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Structural Layout

AE460

Greg Marien
Lecturer

Introduction

- Complete Aircraft wing, tail and propulsion configuration and loft
- Structural Layout/Load path
- V-n Diagrams/Air-loads
- Structural Sizing
- Weight maturity and MOIs

Reading:
Nicolai - CH 19
Roskam – III (yellow), sections 3.5, 4.2, 4.3, 5.2 with structural layouts

Other references:
On-line – inboard profiles/cutaways of aircraft

Loads and Load Path

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- Structures – all about load path
  – Most weight efficient layout “wins!”

- Wing Structure loads
  – Load – MGTOW x n (load factor) x factor of safety – typical
    - SRD or V-n diagram is the governing basis for load

- Primary loads – reacted through the “wing box”
  – Bending loads
  – Torsion Loads

- Secondary Loads (local loading)
  – Engine nacelle loads
  – Payload attachments
  – Fuel pressure, static and dynamic
  – Landing gear loads
  – Leading and trailing edge loads, controls and high lift devices

Wing Parts

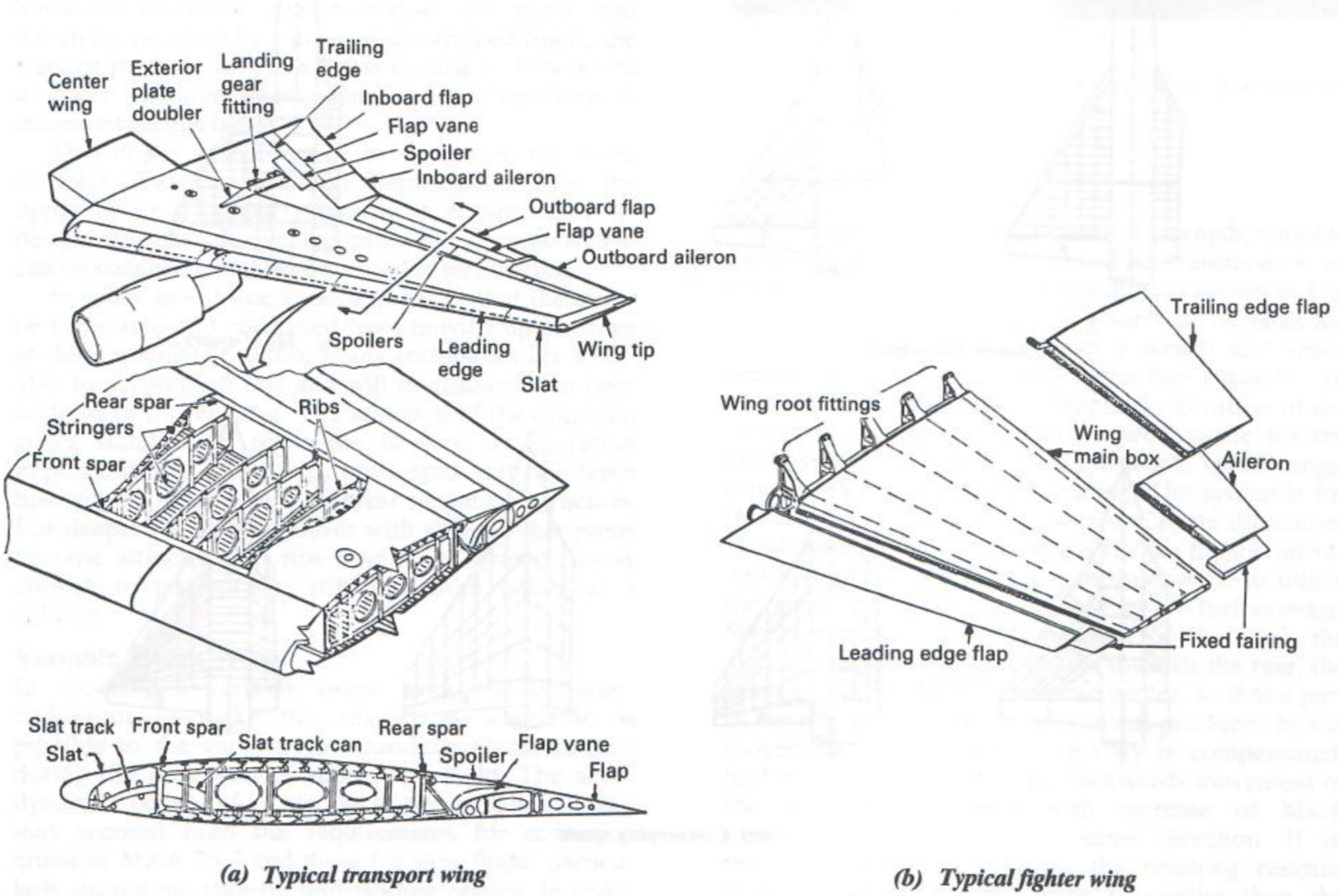

Fig. 8.1.1 Typical transport and fighter wing.

REF: Niu, Michael. Airframe Structural Design

Wing layout

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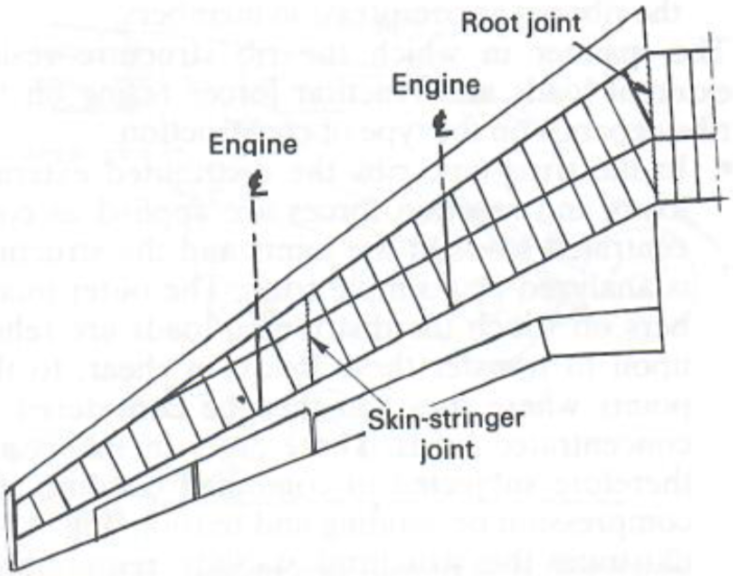
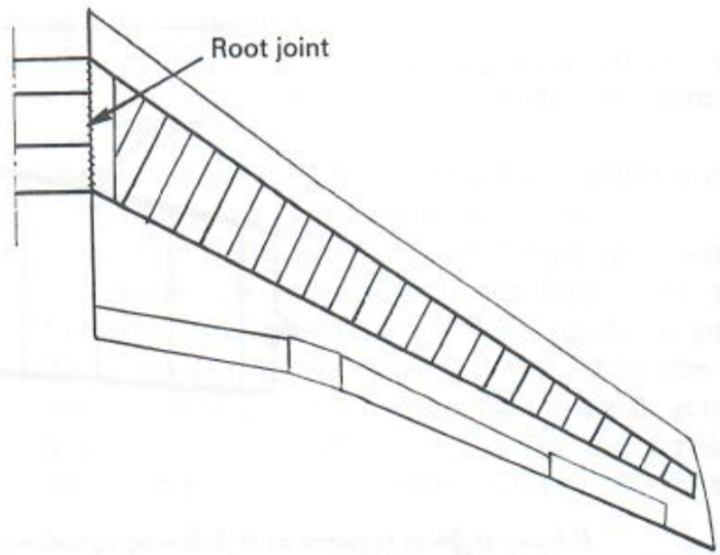
- Start with planform drawing – sketch it out!
- Locate front spar (leading edge flaps/slat attachment points)
  - Constant cf/c, .12c-.17c
- Locate aft spar (flaps and control surface attachments)
  - Constant cf/c, .55c-. 60c
- Locate
  - Engine and nacelle attachments
  - Control surface breaks (if you have a .30c aileron, put the spar at .60c, giving you .10c for volume margin for hinges/mechanisms)
  - Ribs - Where should you put them?
  - Stringers
  - Wheel well, and structural load path around it.
- CAD it up – only surfaces until you are happy with the configuration and all load paths/attachments have been accounted for

Wing Structural Layout Examples



(a)DC-8



(c)B727

REF: Niu, Michael. Airframe Structural Design

Wing Structural Layout Examples

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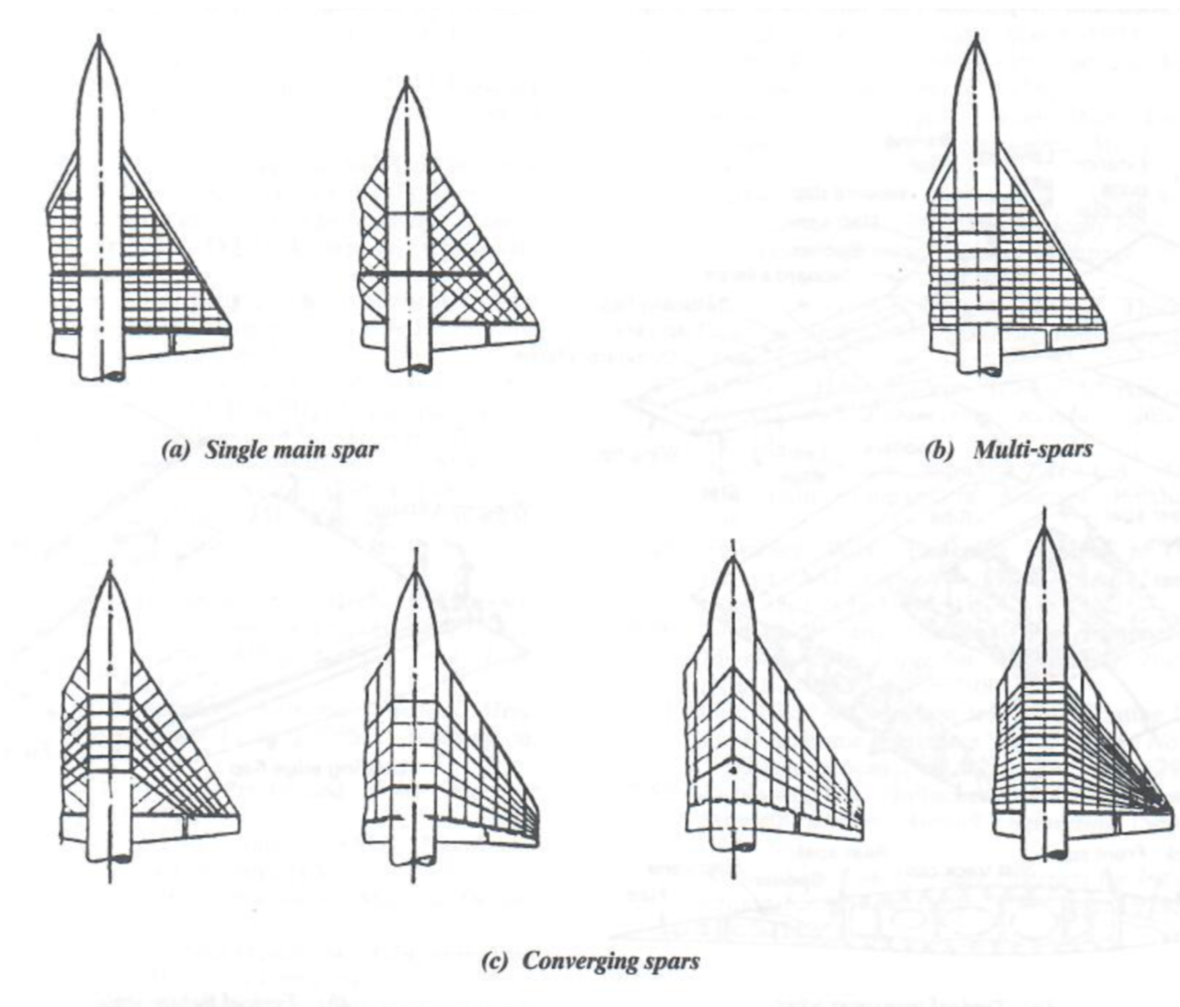

Fig. 8.1.3 Several structural arrangements for delta wing box.

REF: Niu, Michael. Airframe Structural Design

Spars

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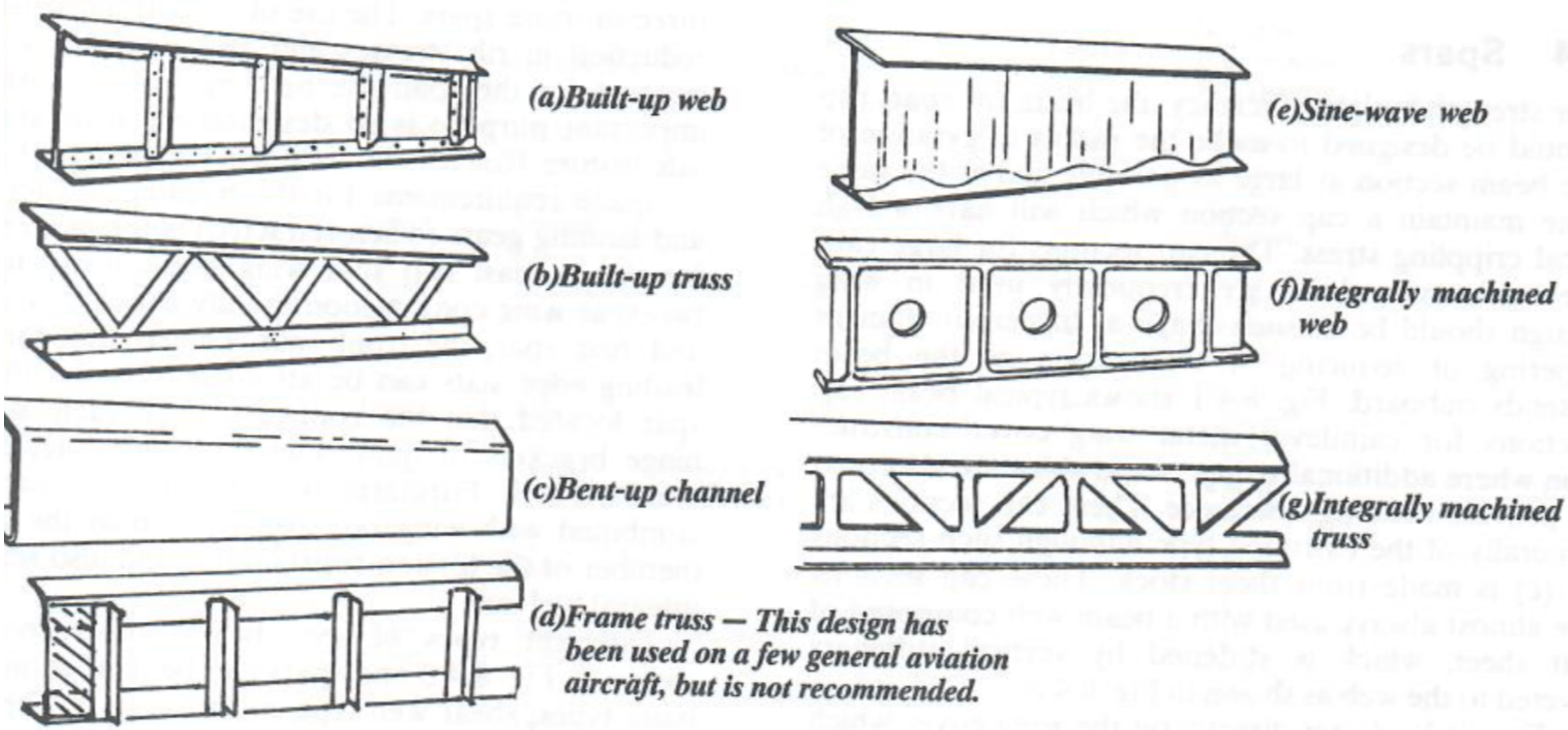

Fig. 8.4.3 Typical spar configurations.

REF: Niu, Michael. Airframe Structural Design

Stringers

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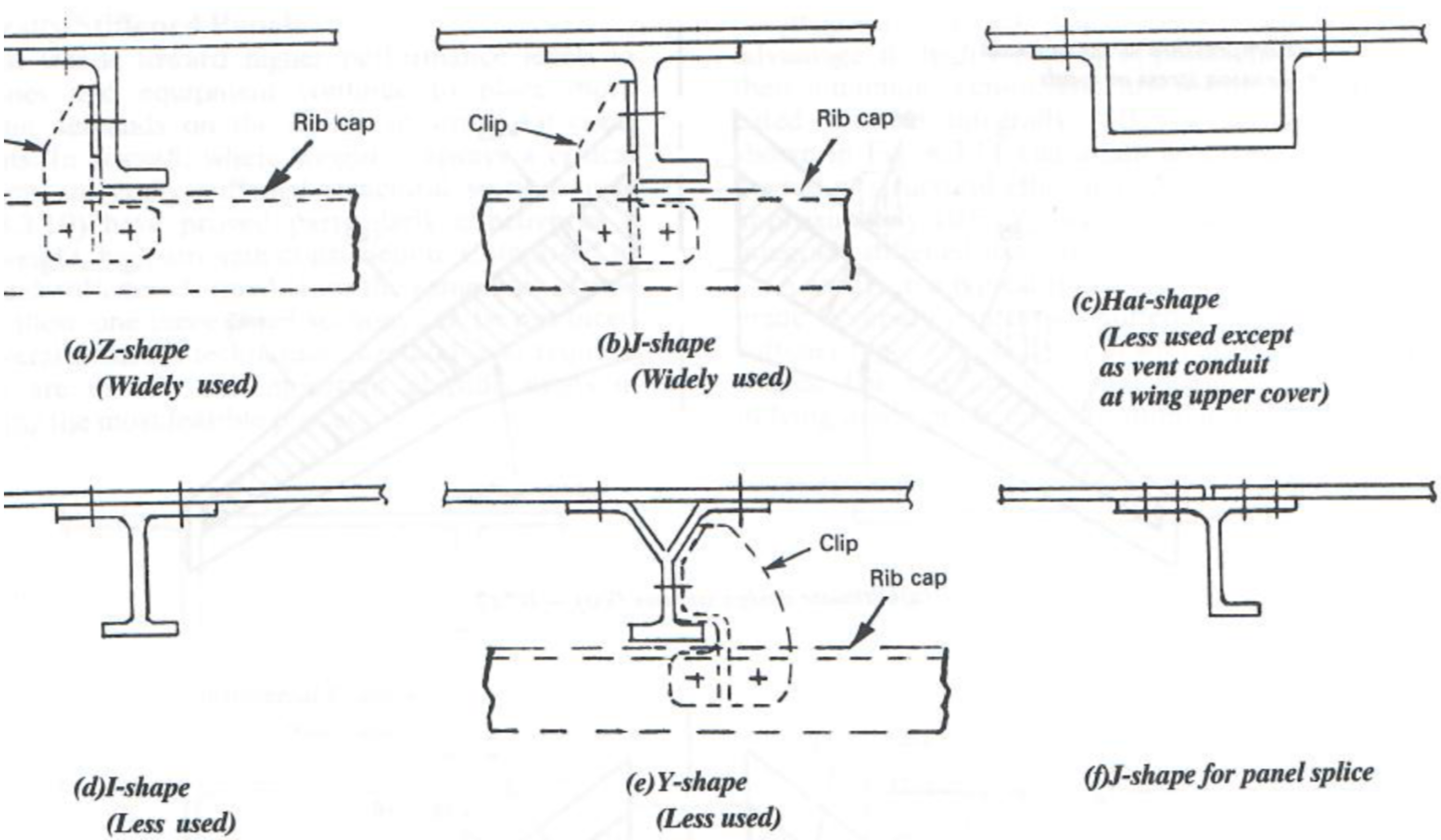

Fig. 8.3.7 Typical wing skin-stringer panels.

REF: Niu, Michael. Airframe Structural Design

Integral Stiffened Panels

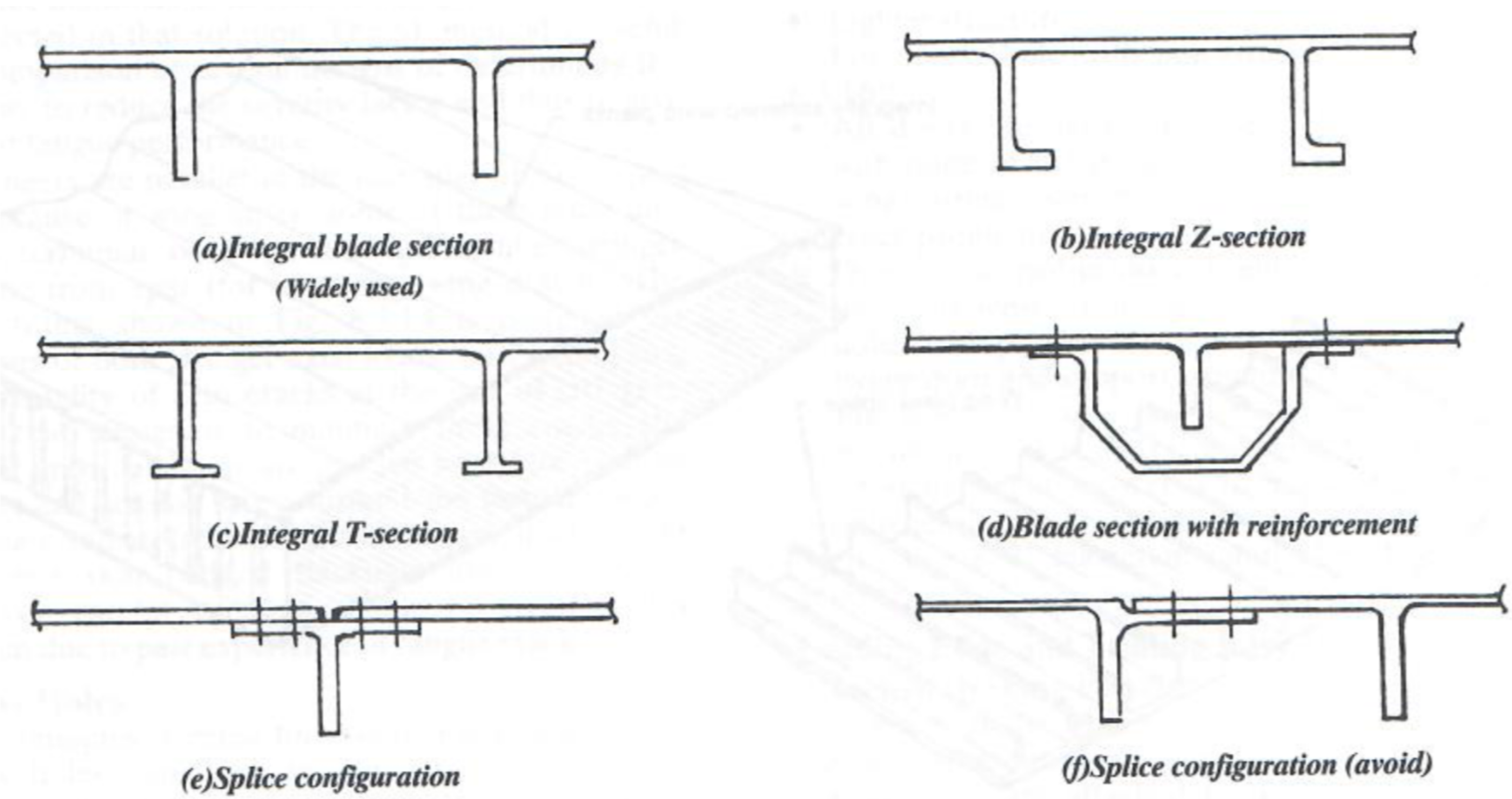

Fig. 8.3.10 Typical integral stiffened panels (planks).

REF: Niu, Michael. Airframe Structural Design

Integral Stiffened Panels

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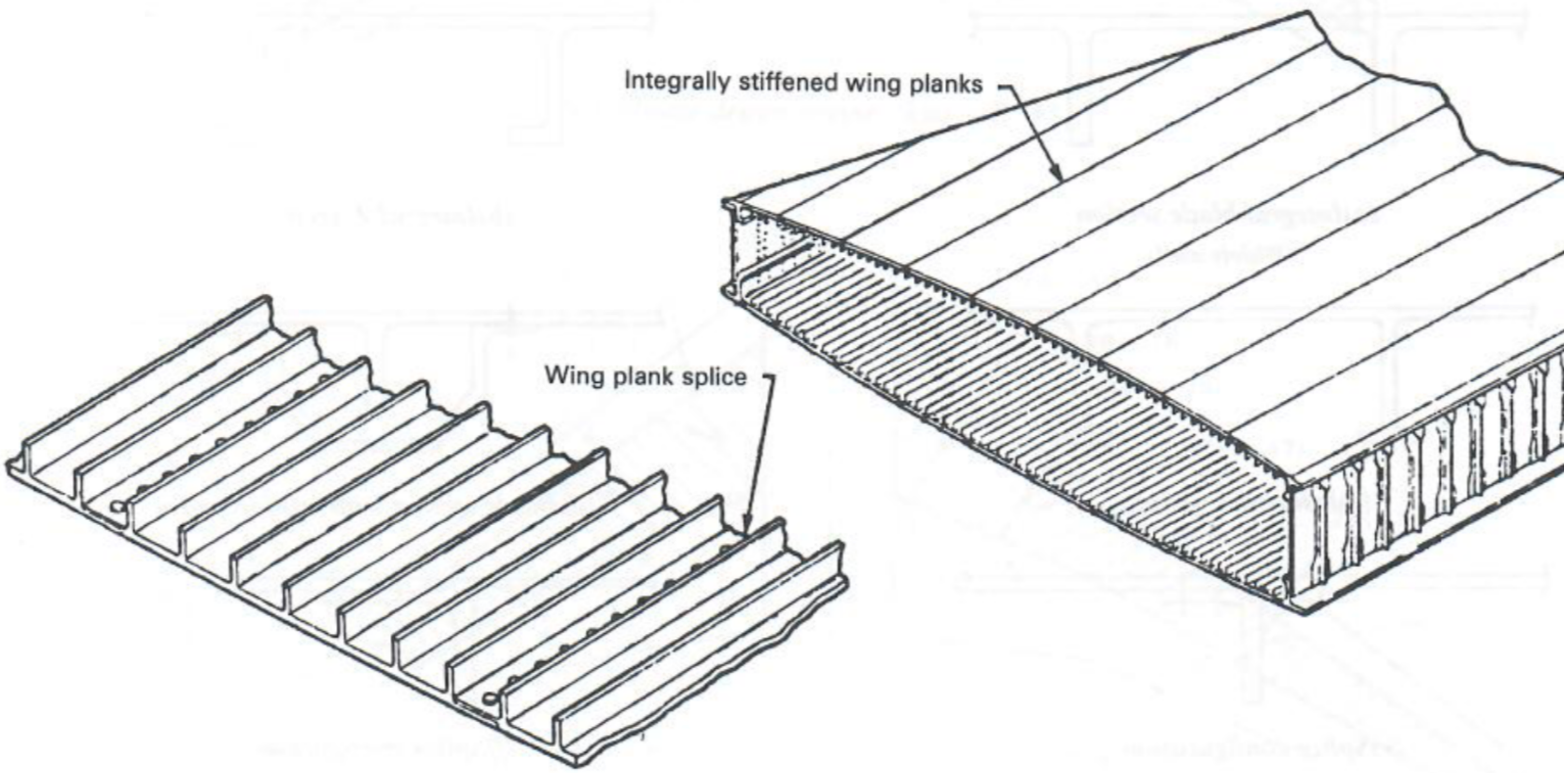

Fig. 8.3.11 Integrally stiffened panels — wing covers.

REF: Niu, Michael. Airframe Structural Design

How to react load to/from fuselage

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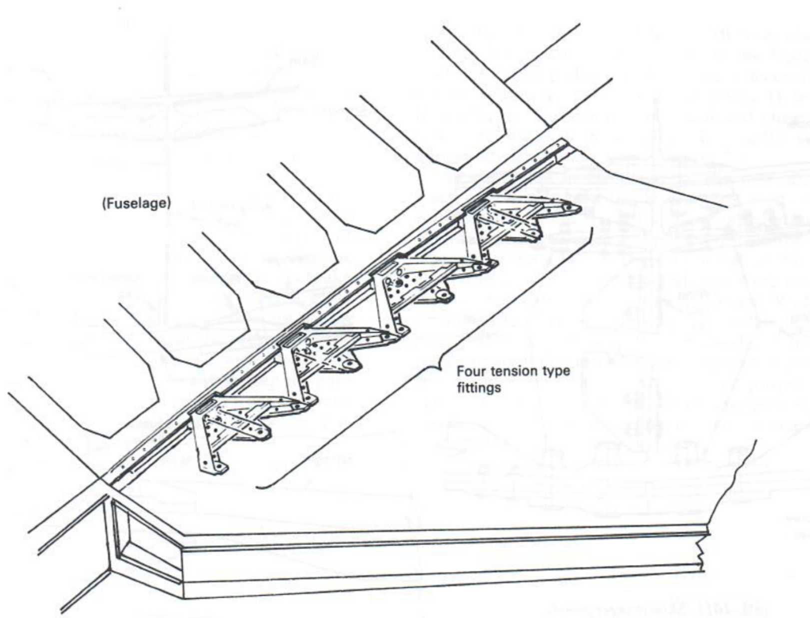
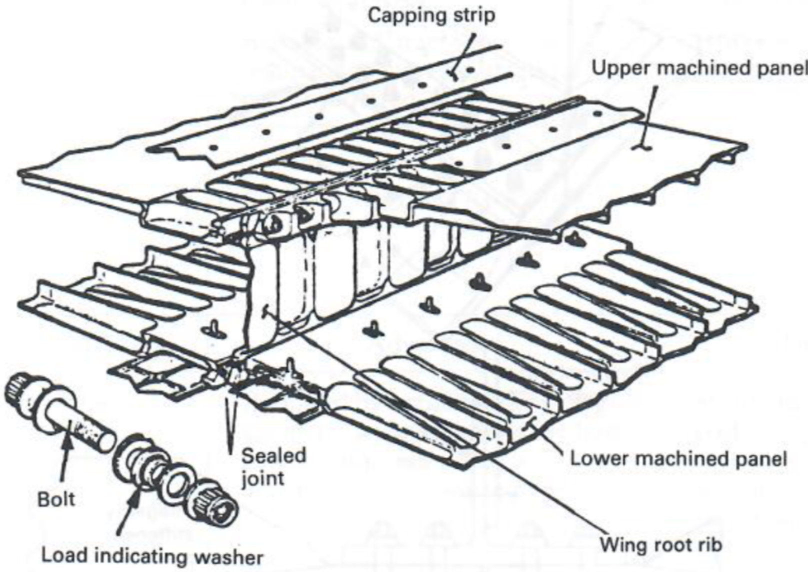


(a)F-16 fighter



(b)Concord supersonic transport

(Courtesy of Aerospatiale)

Fig. 8.6.4 Wing root joint — tension bolts.

Or carry load through entire fuselage

REF: Niu, Michael. Airframe Structural Design

Empennage Design

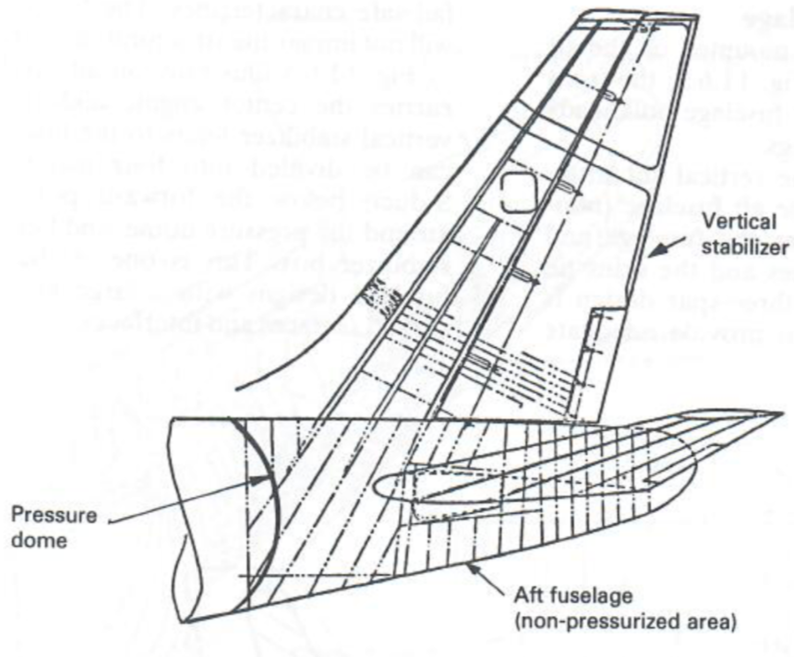


Fig. 11.6.4 Aft fuselage and vertical stabilizer intersection.

REF: Niu, Michael. Airframe Structural Design

Empennage Design

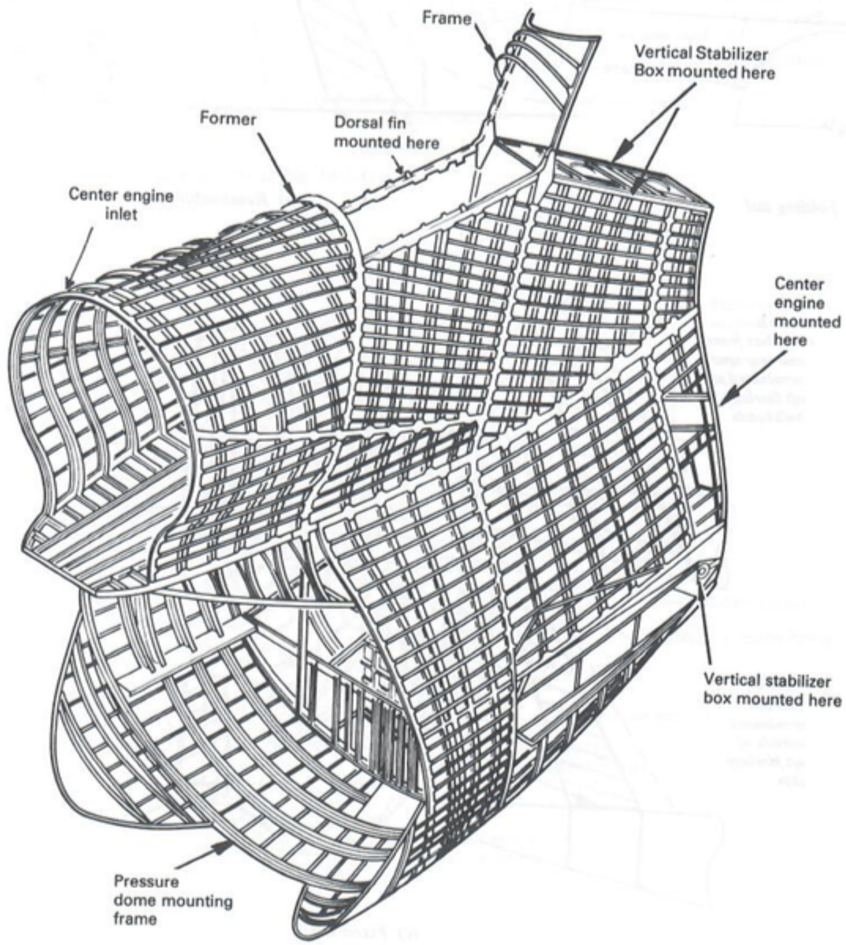


Fig. 11.6.5 Aft fuselage (aft body) structure — L-1011.
(Courtesy of Lockheed Aeronautical Systems Co.)

REF: Niu, Michael. Airframe Structural Design

Assignment

- Reading
  - Nicolai - CH 19
    Roskam – III (yellow), sections 3.5, 4.2, 4.3, 5.2 with structural layouts
- Loft complete
- Sketch structural layout on loft
- Bring to me for review
  - Due – Thursday, 2/22

Expectations for CAD modeling

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- Layout only, no sizing or detailed design required
- Spars/Ribs/Frames/Bulkheads placed
- Load path defined between major components
  - Fuselage-Wing
  - Landing Gear to Wing/Fuselage
  - Payload to Wing/Fuselage
  - Engine to Wing/Fuselage

Solids Works – How to layout frame structure-Surfaces

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This is the basics on how every rib, frame, longeron, skin, is created using the loft as the construction surface

- Complete surface loft OML
- Create new STARPART – name it something like this:
  - FRAME150 to identify it is a frame at FS150
- Copy Surface(s) from the loft into the new FRAME150
  - Only copy one side of BL0, as all features will be mirrored later
  - Knit/Merge surfaces, if required
  - Create two FS planes, one for the forward extents of the frame and one for the aft, i.e. FS150 and FS156
  - Trim OML to the two planes
  - Offset the surface to account for skin thickness (creating the IML)
- Sketch and then create a flat surface on FS150,
- Trim the surfaces to obtain the overall shape of the frame, knit as required
- Thicken the frame surface to desired thickness.

Hint: Once you do one, do a "save as," and modify the plane locations to create the rest.

Solids Works – How to layout frame structure-Solids

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- Complete surface loft OML
- Create new STARPART – name it something like this:
  - FRAME150 to identify it is a frame at FS150
- Copy Surface(s) from the loft into the new FRAME150
  - Only copy one side of BL0, as all features will be mirrored later
  - Knit/Merge surfaces, if required
  - Create two FS planes, one for the forward extents of the frame and one for the aft, i.e. FS150 and FS156
  - Create solid plate, larger than the OML using FS150 and extrude to FS156 (6" thick flange)
  - Offset the OML surface to account for skin thickness (creating the IML)
  - Trim Solid with IML
- Shell the frame to obtain basic shape

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