NUMA Engineering Services Ltd: Analysis and Design capabilities for the space industry

NUMA is an engineering services company specialising in the provision of an integrated design & analysis expertise for a range of industries. We use advanced analysis techniques to optimise our customer designs, reduce physical testing and qualify the products in a shorter time frame.

NUMA is proficient in the use of finite element analysis and NASTRAN is the solver of choice used by the company with PATRAN used for pre- and post-processing. These programmes have been utilised in the past on the following projects for the European Space Agency(ESA):

- Payload Data Router (PLDR)
- Advanced Closed-Loop System (ACLS)
- Intermediate eXperimental Vehicle (IXV)

Aside from structural analysis capabilities we have also worked on thermal design projects for ESA in the past. This has allowed us to become proficient in the use of ESATAN and ThermXL as well as supporting software such as the Thermal Concept Design Tool. All of these thermal analysis programmes were developed and are used by ESA.

Case Study of NUMA's capabilities: Payload Data Router Project

NUMA was involved in the development of the Payload Data Router (PLDR). The PLDR is a networked data acquisition system which is intended for use on the International Space Station. The system is being developed by the European Space Agency who chose Curtiss-Wright Control Avionics and Electronics as the prime contractor to develop the system.

NUMA was sub-sequentially selected as the sub-contractor responsible for the preliminary design of the PLDR's structural and thermal control subsystem (STCS). Over the course of several months the team assigned to the project at NUMA liased with our customers to develop the design of the STCS and analyse this design to ensure that it met the specified requirements.

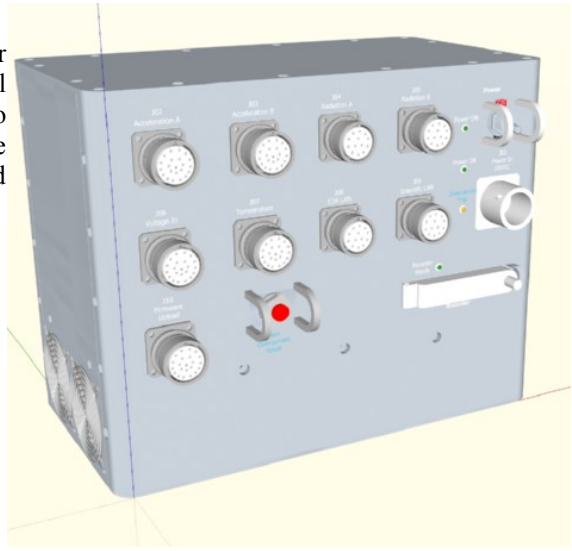

Illustration 1: Proposed preliminary design of Payload Data Router

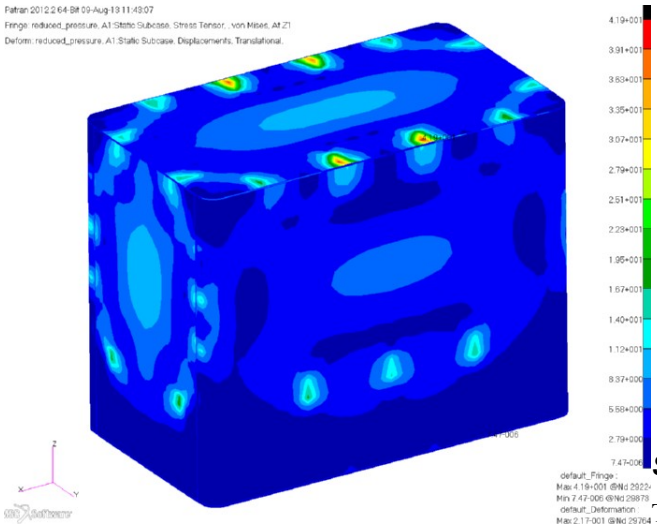

Illustration 2: Finite element model of PLDR showing stress distribution during depressurisation loading

Structural Design

The analysis of the PLDR structure was carried out using a combination of numerical analysis techniques and hand calculations based on sound engineering fundamentals and industry-standard methods. First the loads which the unit would have to withstand were obtained from the various requirements pertaining to payloads launched for us on board the ISS. Based on these loads some basic hand calculations were conducted to estimate the thickness required of the various structural components and their resonant frequencies.

The results of these calculations were then used in developing a detailed NASTRAN finite element model of the design using PATRAN. This allowed for the distribution of stress in the structure due to the applied loads to be calculated much more accurately. But the refinement of the results didn't stop there. Instead the most critically loaded points of the structure, namely the fasteners and the panels in their vicinity, were analysed further to ensure that the minimum margin of safety (MoS) values were sufficiently high. The fastener analysis was performed using data obtained from the finite element model which was fed into a tool developed in-house based on the theory and methods outlined in the ECSS standard on threaded fasteners.

Thermal Design

NUMA also conducted the preliminary level design of the thermal control sub-system. This system had to meet the very stringent requirements for payloads operating in the International Space Station. The chief requirement to meet was ensuring that the surface of the PLDR did not exceed a specified “touch temperature” as this would present a safety risk to astronauts aboard the ISS.

The analysis was conducted using ThermXL, a spreadsheet tool which is based on the capabilities of ESATAN. The various instruments housed in the PLDR and its casing were discretised into a number of nodes. The heat generated by the instruments inside the PLDR were used as inputs to the thermal model and the resulting temperature profile was the output of the analysis. Again ECSS standards were employed to quantify the thermal contact resistances between the unit's components which vastly improved the accuracy of the final temperature distribution. The design was also made to be fail-safe by using two fans to cool the unit but ensuring that one was still able to maintain the casing at a safe temperature.

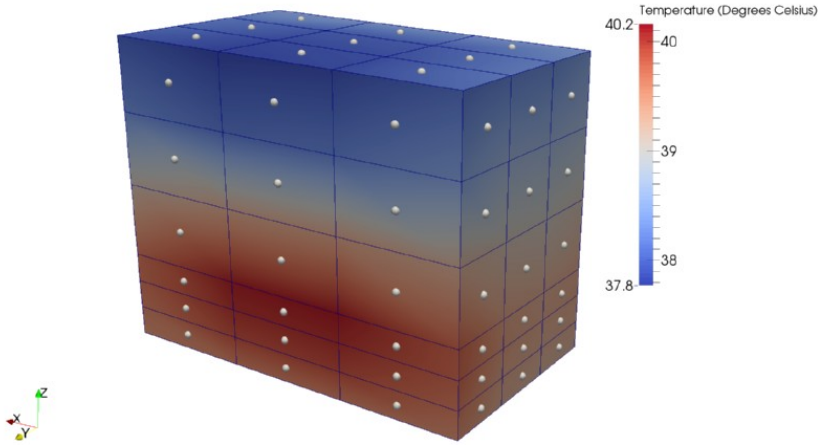

Illustration 3: Worst-case temperature profile of PLDR

Result of PLDR project

By using these numerical methods and the ECSS apporaches to gradually increase the accuracy of the predictions of both the structural and thermal analyses, NUMA and its customer could be confident that the proposed design would be capable of meeting the specified requirements. The end result was that the design was successful in passing the European Space Agency's preliminary design review.