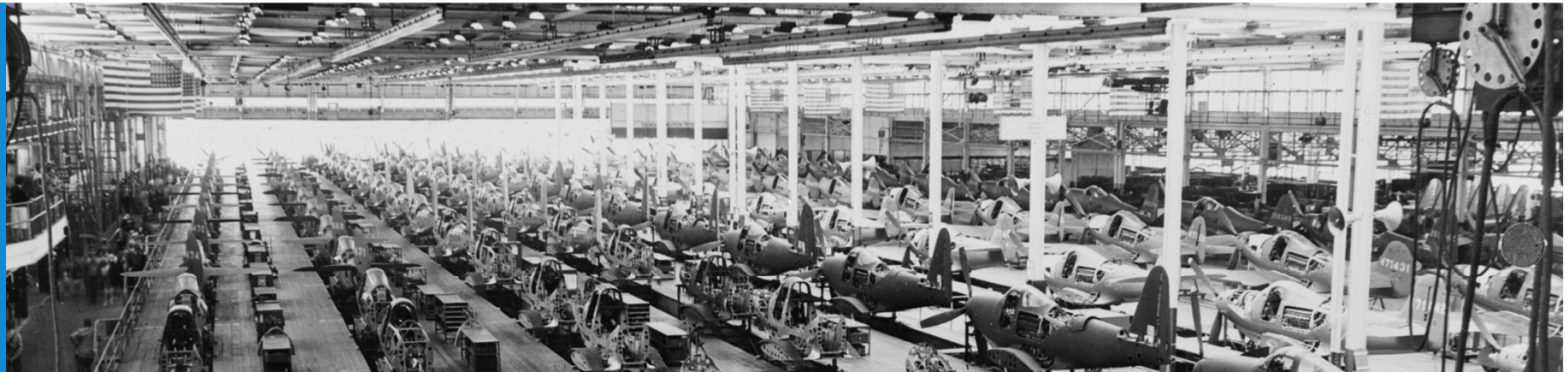


Introduction to Aerospace Engineering

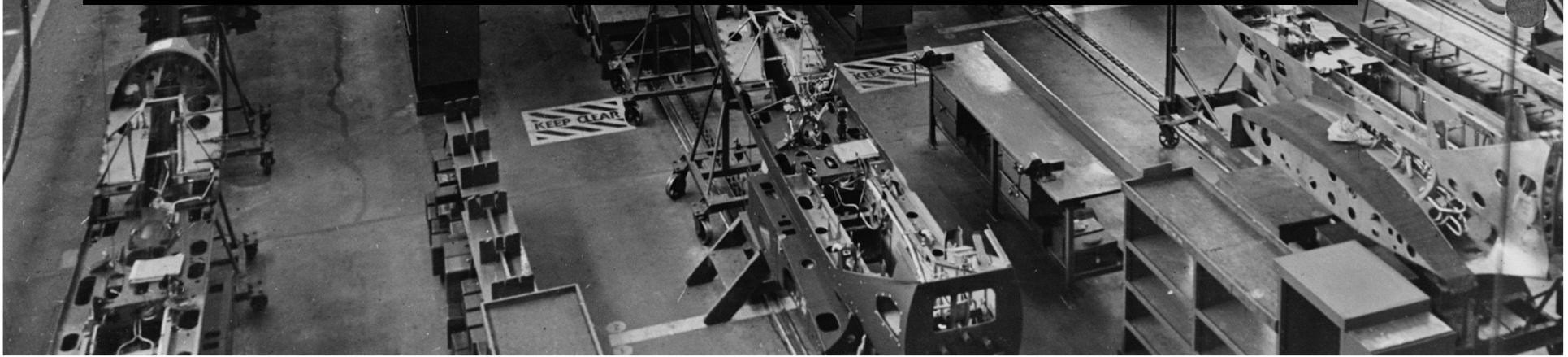
Lecture slides



Selection of material & structure

Manufacturing

Faculty of Aerospace Engineering
10-1-2012





Learning objectives

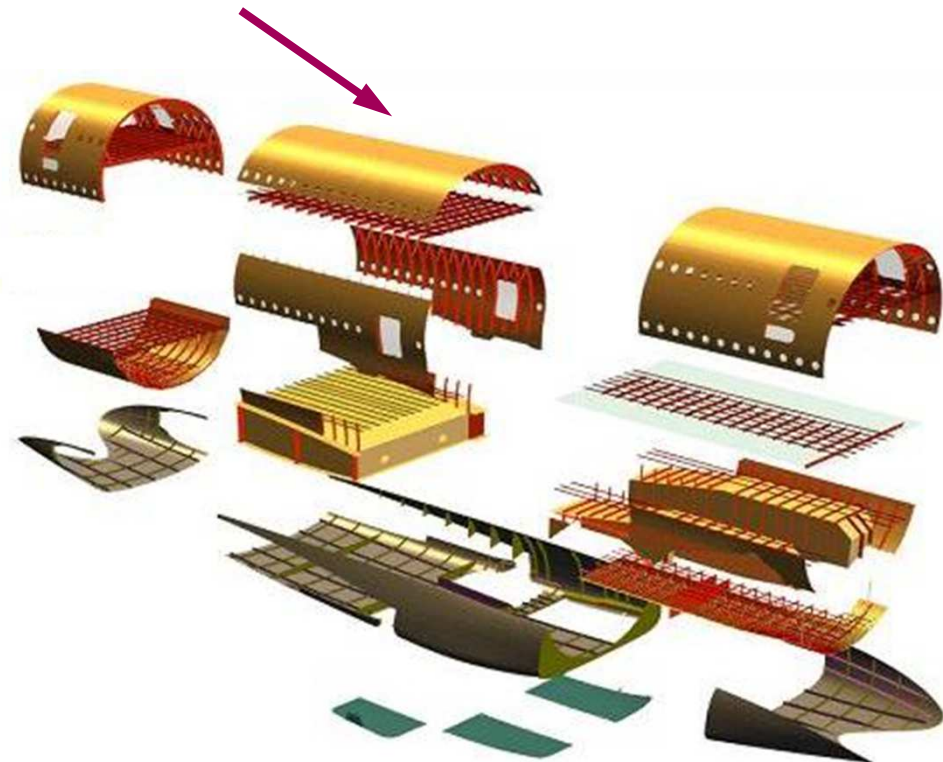
Student should be able to...

- Discuss the reasons for selecting certain structural types based on manufacturing processes

Stiffened shell structure

Aspects to consider

- Design & manufacture upper fuselage shell



Stiffened shell structure

Aspects to consider

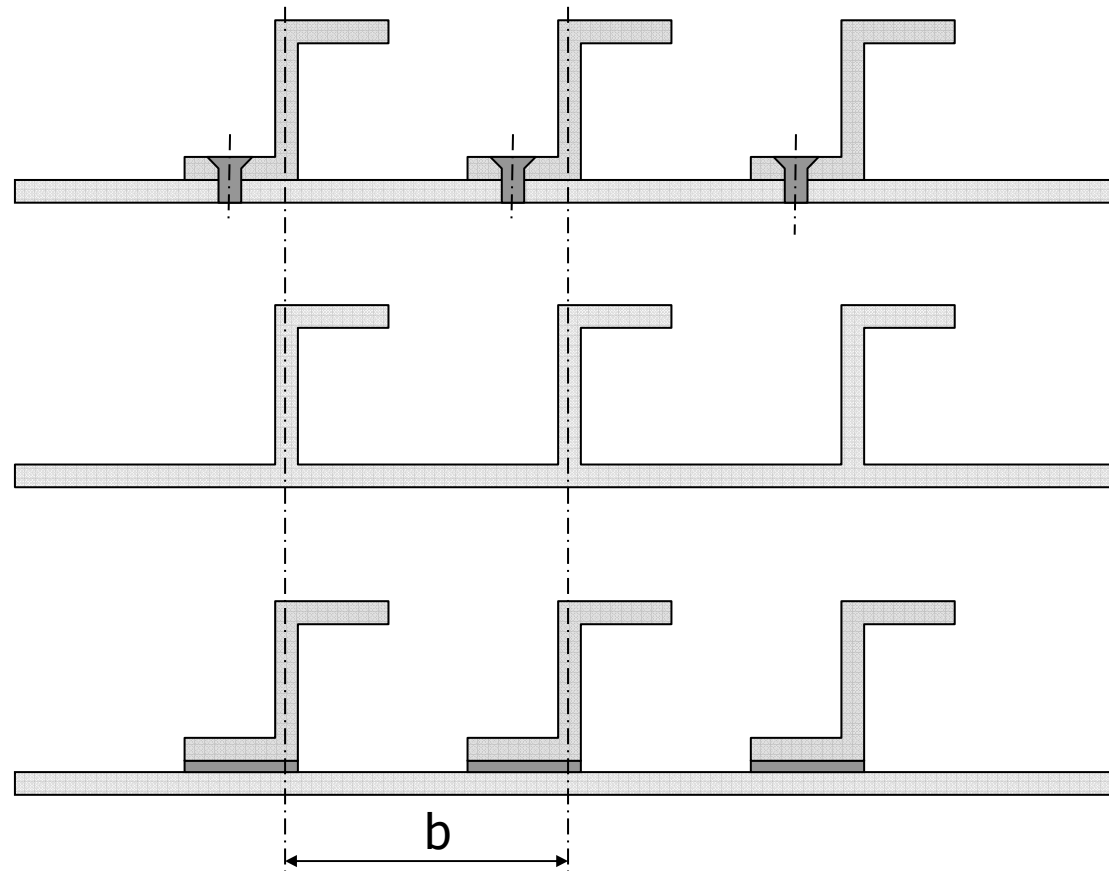
- Options

- Riveted panel

- Integral panel

- Welded panel

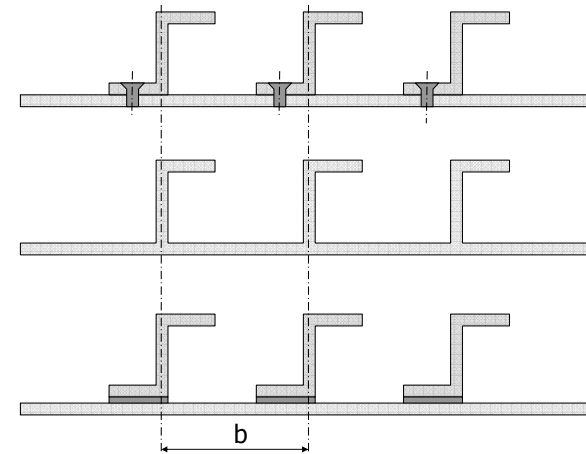
- Bonded panel



Stiffened shell structure

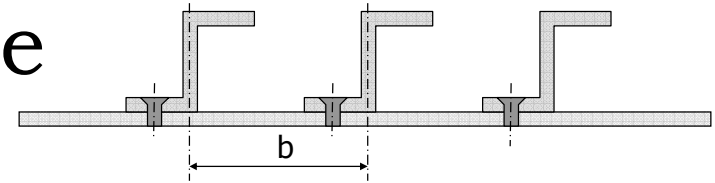
Aspects to consider

- Manufacturing aspects (manufacturing costs)
 - Parts
 - Production steps
 - Logistics
 - Tooling
- Structural performance (maintenance costs)
 - Inspections
 - Repairs

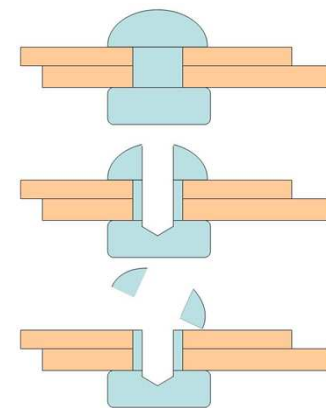
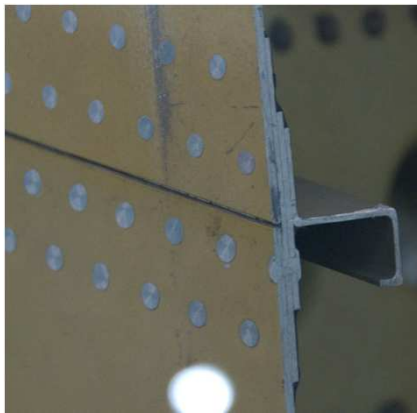


Stiffened shell structure

Riveted panel

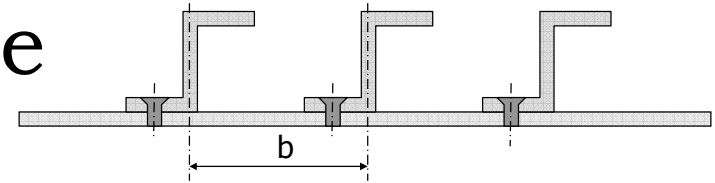


- Advantages
 - Allows joining different materials
 - Rather easy, straight forward, and robust process
 - Multitude of rivet types are available, including installation processes (solid rivets, titanium rivets, blind rivets, etc.)
 - Can be removed for repair (only once or twice – bolts more often)
 - Assembly tolerances can be rather wide (adjustment on the spot)



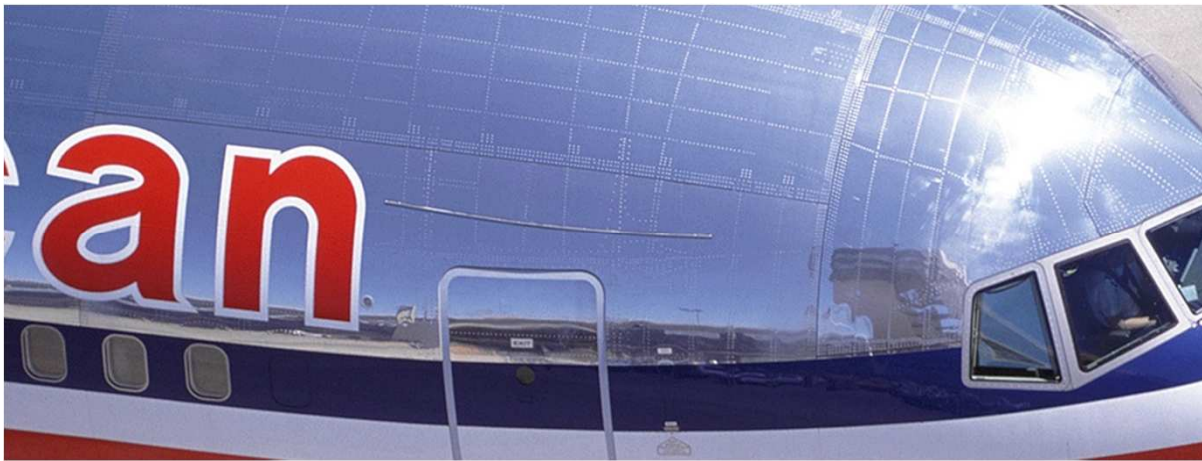
Stiffened shell structure

Riveted panel



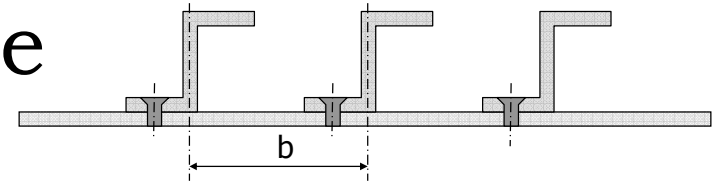
- Disadvantages

- Labor intensive
- Requires often two-sided accessibility
- Drilling at assembly stations is a disadvantage (tendency to hole-to-hole assembly)
- Not air- & liquid tight

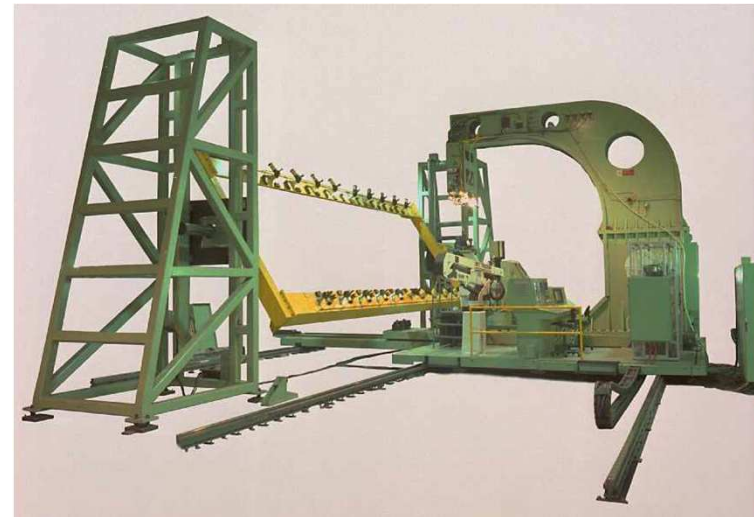


Stiffened shell structure

Riveted panel

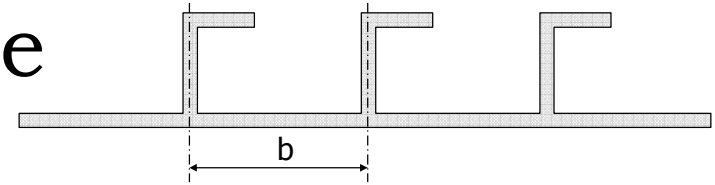


- Other manufacturing aspects
 - Multiple parts (skin, stringer, rivets)
 - Multiple tools
 - Logistics and monitoring for the flow of the parts
 - Parts manufactured in batches



Stiffened shell structure

Integral panel

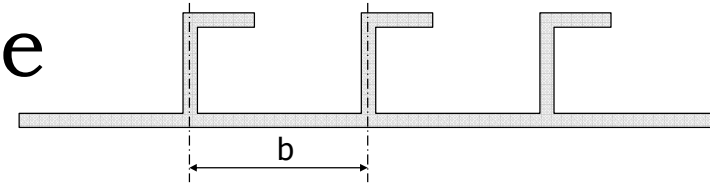


- Advantages
 - Relative cheap process
 - Joint is air- and liquid tight
 - Milled panel consist of single part (in production)
 - High accuracy possible
- Disadvantages
 - Investment for (expensive) tooling & machines
 - Significant amount of waste material



Stiffened shell structure

Welded panel



- Advantages

- Cheapest process of all
- Joint is air- and liquid tight
- Currently used method is Laser Beam Welding (option is Friction Stir Welding, FSW)

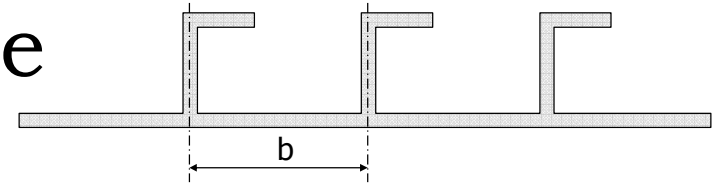
- Disadvantages

- Only applied for similar materials (some wider range for FSW)
- Welding in final assembly line difficult

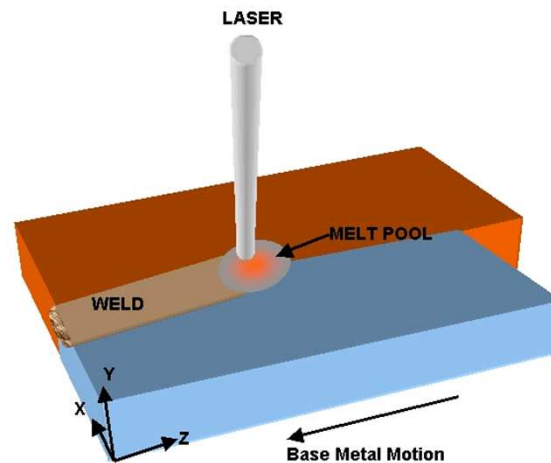


Stiffened shell structure

Welded panel

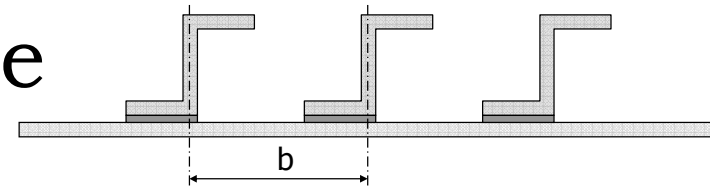


- Other manufacturing aspects
 - Welding disrupts the microstructure in a material
 - Accurate positioning of parts before welding is important
 - Welding surfaces should be cleaned beforehand (simple cleaning)
 - Pretreatment of sub-structures after welding is difficult
 - Welded structures consist of multiple parts (in production)



Stiffened shell structure

Bonded panel

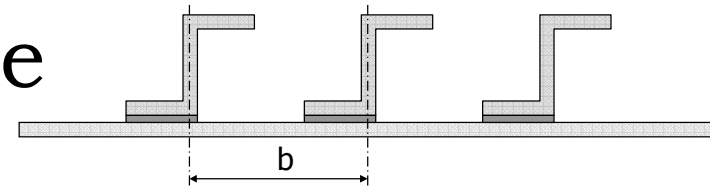


- Advantages
 - Allows joining different materials
 - Number of parts is (much) less than for riveted structures
 - Joint efficiency is high (but special care is required for degradation by moisture/temperature)
 - Joint is air- and liquid tight



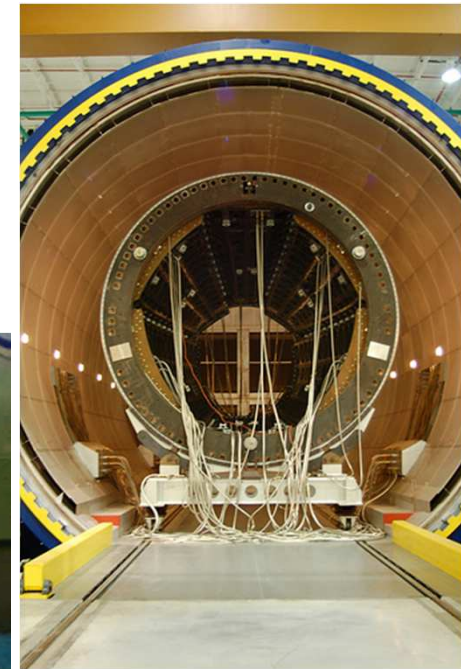
Stiffened shell structure

Bonded panel



- Disadvantages

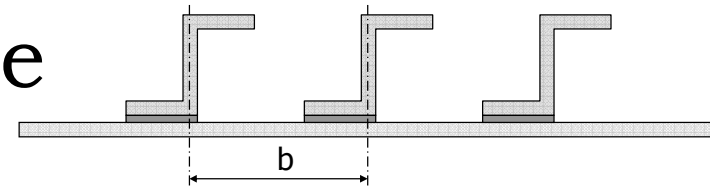
- (expensive) autoclave process is required for curing
- Autoclaving is curing at high temperature and pressure according to a particular cycle
- Preparing for autoclaving requires a significant amount of consumables (foils, tape, etc.)



Stiffened shell structure

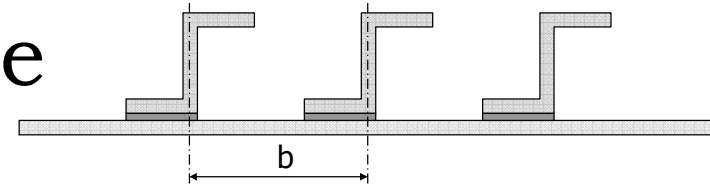
Bonded panel

- Pretreatments
 - Highly important for adhesive bonding
 - Necessary for strength and durability
 - Material dependent
 - Process is rather sensitive
 - Current processes are not environmentally friendly & should be replaced

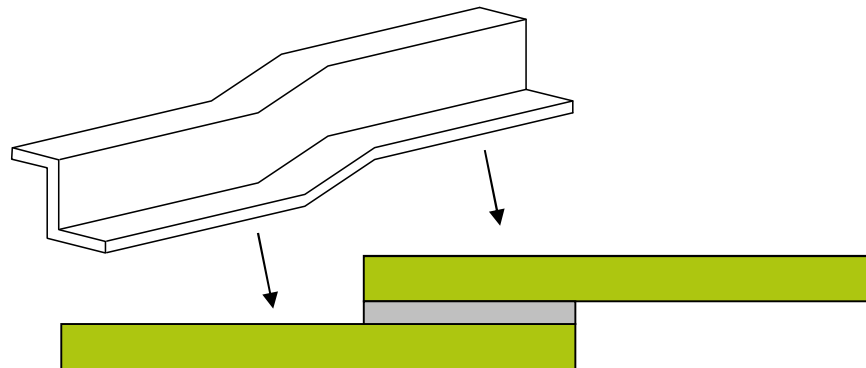


Stiffened shell structure

Bonded panel



- Other manufacturing aspects
 - Bonded joints have significant contact surfaces
 - Overlaps can be problematic for backup structure (extra joggles)
 - High accuracy required for non-flexible parts;
bond line thickness only ~ 0.1 mm
 - Bonding of sub-assemblies; bonding in final assembly line not feasible



Stiffened shell structure

Aspects to consider

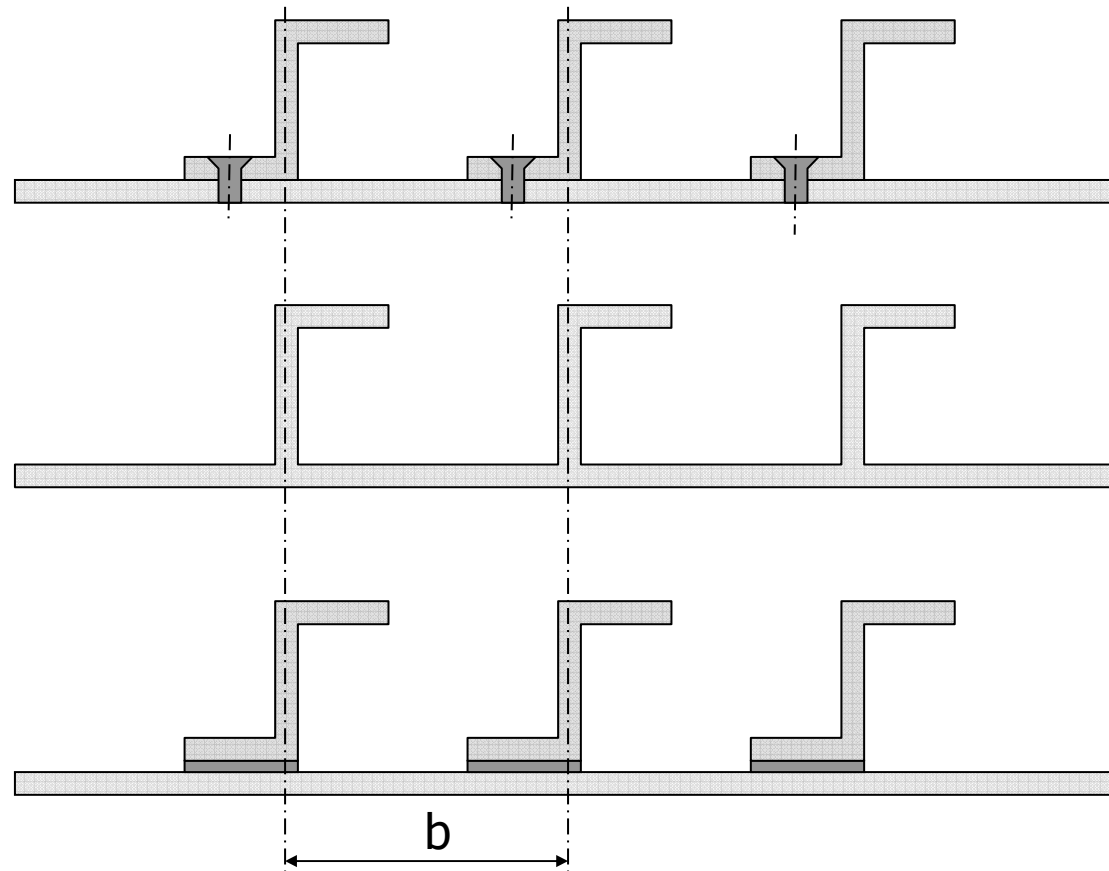
- Options

- Riveted panel

- Integral panel

- Welded panel

- Bonded panel



Stiffened shell structure

Manufacturing the structure...

