

PTC and Partner Comet Solutions enable The Aerospace Corporation to reduce design-analysis cycle time by 50%

The Aerospace Corporation, El Segundo, California

The Aerospace Corporation provides independent technical and scientific research, development, and advisory services to United States' national-security space programs. It operates as a federally funded research and development center for the United States Air Force, the Dept. of Defense, and other national-security agencies, and supports all national-security space programs. Projects are also conducted for civilian agencies, such as NASA, the National Oceanic and Atmospheric Administration, commercial companies, universities, and international organizations in the US national interest.

The Aerospace Corporation was asked to undertake a highly precise analysis of how electro-optical (EO) sensors perform in space. Specifically, engineers running STOP (Structural, Thermal, Optical Performance) analysis wanted to know whether the clarity of images returned by a space-borne EO sensor would meet stringent optics performance requirements within the harsh temperature variations in space. The company needed to simulate how the EO sensor would act in these various extreme temperatures while in space.

Additionally, the researchers aimed to reduce the cost of analyzing the EO sensors while improving sensor performance. According to Dr. David Thomas, senior project engineer with The Aerospace Corporation, "About 25% of space-borne electro-optical (EO) sensor programs in both the civil and National Security Space (NSS) communities have experienced reduced on-orbit reliability, and cost and schedule overruns of 100% or more." (Refs 1-3)

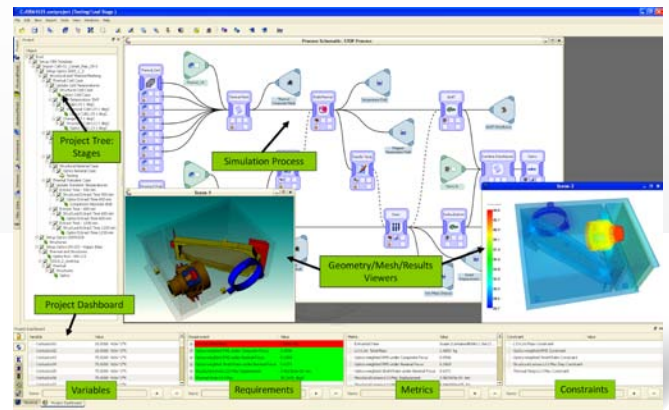


Figure 1: Comet's Performance Engineering Workspace

The Comet-PTC Creo™ Elements/Pro™ (formerly Pro/ENGINEER®) solution: A collaborative design and analysis environment

Cost overruns are largely caused by delays, errors and inadequate communication among team members and contractors in the design process. This leads to the late discovery of technical problems at the hardware-build stage, when problems are more expensive and time-consuming to fix. Dr. Thomas envisioned a three-part solution:

- Integrating the design/build/test processes.
- Providing engineering teams with a means to work collaboratively across discipline boundaries.
- Ensuring a high level of systems-engineering understanding across the entire team.

At the same time, his team members wanted to automate their complex, multidisciplinary STOP analysis process, while still using their current commercial CAD and CAE tools—Creo Elements/Pro, Thermal Desktop®, Nastran®, Abaqus®, SigFit, CODE V®, Microsoft Excel® and Matlab®.

The Aerospace Corporation found its total solution in the partnership between PTC and Comet Solutions. The integration of Comet's desktop-based Performance Engineering Workspace with PTC's Creo Elements/Pro 3D CAD software and other programs has unified team members, allowing them to capture, automate, execute, reuse and share multidisciplinary simulation processes effectively, as the design evolved in Creo Elements/Pro.

Comet's Performance Engineering Workspace (Figure 1) provided a single, consistent view of all the project data—models, environments, processes and results. Domain experts could work within their own “sandboxes” to understand their aspect of the sensor, but also easily work together with other domain experts to gain overall system-performance insights. By automatically reusing the knowledge captured by experts in abstract, modeling-based simulation templates, manual data handoff and translation errors were eliminated, and confidence in the accuracy of analysis iterations increased significantly.

“An additional benefit of using Creo Elements/Pro for this project versus their legacy CAD system was the ability to create simplified representations in Creo Elements/Pro,” states Malcolm Panthaki, CTO and founder of Comet Solutions. “Simplified representations allowed the project team to easily suppress geometry details—without removing the design knowledge—and analyze only key components. This reduced the time it took to complete ‘what-if’ design studies.”

The simplified representations also enabled the CAE analysts to create more computationally efficient structural and thermal models. The user could complete all of the analysis studies on a single computer, without the need for multi-CPU clusters. Previously, lack of integration in this area [between the CAD and the downstream CAE programs] contributed to persistent cost and schedule overruns.

Satellite flight hardware program

As part of the EO sensor analysis project, Dr. Thomas's team completed a major design-analysis effort on a satellite flight hardware program in less than half the previous overall design evaluation cycle time by using Comet's Performance Engineering Workspace and Creo Elements/Pro.

The team used the Comet process template shown in Figure 2. Key factors to reducing the cycle time were:

- The simulation template captured the entire process, from design concept through test data for validation, and automatically reran the entire analysis cycle as design changes were made.
- Comet's bi-directional connection to Creo Elements/Pro allowed the Aerospace team to easily run a large number of analysis-design studies while modifying both 3D geometric parameters in the Creo Elements/Pro CAD model—as well as non-geometric model parameters and the thermal environment conditions—within Comet.
- After each design-analysis iteration, key performance metrics were available in the Comet project dashboard for immediate visualization, so the results could be compared with the system-analysis performance requirement and metrics, which were directly captured within Comet.

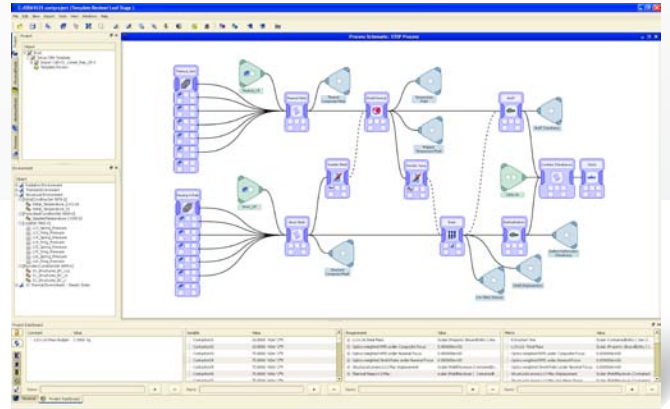


Figure 2: Simulation best practices and standard simulation processes are encapsulated within the Comet process templates to enable knowledge reuse of engineering expertise across multiple physics domains.

Also important to the project was Comet's abstract engineering modeling technology, which allows teams to reuse automated simulation processes on vastly different design concepts with little or no modification of the process template, reducing a huge bottleneck in the design-iteration cycle time.

“Because Comet’s Abstract Engineering Model (AEM®) is based on a single, generic, functional view of the product and its key design components—and is not tied to any specific version of the 3D geometry associated with those components—engineers can create performance-simulation process templates that evaluate multiple design configurations at any desired level of fidelity,” according to Panthaki.

A closer look at the abstract engineering model and active tags

The AEM (Abstract Engineering Model) spans the traditional chasm between low-fidelity modeling (using tools such as Excel) and high-fidelity modeling using tools such as PTC’s Creo Elements/Pro Mechanical® for finite element analysis (FEA). Results from low-fidelity calculations can be fed to downstream, high-fidelity calculations and vice versa. The AEM also allows users to create and manage multiple representations of each component in the design product structure. These representations are required for various types of downstream analyses and different physics calculations at different levels of fidelity. For example, the optics functional prescription representation of a lens element and the Creo Elements/Pro 3D CAD representation of the same component are managed simultaneously; the former is used to perform optics calculations, while the latter is used for creating both the thermal and structural meshes.

By using a “functionally tagged,” abstract Creo Elements/Pro model (Figure 3), all modifications made to the geometry throughout the design process were automatically available for use downstream in the process. The Aerospace Corporation’s customer supplied a Creo Elements/Pro CAD model. Dr. Thomas’s team had planned to re-create the Creo Elements/Pro model using their in-house CAD program, but they knew that losing all of the parametric data would cause delays and increase potential for errors. To avoid these problems, they decided to purchase Creo Elements/Pro, so they could take the instrument contractor’s model directly into the Comet workspace. The transition to Creo Elements/Pro was facilitated by using Comet’s Active Tag Application, which communicates directly with the Creo Elements/Pro user interface.

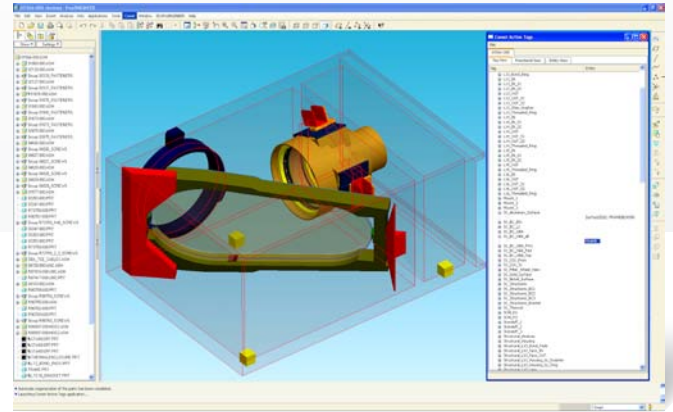


Figure 3: The Creo Elements/Pro model is tagged using Comet’s Active Tag Application; when changes are made to the model, the simulation template can be easily rerun with minimal rework.

The results: Time- and cost-savings using Comet and Creo Elements/Pro

The Aerospace Corporation team achieved the following results on the EO sensor analysis project:

- Reduced overall design-evaluation cycle time by over 50%. While this provided immediate cost- and time-savings, the greatest value came from the capture of knowledge and the ability to apply it to iterative analysis, a crucial competitive advantage.

“Almost all defective projects result from not having the right knowledge in the right place at the right time. Therefore, usable knowledge is the basic value created during development. Usable knowledge prevents defects, excites customers, and creates profitable operational value streams.”

– Allen C. Ward, Lean Product and Process Development (Ref 4)

- After the Comet template was developed and validated using test results, each new EO sensor analysis iteration could be performed and evaluated within a single day; the previous process required weeks to perform the same analysis.

- Conducted real-time design reviews, with program management and the customer directly involved via live concurrent engineering sessions, using results displayed directly within the Comet graphical user interface and Project Dashboard. All the key performance data and full 3D models and results were available for these discussions, which centered around system-level characteristics impacting the sensor behavior and performance. Collaborative engineering sessions such as these can be conducted in person as well as using web-based meeting tools, and can eliminate much of the prep time required to create static Microsoft PowerPoint® and Microsoft Word® documents.
- Eliminated most of the manual rework that usually accompanies changes to the 3D CAD geometry, which saved significant cycle time and eliminated human errors.
- Individual team members developed a deeper understanding of the multidisciplinary behavior of the overall system by performing more “what-if” design studies with Creo Elements/Pro.
- Used instant feedback on the accuracy of the simulation model, which allowed the team to quickly predict the optics design performance and adjust individual domain models to improve subsequent design iterations.

According to Dr. Thomas, “The integrated STOP (Structural, Thermal, Optical Performance) process that we developed allows an interdisciplinary analysis that formerly took several days or weeks to perform to be completed in a single day. The savings in cost and schedule required to perform this independent assessment, due to this dramatic reduction in design cycle time, were substantial, given that six different integrated design analyses were required to complete this work.”

Comet’s active involvement in the PTC PartnerAdvantage™ Program is critical to supporting the companies’ common customers, such as The Aerospace Corporation, noted Don Tolle, VP of Business Development for Comet.

“Comet’s ability to provide a robust, bi-directional integration with Creo Elements/Pro relies on PTC’s Creo Elements/Pro TOOLKIT Customization API access, as well as the strong technical support provided by the PTC PartnerAdvantage team. As a Gold Partner, we will continue to expand our integration with Creo Elements/Pro and with other core PTC tools such as Mathcad® and Windchill®.”

Andy Barlow, Senior Director of Business Development at PTC, agreed:

“Comet’s participation in the PartnerAdvantage Program is clearly mutually beneficial. Comet’s integration of their desktop-based Performance Engineering Workspace with PTC’s Creo Elements/Pro benefits our customers and enhances Creo Elements/Pro. We look forward to the work planned with Mathcad and Windchill.”

A copy of Dr. David Thomas’s presentation and white paper for the 2009 SPIE Optics+Photonics Conference is available for download at www.cometsolutions.com.

[Ref 1] Pavlica, Steve and William Tosney, “Assessment of NRO Satellite Development Practices,” The Aerospace Corporation; 2003.

[Ref 2] Young, Thomas A., Chair, “Report of the Defense Science Board/Air Force Scientific Advisory Board Joint Task Force on Acquisition of National Security Space Programs,” Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics; May, 2003.

[Ref 3] Leon, John and Juan Rivera, chairs, “NASA Instrument Capability Study Final Report,” NASA Office of the Chief Engineer, NASA Headquarters, Washington, DC; December, 2008.

[Ref 4] Ward, Allen C., Lean Product and Process Development, The Lean Enterprise Institute, Cambridge, MA; March, 2007.

For more information:

www.aero.org/programs/satellites.html,
www.cometsolutions.com,
www.crtch.com/stop.html,
www.opticalres.com

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