Modeling Languages Refine Vehicle Design

Originating Technology/NASA Contribution

When we watch a space shuttle launch on television, we have only the vaguest sense of the extraordinary amount of work required to make such a complex operation successful. Even with the most highly trained engineers in the world, designing a space vehicle requires many thousands of hours of labor—and that is just in the early concept phases. With new partnerships and developments in software, however, a design task that formerly took 1,000 hours may take fewer than 100 hours.

The Vehicle Analysis Branch (VAB) at Langley Research Center is responsible for a variety of important tasks in support of the Agency's space and planetary exploration missions, including performing preliminary design and analysis of space transportation system concepts. Recent industry collaboration with this advanced analysis branch resulted in a novel software platform that is assisting both NASA's missions and the aerospace industry in general.

Partnership

Cincinnati, Ohio's TechnoSoft Inc. is a leading provider of object-oriented modeling and simulation technology used for commercial and defense applications. The company designed its Adaptive Modeling Language (AML) software for the U.S. Air Force to assist the military with saving time and costs during new vehicle development. This software has since evolved through NASA involvement and is applicable to a wide variety of industries.

AML is an object-oriented, knowledge-based engineering modeling framework upon which other applications can be built. It enables multidisciplinary modeling and integration of the entire product and process development cycle.

TechnoSoft's president, Adel Chemaly, believes the AML product is unique for two reasons: "One aspect

Artist's concept of the air-breathing X-43A Hypersonic Experimental Vehicle, or "Hyper-X." NASA is using software by companies such as TechnoSoft Inc. to design these supersonic combustion ram-air compression jets (scramjets).

is doing modeling—capturing model requirements for different disciplines, like multianalysis design environments. The other aspect is computing—collaboration, distributed computing, object computing, and web-enabled capabilities."

Because the Air Force had such success with the AML framework, TechnoSoft knew that it would also be useful to others who had similar research initiatives, such as NASA. The Air Force helped pave the way for the firm to meet with NASA researchers at Langley: A researcher from the Air Force Research Laboratory was collaborating with Langley engineers on different projects to learn best practices in vehicle design. The researcher recommended using TechnoSoft's AML program.

According to John Martin at Langley's VAB, the team there had invested "quite a bit of time into developing code for collaborative applications, but it didn't perform that well."

"The AML software also came with extensive corporate knowledge, and that was a real plus for us," says Shelly Ferlemann, another VAB researcher. With the vote of confidence from VAB, TechnoSoft eventually received a **Small Business Innovation Research (SBIR)** contract from Langley to develop the software further.

TechnoSoft built the Collaborative Hypersonic Air-breathing Vehicle Design Environment (CoHAVE) on its AML framework. According to Chemaly, the partnership ended up benefiting everyone: TechnoSoft tapped into NASA expertise, and eventually, the company took a leadership role, customizing CoHAVE to help NASA engineers analyze scramjet/ramjet vehicles for two-stage-to-orbit and hypersonic cruise missions.

NASA aerospace partners became interested in the capabilities of the enhanced software. Because it provided a mechanism for different disciplines like structural analysis and optimization to work together, CoHAVE improved the product and process design, saving time and money. "If analysis can be performed at an earlier stage," Chemaly says, "it will help prevent a lot of problems. In the past, you had to choose one or two concepts to pursue and hope the gamble paid off." Now, designers who utilize TechnoSoft's AML framework can perform analysis at earlier stages, with higher or lower fidelity as needed. "NASA provided us the methodologies for automation at the various levels, enabling people to introduce higher fidelity earlier in the design process," says Chemaly.

TechnoSoft was ahead of schedule on the software's development, and by the time they were in an SBIR Phase II contract, the product was already being used in design processes. The success of CoHAVE led to a Phase III contract from Langley. "NASA's investing in TechnoSoft has helped prove that this technology is valid and that it reduces risk," Chemaly says. "Once we proved it within certain programs in NASA, we were able to leverage these successes with the Air Force and commercial sectors."

NASA found that CoHAVE is applicable to the Reusable Space Transportation System's product area for evaluating the architectures of the Space Transportation Architecture Study and second-generation reusable launch vehicle studies. Recently, CoHAVE has been extended to incorporate models for other applications such as reentry vehicles. Since the environment now includes vehicles other than traditional hypersonic air-breathing vehicles, the name has morphed into the Integrated Design and Engineering Analysis Environment, or IDEA.

Product Outcome

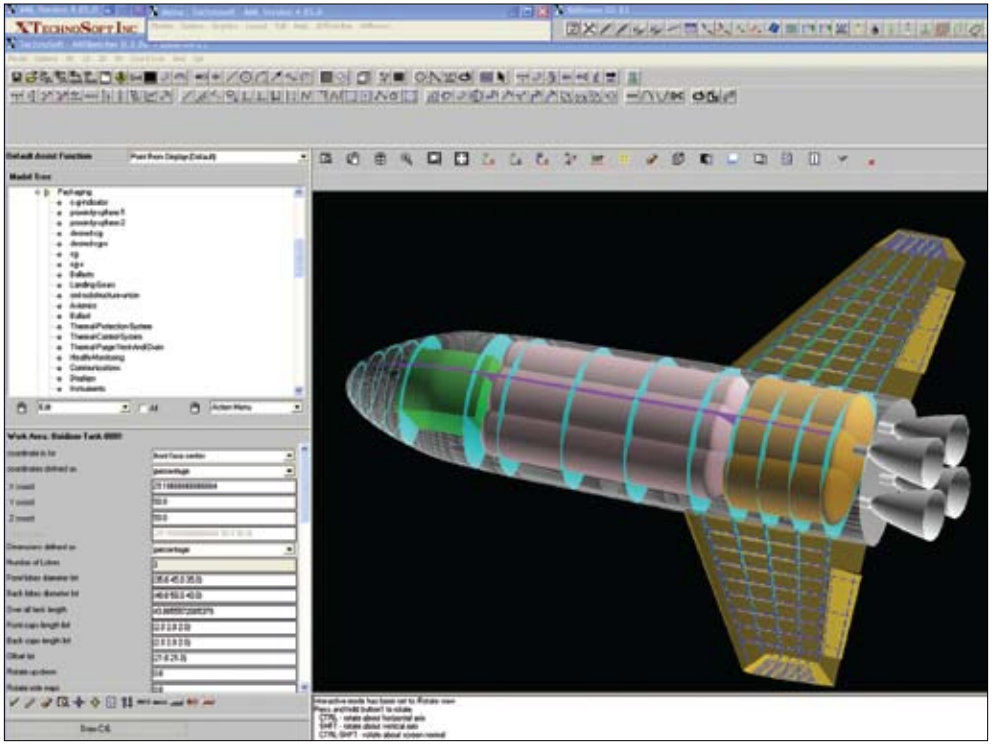
Engineers can use IDEA and the enhanced AML platform early in the design process to analyze a variety of customized models for different designs including fluid dynamics, aerodynamics, structural design, and plenary models. AML offers an advanced modeling paradigm with an open architecture, enabling the automation of an entire product development cycle, integrating product configuration, design, analysis, visualization, production planning, inspection, and cost estimation.

AML enables generative modeling, which leaps beyond present approaches to integrated design and analysis processes. In a generative modeling environment, knowledge of the engineer's tools and the intricacies associated with executing them is captured within a modeling language. This empowers the engineer to search a broader set of product design configurations, rather than being limited to simple parameter changes. "These can be built to switch back and forth and allow a lot of iterations early on, making the process affordable and fast," Chemaly explains.

The software also greatly improves efficiency, says Chemaly. "We have reduced the design time by at least 50 percent, and some of our customers are quoting 90 percent improvement or better." Since "physics is physics," he says, the TechnoSoft AML can easily be adapted to different vehicle designs, whether the vehicles are traveling in space, the sea, or on Earth.

Current advancements in AML also allow engineers to incorporate changes in cost in a product's life cycle. This could once again benefit NASA engineers and commercial designers, enabling ongoing cost analysis for everything from surface ships and automobiles to the space shuttles. With AML, Chemaly says, "We can look at the cost of sustaining the design in the long-run," taking into account such factors as ongoing maintenance and repair costs. "If the technology evolves or if costs change, we need to be able to insert that into a design," he says.

The Adaptive Modeling Language platform can reduce 10,000 work hours to 1,000.



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The program encourages integration with third-party applications through a number of standard methodologies, including shared memory, pipes, TCP/IP sockets, file transfer, and foreign functions. Built-in XML export capability enables a state model of the AML object hierarchy and geometry to be exported automatically to an XML file, which is viewable using TechnoSoft's AML Viewer. The available "Net Conference" mode enables real-time collaboration among team members across local and global computer networks. A suite of graphical user interface (GUI) classes is provided to allow developers to create customized front-ends to their AML applications. In addition, a visual GUI-builder can be used, making it easier to layout forms and controls, and to assign their associated methods and properties.

TechnoSoft is now customizing AML for clients in green industries, which includes designers for power plant exhaust filtration systems and for wind turbines. TechnoSoft's focus on making the technology more affordable and deployable by the end of 2009, says Chemaly, has opened the doors to smaller commercial customers. With a platform that can reduce 10,000 work hours to 1,000, it is clear there will be ongoing demand for TechnoSoft's Adaptive Modeling Language. ❖

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