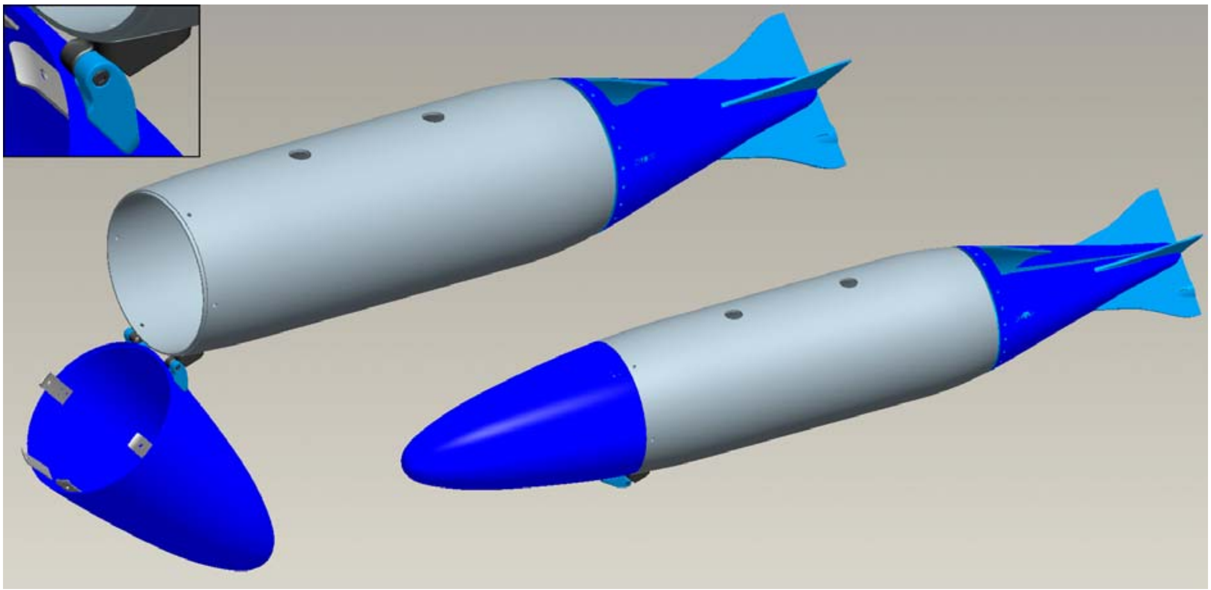
Design Summary: Pod Hinges

Background

A small Australian company call ‘Airspeed’ has previously developed a series of ‘Pods’ which are designed to mount to external hardpoints, located under the wings and fuselage of fast military jets such as the F/A-18 and BAE Hawk. These pods for stowage of electronics, camera equipment and cargo, with different versions of the pod available for different payloads.

The original version of the pods had a nose-cone which fully separated from the body for loading and unloading. However, through dialogue with the end-users of the pods, Airspeed has determined that loading and unloading certain pod variants would be easier if the nose-cone were hinged, and so remained attached to the body during loading. This report describes the set of hinges which were developed to facilitate this improvement to the original product.



Summary of Design Requirements

- The hinges should fit directly onto the original nose-cone / body attachments, thus requiring minimal work to fit them to the existing pods
- The hinges should meet all the environmental criteria (corrosion, mould growth, exposure to hot/wet conditions, etc) imposed upon the original pod
- The hinges should be sufficiently strong to meet the worst case loads found for carriage on the F/A-18 and BAE Hawk aircraft (see the following section for details)

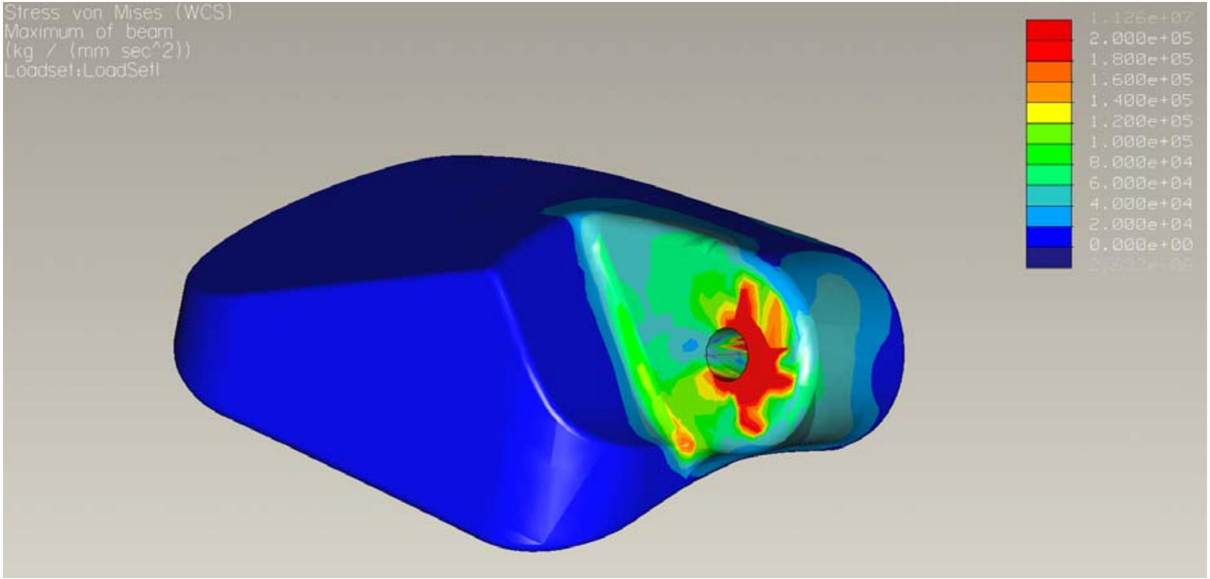
Loading

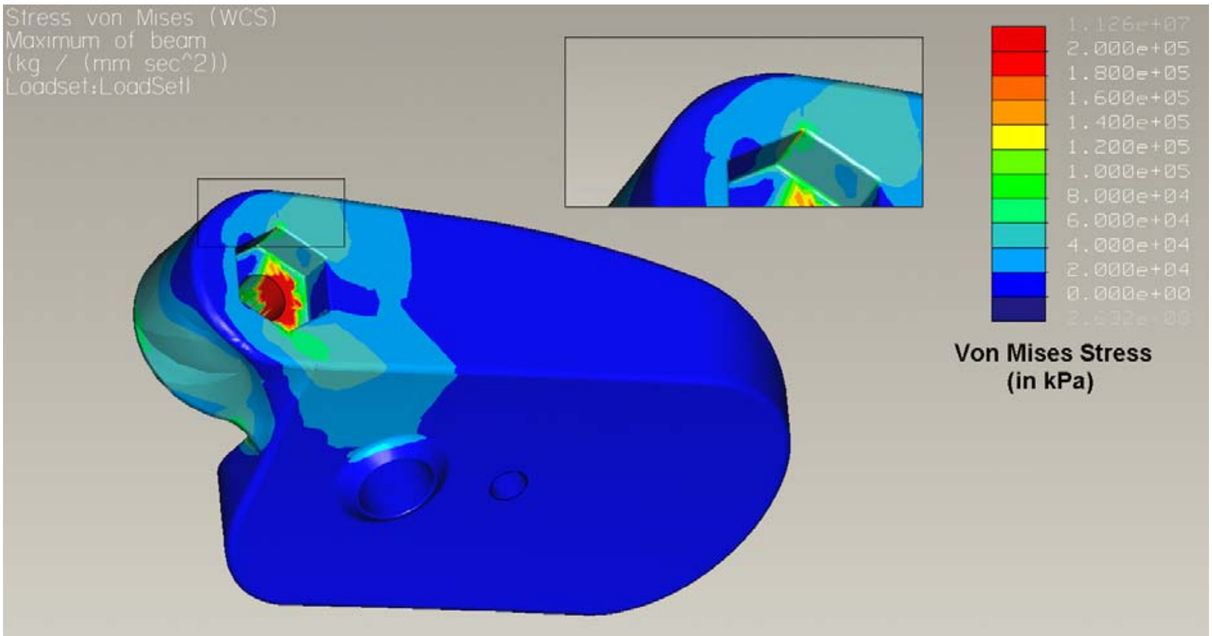
A review of the ‘Loads Definition Reports’ and ‘Stress Analysis Reports’ for the pods as installed on the BAE Hawk and F/A-18 found that the highest ultimate load acting on a hinge-point (which simply replaces the original bolted attachment, and so will have the same load acting upon it) was 1084 lbf (Document SSCP-SAR-001, Table 30, Load Case 5). It was conservatively assumed that this load acted perpendicular to the axis of the hinge’s pivot-screw.

Design Load: 1084 lbf = 4824 N (ultimate), perpendicular to the pivot axis

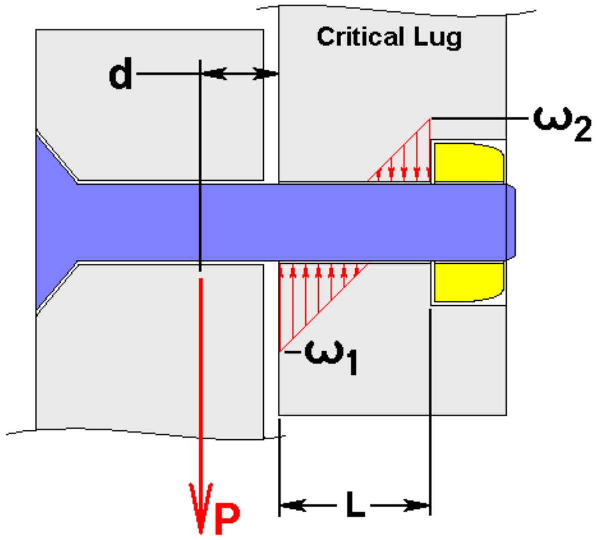
Stress Results:

Von Mises Stresses for the hinge design were analysed using ‘pro/mechanica’ (the finite element analysis tool for pro/Engineer), with the loading described above. The results are displayed graphically for the worst of the two hinges, in the figures below:





These results show that the only area of concern is the stress where the bolt bears on the edge of the hole. Stress in all other areas on the lug are below 200MPa (29ksi), which is well below the material allowable of 42 ksi (see MIL-HDBK-5H for Al6061-T6, ‘A’ basis). It was thought that the FE calculated bearing stress was greatly exaggerated due to simplistic method used for attaching the bolt to the lug. So, a manual analysis of this area was undertaken, as shown below:



Where:

d = assumed load offset on non-critical lug
= conservatively estimated to be 5.0mm

L = 12.1mm

P = Applied load = 4824 N (Ultimate)

ω_1 = distributed bearing load at inside face

ω_2 = distributed bearing load at nut face

The solution was found numerically in a spreadsheet, and the spreadsheet successfully verified by hand. This solution was found to be:

$$\omega_1 = 2583.2 \text{ N/mm}$$
$$\omega_2 = 1785.8 \text{ N/mm}$$

So, the inside face is critical. The bearing stress associated with this distributed load can be easily found:

$$\begin{aligned}\sigma_{br} &= \omega_1 / \phi_{\text{BOLT}} \\ &= 2583.2 / 6.35 \\ &= 407 \text{ Mpa} \\ &= 59 \text{ ksi}\end{aligned}$$

According to MIL-Handbook-5H, the ultimate bearing stress of Al 6061-T6 (the lug material) for a hole edge offset : hole diameter ratio of 2.0*, calculated on the ‘A’ basis is:

$$\sigma_{br} = 88 \text{ ksi}$$

Therefore, our reserve factor for bearing under the critical case, with a 5mm load offset is:

RF = 88 / 59 = 1.5

* In this case, we have an edge offset of 12.0 and hole diameter of 6.35, so the ratio is 1.9, which very closely matches this data point for e/D = 2.0