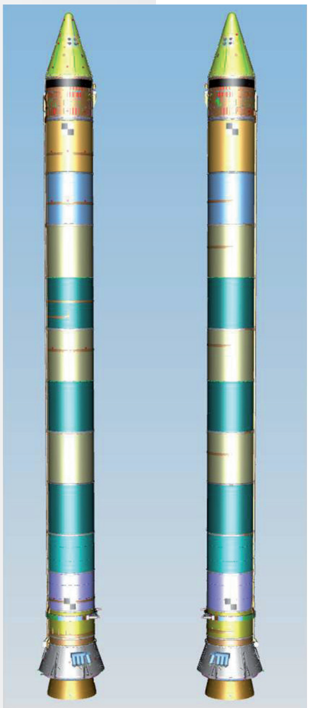
SUCCESS STORY



Zuken's software solution for electrical wiring, control systems and fluid engineering.

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Nathan Holyoak,
Engineer PLM Processes
ATK

ATK increases cable design productivity for space shuttle booster replacement by moving to a digital design process

ATK was tasked by NASA with designing the wiring harnesses for the booster rockets powering the replacement for the Space Shuttle while employing a team that is significantly smaller than that used on the now-cancelled Ares I project. ATK accomplished its mission by using E³.series to substantially increase productivity, while eliminating the need for a physical mock-up and costly test lab.

Powering the next generation of human space flight

ATK is the prime contractor for a new solid rocket booster that will be used on NASA's Space Launch System (SLS), which is intended to replace the retired Space Shuttle. The SLS is designed to take astronauts further into space than ever before and provide the cornerstone for future human space exploration efforts. NASA plans to launch the first unmanned test flight from Kennedy Space Center in 2017 and a crewed flight is scheduled for 2021. The solid rocket boosters being developed by ATK will be mounted on either side of the core stage, fire for the first two minutes of flight, and provide approximately 80% of the initial thrust needed to leave earth's orbit. After a two-minute burn, the disposable boosters will fall into the Atlantic Ocean.

ATK recently performed three successful static fire tests of the five-segment booster motor that was repurposed from the Ares I for the SLS which is shown in Figure 1. The recent demonstration motor #3 (DM-3) test was the most heavily instrumented solid rocket motor test in NASA history, with 37 test objectives measured using more than 970 instruments. The successful DM-3 tests marked the completion of the booster's Preliminary Design Review (PDR) phase, well within the planned schedule path for the 2017 launch. With the successful completion of PDR, ATK's SLS booster is now advancing towards the Critical Design Review (CDR), which will come after the next series of static tests.

Classic approach

Launch vehicles powered by rocket motors accelerate rapidly and their guidance systems are extremely complex. Imagine maintaining control of your car with the cruise control set to 17,000 mph. *"We used the classic approach in designing the wiring harness for the Ares I booster,"* said Nathan

Ares I with solid rocket boosters developed by ATK (fig. 1)

Results

- Feasibility testing timescale reduced from months to weeks
- Design team size cut significantly by using automated interface and smarter working
- Automatic design checks achieved time savings and improved quality
- ECAD and MCAD systems integrated using Siemens Teamcenter

ATK Aerospace Group is the world's top producer of solid rocket propulsion systems and a leading supplier of military and commercial aircraft structures. It also specializes in small and micro-satellites; satellite components and subsystems; lightweight space deployables and solar arrays; low-cost, quick-to-market launch solutions; flares and decoys; and energetic materials and related technologies. The group has extensive experience supporting human and space payload missions.

E³.series is Zuken's software solution for electrical wiring, control systems and fluid engineering.

E^3.series from Zuken is a Windows-based, scalable, easy-to-learn system for the design of wiring and control systems, hydraulics and pneumatics. The out-of-the-box solution includes schematic (for circuit and fluid diagrams), cable (for advanced electrical and fluid design), panel (for cabinet and panel layout), and formboard (for 1:1 wiring harness manufacturing drawings). Integrated with MCAD, E^3.series is a complete design engineering solution from concept through physical realization and manufacturing output.

Prototype used for the Ares I Booster: cable runs were simulated using ropes (fig. 2)

Holyoak, Engineer PLM Processes for ATK. The Ares I is shown in Figure 1. Technicians built a full-size mock-up of the Ares first stage integration components and ran rope through it to simulate cable runs as shown in Figure 2. Wooden boxes were used to simulate electronic components. Different diameters of rope helped determine how many wires would fit in a given area. The cable information was then captured in a massive spreadsheet that was used to store information on each cable and perform a variety of calculations such as voltage drop. Electrical schematics were created using Microsoft Visio and mechanical computer aided design (MCAD) drawings were created using the Siemens NX CAD system with a sweep along a spline with a fixed diameter (often referred to as space reservation). ATK also built a testing lab using engineering workstations to perform a wide range of simulations and analyses on the wiring harnesses. After the review, the prototypes were developed.

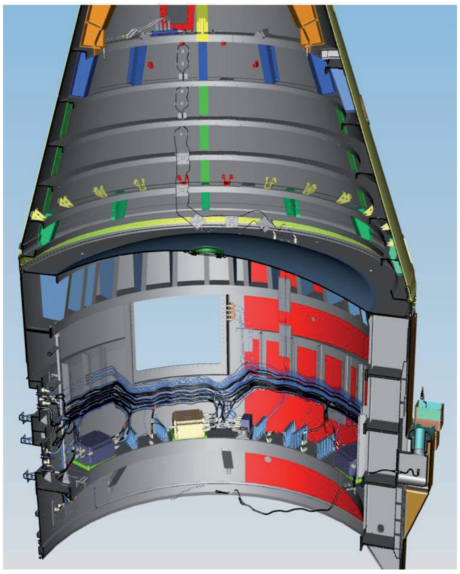
"It took several full-time engineers to maintain the mock-up and the spreadsheet was so large and complex that managing it was very resource-intensive," Holyoak said. *"It was difficult to ensure that the spreadsheet entries were correct and up to date, so additional time was spent measuring and performing calculations over and over again. Our MCAD drawings showed nice pictures of harnesses but told us nothing about their functionality. Generating schematics and drawings with Viso was a long, drawn-out manual process and changes were time-consuming. In addition to the less effective prototype method, the lack of accurate electronic formboard documentation meant the cost of producing the wire harnesses was excessive. Additionally, the prototype's physical location was not central relative to all the design teams, which added extra travel requirements."*

Nathan Holyoak,
Engineer PLM Processes for ATK.

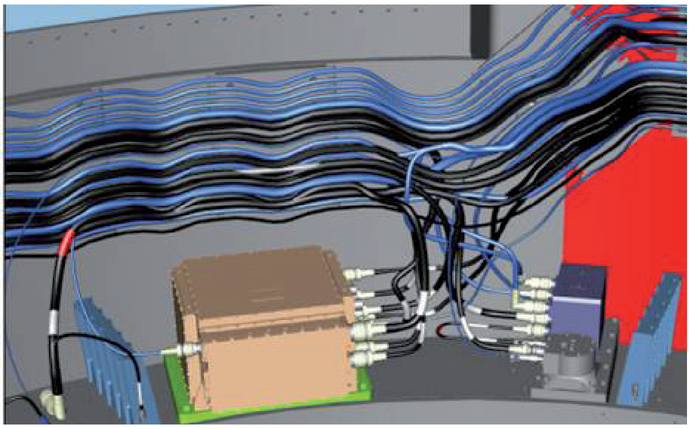
NASA changes programs

ATK and NASA wanted to leverage work and experience from the Ares I for the SLS, yet the SLS design was different enough from Ares that the wire harnesses needed to be essentially designed from scratch. Under the terms of the SLS booster contract, ATK was tasked with testing and delivering the new boosters with a team that was significantly smaller in size than the one that developed the harnesses for the Ares I.

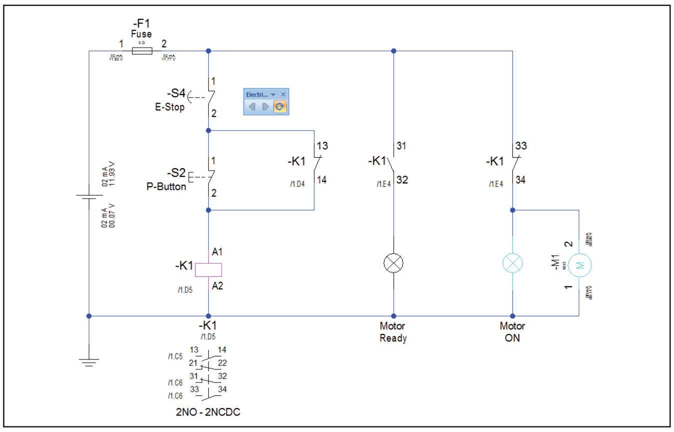
"When NASA came to us and said they wanted to change direction, it was an eye-opener to discover that we had made a significant investment that suddenly had little to no value," Holyoak said. *"Despite the fact that the SLS boosters were based on the Ares design, the differences were large enough that they would have required starting from scratch by constructing a new prototype, new spreadsheet, and new drawings. Very little from the previous project was reusable. We were also conscious that our previous methods were very labor-intensive, so when we discovered that our next project would be equal in magnitude yet would have to be done with less manpower, we realized we needed to improve our process – and do it quickly."*



Through the integration of MCAD and ECAD environments wire length information can be directly transferred (fig. 3) without relying on a physical prototype.



A typical MCAD drawing in Siemens NX (fig. 4)



The data generated in E³.series projects provides intelligence to enable automation of many downstream activities. (fig. 5)

Developing a digital approach

"We decided to develop a digital approach that was less labor-intensive and would enable us to more easily adapt to change," Holyoak said. "We wrote a set of requirements for an electrical CAD (ECAD) system that would be both logical and functional. It had to communicate with our MCAD system so we could quickly determine whether a cable would fit or not and how long it needed to be without mocking it up in a lab. We also insisted that the ECAD system be integrated with the MCAD system and that the results be controlled so that only authorized users could make changes and the change history would be recorded. We selected E³.series because it met all our requirements."

ATK worked with experts from Zuken and Siemens PLM to get the two software packages working together using Zuken E³.3D Routing Bridge, which communicates using PLXML. NX librarians and checkers created over 3,000 new or modified piece parts to ensure the libraries were synchronized. Outputs from Zuken's E³.series and Siemens' NX are released and controlled through Siemens Teamcenter, which also handles released engineering data.

Each placement of a component in the E³.series project provided intelligence that automated many of the downstream activities that in the past had to be performed manually. E³.series ensured consistency of the entire project by keeping track of the logical design and ensuring that the physical design was consistent. The software checked the consistency of connectors, ensuring, for example, that connectors mated with each other and there were enough pins to handle each wire in an assembly. E³.series automatically tracked the components used in the project. Siemens NX calculated wire lengths and passed the information back to E³.series, which in turn calculated the voltage drop in the cables. Instead of manually producing drawings as required in the past, engineers were able to generate alternate views of the wire harnesses for formboard or cable documentation as required with very little effort.

Fewer people working smarter

"In the past we had a lot of people working hard," Holyoak said. "Today we have a much smaller number of people working smart, with an automated interface, and the results are impressive. The electrical engineers enter requirements and the software makes sure they have been met. If there is a problem, E³.series greatly reduces the checking time by enabling the engineer to simply click on a signal to trace its route through the design. With a virtual logical and physical model, the teams of engineers save time by not having to travel to get to the prototype lab. Instead they can just view the design on their computer screen. With the automatic checks performed by the software, people have a much higher level of confidence that everything is right, so we are saving a huge amount of time that was previously spent checking and double-checking. We talked to our suppliers and asked them how much they would charge us to produce the formboards themselves if we provided them with the electronic documentation. We have to include some extra information in the drawings, such as braid overlaps, but compared to the original cost, the savings were substantial."

The cables for the entire SLS program were developed in E³.series and Siemens NX without a physical model, so the prototype lab was closed. With verification automatically performed within E³.series, the test lab was no longer needed so it was repurposed into a verification lab. The SLS project, which is similar in magnitude to the Ares I project, was completed in roughly the same amount of time with significantly fewer resources.

"Now we are getting requests for different configurations of these boosters," Holyoak said. "In the past it might have taken us months to design the wire harnesses and agree to a POC (proof of concept). Now we can do a feasibility test in weeks by copying and making changes to the existing model. Going from months to weeks has not only made ATK more competitive, but has established us as a trusted partner of NASA. Besides these savings, we also have much more confidence that our designs are correct. Zuken has been an exceptional partner throughout this process and was there with us the entire way."