SIEMENS | SARATECH

AEROSPACE AND DEFENSE

Northrop Grumman

Automating the design space exploration process to reduce analysis time by 30 to 50 percent

Products

Simcenter, Teamcenter, NX

Business challenges

Contribute to long-term space projects

Streamline the work between design analysis, testing and manufacturing teams

Simulate and analyze non-terrestrial performance in extreme conditions

Keys to success

Commit to digital transformation using Siemens Xcelerator, including Simcenter advanced engineering tools

Manage complexity and vast amounts of data amongst partners and suppliers

Closely partner with Siemens to implement their shared digital transformation vision

Results

Automated the design space exploration process to reduce analysis time by 30 to 50 percent

Performed efficient parallel work and reused space vehicle system models

Used closed loop between analytical models and physical tests to achieve excellent simulation accuracy

Northrop Grumman uses Siemens Xcelerator to lead a digital transformation of advanced space engineering processes

Sustained lunar exploration

NASA's Habitation and Logistics Outpost (HALO) and its Lunar Gateway will be a staging point for sustained lunar surface exploration and a step toward long-term exploration of the Moon and destinations beyond.

HALO and the Lunar Gateway megaprojects involve NASA, Northrop Grumman, SpaceX and hundreds of other private companies in the space industry ecosystem as well as international organizations such as the European Space Agency (ESA), the Japan Aerospace Exploration Agency (JAXA) and the Canadian Space Agency.

The HALO design builds on Northrop Grumman's Cygnus spacecraft, a versatile vehicle that has been part of nearly 20 missions to deliver supplies, equipment and scientific experiments to the International Space Station.



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Dr. Tom Stoumbos
Simulation & Test leader
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A serious space problem solver

With the digital design and engineering of HALO, Northrop Grumman is taking its reputation as a space problem solver and mission/space system architect to the next level. Northrop Grumman counts on the Siemens Xcelerator business platform of software, hardware and services, including Simcenter™ software for spacecraft performance engineering, to accelerate development, manage complexity, share large amounts of data among partners and suppliers and improve project efficiency.

Dr. Tom Stoumbos, simulation and test leader, is one of the pioneers driving the digital transformation at Northrop Grumman. Stoumbos and his team of over 100 experts work on long-term projects ranging from low-earth orbit satellites to deep-space missions. This includes the Lunar Gateway and Artemis missions.

Advocating for digitalization

A long-time supporter of digital transformation, agile simulation, virtual testing and industry-academic partnerships, Stoumbos and his team realize that leveraging simulation and data analytics is key to succeeding in space exploration.

"Since my early days in the space industry I have been using simulation and testing tools to virtually explore the hardware design universe," says Stoumbos. "Siemens has done a tremendous job bringing all these tools together into what is now the Siemens Xcelerator business platform. It is priceless that we can work in the digital realm with proper design analyses, close connections to the hardware we design and properly analyze and control mission requirements."



Figure 1. Thaicom 8 commercial satellite.

> "Interconnecting and integrating Simcenter tools in the Siemens Xcelerator business platform has been groundbreaking for us."
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Figure 2. Orbiting Carbon Observatory-2 (OCO-2).

The digital realm is priceless

Stoumbos and his team work on space vehicle designs that have stringent requirements because they are exposed to adverse environments. This includes extreme thermal, mechanical, dynamic and vibroacoustic environments during handling, launch and separation as well as mission operations, analysis, design optimization and testing. Examining all this presents a variety of challenges for mission design and lunar exploration projects.

"Siemens has a similar vision to Northrop Grumman in terms of growing with the product," says Stoumbos. "Our team performs all kinds of simulation, including stress, dynamics, kinematics, shock utilizing and rigid and flexible bodies using the powerful and user-friendly Simcenter pre-post processors and solvers. All these analyses can be streamlined utilizing HEEDS. With the revolutionary search strategies available only in HEEDS, we can uncover new design concepts that improve our products and significantly reduce development costs. Interconnecting and integrating Simcenter tools in the Siemens Xcelerator business platform has been groundbreaking for us."

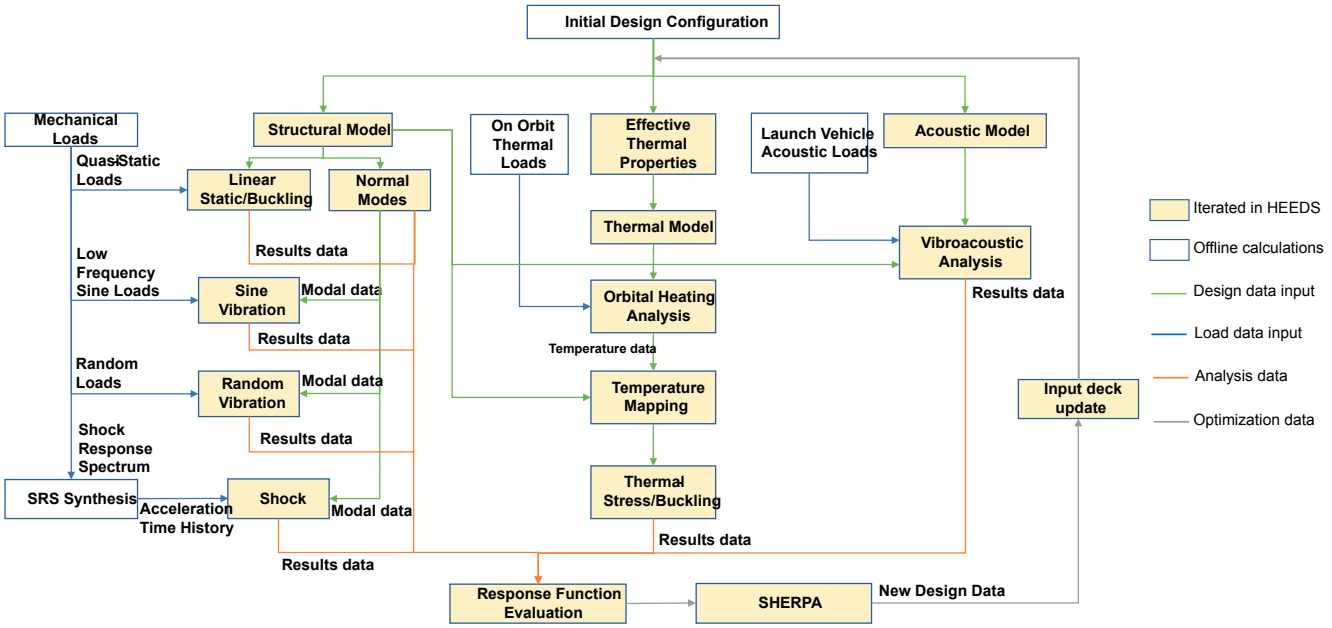


Figure 3. The team at Northrop Grumman uses HEEDS to link different types of analyses.

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The team also counts on Siemens Xcelerator solutions, like Teamcenter® Simulation software, to keep the digital thread running accurately throughout complex processes as well as other advanced engineering tools, including Simcenter Testlab™ software, Simcenter 3D, Simcenter Nastran, Simcenter Amesim™ software, the Simcenter Multimech™ platform and HEEDS™ software for design of experiments, which are all part of Siemens Xcelerator.

A common digital thread and optimal DoE network

The team uses common threads to run analyses with Simcenter, minimizing the time it takes to update space vehicle systems and subsystem models.

The team generates several terabytes of analytical and test data every week. They have worked closely with Siemens experts to tailor Teamcenter Simulation to suit their complex simulation processes, multiple requirements and system-level reporting.

"Together with Siemens, we have been integrating all these key tools, moving away from an analytical, kind-of-deterministic-and-serial process to an optimum design-of-experiments network," says Stoumbos. "Numerous analyses can be performed in parallel. Our analysts operate in an agile environment with a Scrum project management framework providing just enough structure and insight. This way our people and teams can see how they work together optimally and add the right analyses work to optimize the design.

"We can execute solvers in parallel and optimize our products with HEEDS. Using HEEDS design of experiments has been invaluable in improving the efficiency of our analytical process. It can easily save 30 to 50 percent of our analysis time. We can run hundreds of solutions through HEEDS in a week, which previously would have taken more than a couple of weeks."

Complex and competing design constraints

"All the products we build for space missions require extensive end-to-end testing to prove they're ready for the life of the mission," says Stoumbos. "With space operations and multi-million-dollar programs, there's no room to go back and fix something once launched. It is just not possible right now. It may become possible in the future. This is why we do extensive testing.

"It's important for our simulations to be directly related to the various system-level and subsystem-level testing. We use Simcenter Testlab to tie all this space vehicle test data together, from static to dynamics and shock back to our digital models, and then detailed model correlation. We create a loop, which feeds the analytical information into the test and from the test back to the analytical models, allowing us to perform detailed correlations on our way to the digital twin. These correlated models, a comprehensive digital twin of our flight hardware and space systems, allow us to be successful with our environmental predictions and enable mission data extrapolation with accurate results from other mission cases."

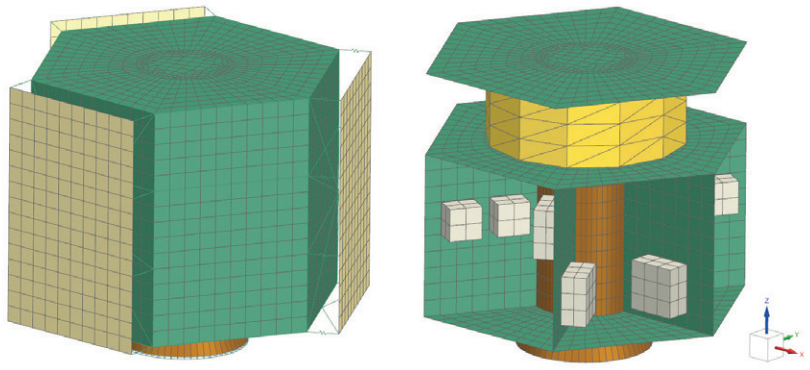


Figure 4. Visualization of a satellite and its equipment.

Internal framework to balance attributes

To accelerate the design process internally, the team has worked out its own multidisciplinary structural analysis and design optimization (MSADO) framework to balance attributes for missions, like launch vehicle vibration loads, orbital thermal heating and acoustics with numerous design constraints. The framework is used to determine structural interactions with different orbital environments when designing complex space systems for deep space satellite missions. Recently, the MSADO framework has been extended to cooperative space logistics and in-orbit satellite servicing missions. These are complex missions that include elaborate robotic systems and mission-critical docking systems.

The openness and interconnectivity of Simcenter tools as well as the digital thread provided by the Siemens Xcelerator, such as Teamcenter Simulation and NX™ CAD software, significantly reduces the time needed to set up the MSADO framework for each mission or project.

"We are excited about this process and its future contribution to numerous satellite system operations," says Stoumbos.

"We are confident it will improve the design cycle for our future space vehicle design analysis as well as lunar and Mars missions."

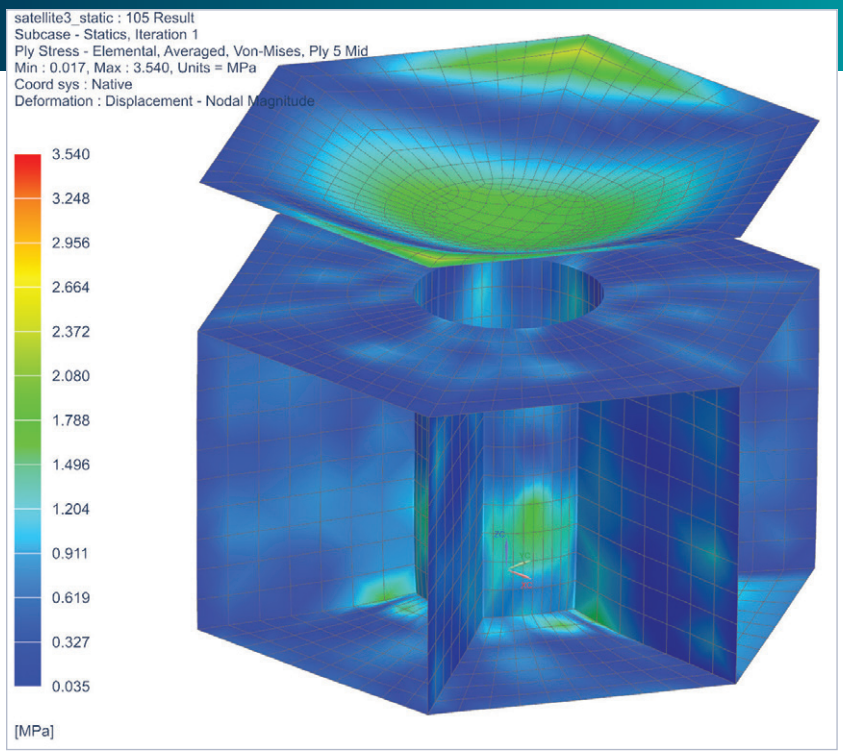


Figure 5. Simcenter 3D is used to run stress analysis to study failure behavior of composite materials.

Working together in the new space industry ecosystem

There is an extensive list of suppliers, vendors and subsystem owners that contribute to building a satellite or a space station. As a principal integrator, Northrop Grumman and Stoumbos and his team do not need to worry if the tools they work with are compatible with the Siemens Xcelerator digital thread.

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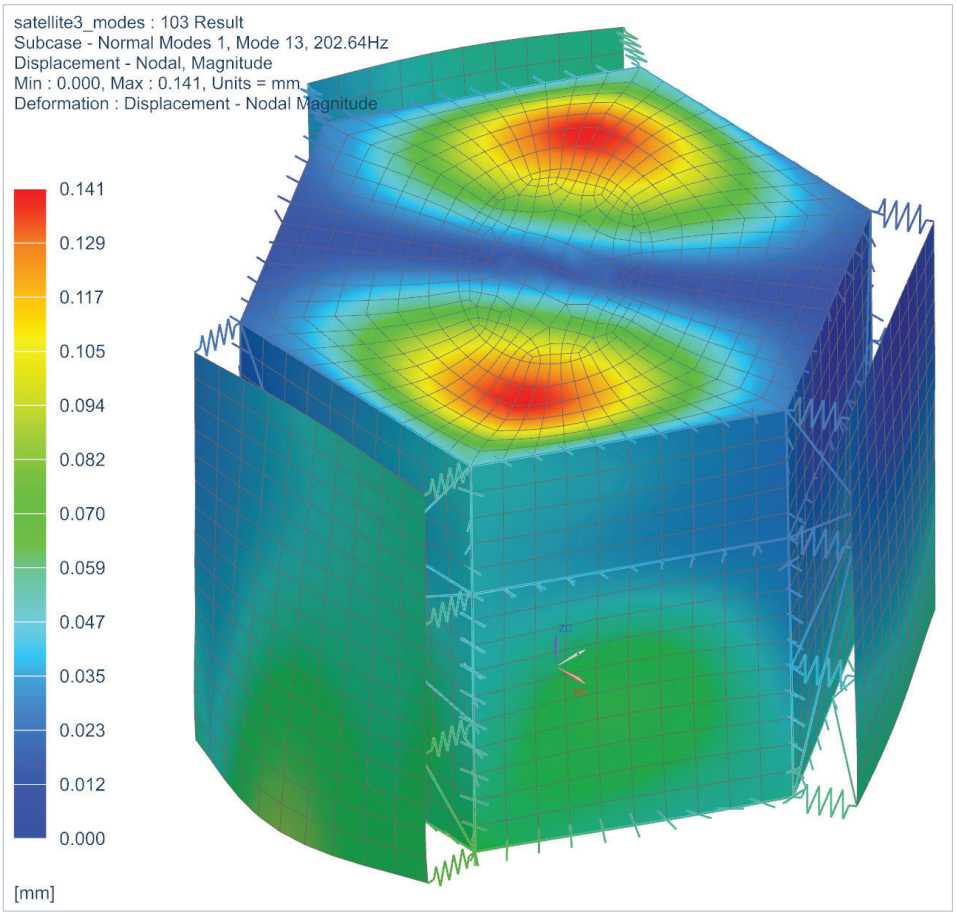


Figure 6. Dynamic behavior analysis of a satellite.

"Siemens Xcelerator allows our CAD and CAE models to 'talk' to each other regardless of who the developer is," says Stoumbos. "This saves considerable time since model conversion is typically time-consuming and can result in modeling errors.

"A satellite runs up to a couple of million degrees of freedom," says Stoumbos. "As the ultimate system integrator, it is our job to align all the subsystems, digital models and mathematical models we receive from customers and vendors. With the help of Siemens, we can seamlessly integrate models, run the simulation analysis, get accurate results and directly interface with the customer utilizing our space vehicle digital twin."

The ultimate goal at Northrop Grumman is a real-time digital twin within a digital thread.

"Northrop Grumman and Siemens share the same goal of a pure digital thread, where the system models will be able to accurately represent the physical system and enable us to perform simulations in real time during the mission while the vehicle or satellite is in orbit," says Stoumbos. "If there's a specific issue or discovery, we can always go back to the digital twin and try to understand what happened during the mission."

Solutions/Services

Simcenter
siemens.com/simcenter

Teamcenter
siemens.com/teamcenter

NX
siemens.com/nx

Customer's primary business

Northrop Grumman is a leading global aerospace and defense technology company. Its pioneering solutions equip customers with the capabilities they need to connect and protect the world and push the boundaries of human exploration across the universe. Northrop Grumman's 95,000 employees strive to define what is possible every day.
northropgrumman.com

Customer location

Dulles, Virginia
United States

An accurate digital twin of HALO for future generations

The HALO design has undergone preliminary and critical design reviews, two of a series of checkpoints for complex engineering projects.

The spacecraft's design is being validated to ensure the overall system is safe and reliable for flight and meets NASA's mission requirements. HALO is currently undergoing further detailed design as well as hardware development. When validated, this model will be the basis for the HALO digital twin that future generations of engineers will build on.

A multifaceted and multigenerational team will eventually bring HALO to life at Northrop Grumman's Gilbert Arizona facility, which can tap into its space systems production and integration experience to prepare the space module for launch.

"In a decade or two, we have gone from designing communication satellites to developing complex robotic systems for servicing missions up in space and moving toward a digital twin for future space vehicles," says Stoumbos. "That is an incredible pace of innovation. Siemens has the vision and the suite of tools that allow us to move quickly into digitalization and advanced engineering simulation. We hope to continue to grow along with Siemens as a partner."

For more information on **NX, Simcenter, & Teamcenter**, please contact us at: 949.481.3267 | info@saratech.com

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