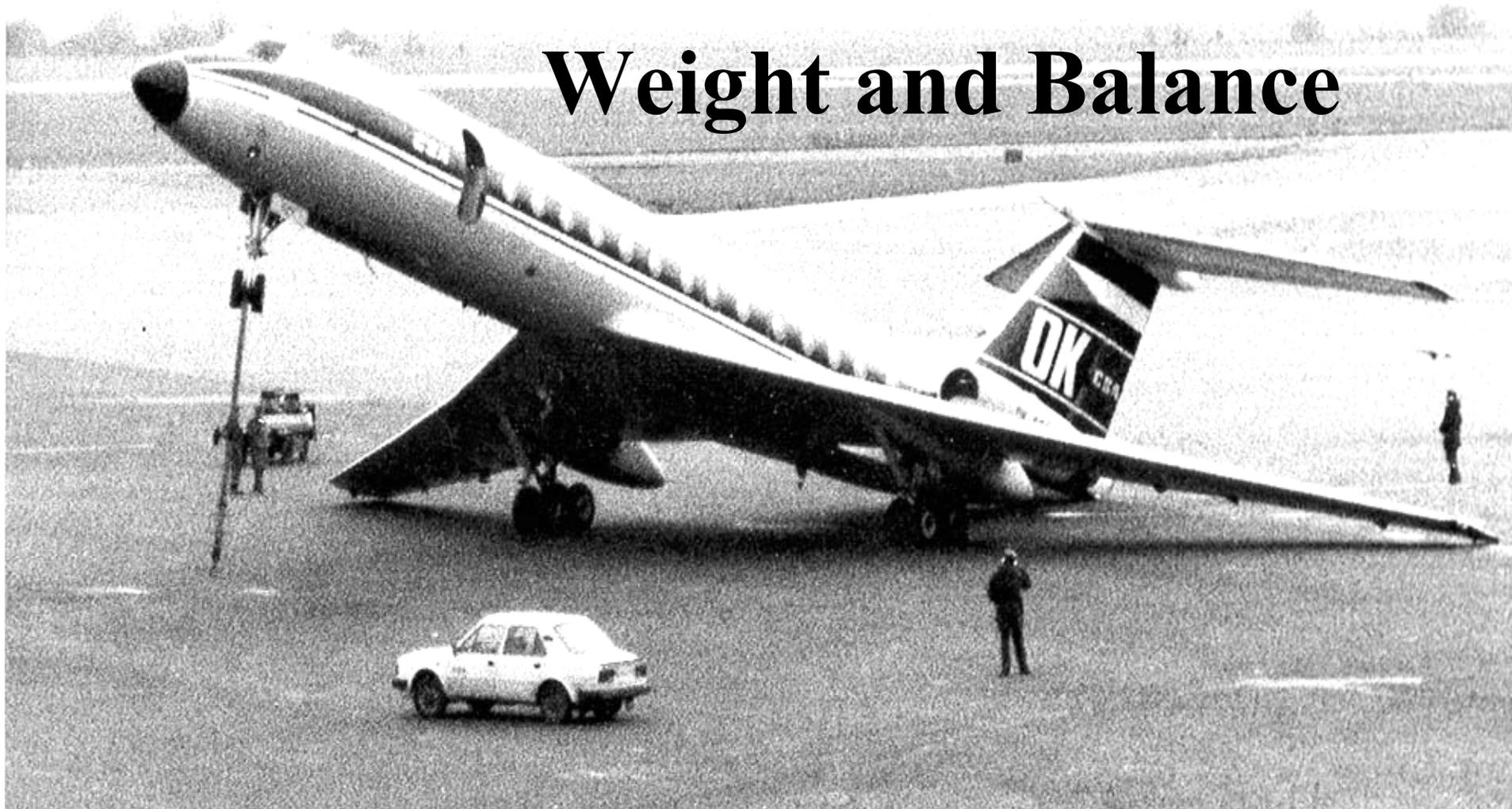
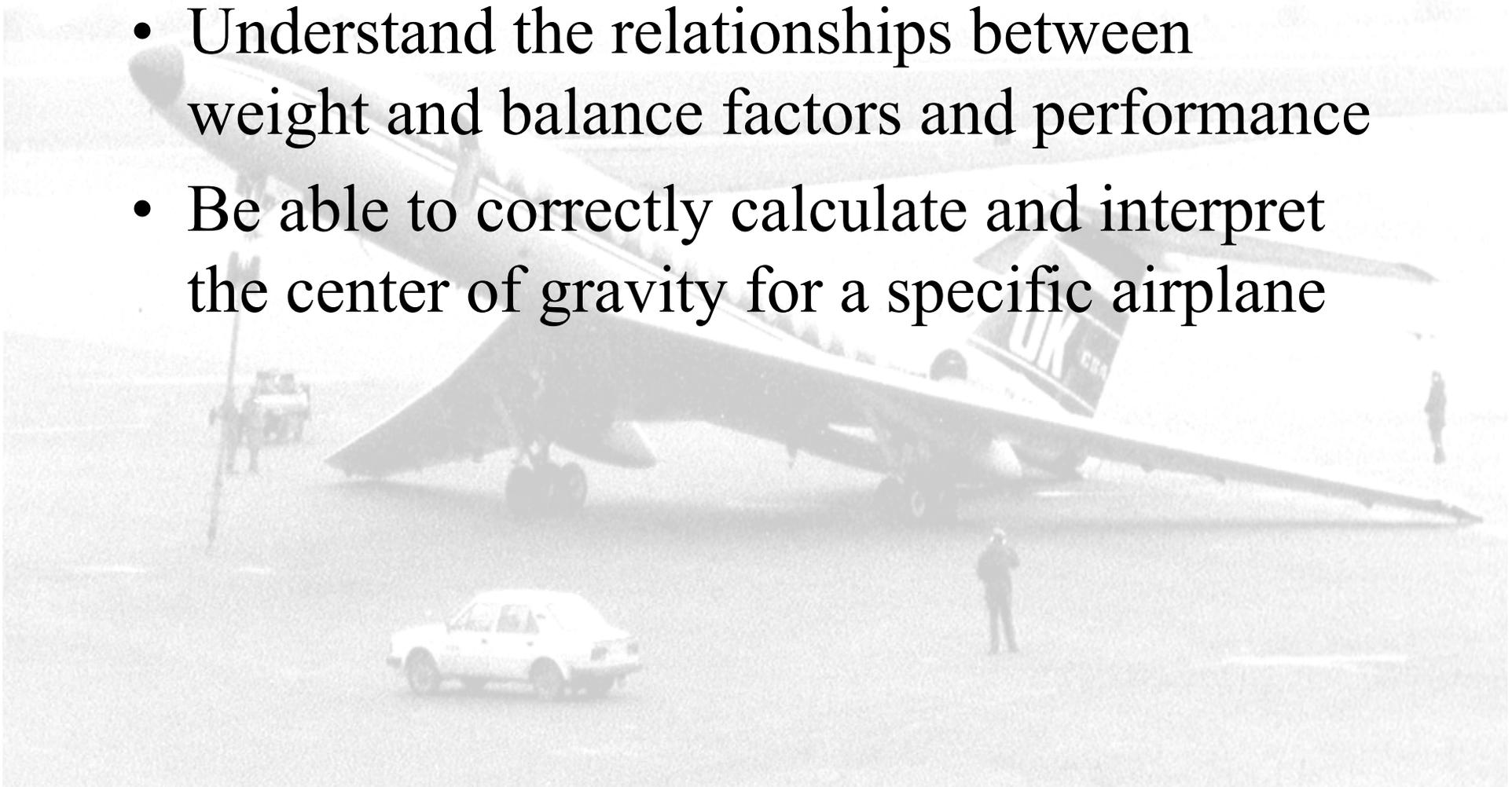


Weight and Balance



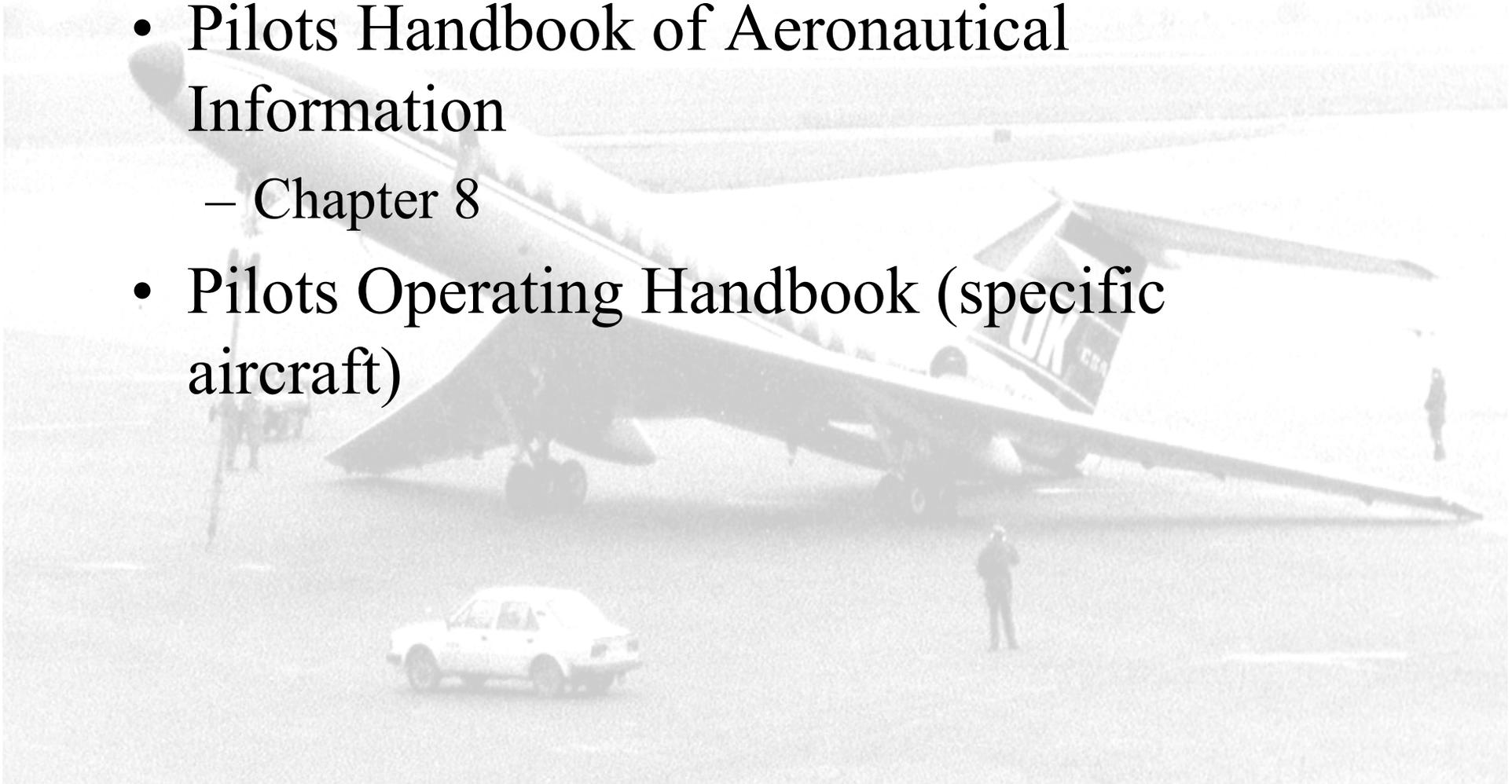
Objectives

- Understand the relationships between weight and balance factors and performance
- Be able to correctly calculate and interpret the center of gravity for a specific airplane



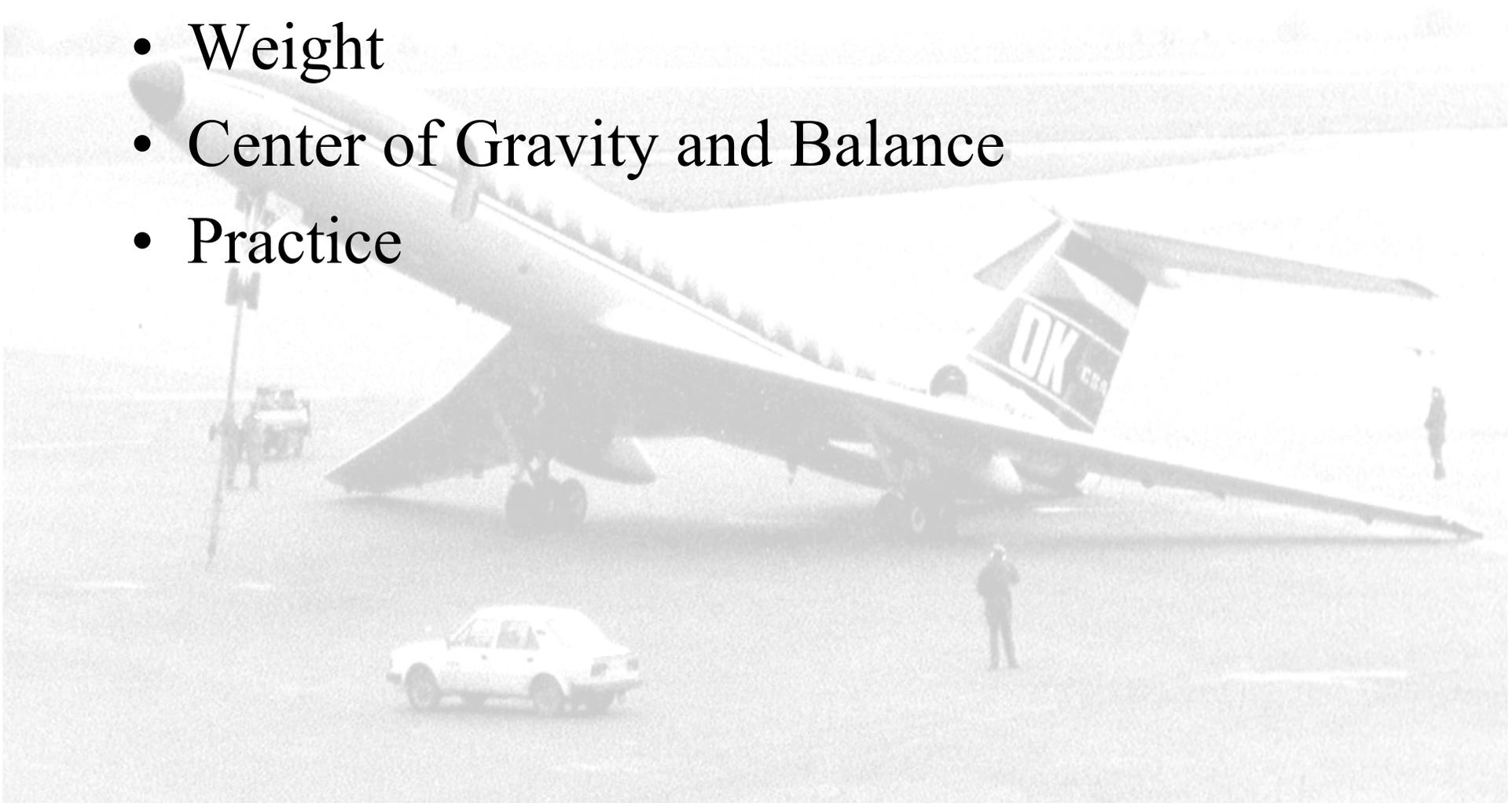
References

- Pilots Handbook of Aeronautical Information
 - Chapter 8
- Pilots Operating Handbook (specific aircraft)



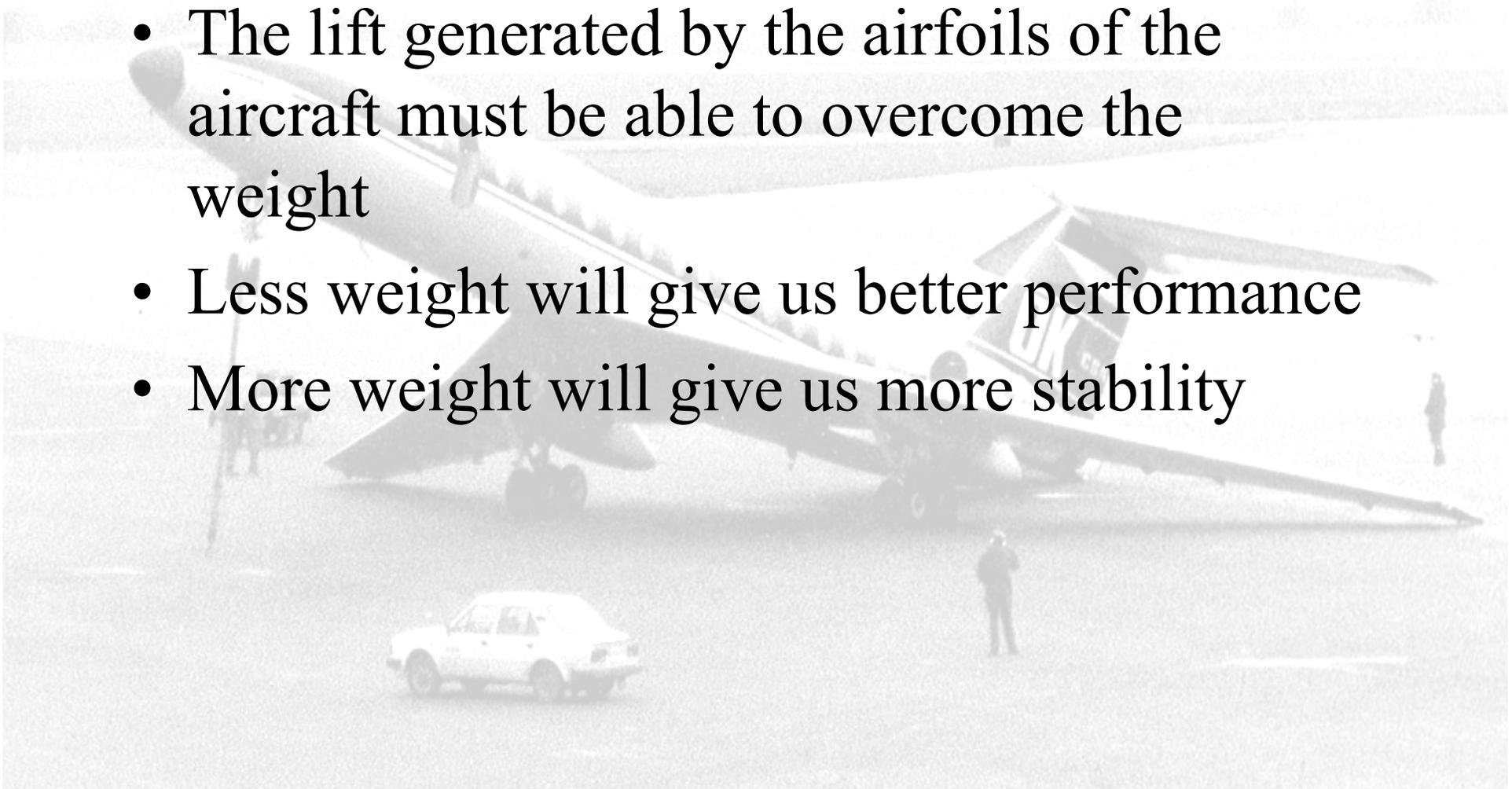
Overview

- Weight
- Center of Gravity and Balance
- Practice



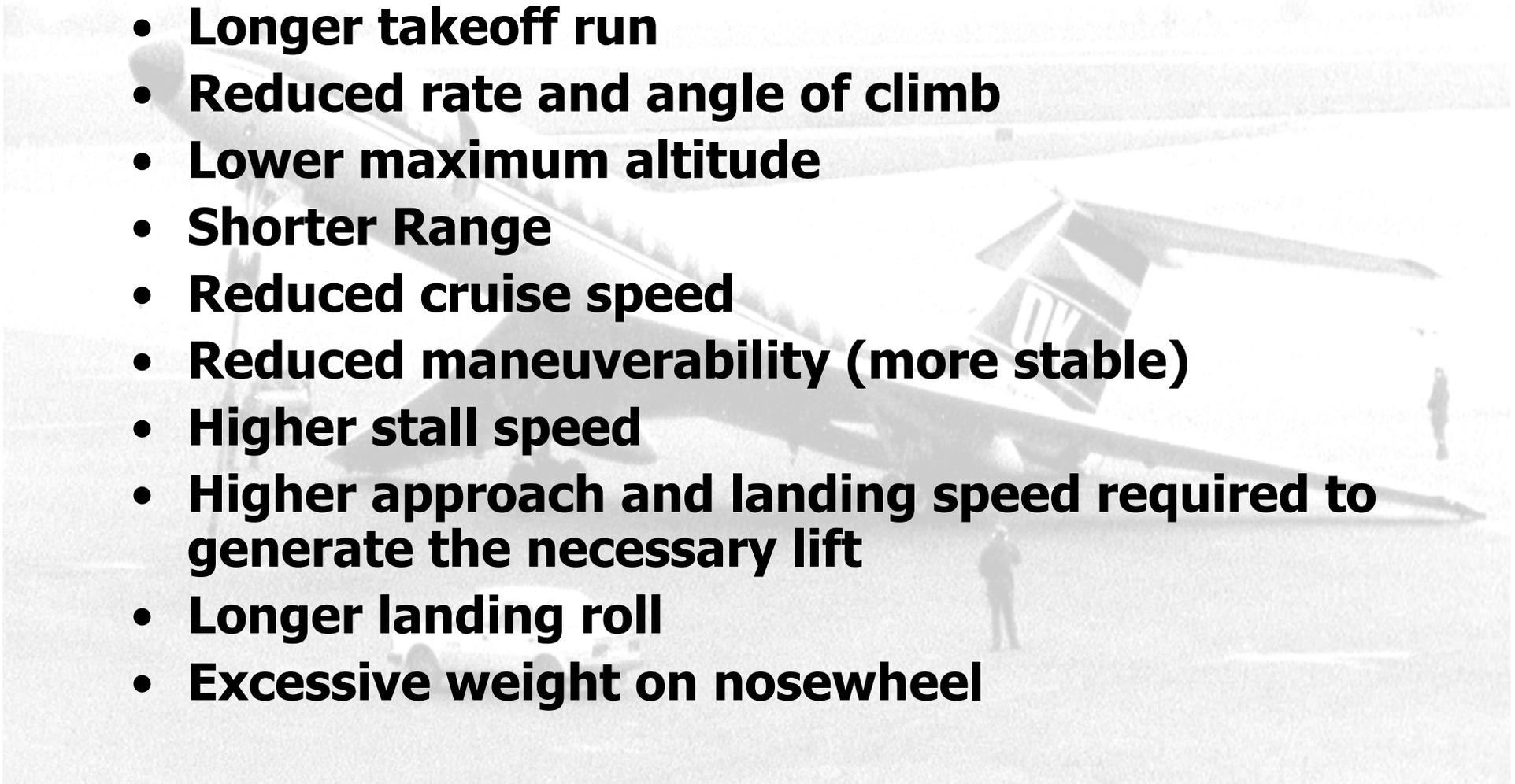
Weight

- The lift generated by the airfoils of the aircraft must be able to overcome the weight
- Less weight will give us better performance
- More weight will give us more stability



Excessive Weight

- **Higher takeoff speed required**
- **Longer takeoff run**
- **Reduced rate and angle of climb**
- **Lower maximum altitude**
- **Shorter Range**
- **Reduced cruise speed**
- **Reduced maneuverability (more stable)**
- **Higher stall speed**
- **Higher approach and landing speed required to generate the necessary lift**
- **Longer landing roll**
- **Excessive weight on nosewheel**



Weight Control

- Adequate pre-flight planning
 - Use charts provided
 - Consider performance and emergency factors
- Fuel load
 - 6 pounds per gallon
- Passengers and baggage
 - Mother in law?

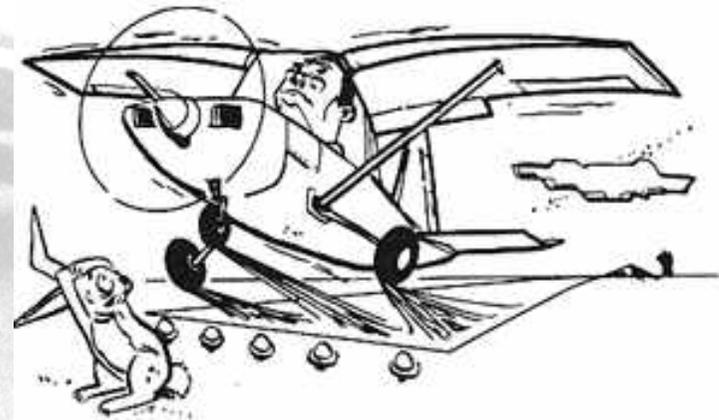
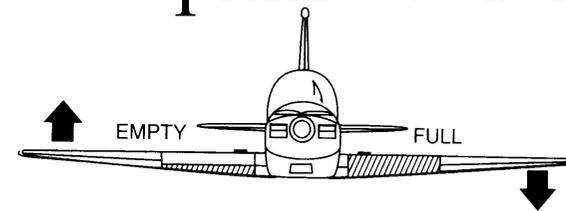


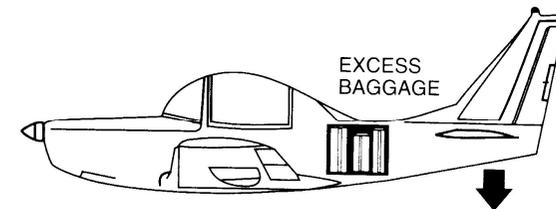
FIGURE 2. Overweight causes longer takeoff run.

Center of Gravity

- Definition: Point at which the airplane would balance if suspended
- Lateral CG
 - Fuel Consumption
- Longitudinal CG
 - Can move fore or aft depending on load
 - POH has published “CG limits”



Lateral unbalance will cause wing heaviness



Longitudinal unbalance will cause either nose or tail heaviness

Forward Center of Gravity

- Nose – Heavy
 - Problems controlling and raising the nose
 - Inability to flare for landing
- Acts as more weight
 - More stable
 - Decreased Performance
- Higher stall speeds



FIGURE 4. Forward c.g. critical on landing.

Aft Center of Gravity

- Tail Heavy
 - Light control forces
 - Easy to over-control and overstress
- Reduced capability to recover from stalls and spins
 - Can not lower nose
 - Flat spin: nearly impossible to recover
- Decreased stability
 - Difficult to right itself after maneuvering/turbulence

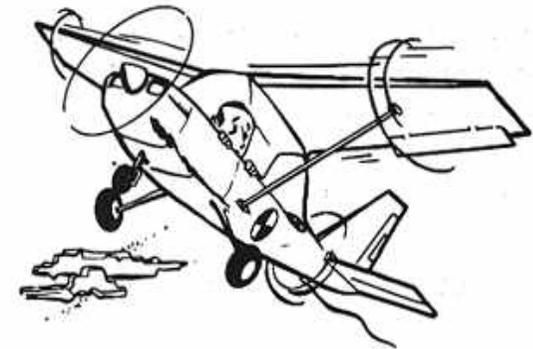
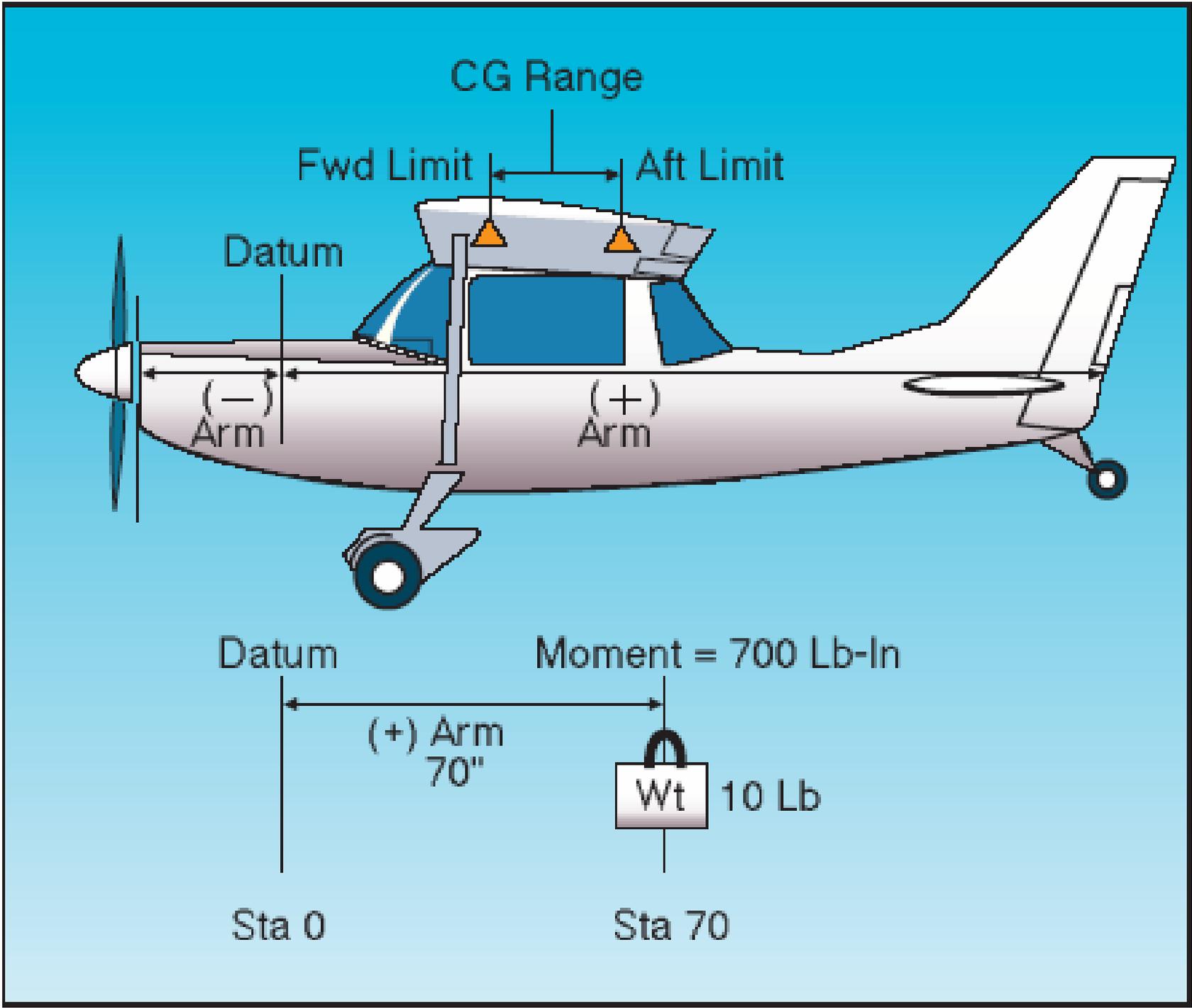
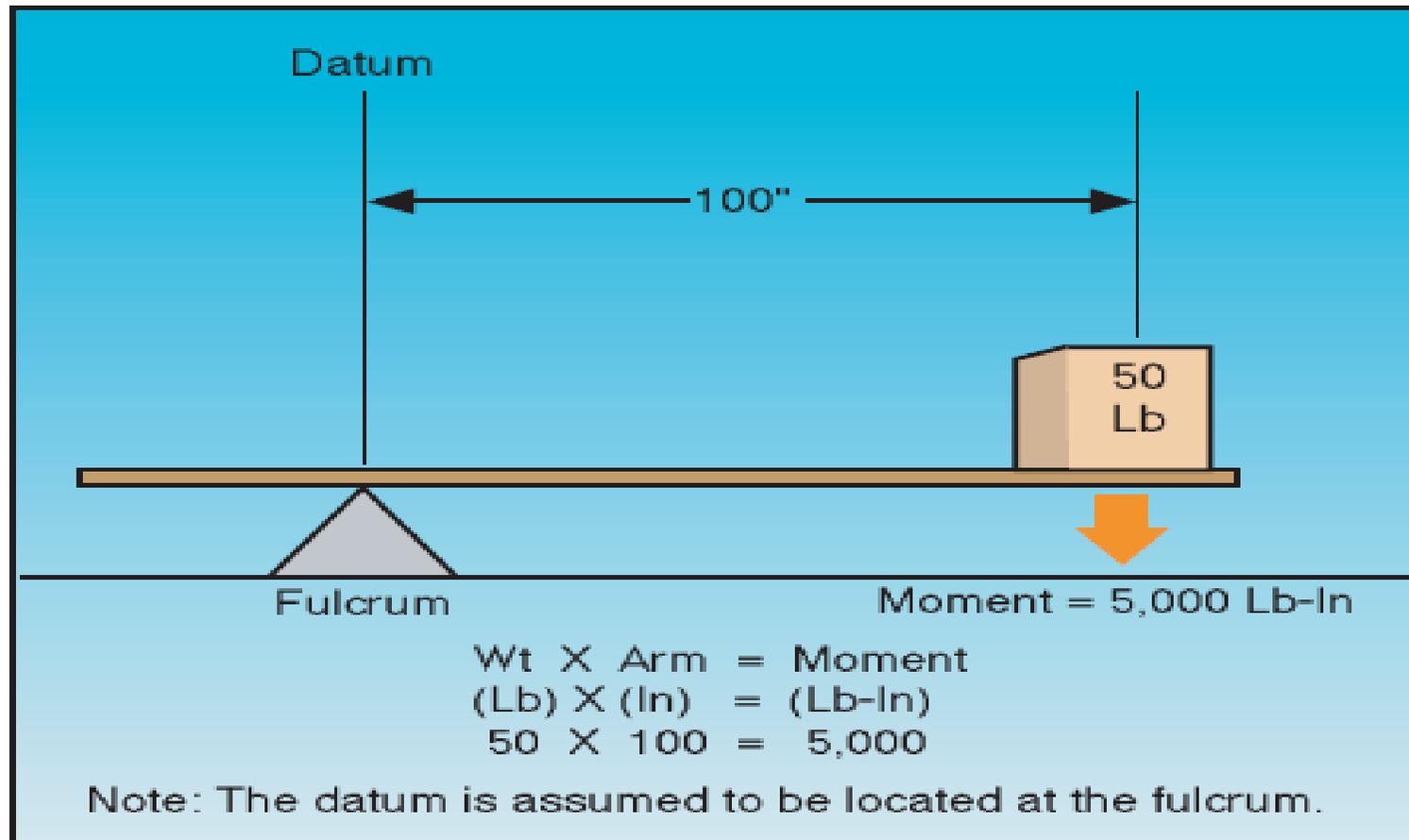
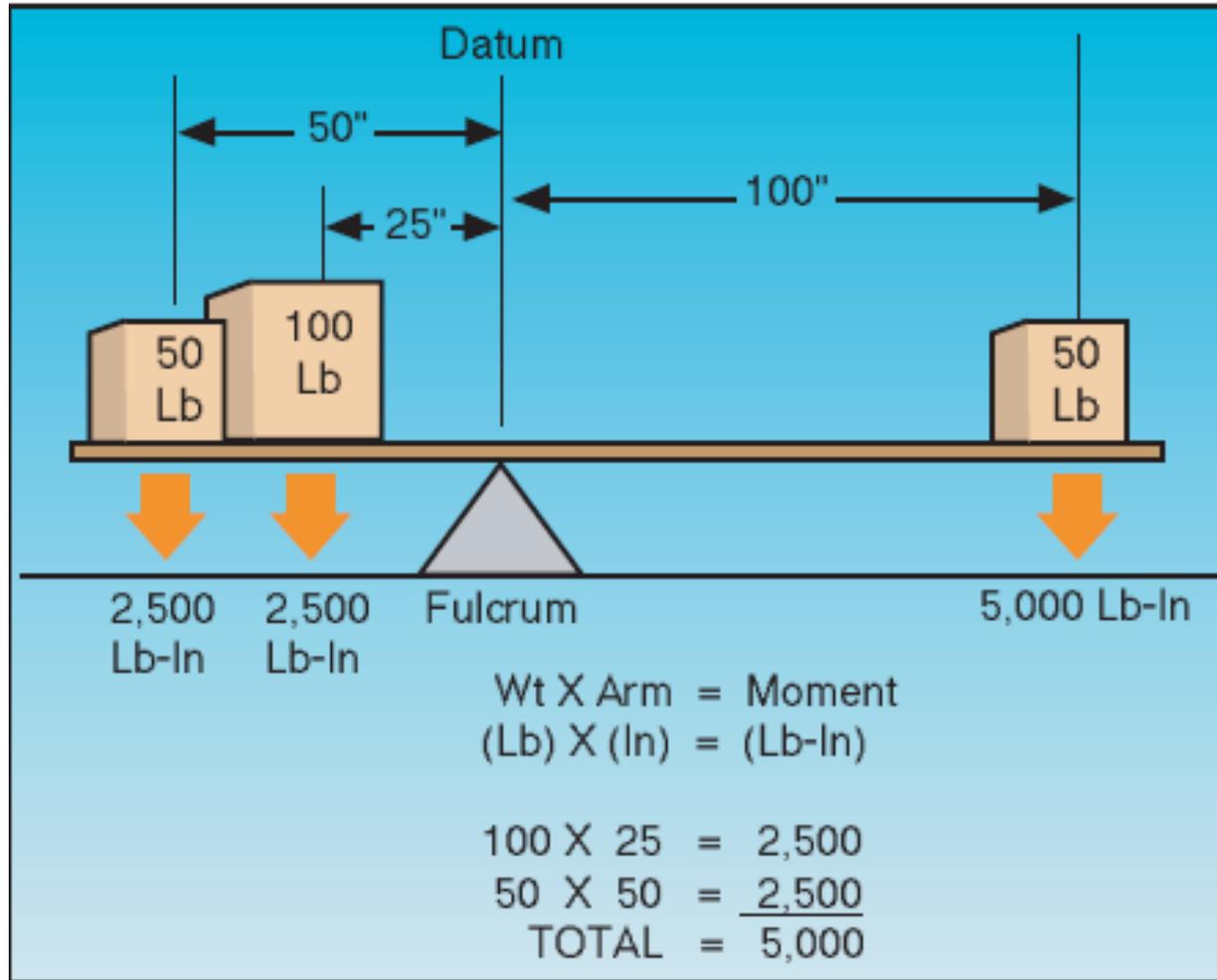


FIGURE 5. Aft c.g. critical in a stall.



Moment



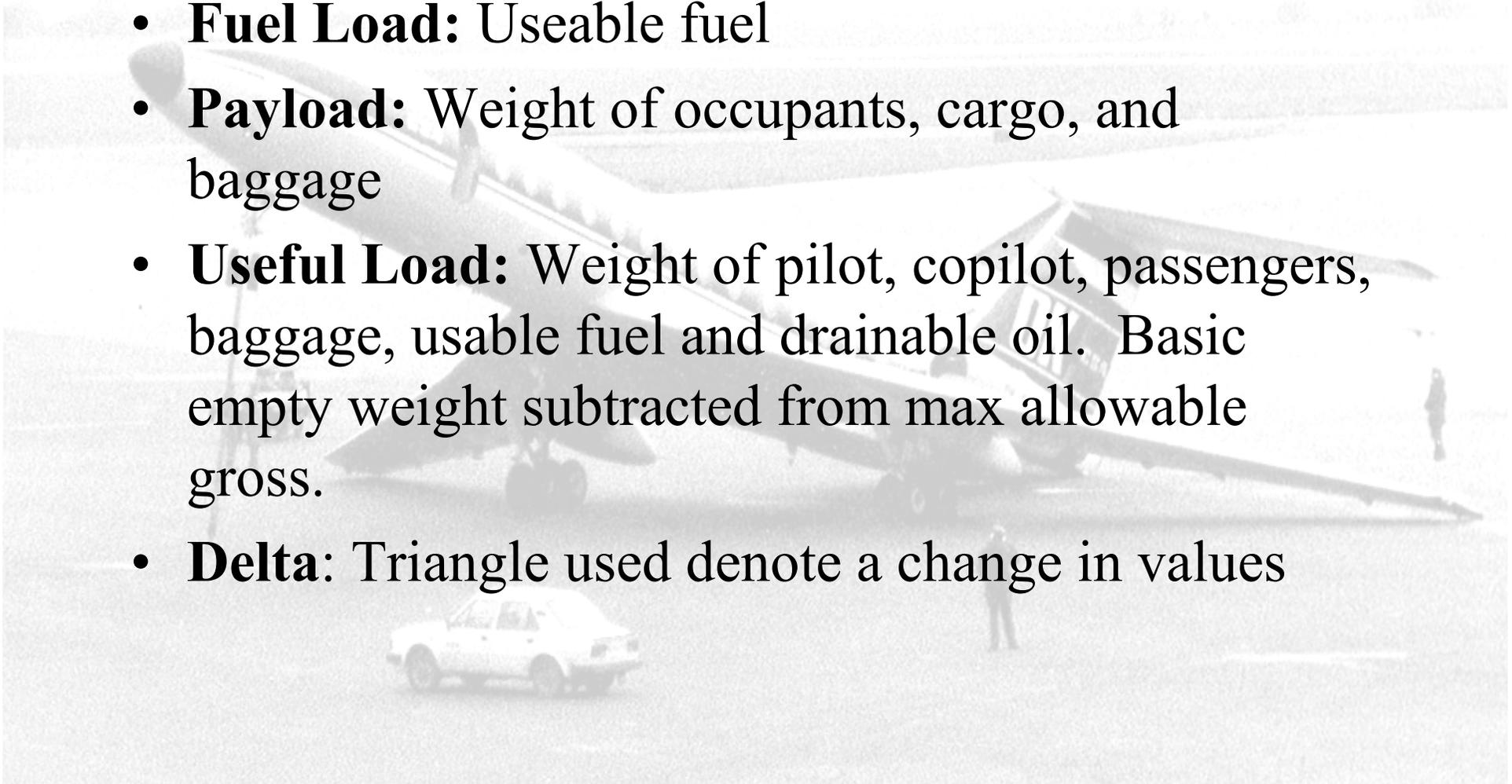


Definitions

- **Arm:** horizontal distance in inches from the reference datum line to the center of gravity of an item. (+) denotes aft of datum, (-) denotes forward of datum
- **Moment:** Product of the weight of an item multiplied by its arm
- **Datum:** Imaginary vertical plane or line from which all measurements of arm are taken. Established by manufacturer. Everything (moment arms, CG range) measured from this point.
- **Station:** Location in the airplane identified by a number designating its distance in inches from the datum.

Definitions (cont'd)

- **Fuel Load:** Useable fuel
- **Payload:** Weight of occupants, cargo, and baggage
- **Useful Load:** Weight of pilot, copilot, passengers, baggage, usable fuel and drainable oil. Basic empty weight subtracted from max allowable gross.
- **Delta:** Triangle used denote a change in values

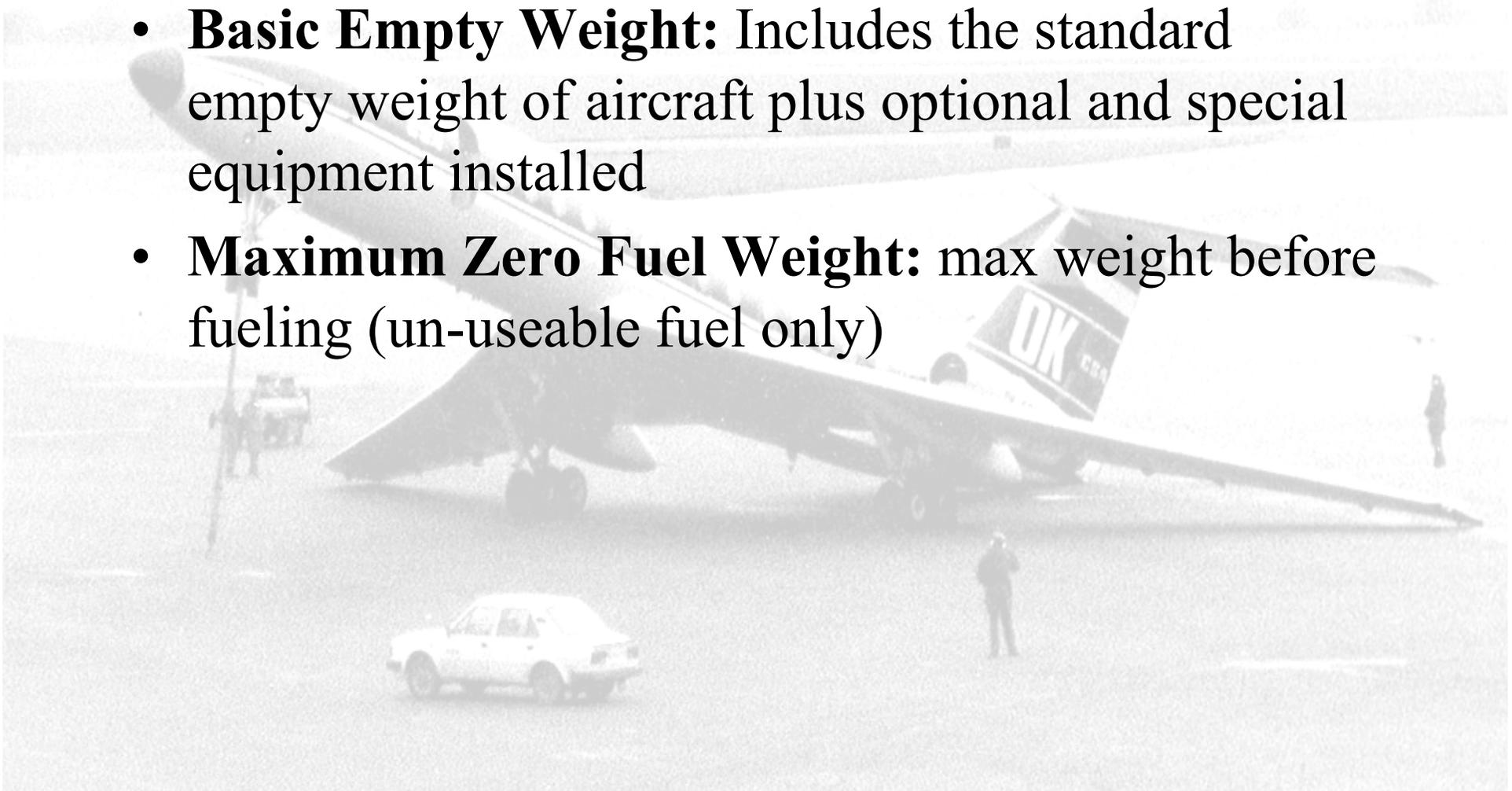


Definitions (cont'd)

- **Standard Empty Weight:** Consists of the airframe, engines and all items of operating equipment that have fixed locations and are permanently installed in the airplane including fixed ballast, hydraulic fluid, unusable fuel and full engine oil
- **Licensed Empty Weight:** Empty weight of aircraft including airframe, engine, unusable fuel, undrainable oil, standard and optional equipment

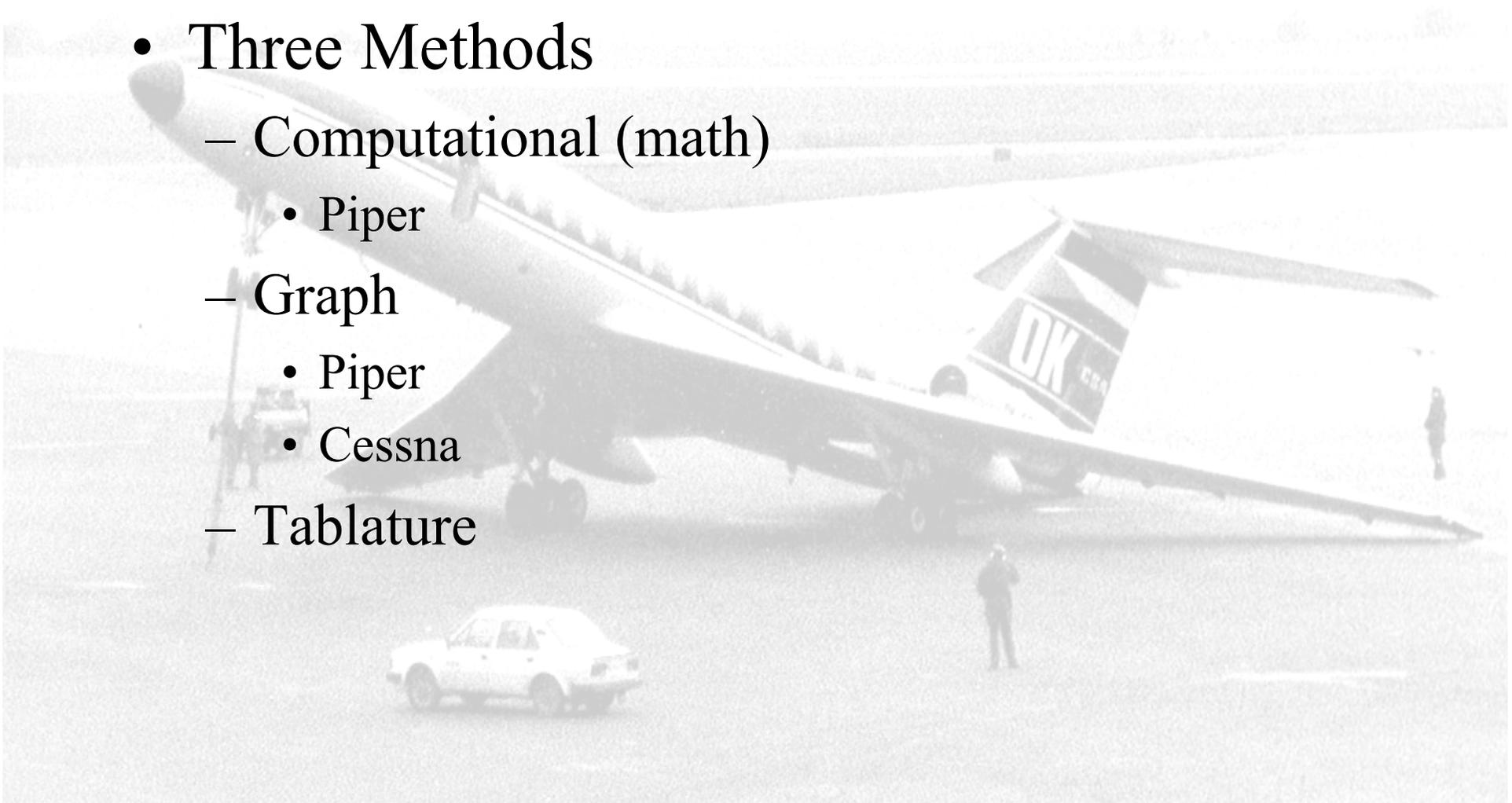
Definitions (cont'd)

- **Basic Empty Weight:** Includes the standard empty weight of aircraft plus optional and special equipment installed
- **Maximum Zero Fuel Weight:** max weight before fueling (un-useable fuel only)



Controlling Center of Gravity

- Three Methods
 - Computational (math)
 - Piper
 - Graph
 - Piper
 - Cessna
 - Tablature

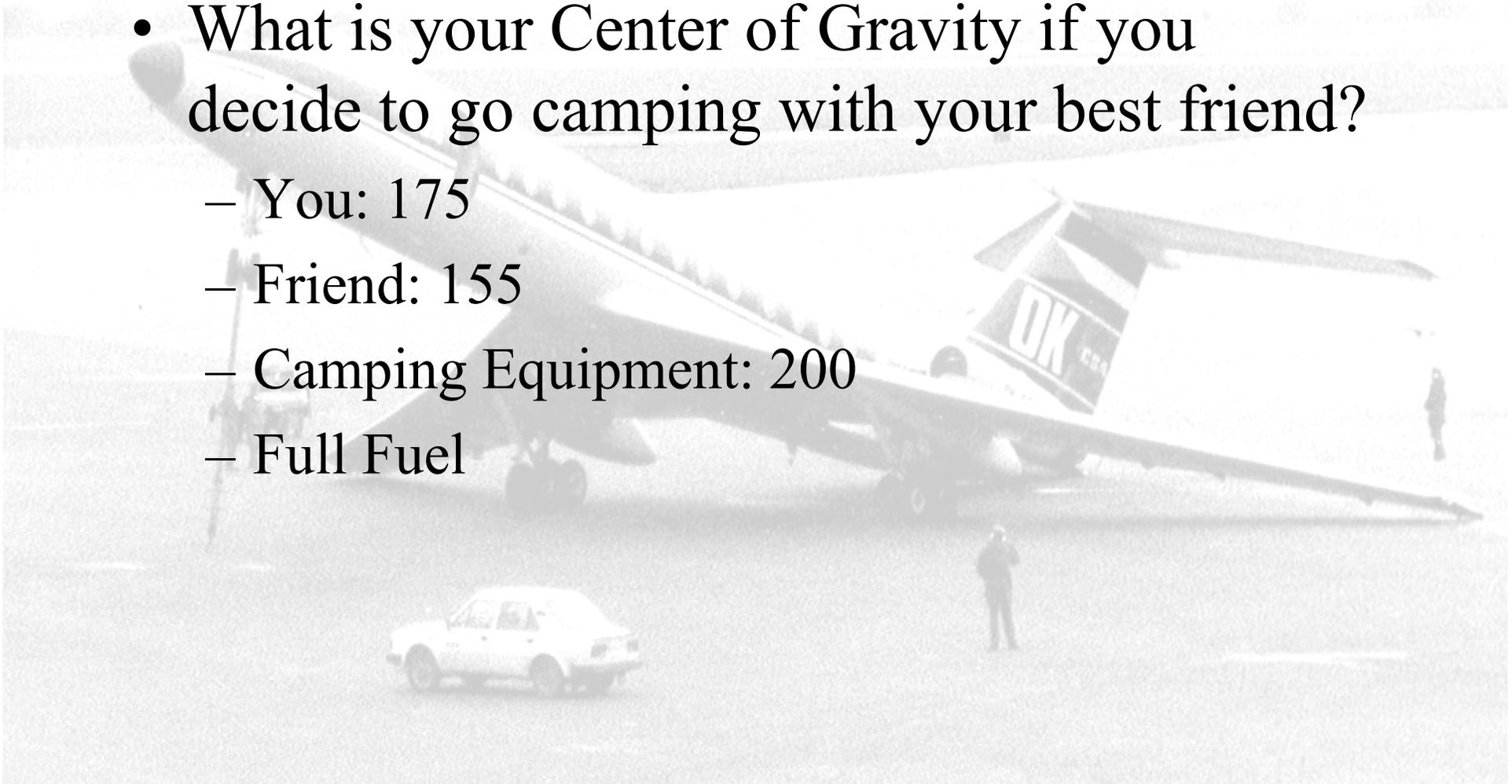


Computation Method

- After receiving your Private Pilot Certificate, you decide to take your family on sight-seeing flight around Grand Forks. If your mom weighs 150 lbs and sits in the co-pilot seat, your dad is 200 lbs, your sister is 115 lbs and you weigh 130 lbs, how much fuel can you bring? What will be your CG?

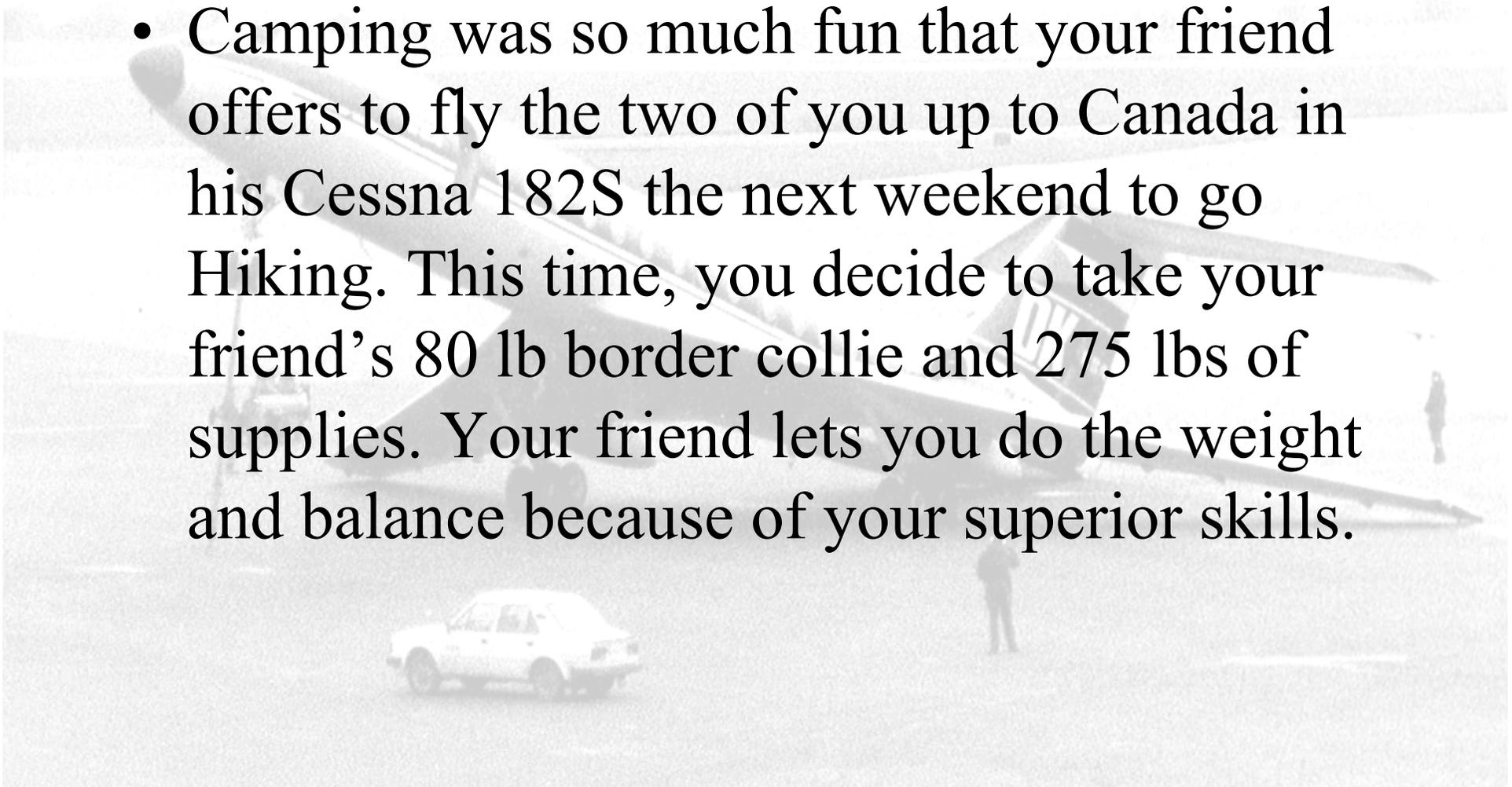
Graph Method

- What is your Center of Gravity if you decide to go camping with your best friend?
 - You: 175
 - Friend: 155
 - Camping Equipment: 200
 - Full Fuel



More Practice

- Camping was so much fun that your friend offers to fly the two of you up to Canada in his Cessna 182S the next weekend to go Hiking. This time, you decide to take your friend's 80 lb border collie and 275 lbs of supplies. Your friend lets you do the weight and balance because of your superior skills.



Weight Addition and Removal

- Unfortunately, it looks like you're overweight for the trip. Determine our new CG if we remove 50 lbs from station 74. (Remember, our old weight was 3,128 lbs with a CG of 44.5)

$$\frac{\text{Weight Removed}}{\text{New Total Weight}} = \frac{\Delta\text{CG}}{\text{Distance between weight and old CG}}$$

- Remember, a positive number means a more forward CG, you will have to subtract the number from the old CG. A negative number means a more Aft CG, you will have to add the number to the old CG.

Weight Shifting

As long as you are shifting things for the flight, you decide to move 75 lbs from station 74 (pax seats) to station 129 (baggage area C). What is your new CG?

$$\frac{\text{Weight to be Shifted}}{\text{Total Weight}} = \frac{\Delta\text{CG}}{\text{Distance weight is shifted}}$$

Practice

- Using the the Cadet, what is your CG for the following:
 - Pilot and Front Passenger 220
 - Pax: 20
 - Fuel: 50 gal.

Practice (Cont'd)

- How much fuel can you take in the Cadet with the following?
 - Pilot: 200
 - Co-Pilot: 250
 - Pax: 330
 - Baggage: 50

Practice (Cont'd)

- In the Cessna, find your weight and balance for the following:
 - Pilot: 175 lbs
 - Co-pilot 190lbs
 - Full Fuel
 - Pax: 330 lbs
 - Baggage: 120 lbs – all in area A
- What are some ways you could reduce the weight into limits?

Practice (Cont'd)

- How much cargo will I need to shift from the aft cargo compartment at station 150 to the forward cargo compartment at station 30 to move the CG exactly within the aft limit of 80.5.
 - Aircraft total weight is 7,800 lbs
 - CG is at station 81.5

Practice (cont'd)

$$\frac{\text{Weight to be shifted}}{7,800} = \frac{1.0}{120 \text{ in}}$$

$$\text{Weight to be Shifted} = 65 \text{ lbs}$$

Practice (Cont'd)

- If my current gross weight is 2800 lbs and I need to move my CG from 90 to 87 to bring it within limitations, how much weight will I need to remove if the baggage is located 60 inches aft of my current CG?