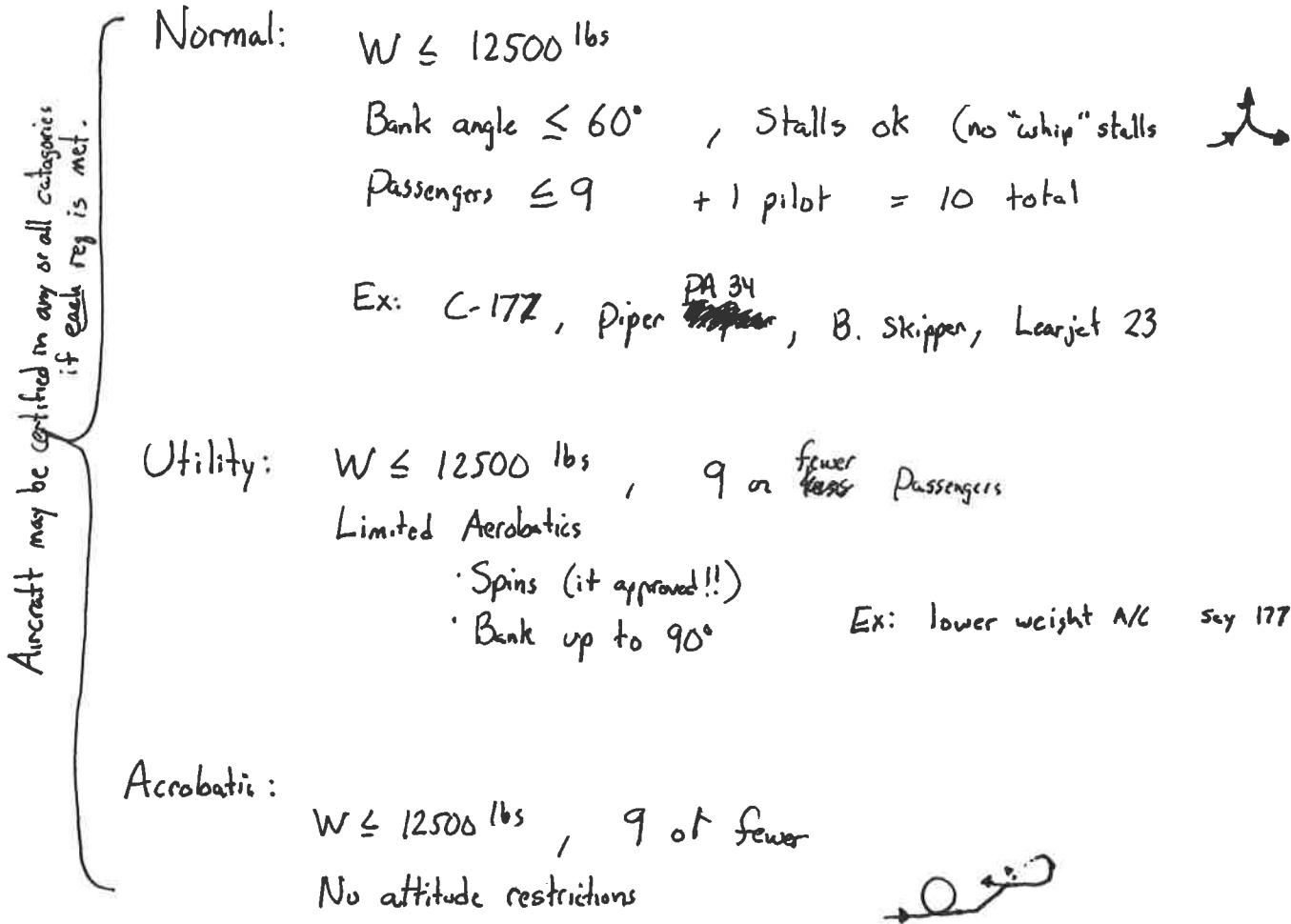
### Equipment

- Instruments
- Electrical
- Lights
- Ice, Oxygen

### Operating Limits

- Airspeeds
- Flight Crew
- Placards
- Flight Manual

# Aircraft Categories



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	Implies Trim requirements
stick	60 lbs	30 lbs		
yoke (2 hands)	75	50		
yoke (1 hand)	50	25		
rudder			150	
<u>prolonged</u>	10	5	20	

Set of transition maneuvers for testing control forces

Ex: landing config to go-around  
M<sub>mo</sub>/V<sub>mo</sub> recovery

- Engine out multiengine  
bank and heading with time limit
- V<sub>mc</sub> and V<sub>mcg</sub> 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  $\rightarrow$  -30 bank angle in 5 seconds for  $W \leq 6000$  lbs  
in  $\frac{W+500}{1300}$  for  $W > 6000$  lbs

## Stability

- Speed stability in Climb, Cruise, Landing
  - Airspeed returns to  $\pm 10\%$  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
    - $\% \text{ amplitude in } 7 \text{ cycles} < 18000 \text{ft}$  and  $13^{\text{cycles}} > 18000 \text{ft}$ .

## 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  $M_D$ :  $\left\{ \begin{array}{l} 3 \text{ seconds of trim } \pm \\ \text{Max autopilot trim } \pm \end{array} \right\}$

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

# Structure

- The structure must support  $\left\{ \begin{array}{l} \text{limit loads without permanent deformation} \\ \text{ultimate loads for 3 seconds} \end{array} \right.$
- Compliance w above must be shown for each critical load condition.

# Flight Envelope

- Positive maneuvering limit

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

$$n^+ \geq 4.4 \quad \text{utility}$$

$$n^+ \geq 6.0 \quad \text{acrobatic}$$

- Negative

$$n^- \geq 0.4 \cdot n^+ \quad \text{normal + commuter + utility}$$

$$n^- \geq 0.5 \cdot n^+ \quad \text{acrobatic}$$

- Special Case

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

- Gust loads

50  $\frac{ft}{s}$  at  $V_C$  tapers to 25 between 20  $kt$  to 50  $kt$

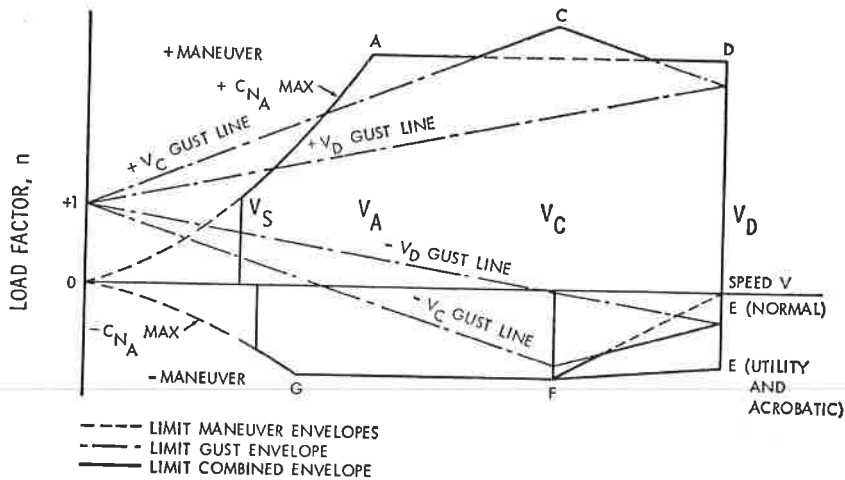
25  $\frac{ft}{s}$  at  $V_D$

except 66  $\frac{ft}{s}$  for commuter



# Design Airspeeds

- Cruise  $V_c \geq \sqrt[3]{33 \frac{W}{S}}$  wing loading or  $\sqrt[3]{36 \frac{W}{S}}$  for acrobatic
- Dive  $V_D \geq 1.25 V_c$   
 $M_D \geq 1.25 M_c$  many other criteria
- Manoeuvring  $V_A \geq V_S \sqrt{n}$
- 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]

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

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

$g$  = gravity

$C$  = chord

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

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

- Gyroscopic and Aero loads on engine mounts

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


$$\dot{\phi} \approx 57\%/\text{sec}$$

$$n = 2.5$$

Max Thrust

- Control system

Max pilot Forces (if  $W \leq 5000\text{lb}$ , 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 landings

Occupants must escape 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 aft of cabin must withstand 18g load and not enter the cabin

Example: Normal Category

$$W = 24000 \text{ lb}$$

$$S = 180 \text{ ft}^2$$

$$C_{L_{\max}} = 1.8$$

$$z = 4 \text{ ft}$$

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

2) Dive  $V_D \geq 1.25 \cdot V_c = 150 \text{ kt}$

3) Manoeuvring

$$V_s \text{ from } W = \frac{\rho}{2} S C_{L_{\max}} V^2$$

$$\Rightarrow V = \sqrt{\frac{2W}{S \cdot C_{L_{\max}} \cdot \rho}}$$

$$= 79 \text{ ft/s} = 46 \text{ kts}$$

lb	ft <sup>2</sup>	ft/s
ft <sup>2</sup>	slugs	lb/s <sup>2</sup>

$$V_A \geq V_s \sqrt{n^+}$$

Normal cat

$$n^+ \geq 2.1 + \frac{24000}{2400 + 10000} = 4$$

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

4) Negative g-load

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

5) Gust constant

$$M_g \approx 13.9 \Rightarrow K_g \approx 0.84$$

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

$$50 \text{ ft/s} : n = 1 + 0.0397 V$$

$$25 \text{ ft/s} : n = 1 + 0.0198 V$$

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

$$50 \text{ ft/s at } V_c : n^+ = 5.77$$

$$n^- = 3.77$$

$$25 \text{ ft/s at } V_D : n^+ = 3.98$$

$$n^- = 1.98$$

