

Introduction to Aerospace Engineering

Lecture slides



Aircraft & spacecraft loads

Static & Dynamic

Faculty of Aerospace Engineering
29-11-2011

Learning objectives

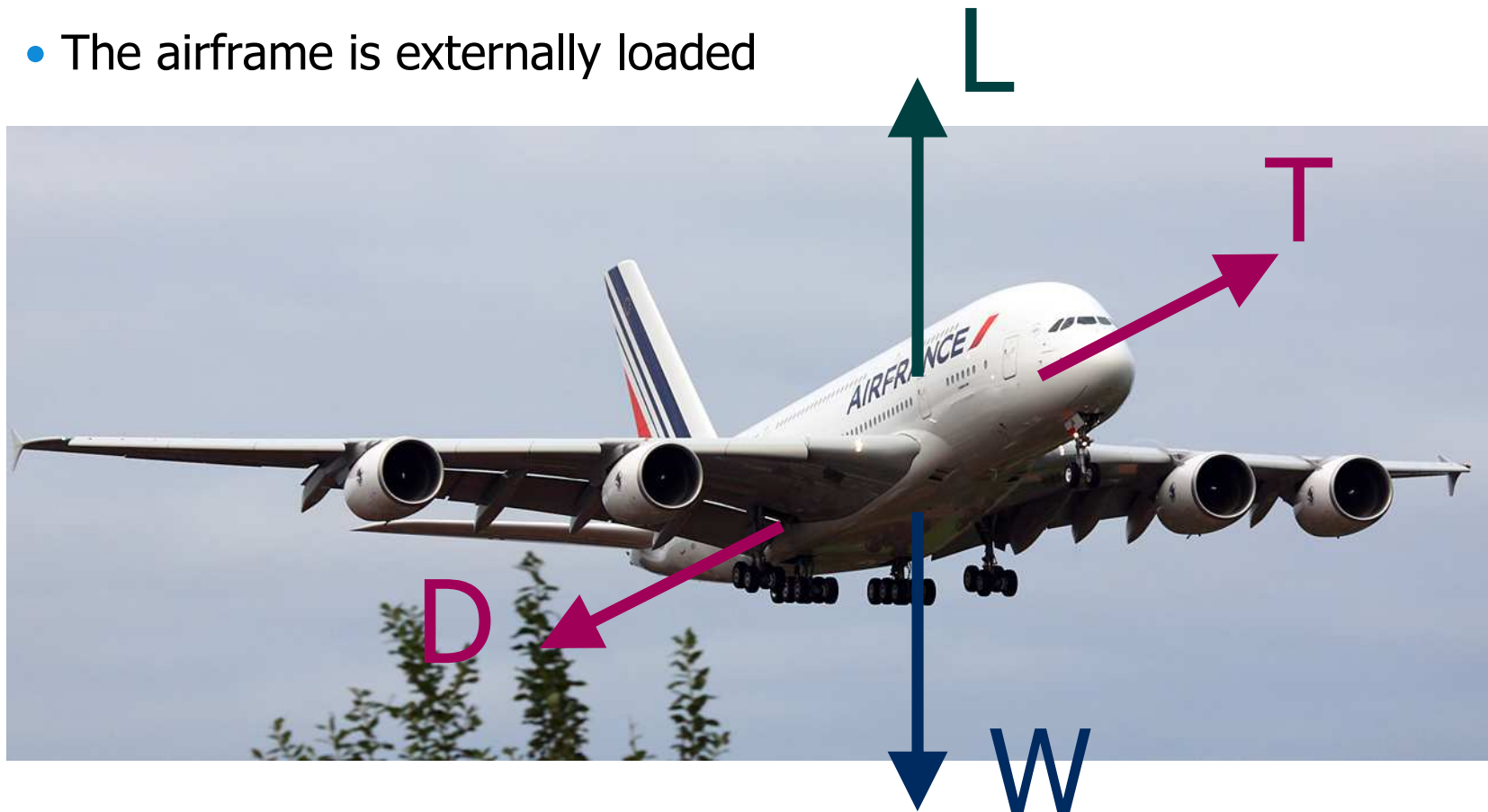
Student should be able to...

- Describe the most relevant loads for
 - An aircraft
 - A spacecraft
- Explain whether these loads are
 - Static or dynamic
 - Concentrated or distributed

Identify relevant loads

Aircraft structure

- The airframe is externally loaded



Identify relevant loads

Aircraft structure

- The airframe is externally loaded



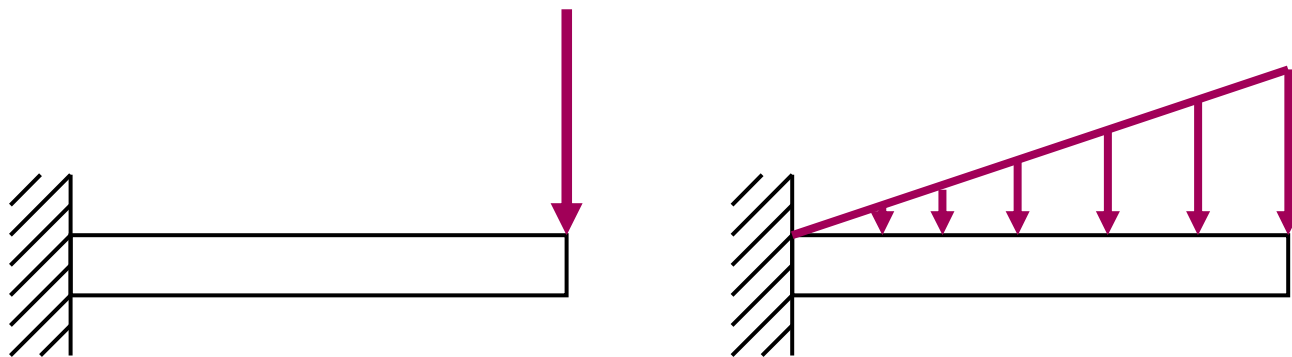
Identify relevant loads

Aircraft structure

- The airframe is externally loaded

- Maneuvers
- Gust
- Cabin pressure
- Landing
- etc.

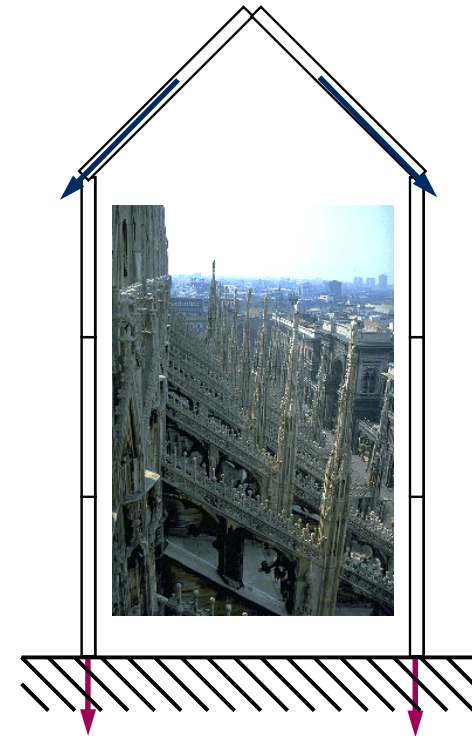
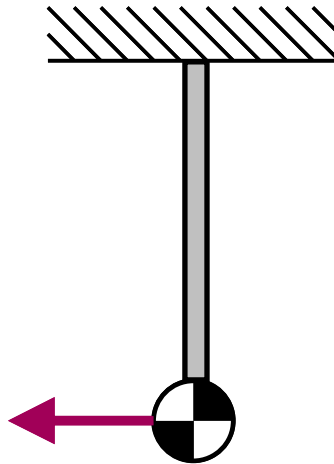
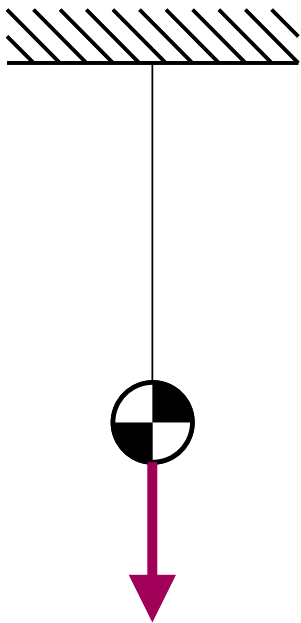
by concentrated or distributed forces



Load paths

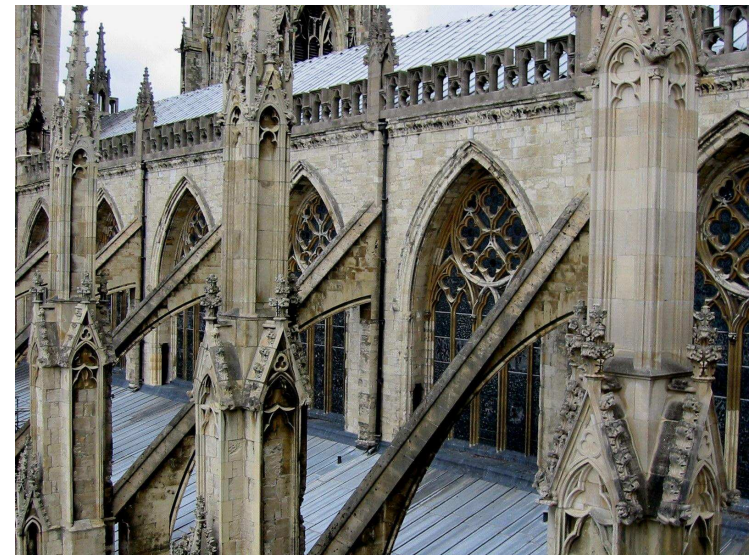
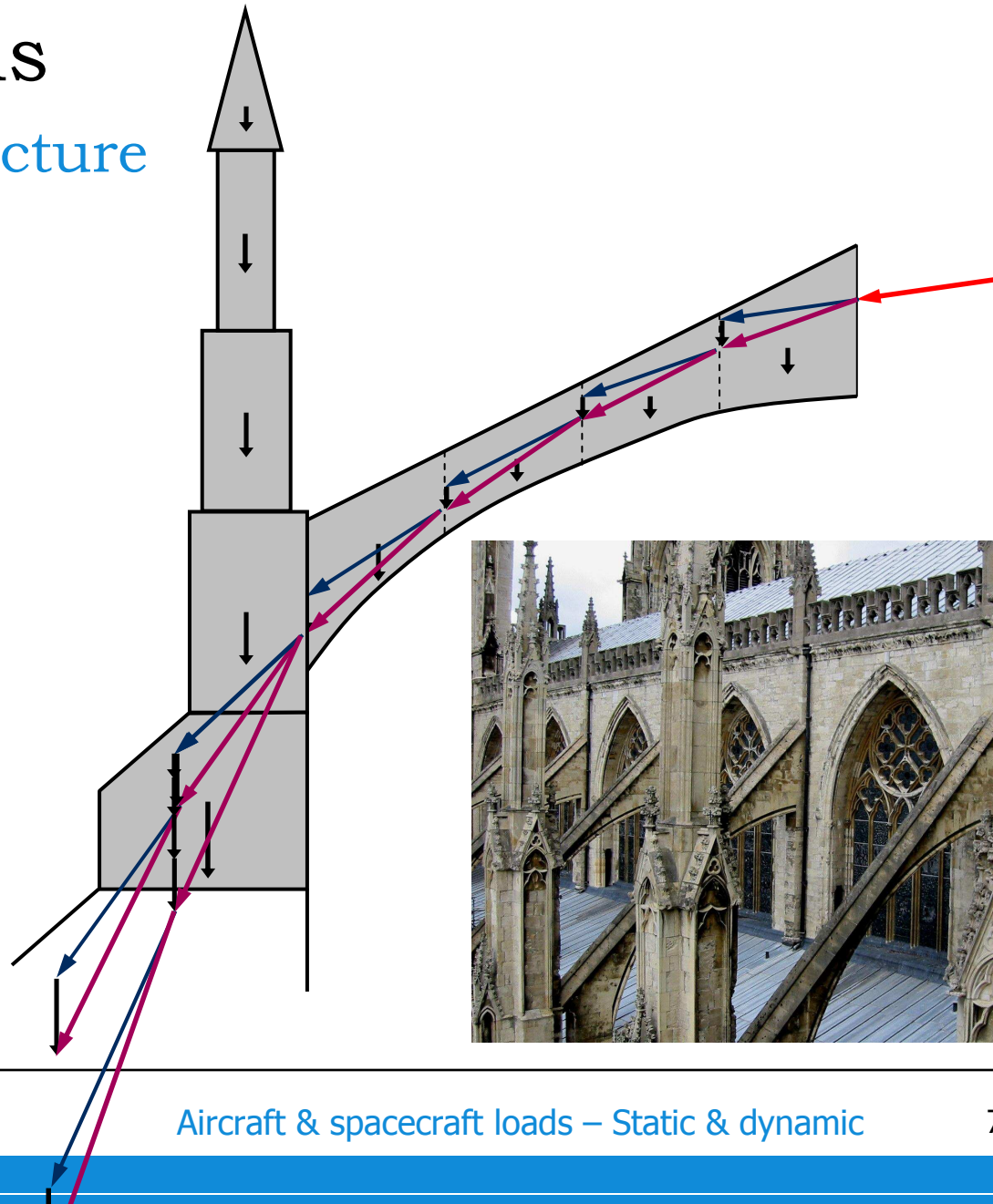
Simple structure

- What is a load path?
 - Path to link applied load to equilibrium forces



Load paths

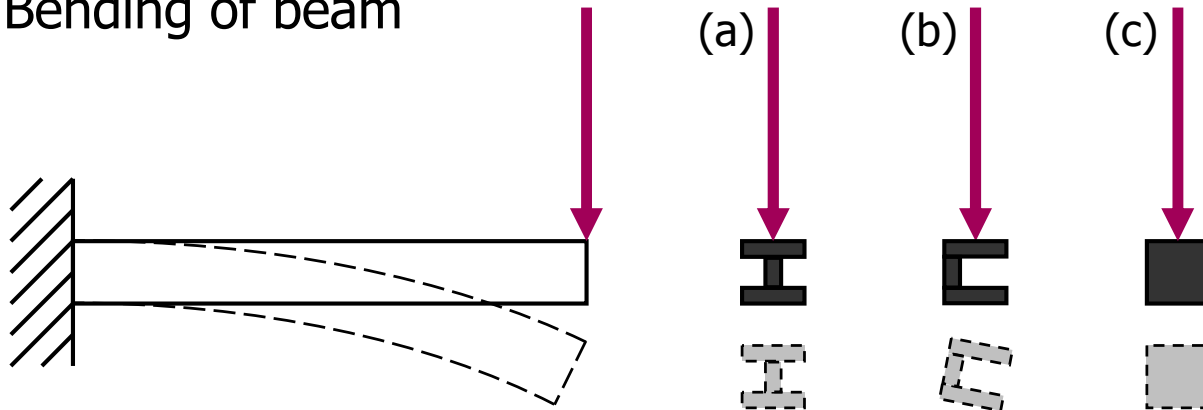
Buttress structure



Load paths

Simple structure

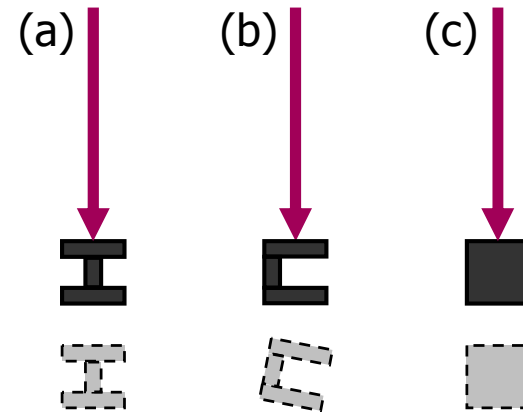
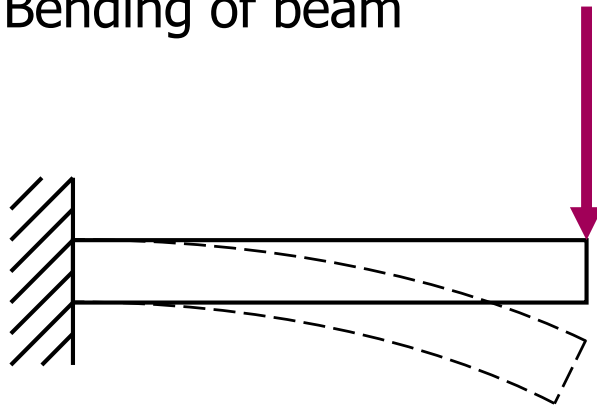
- Bending of beam



Load paths

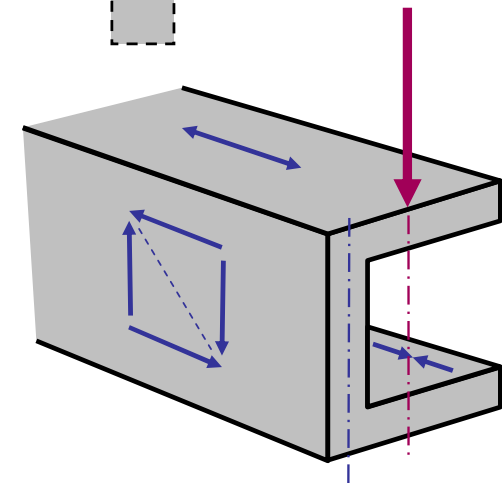
Simple structure

- Bending of beam



- Load path

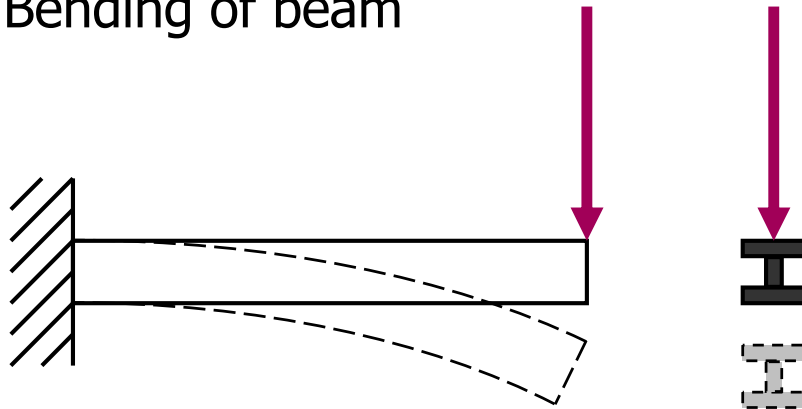
- Upper girder: tension
- Lower girder: compression
- Web plate: shear



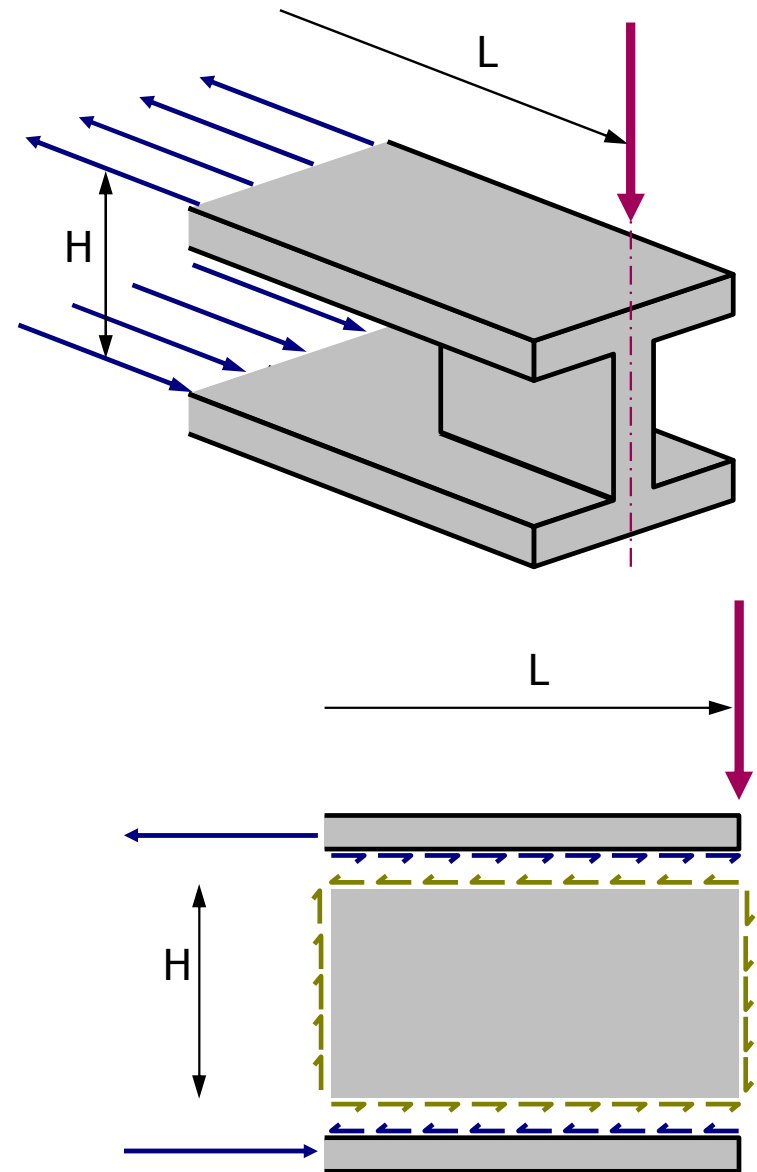
Load paths

Simple structure

- Bending of beam



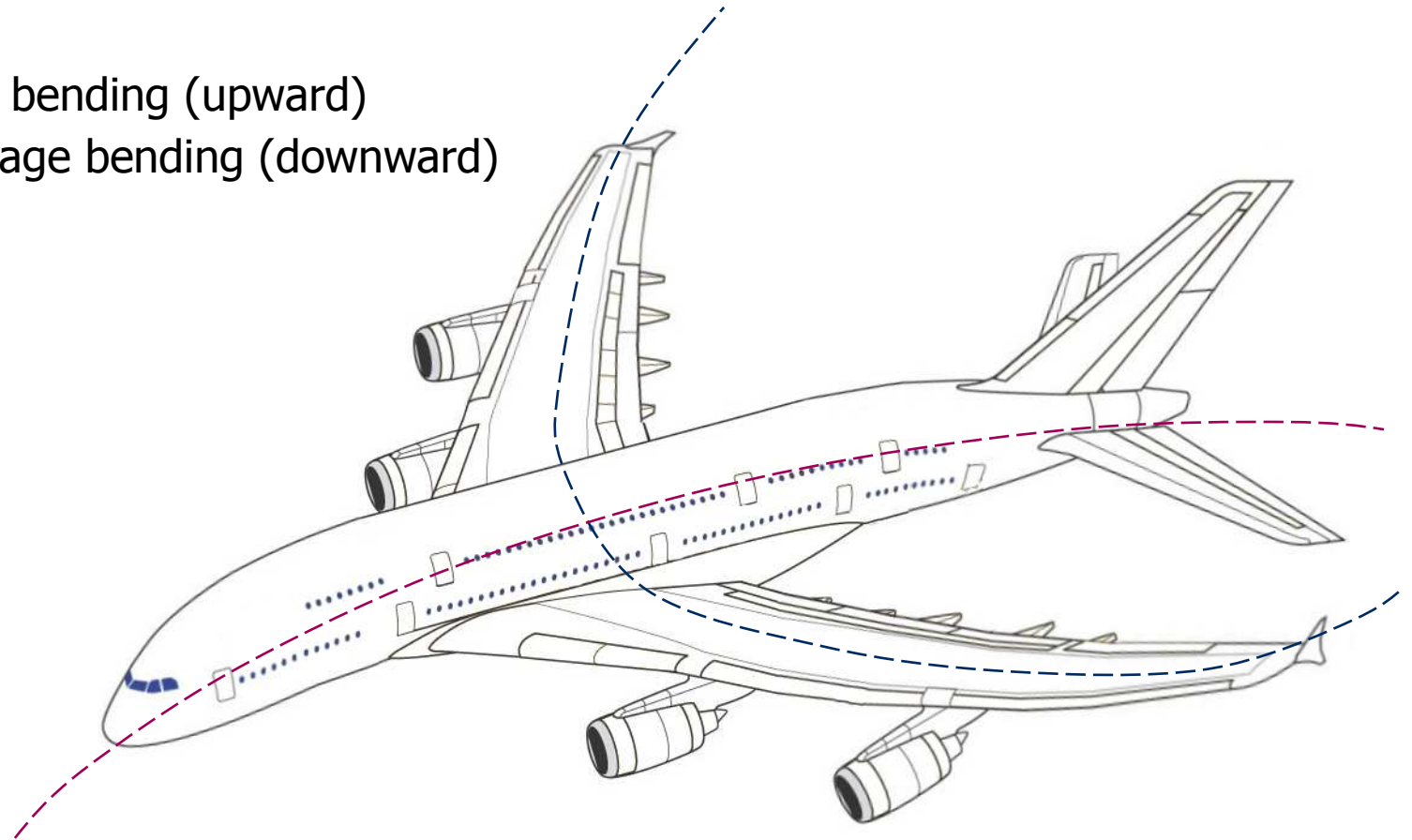
- Load path
 - Upper girder: tension
 - Lower girder: compression
 - Web plate: shear



Identify relevant loads

Airframe

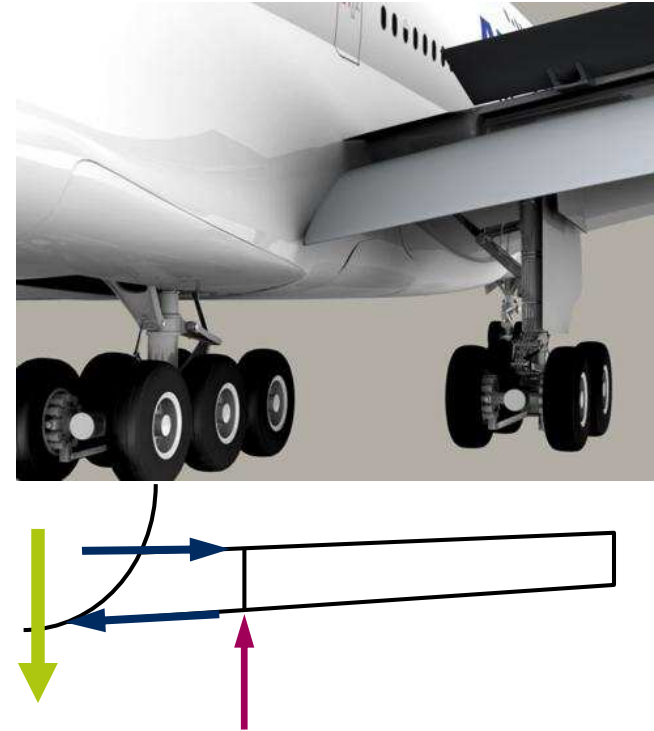
- Bending
 - Wing bending (upward)
 - Fuselage bending (downward)



Load paths

Airframe

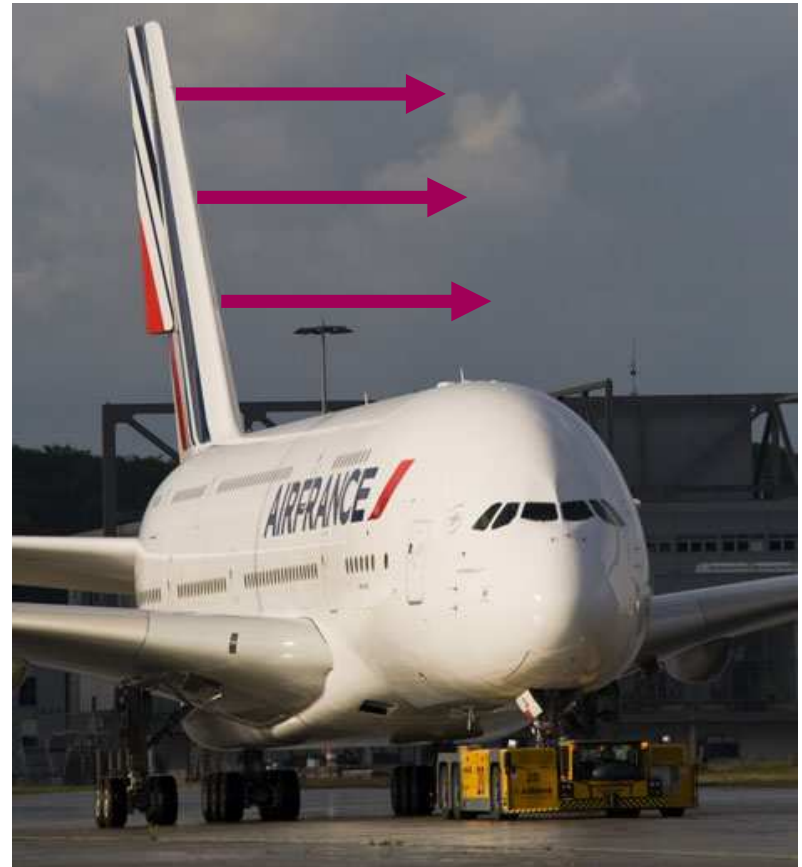
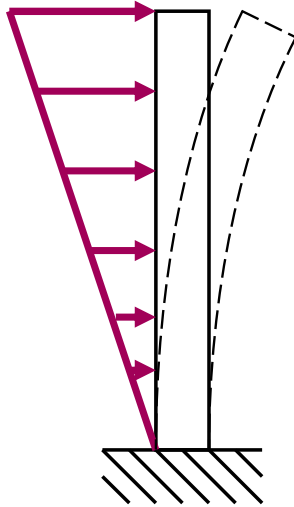
- Landing and taxiing
 - 'concentrated forces' acting on undercarriage



Load paths

Airframe

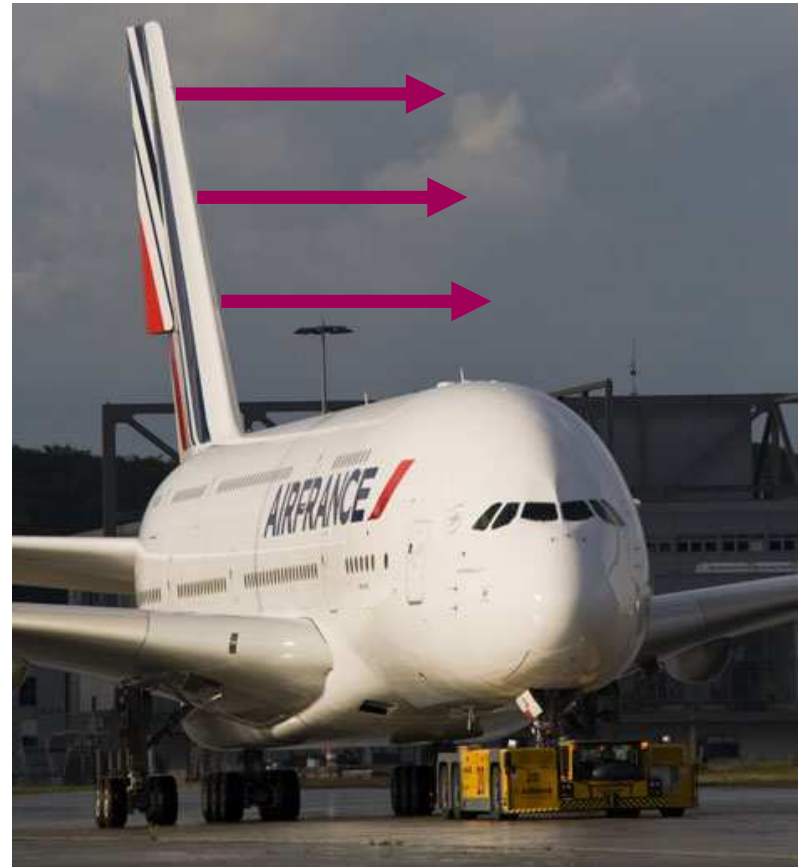
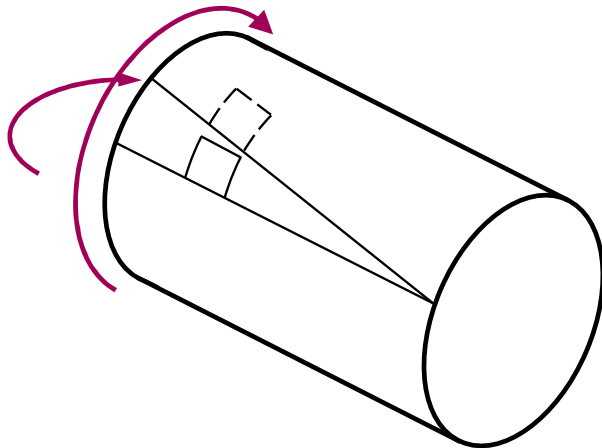
- Vertical tail load
 - Bending of vertical tail



Load paths

Airframe

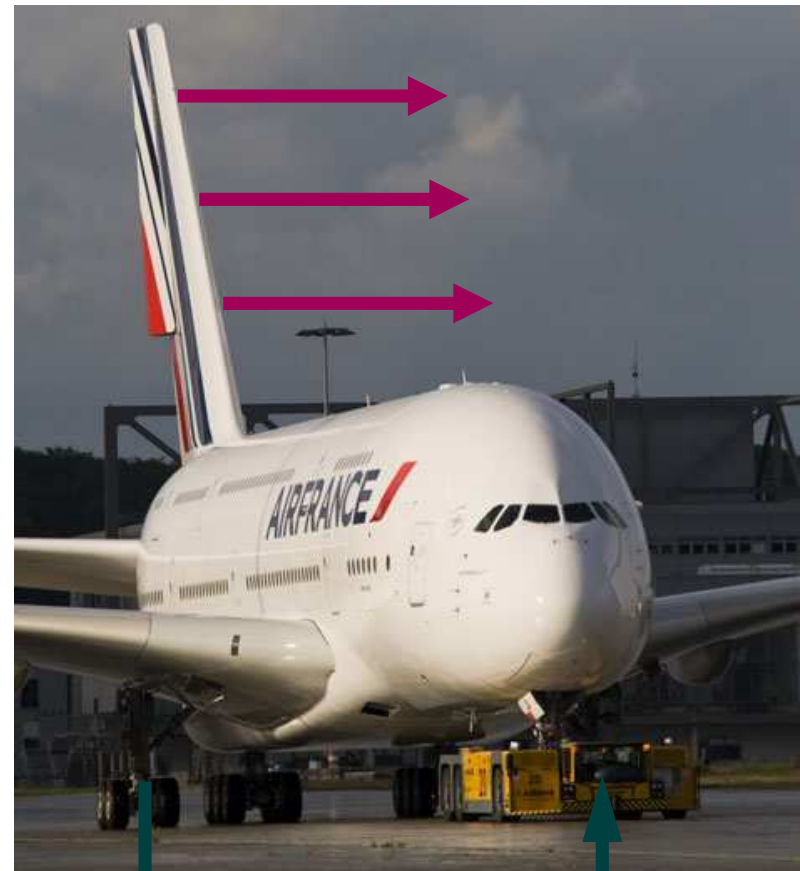
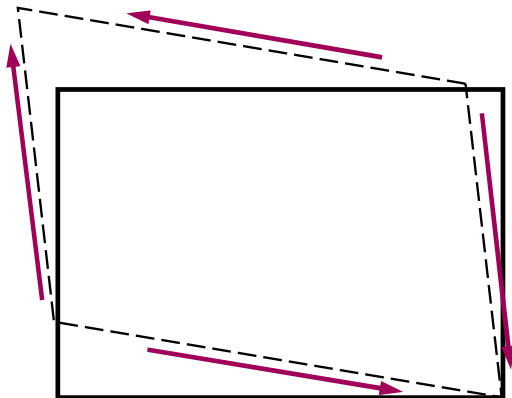
- Vertical tail load
 - Bending of vertical tail
 - Bending & rotation of fuselage



Load paths

Airframe

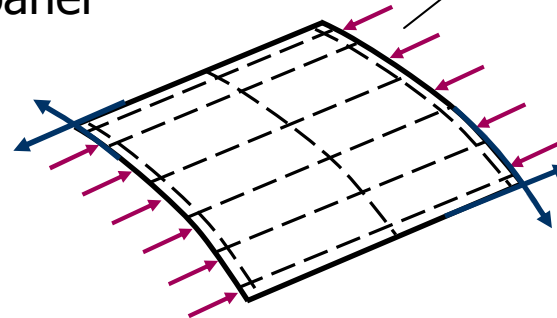
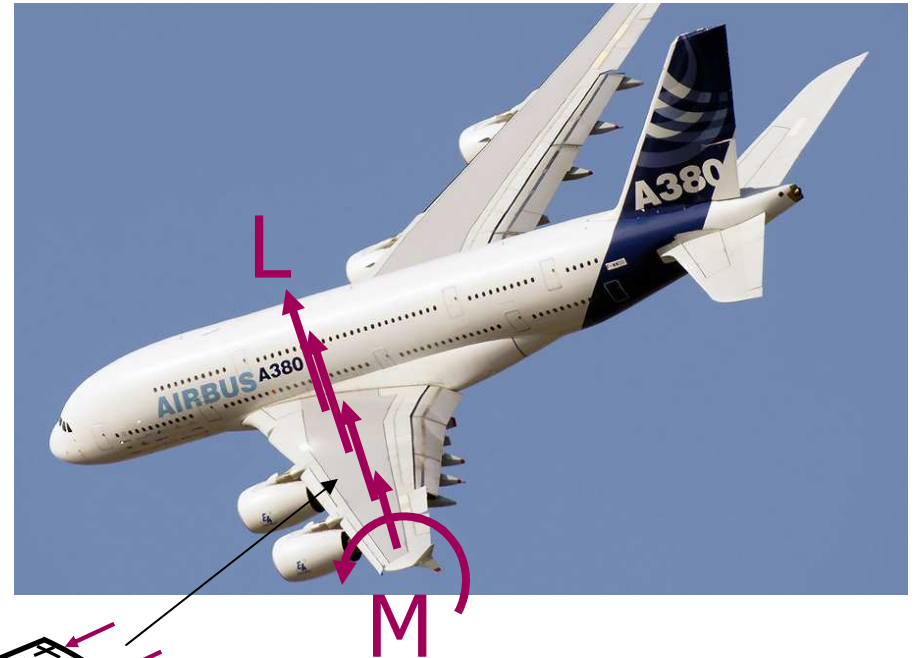
- Vertical tail load
 - Bending of vertical tail
 - Bending & rotation of fuselage
 - Shear of fuselage side panels



Load paths

Airframe

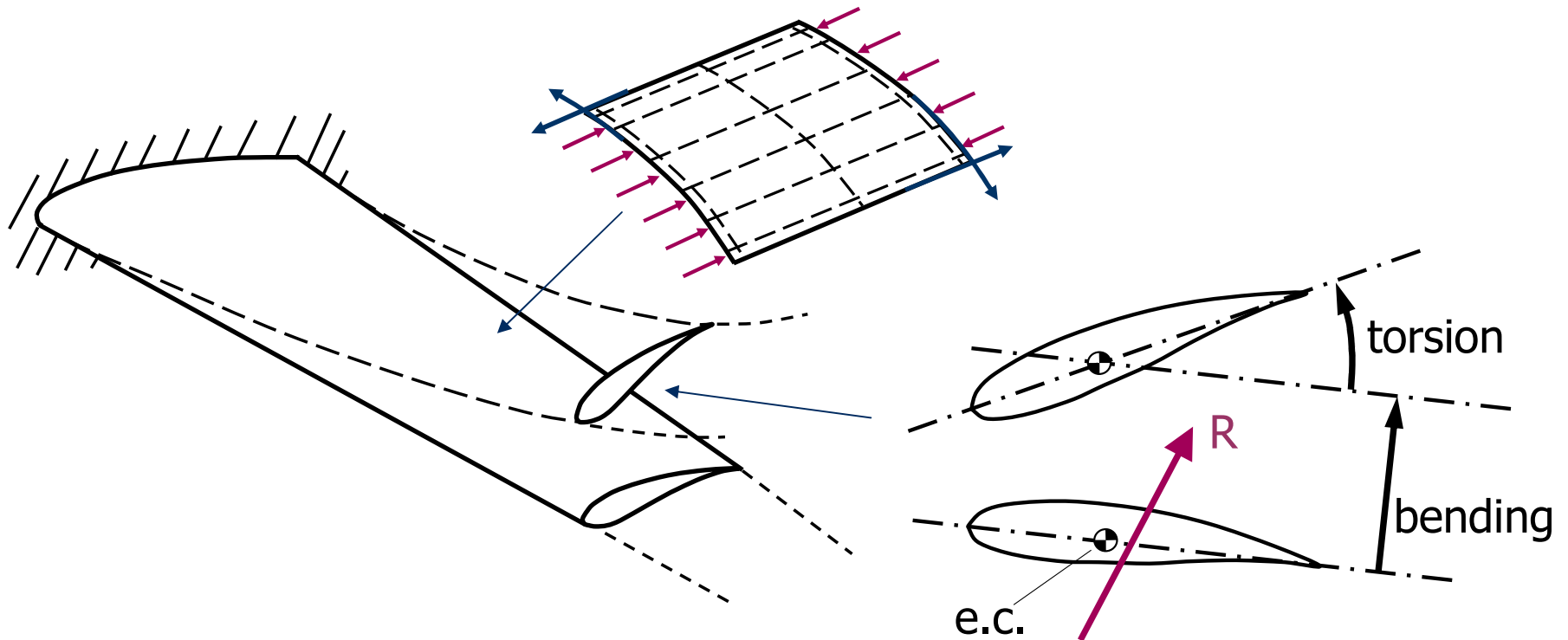
- Wing load \Rightarrow deformation
 - Upward bending of wing
 - Rotation of wing
- Deformation \Rightarrow stresses
 - Compression and shear in upper wing skin panel
 - Tension and shear in lower wing skin panel



Load paths

Airframe

- Bending and torsion



- Measure against torsion?

Load introduction

Wing/fuselage connection

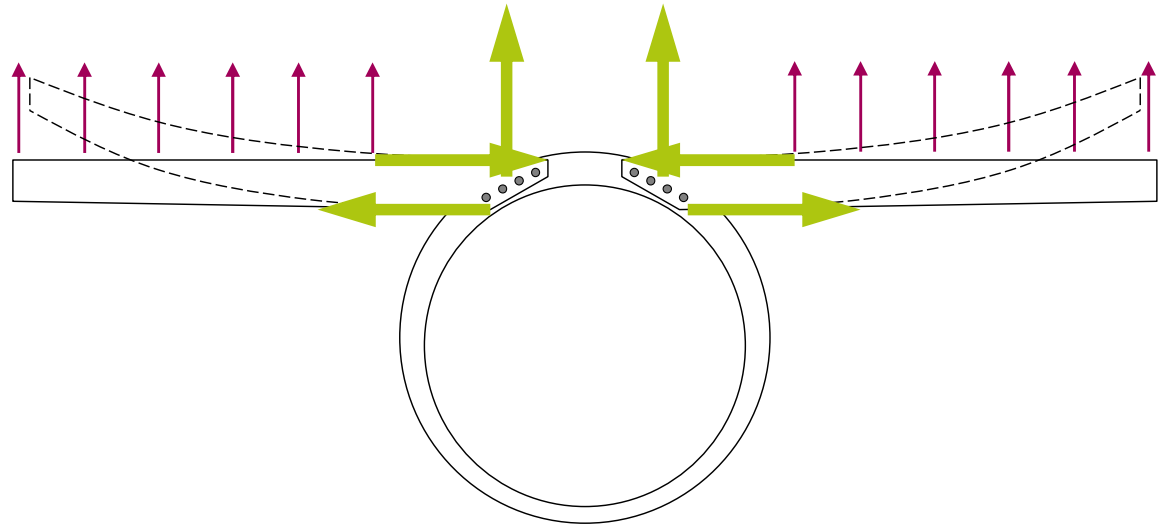
- Example
 - A400M



Load introduction

Wing/fuselage connection

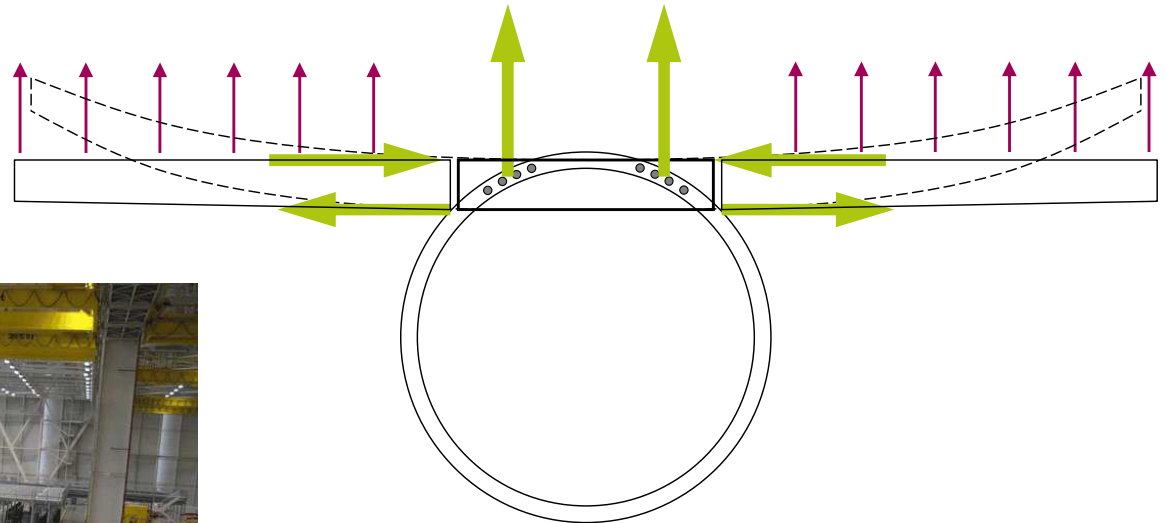
- Example
 - A400M



Load introduction

Wing/fuselage connection

- Example
 - A400M

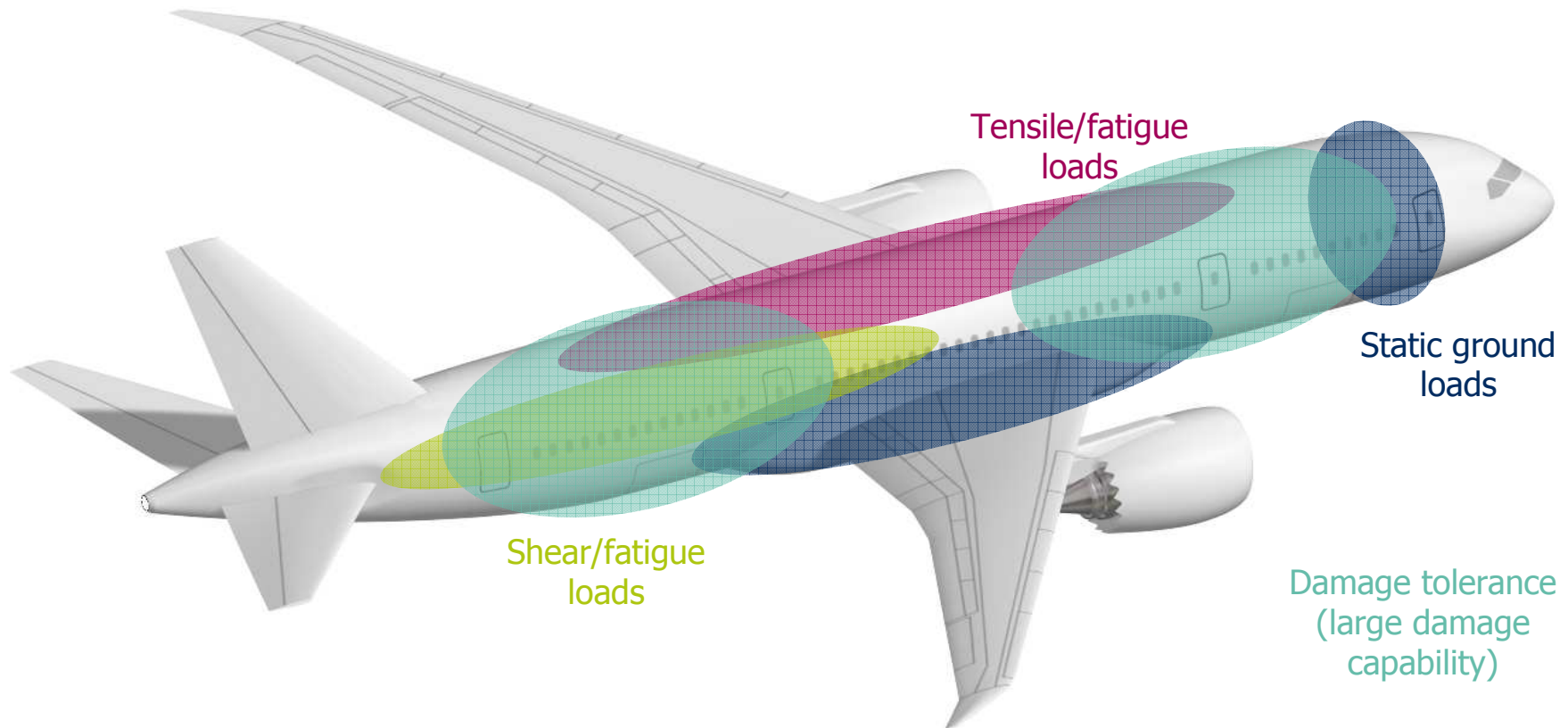


Wing/fuselage connection F-27
See question 14 related to the study collection

Design load cases

Aircraft fuselage structure

- Different locations \Rightarrow different loads & criteria!



Design load cases

Aircraft structure

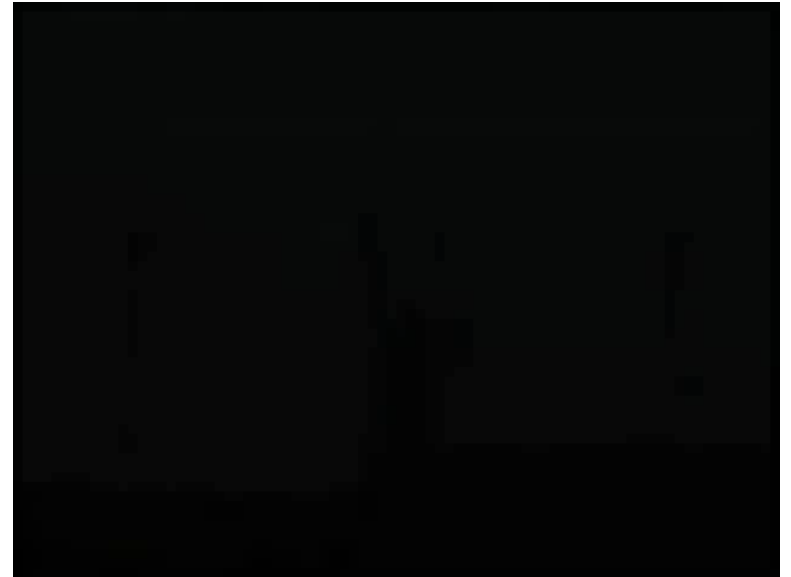
- Dynamic loads (example of flutter)
 - Oscillation of aircraft component caused by the interaction of aerodynamic forces, structural elastic reactions, and inertia



Identify relevant loads

Spacecraft structure

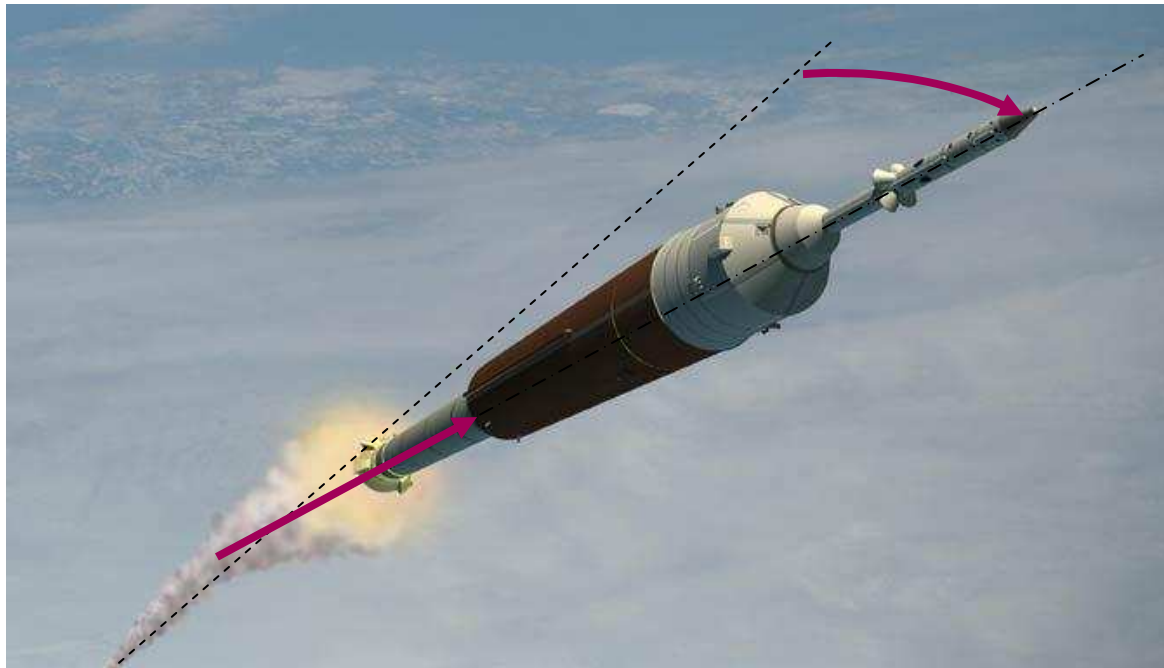
- Gravity
 - Handling and transportation loads
- Vibration and acoustic test loads
- Launch loads (static & dynamic)
 - Quasi-static
 - Sine vibration
 - Acoustic noise and random vibration
 - Shock loads
- In-orbit loads
 - Shocks
 - Structurally transmitted loads
 - Internal pressure
 - Thermal stress



Identify relevant loads

Spacecraft structure

- Steady state load
 - Axial: launch vehicle engine thrust
 - Lateral: wind gust & vehicle maneuvers



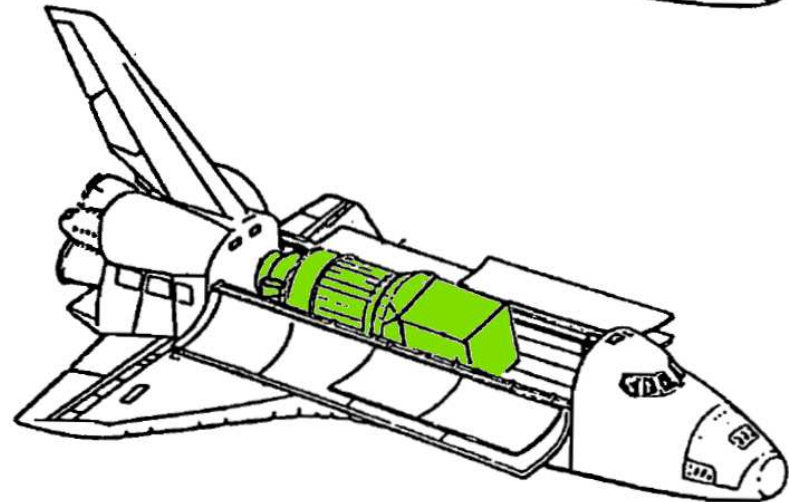
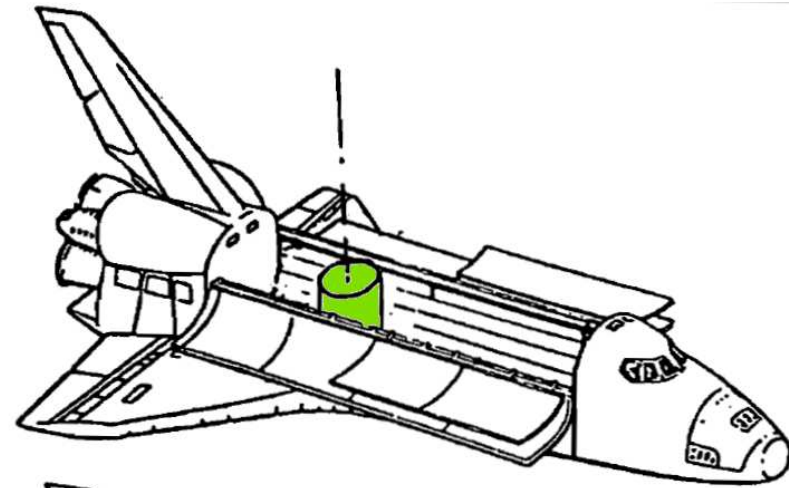
Identify relevant loads

Spacecraft structure

- Load path
 - Primary axis \perp direction of maximum acceleration



- Primary axis $//$ direction of maximum acceleration



Summary

Aircraft & spacecraft loads

- Identify relevant loads
 - Static or dynamic
 - Concentrated or distributed
- Load paths
 - Load introduction
 - Equilibrium