Aerospace Structures

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FUSELAGE

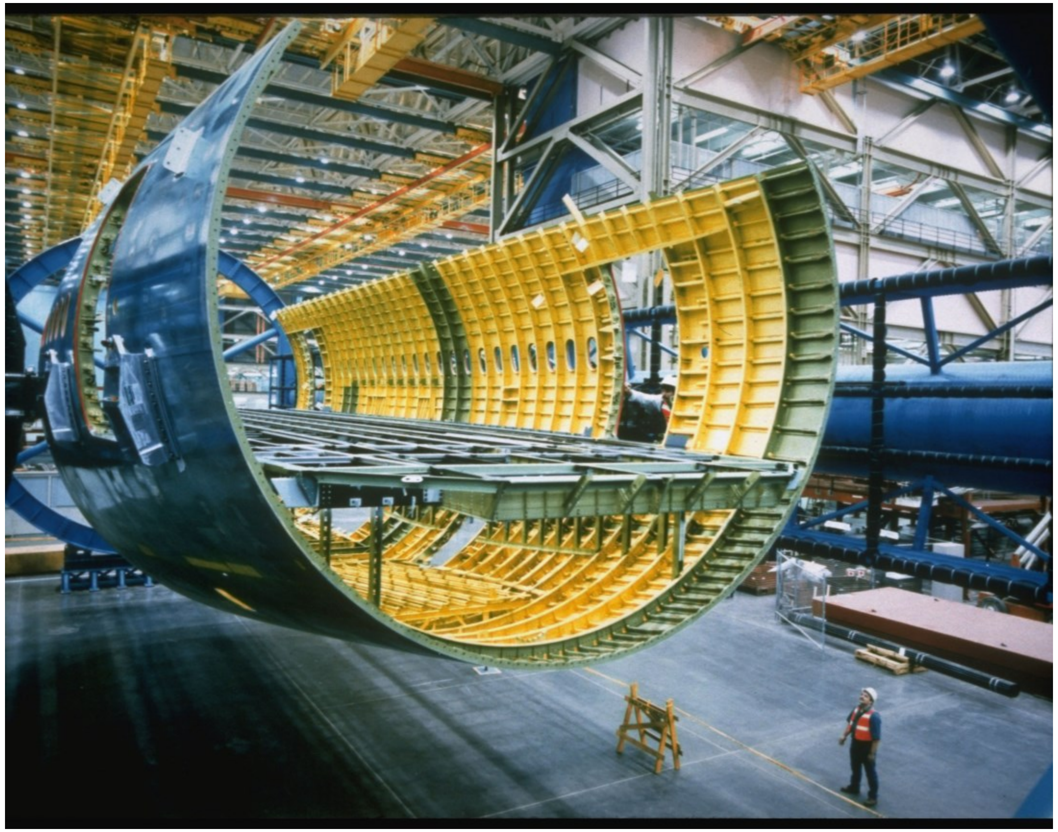
Fuselage

Fuselage of modern aircraft is a stiffened shell referred to as semi-monocoque construction

In a monocoque structure (composites) unstiffened thin skins are unstable in compression and shear

In order to support the skin, it is necessary to provide stiffening members frames, bulkheads, stringers and longerons

Fuselage



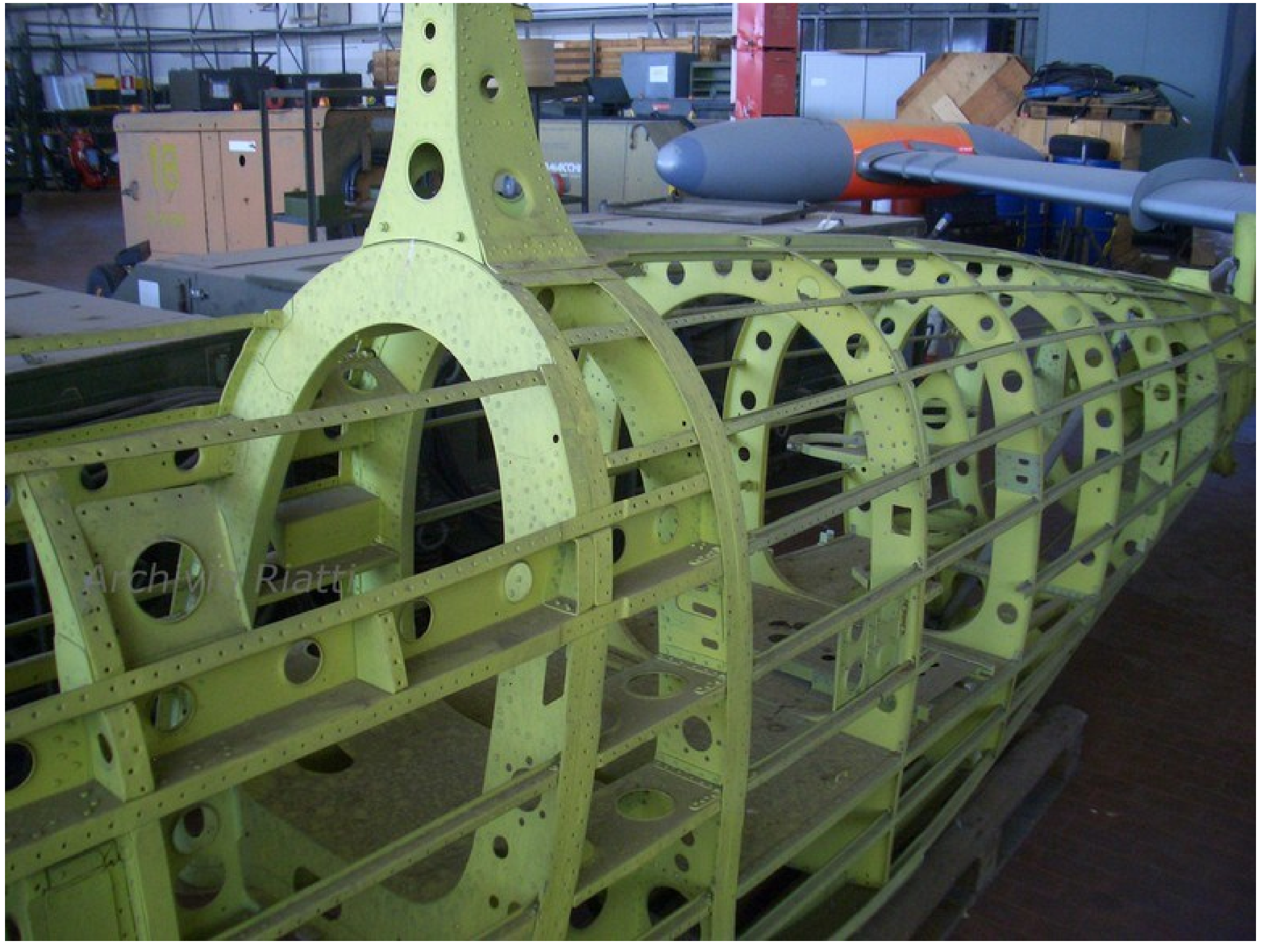
Fuselage

Semi monocoque structure is a **very efficient structure** it has a **high strength to weight ratio** and it is well suited for unusual load combinations and locations.

It has **design flexibility** and **can withstand local failure without total failure** through load redistribution.

Generally, fuselages carry bending moments, shear forces, and torsional loads which induce axial stresses in the stringers and skin together with shear stress in the skin.

Fuselage

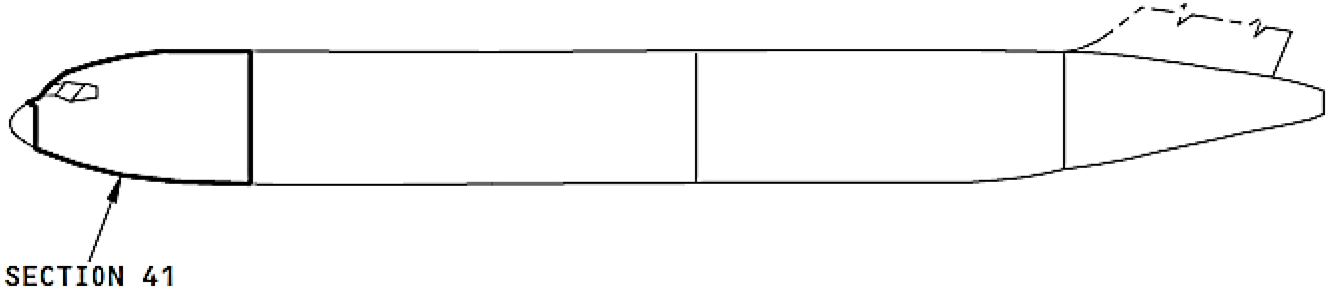


Fuselage

Fuselage

Comac C919

Fuselage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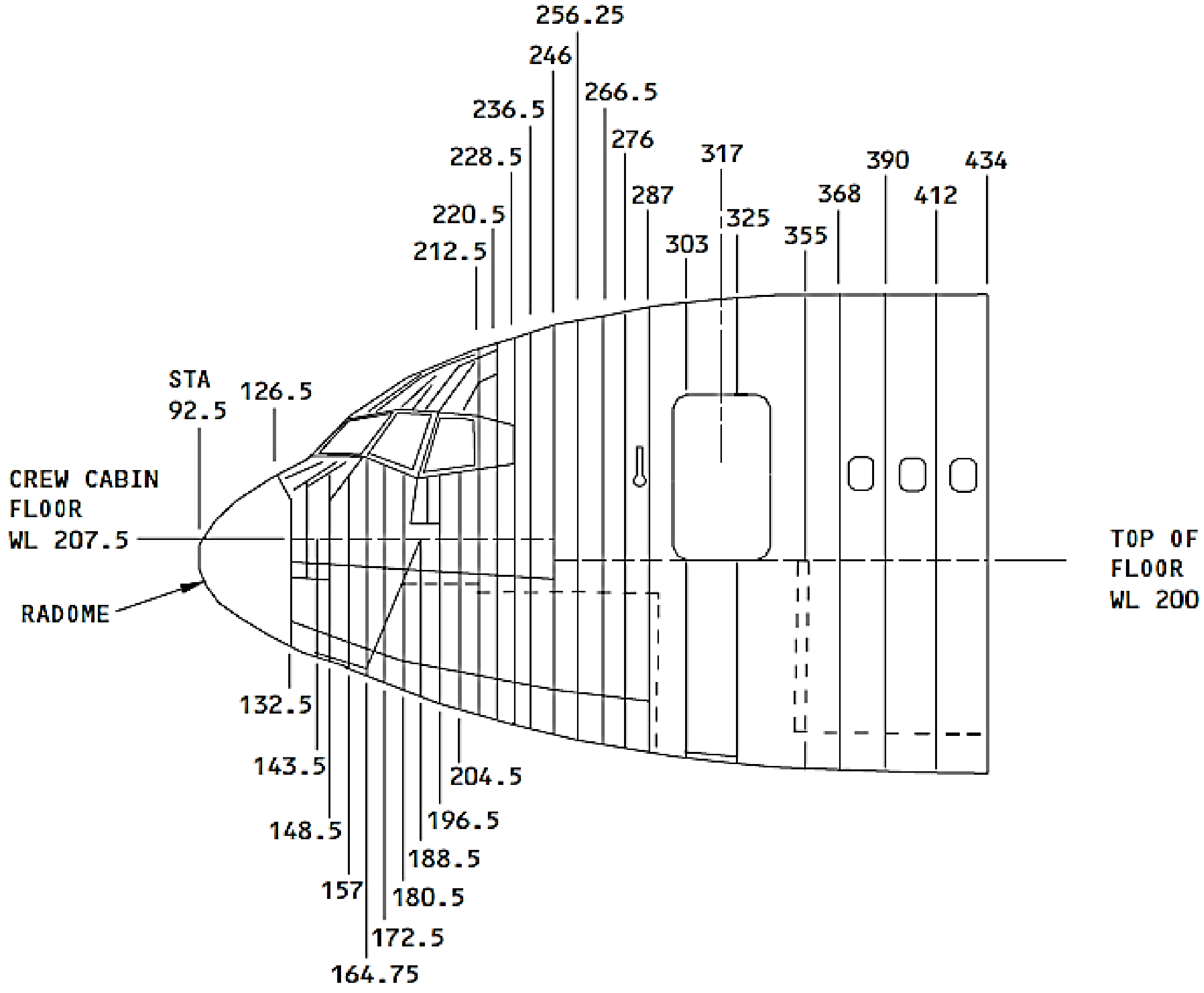
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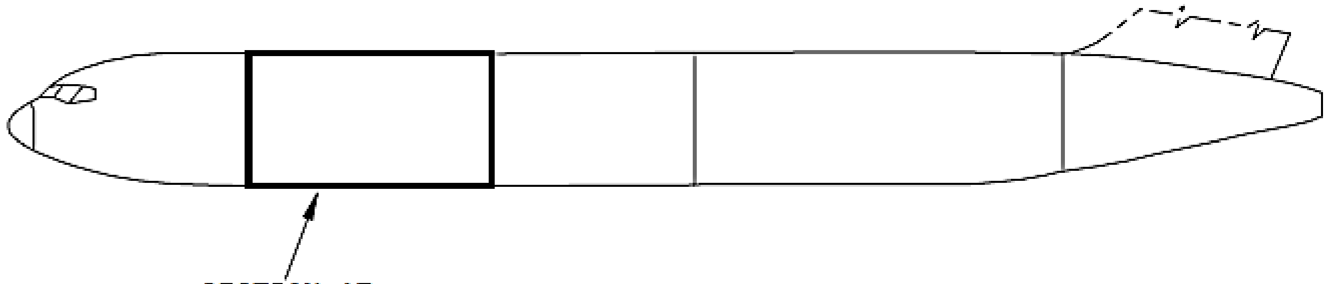
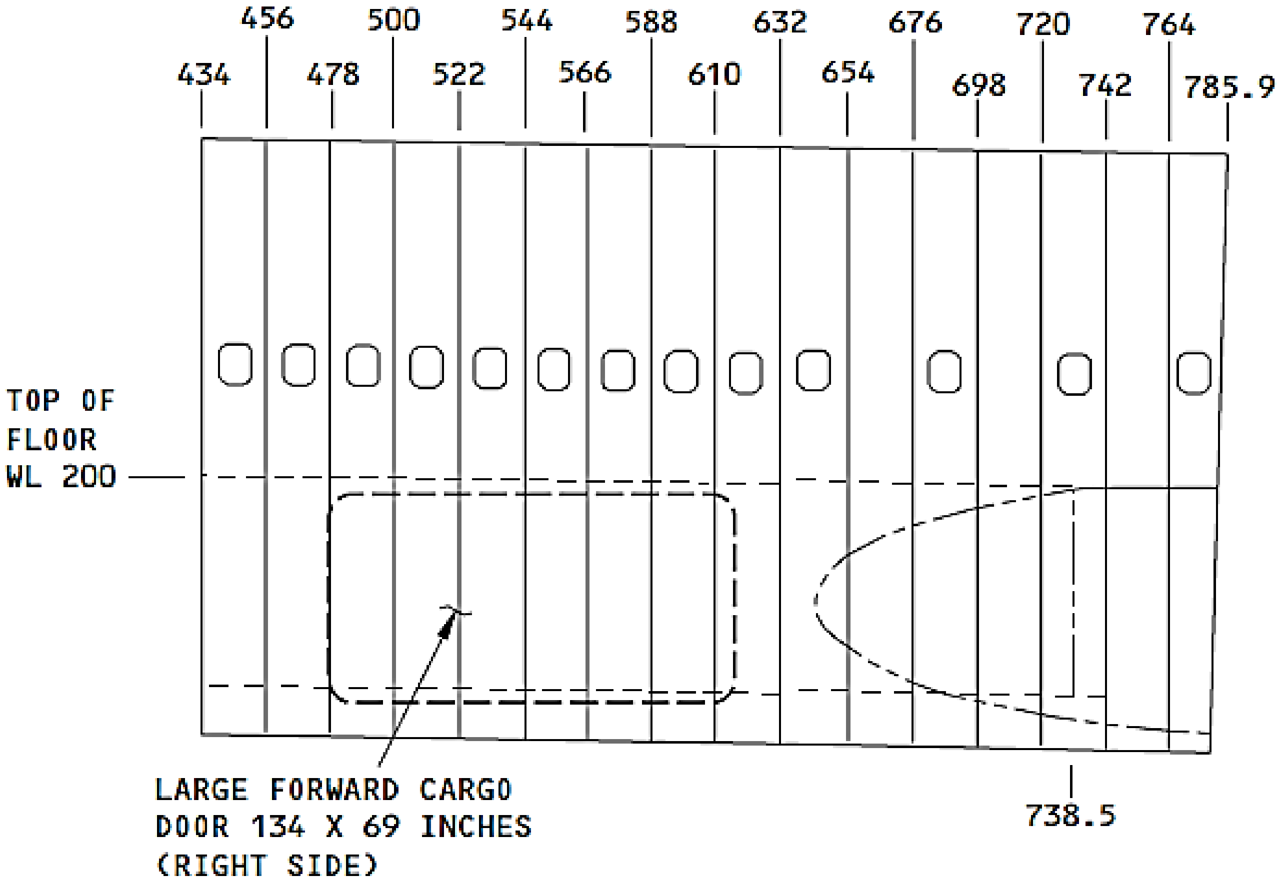
266.5
236.5
276
228.5
317
287
390
434
368
412
220.5
325
355
303
212.5
STA
92.5
126.5
CREW CABIN
FLOOR
WL 207.5
TOP OF
FLOOR
WL 200
RADOME
132.5
143.5
204.5
148.5
196.5
188.5
157
180.5
172.5
164.75

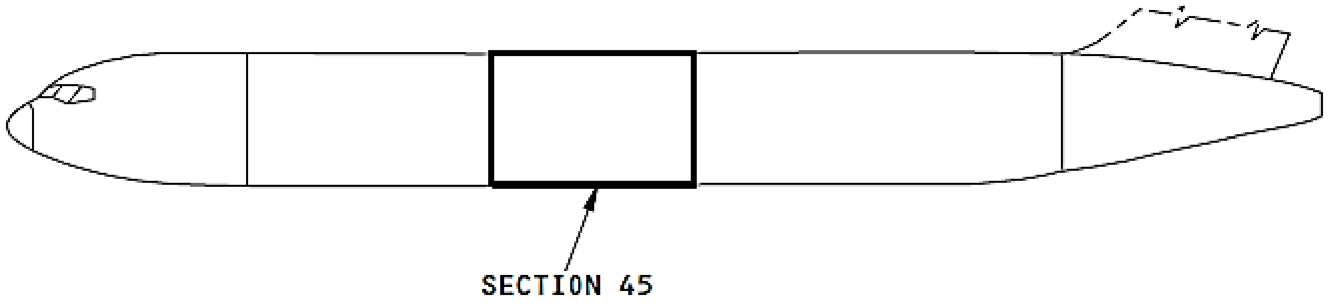
Fuselage

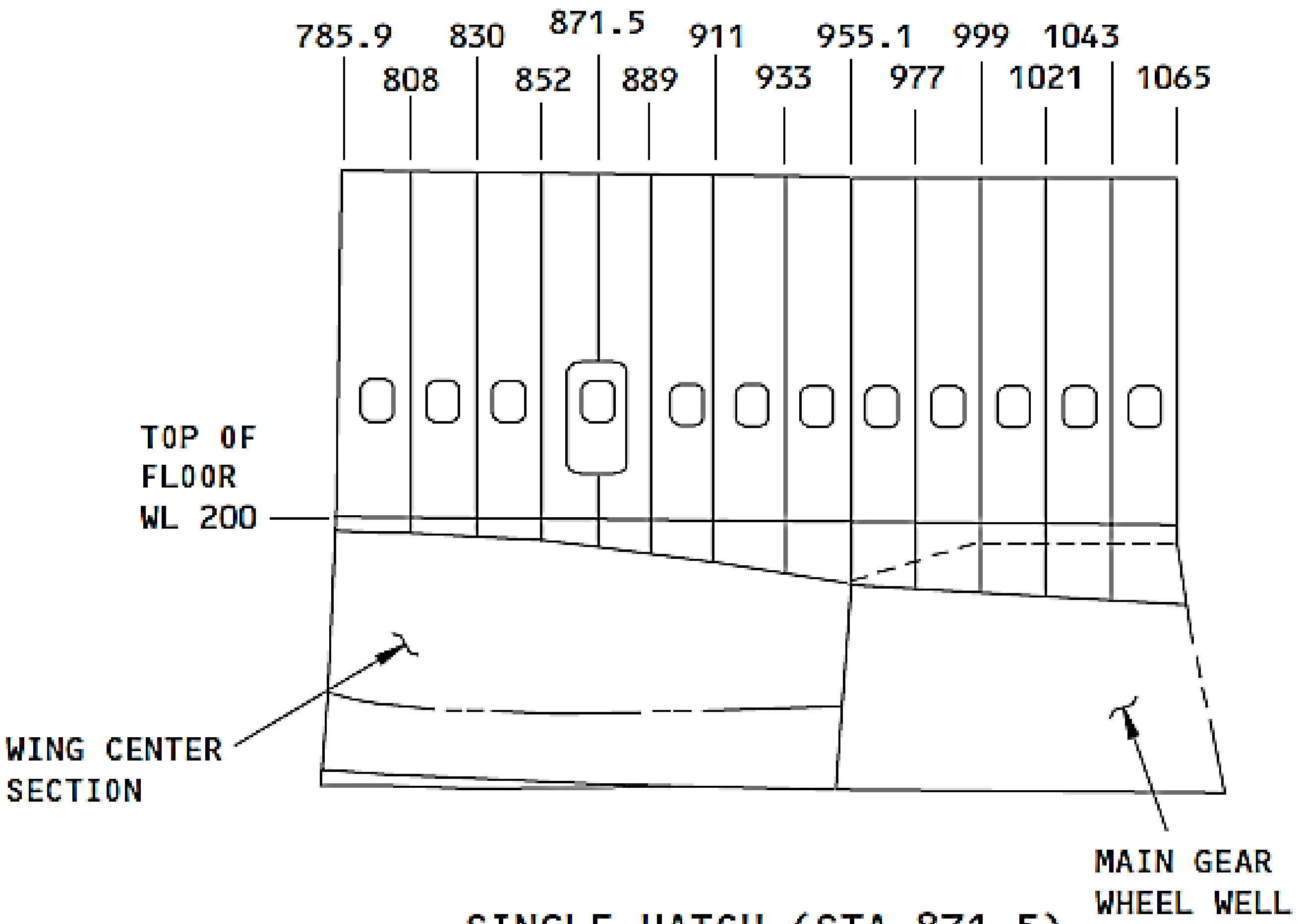




767-200

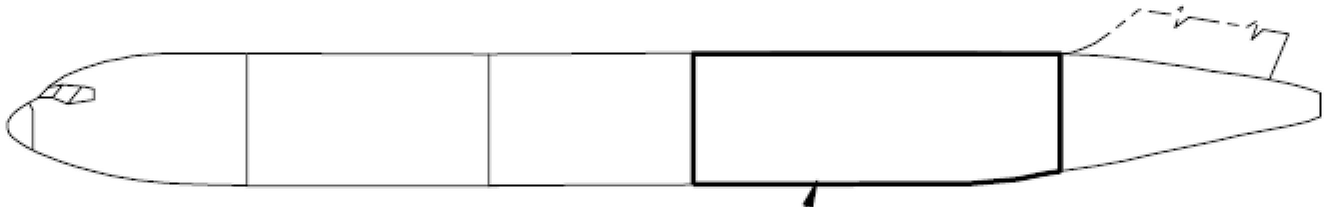
Fuselage

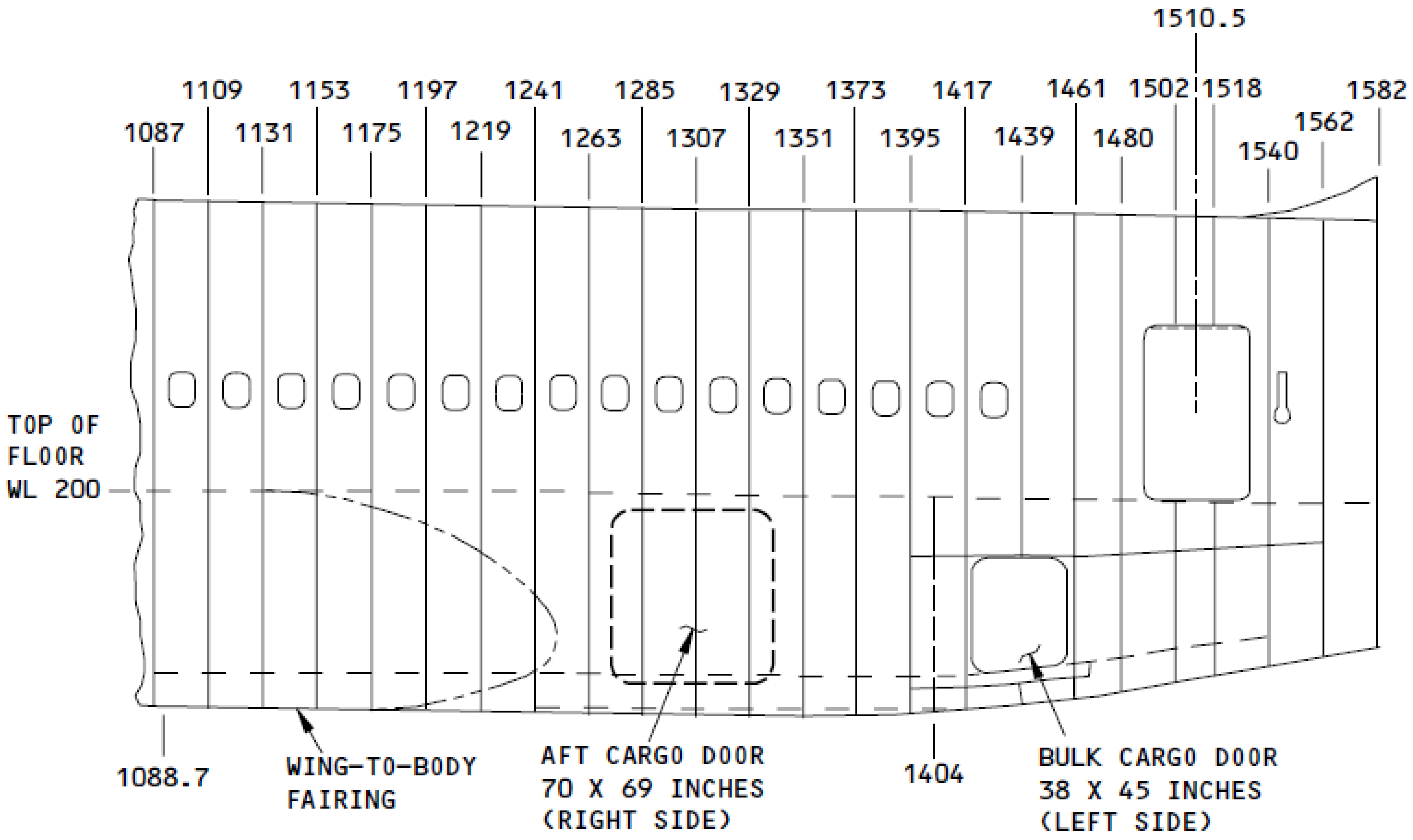




SINGLE HATCH (STA 871.5)

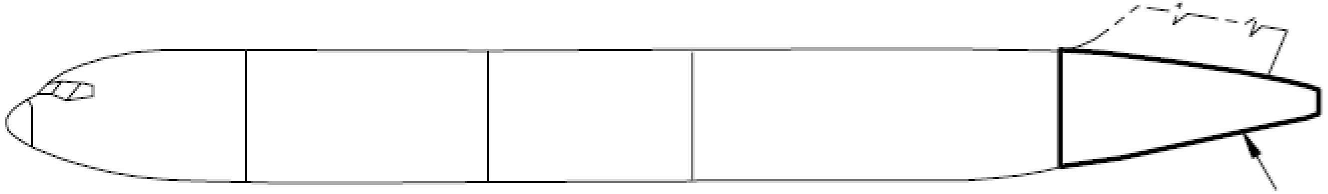
Fuselage





767-200

Fuselage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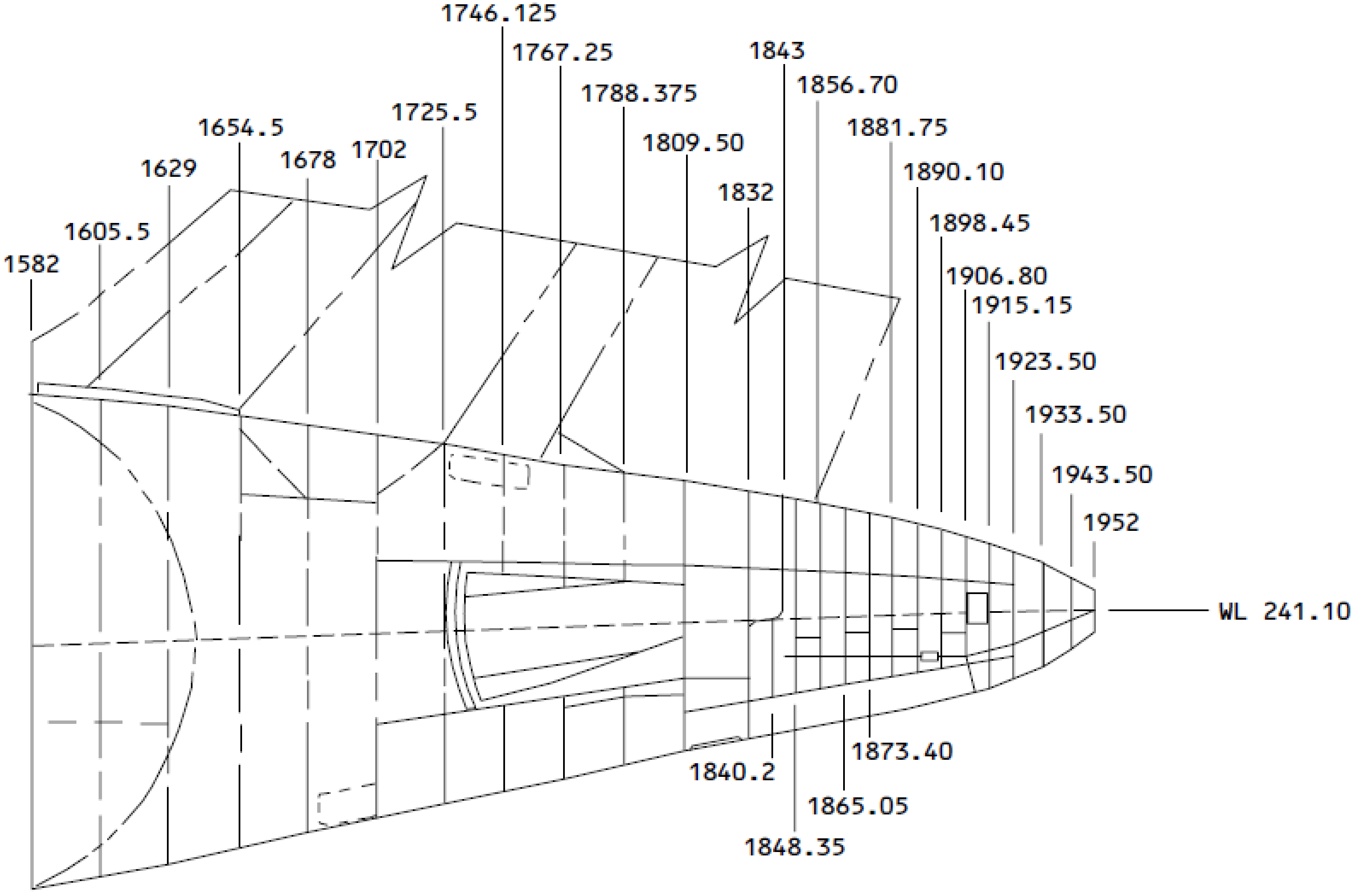
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1654.5
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1629
1890.10
1832
1605.5
1898.45
1582
1906.80
1915.15
1923.50
1933.50
1943.50
1952
WL 241.10
1873.40
1840.2
1865.05
1848.35

Fuselage

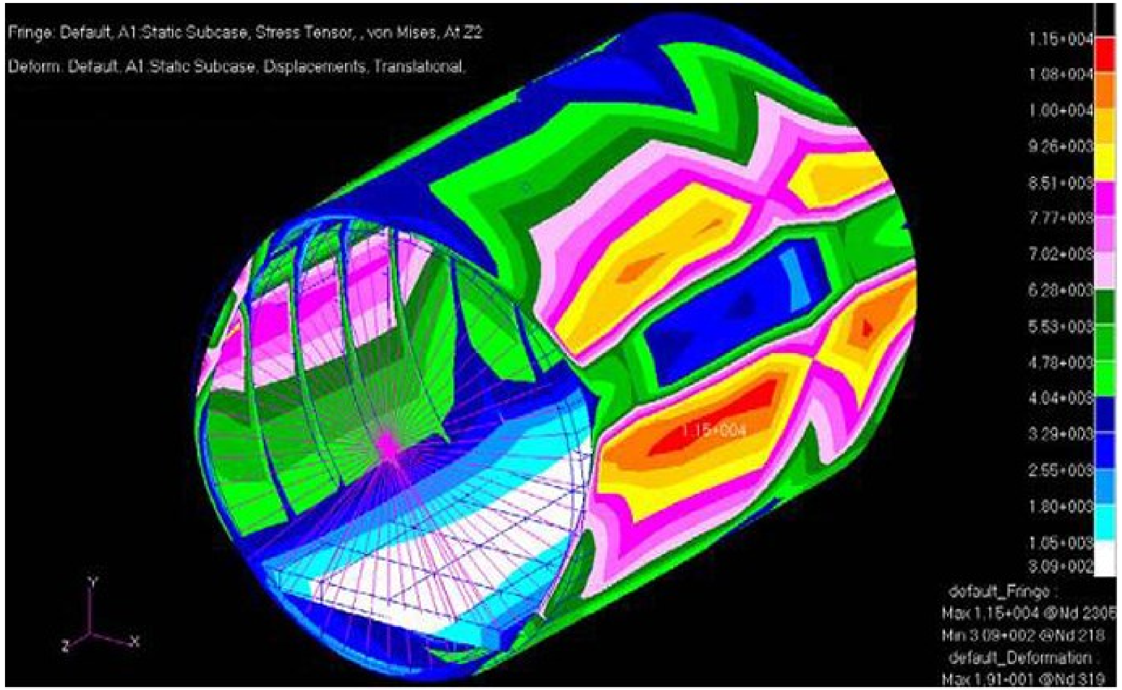
The Fuselage as a beam contains **longitudinal elements (**longerons stringers), **transversal elements** (bulkheads, frames) and its **external skin**

Longerons carry the major portion of the **fuselage bending** moment loaded by axial forces In addition to stabilizing the external skin, stringers also carry axial loads induced by bending moment

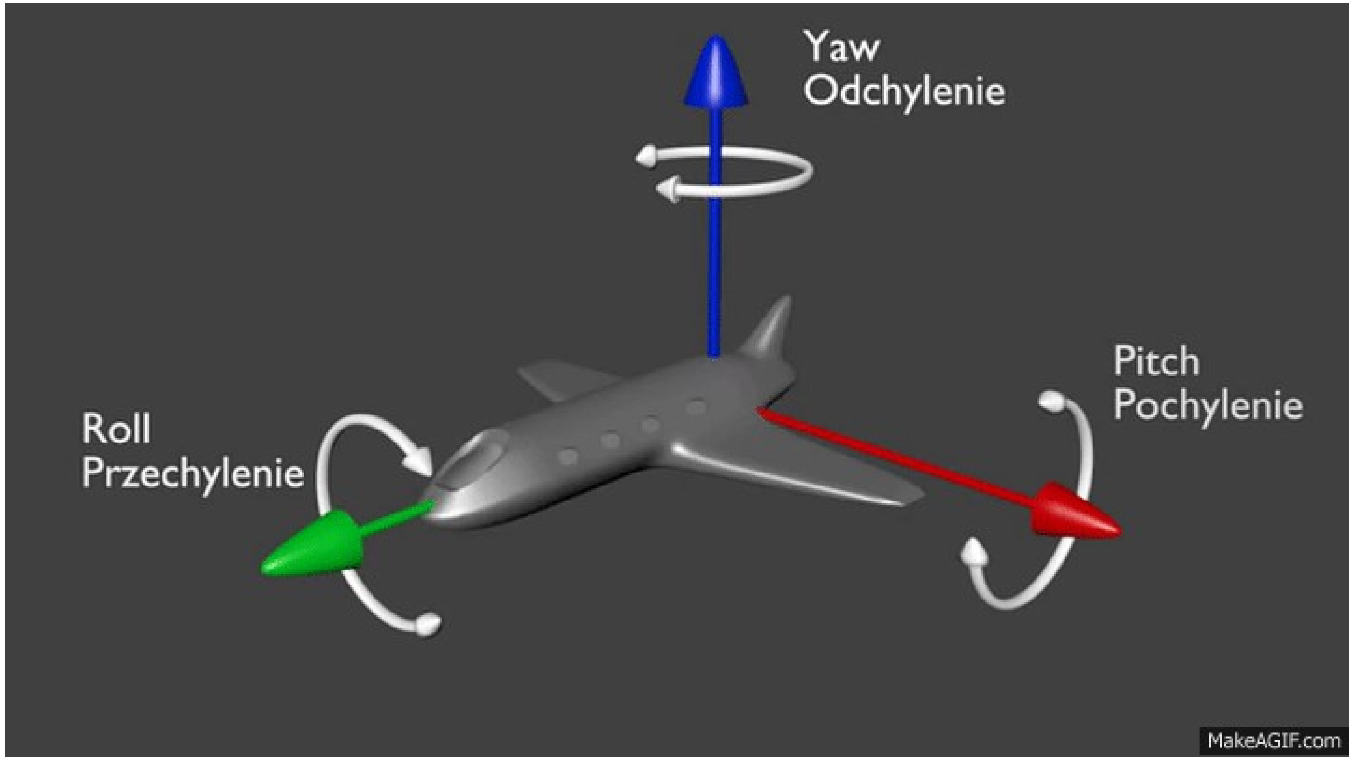
Fuselage skin carries shear from the applied external transverse and torsional forces and cabin pressure

Frames transfer loads to the fuselage shell and provide column support for the longitudinal members. If supports the internal cabin pressure will generate large bending loads.

Fuselage



https://www.longdom.org/open-access-pdfs/stress-analysis-of-an-aircraft-fuselage-with-and-without-portholes-usingcadcae-process-2168-9792-1000138.pdf



https://i.makeagif.com/media/6-06-2016/MybXwU.gif

Fuselage

Frames primarily serve to maintain the shape of the fuselage and to reduce the column length of the stringers to prevent instability of the structure

- Support skin stringer panels
- Distribute concentrated loads
- Crack stoppers (Fail safe)

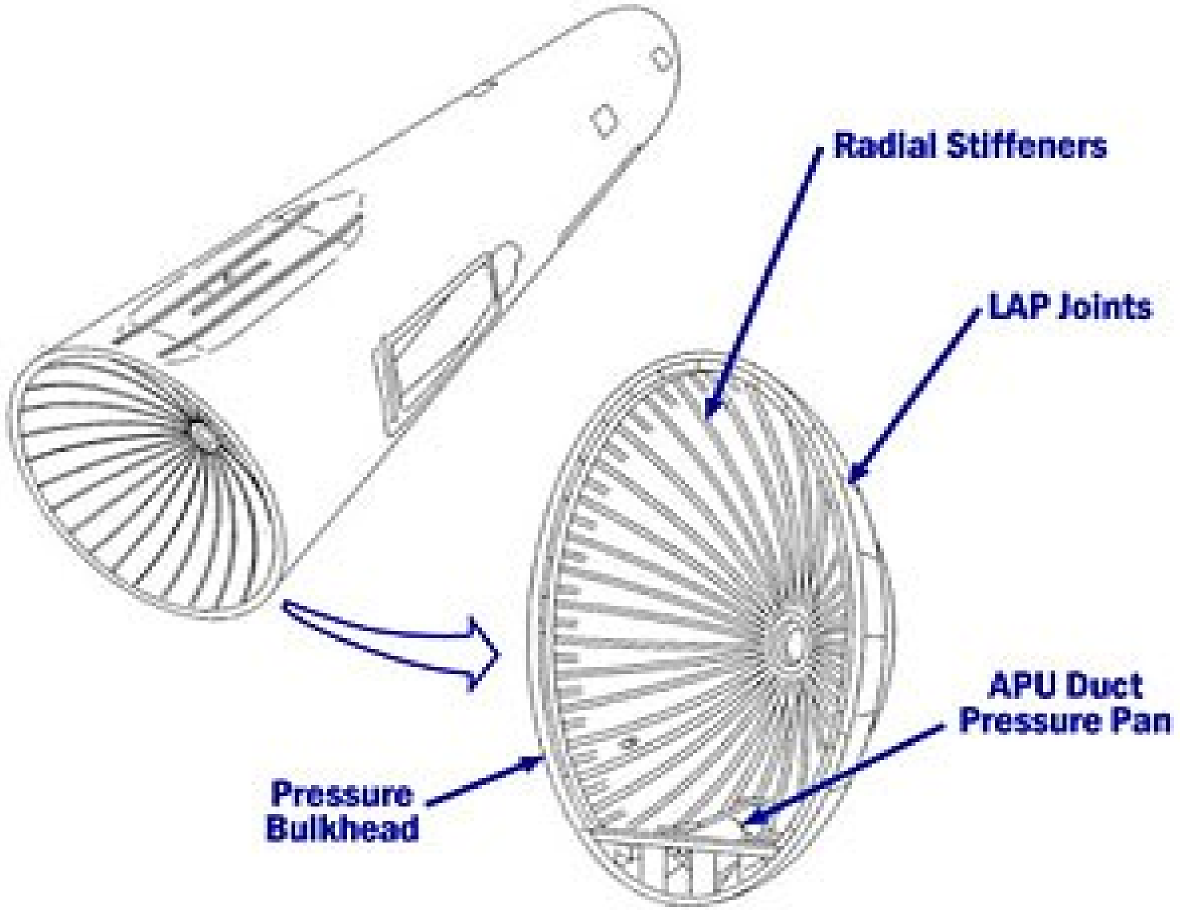
https://www.jetphotos.com/photo/8054236

Fuselage

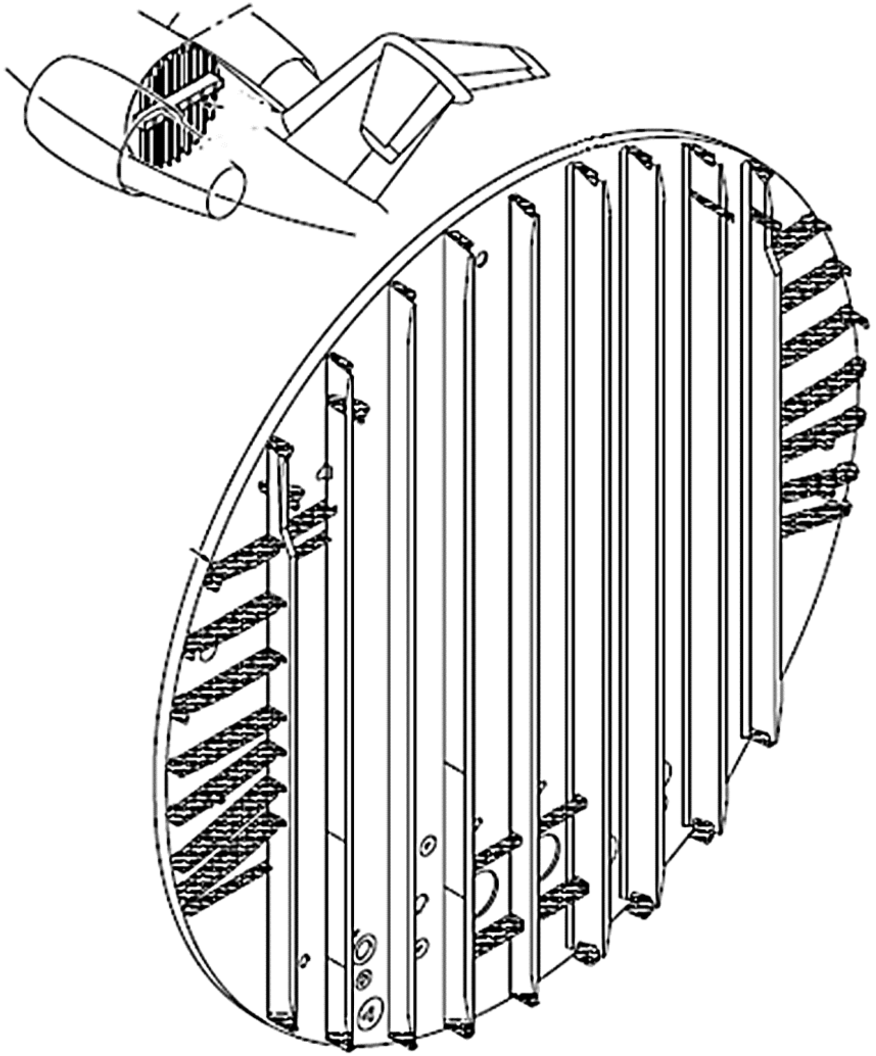
Bulkheads are provided at points of introduction of **concentrated forces** such as those form the wing and tail surfaces and landing gear

Unlike frames, the **bulkhead structure is quite substantial** and serves to distribute to applied load into the fuselage skin

Fuselage



Dome bulkhead



Flat bulkhead

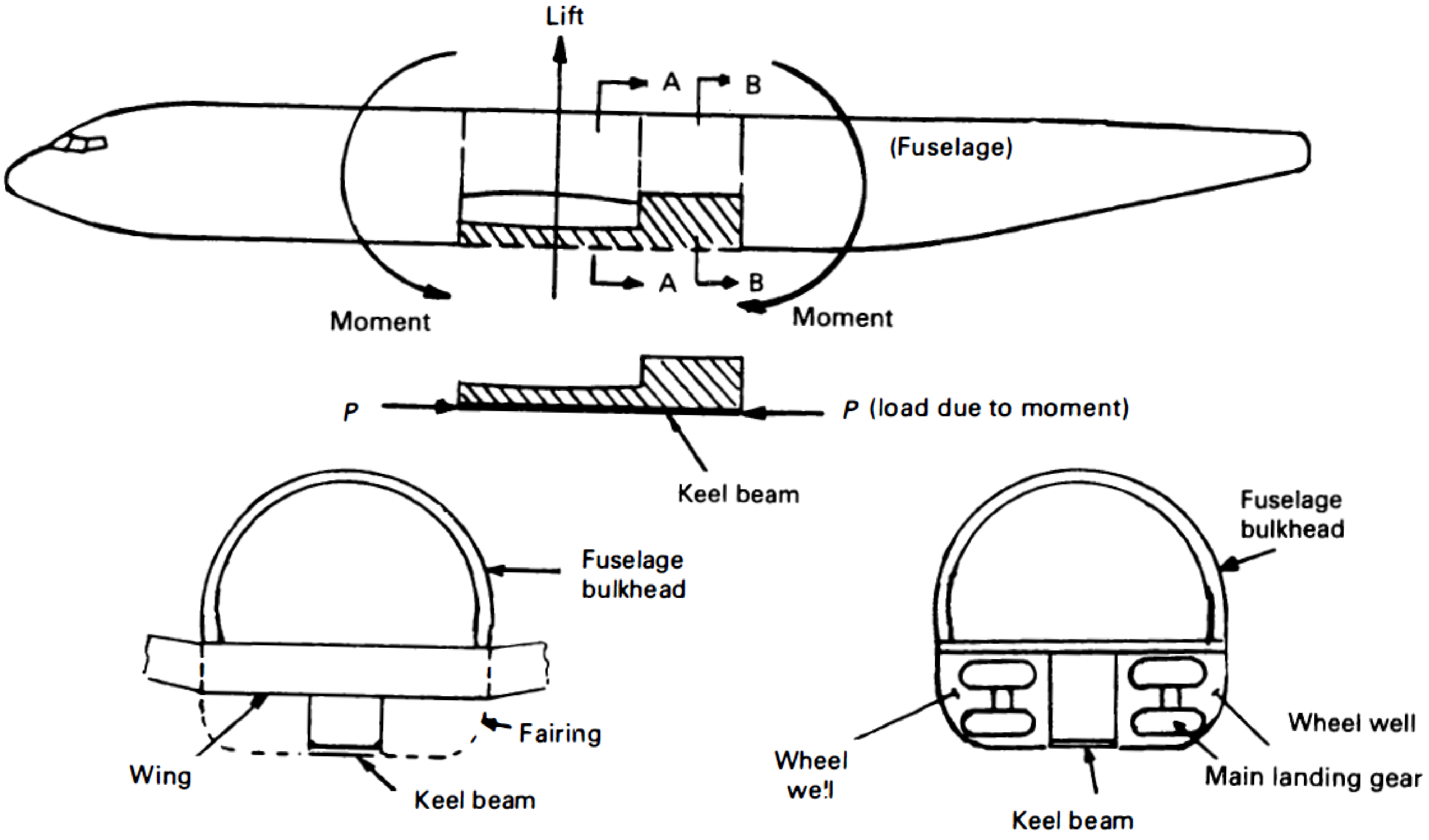
Keel beam

In the wheel area where the **maximum fuselage bending moment occurs**, the **lower half of the skin/stringer system is missing** .

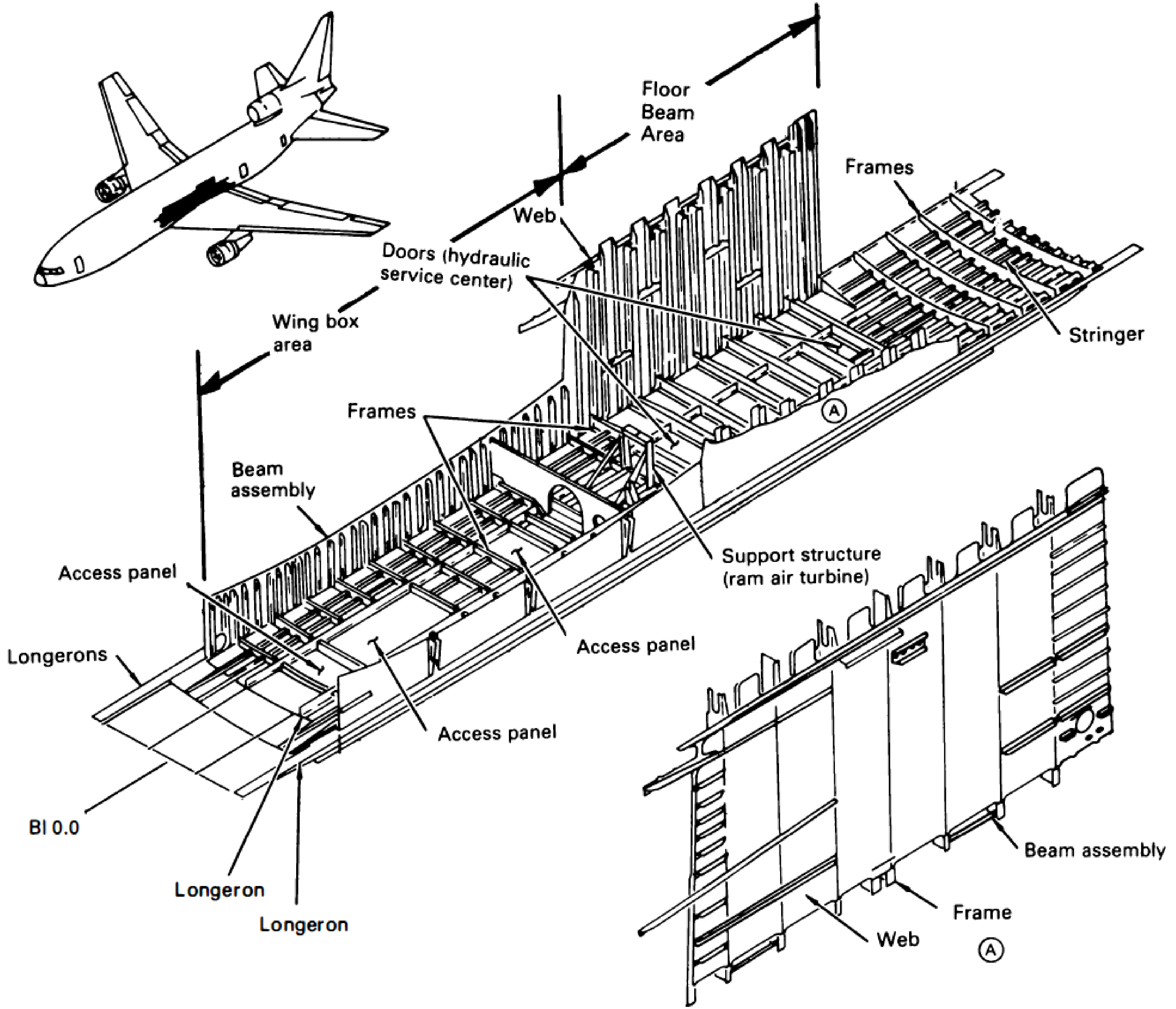
To obtain the **bending integrity** through this area, the load carried by the lower half of the fuselage skin/stringer panel in the fwd and aft fuselage is **concentrated in large longitudinal members** called keel beam longerons.

The structure that **support and stabilize** the keel beam longerons is the keel beam or Keelson beam.

Keel beam

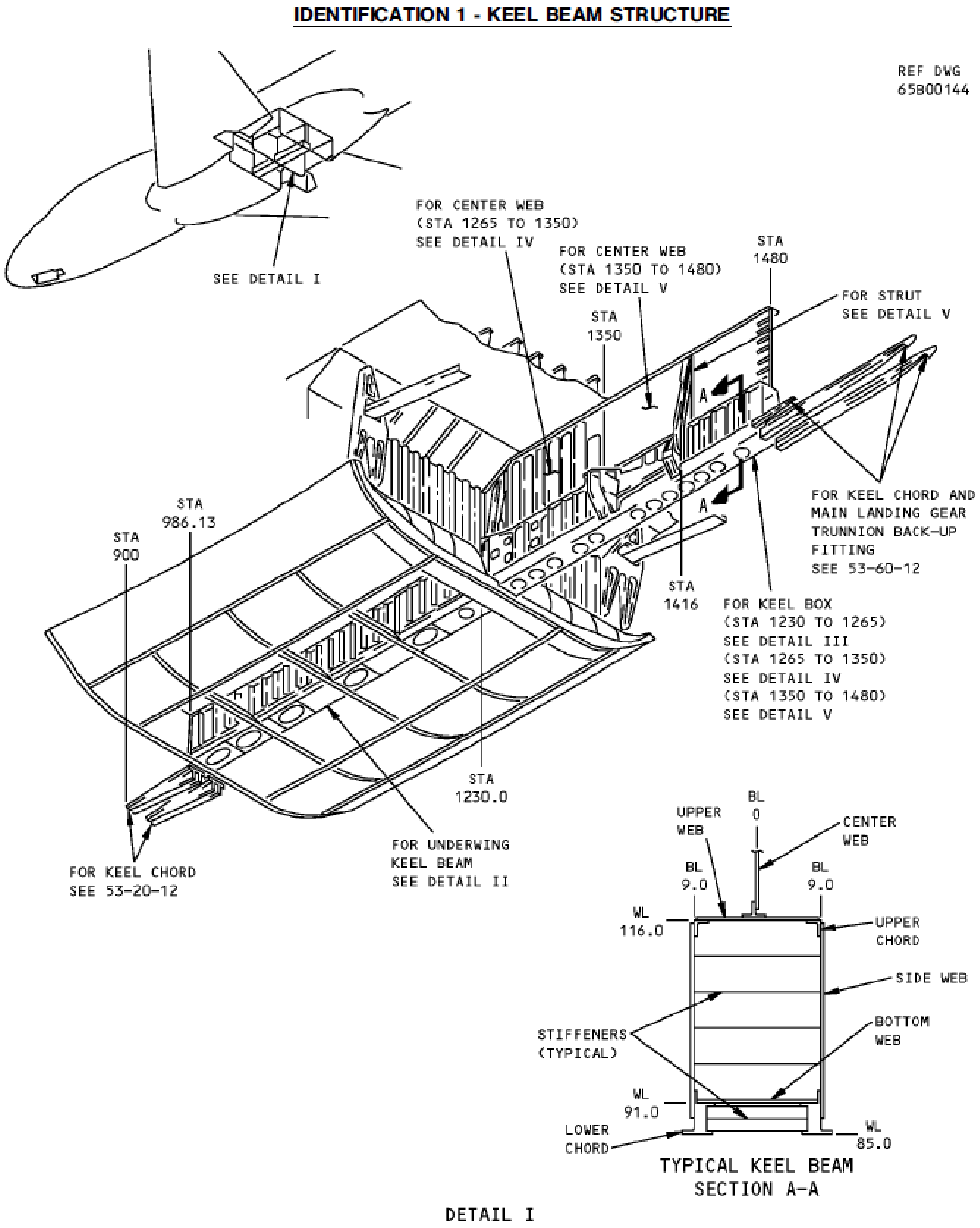


Section A-A



Floor
Beam
Area
Frames
Web
Doors (hydraulic
service center)
Wing box
area
Stringer
Frames
A
Beam
assembly
Support structure
(ram air turbine)
Access panel
Access panel
Longerons
Access panel
Bl 0.0
Longeron
Longeron
Beam assembly
Frame
Web
A

B747
Keel Beam



Keel beam

Skin

Thin sheets are very efficient in resisting **shear and tension loads** in the plane of the sheet, but **must be stiffened by longitudinal and transverse members** to **withstand compression loads**

The design of a semi monocoque system requires an understanding of sheet stability, panel buckling and semi diagonal tension field action

Differences between fuselage and a wing

The function of the stringers and skins of the fuselage and wing are equivalent. Due to their greater curvatures, fuselage skins are more stable under compression and shear loads

External pressure loads are much lower in the fuselage, as a result skin thickness in fuselage will be found to be thinner than on wing skins

Fuselage longerons and stringers and wing beam caps serve similar function of **carrying axial loads induced by bending**

Differences between fuselage and a wing

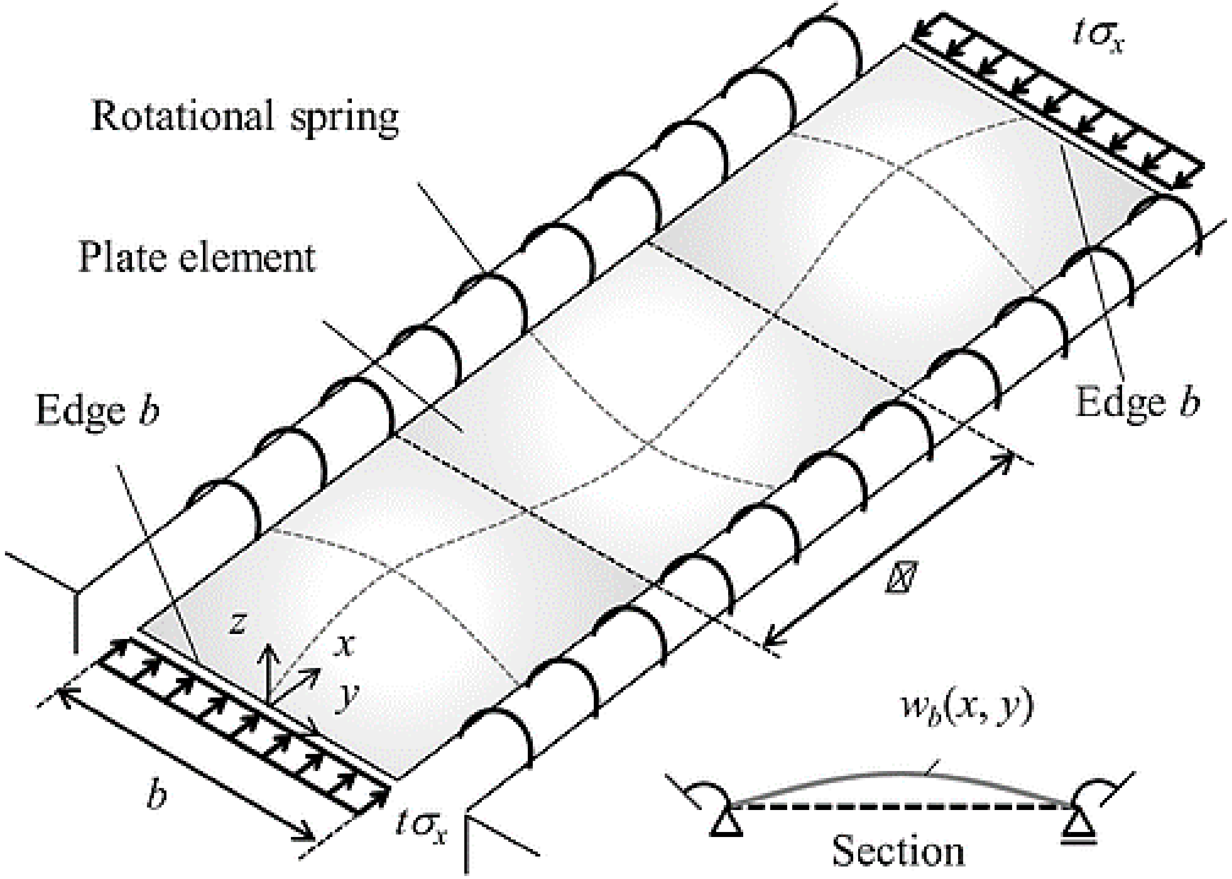
In the fuselage **transverse shear loads are carried by the skin** while **in wing** these loads are predominately resisted **by spar webs**

Fuselage frames are equivalent in function to wing ribs, except that **local air loads will have a large influence in wing ribs** while the design of fuselage frames may be influenced by loads resulting from **equipment mounted in the fuselage** and cabin pressure.

Ultimate strength of a stiffened cylindrical structure (Skin instability)

Thin curved sheet buckle under relatively low compressive stress and shear stress if the design requirements specify no buckling of the sheet under load

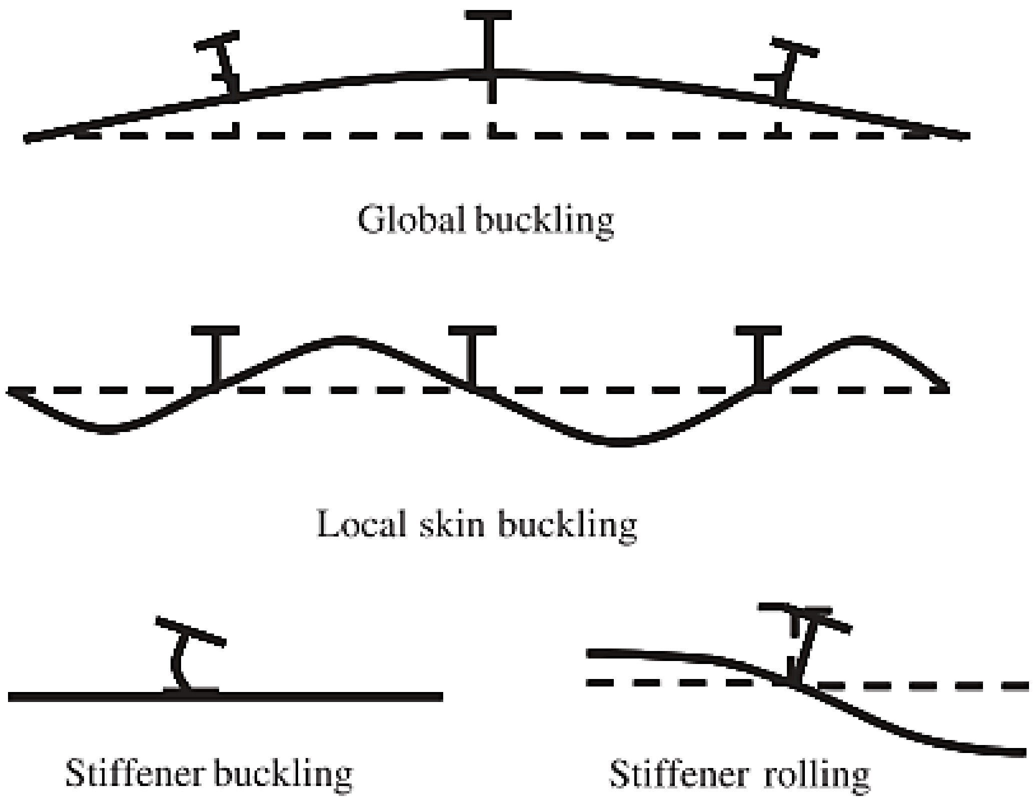
The sheet must be relatively thick however, this results in an inefficient design (strength to weight ratio)



Ultimate strength of a stiffened cylindrical structure (Skin instability)

Longitudinal **stringers** provide efficient resistance to **compressive stresses**

Stress redistribution due to stringers, takes place over the entire structure, however, **buckling of the skin panels will still occurs**

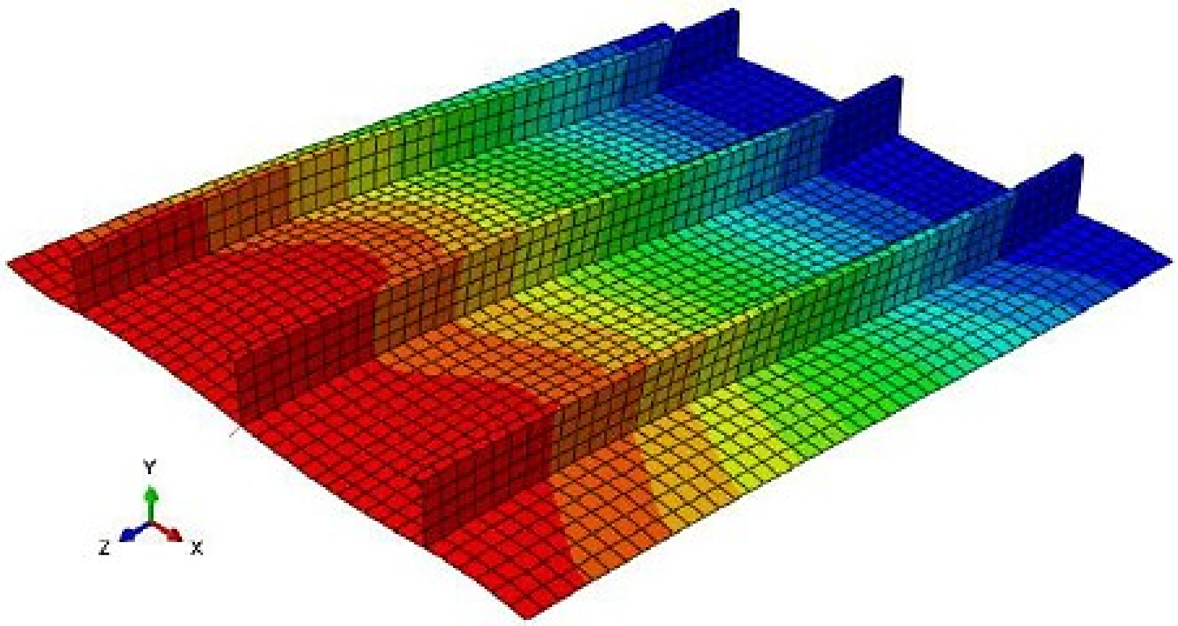


Ultimate strength of a stiffened cylindrical structure (Panel instability, stringer induced)

Longitudinal stringers may also buckle

The length of stringers is limited by frames in a semi monocoque structure ..(Frame spacing)

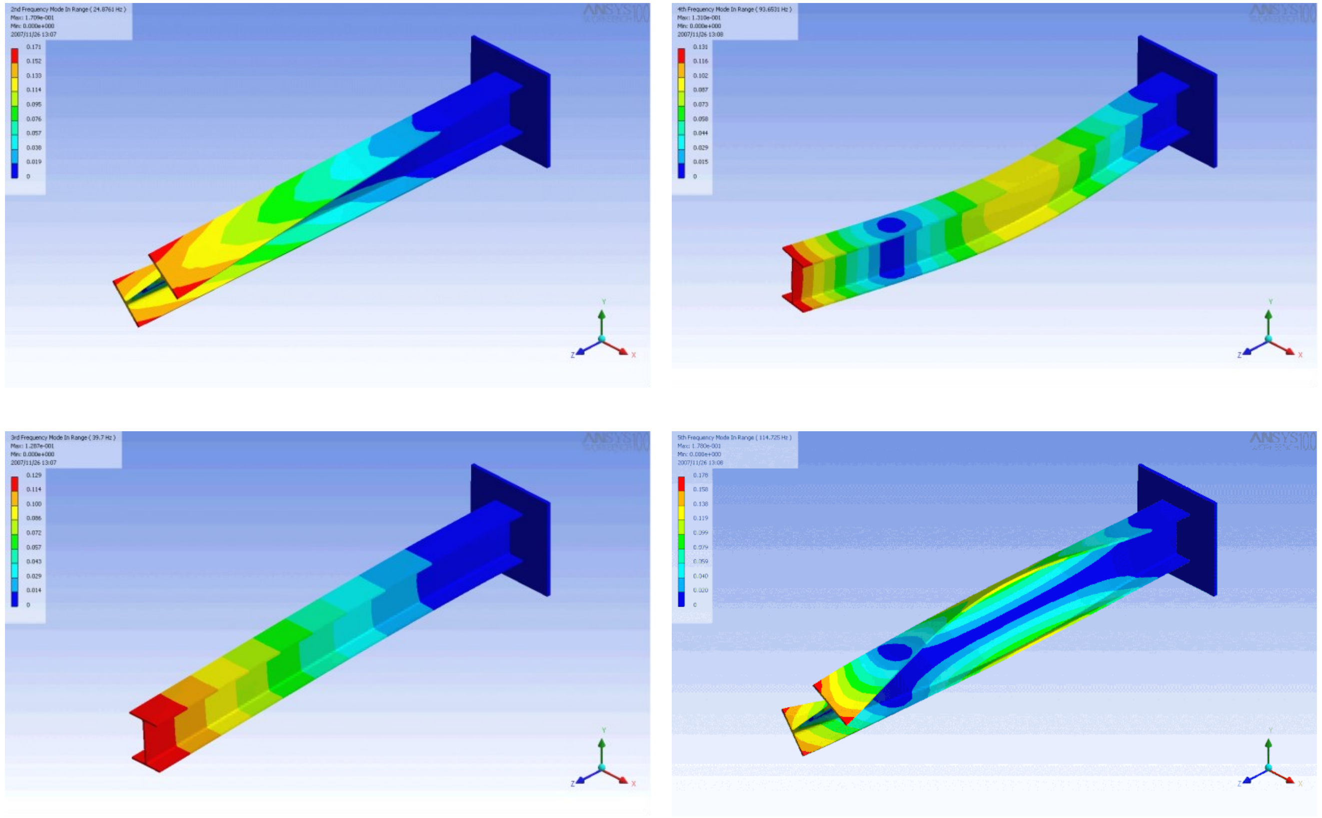
Thus, initial failure may occur in a single panel



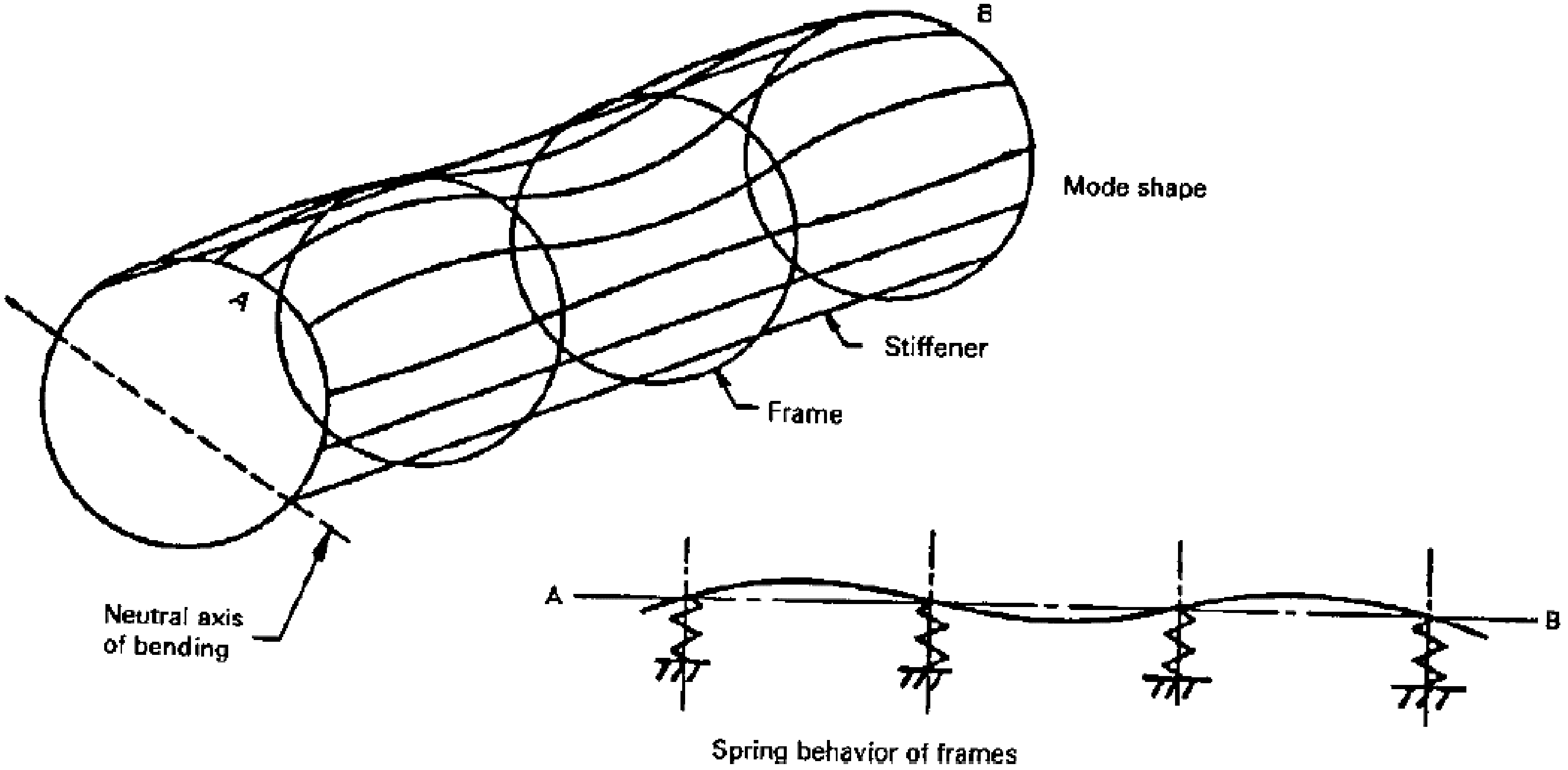
Ultimate strength of a stiffened cylindrical structure (General instability, panel instability)

General instability extends over two or more frames and its not confined between two adjacent frames, this is the case of panel instability

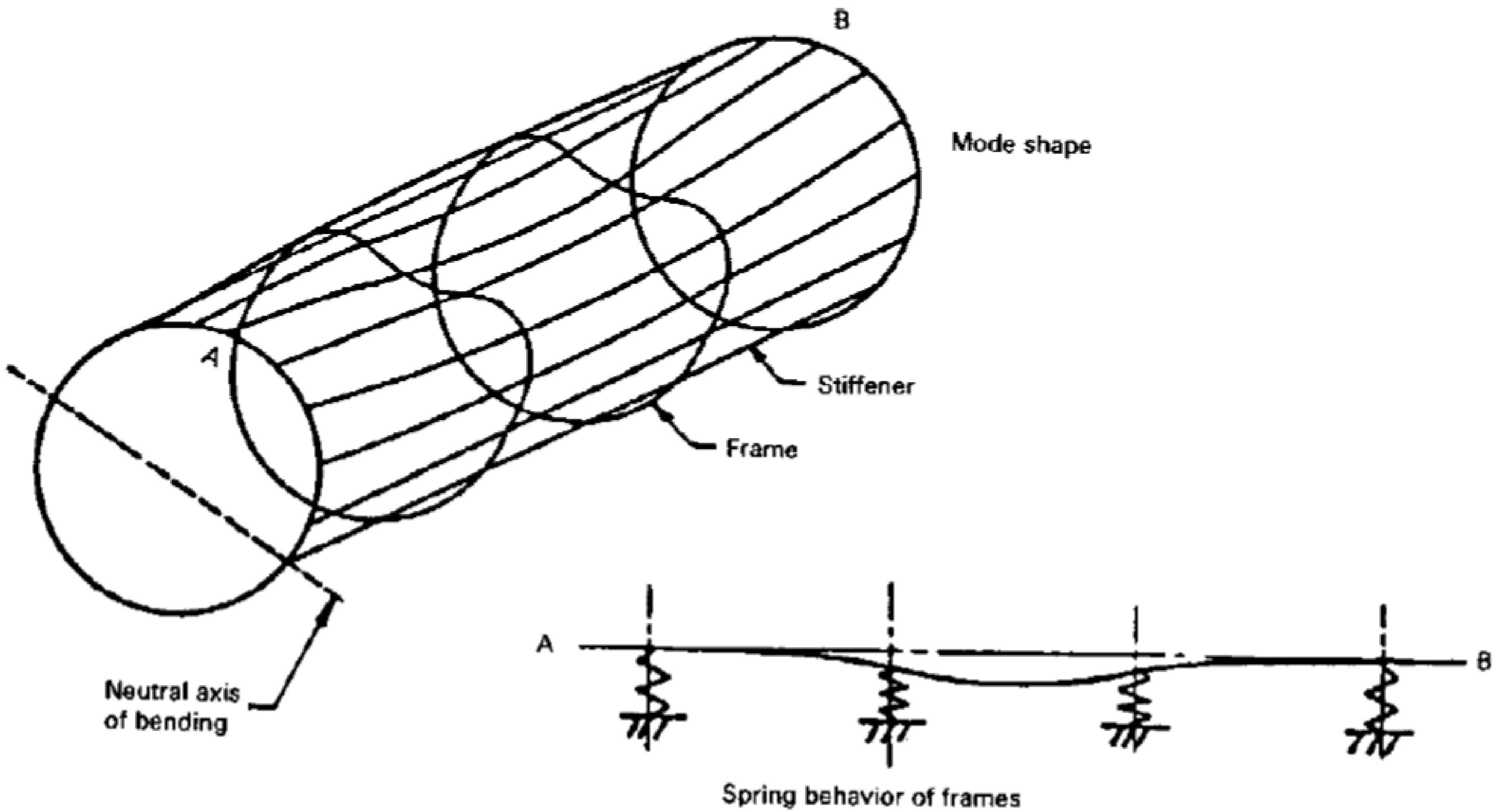
Furthermore, in general instability frames are not rigid enough to enforce longitudinal stringer node points at each frame



Ultimate strength of a stiffened cylindrical structure (Panel instability)



Ultimate strength of a stiffened cylindrical structure (General instability)



https://www.youtube.com/watch?v=tmmrkswDHp0&ab_channel=MechDesignTV

https://www.youtube.com/watch?v=yTo_o8ykdUo&ab_channel=Airbus