CUSTOMERS:
Martinez & Turek
Orbital Sciences Corporation

INDUSTRY:
Aerospace

PROJECT NAME:
Transporter/Erector/Launcher (TEL)

OVERVIEW

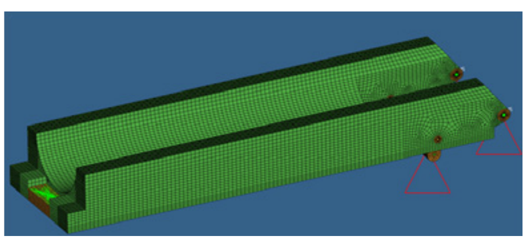
Antares is a two-stage vehicle that provides low Earth orbit (LEO) launch capability for payloads weighing over 5,000 kg. ATA Engineering and its engineering and manufacturing partner Martinez & Turek were selected to design, engineer, manufacture, install, and test the highly optimized Transporter/Erector/Launcher (TEL) system for the Antares. The TEL provides multiple critical operational functions. First, it serves as an assembly and integration platform for the Antares rocket. Once the rocket is assembled, the TEL is placed on heavy load transporters, allowing the TEL to serve as the transport vehicle to the launch site. Finally, upon arrival at the launch site, the TEL becomes the platform used to erect the Antares rocket, place it on the launch mount, secure it in position until fueled, and finally disconnect and pull away when it is launched. ATA provided design and analysis support for the entire system. The process used to optimize the design of the structural backbone of the TEL, known as the strongback, is highlighted here as an example of ATA's analysis-driven design methodology.

STRONGBACK DESIGN/ANALYSIS

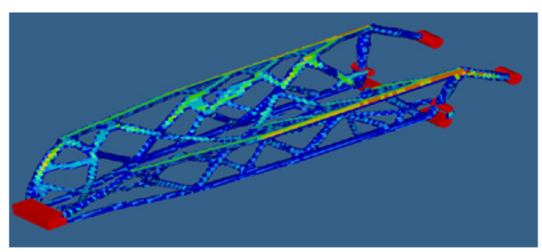
Topological optimization was used to rapidly explore structural concepts for the design space of the TEL strongback. Figures 1 and 2 show the initial design space envelope and the resulting highest-efficiency distribution of material for minimization of mass and maximization of stiffness in the most severe strongback load case. It was found that the stiffest, lightest structure can be achieved by using the full chordal height of the design space along the structure's entire length, resulting in a truss system similar to that shown, and reducing material thickness away from the ground support region of the structure.

A trade study was then performed to assess the relative merits of different classic truss designs (Fig. 3). A Parker-type truss was selected and an ANSYS parametric design study was performed that considered global geometric design variables as well as design details such as plate thicknesses and web and flange widths/tapering (Fig. 4). Multiple configurations of the system were simulated under various load conditions, resulting in a highly optimized structure that satisfied all stress and stiffness constraints while being lightweight and manufacturable. The final optimized strongback design is shown in Figure 5, and the as-built system with payload is shown in Figure 6.

The analysis-driven optimization process described here resulted in significant weight savings compared to the baseline structure developed using traditional design techniques, and this weight reduction resulted in a substantial decrease in material cost for the strongback and its associated lifting equipment. A video showing the TEL in operation is available at http://www.youtube.com/watch?v=tBdV0FroZxl.



▲ Figure 1: Meshed design space for TEL strongback in preparation for topological optimization.



▲ Figure 2: Optimization results showing regions of critical structure for primary load case.

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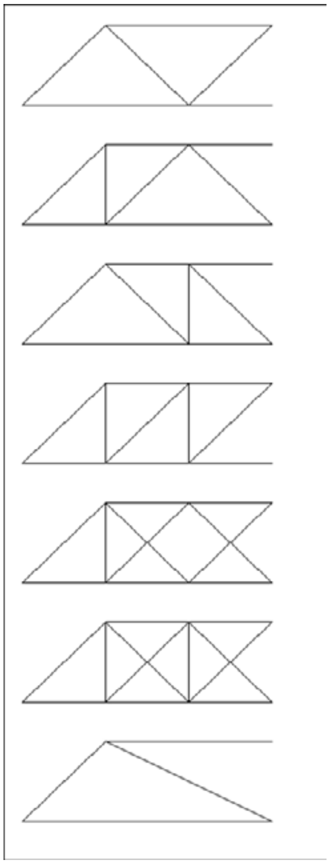

Figure 3: Truss systems considered for strongback design.

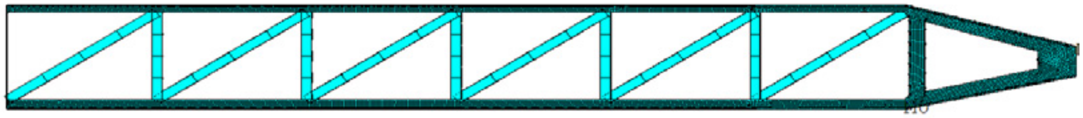

Figure 4: Parameterization of truss system in ANSYS for rapid minimization of weight subject to stiffness and stress constraints.

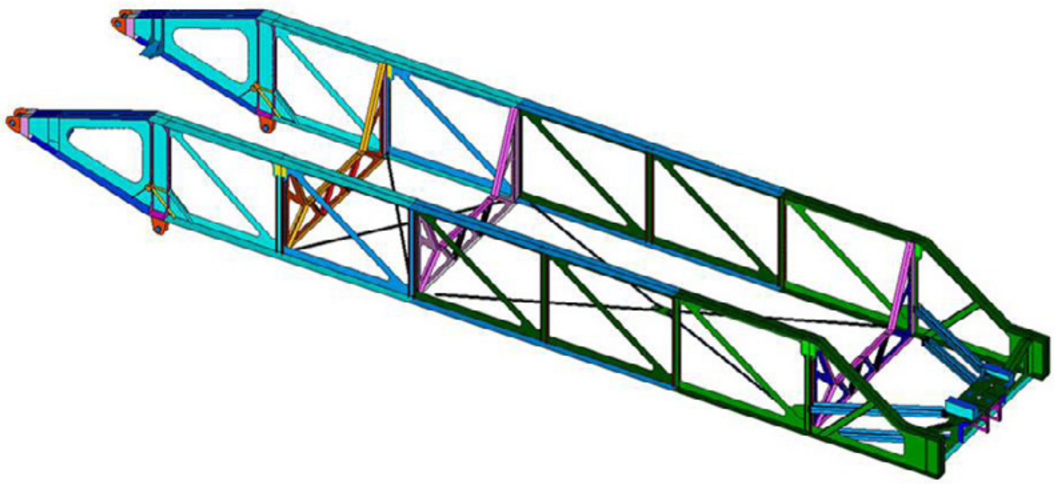

Figure 5: Computer representation of strongback final design.

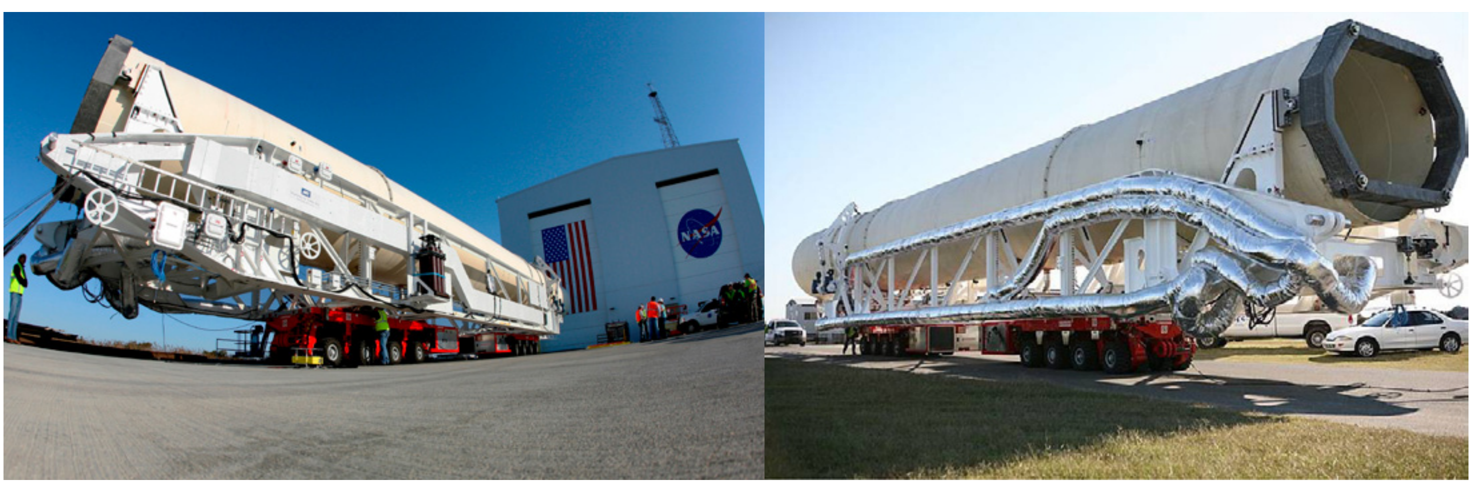

Figure 6: Completed TEL transporting a payload from integration facility to launch pad.