Building Europe's Next Generation of Hypersonic Spaceplanes with Digital Engineering

How POLARIS established a scalable, aerospace-proven digital foundation to support ambitious growth, accelerate iteration and maintain engineering excellence.



POLARIS Raumflugzeuge GmbH is developing one of Europe's most ambitious aerospace programs: fully autonomous, horizontally launched hypersonic spaceplanes designed to provide sustainable, reusable access to space. Drawing on more than 30 years of European spaceplane research originating at the German Aerospace Center (DLR), POLARIS is combining reusable vehicle architectures, combined airbreathing and rocket propulsion, autonomous flight systems and rapid design-build-fly development to fundamentally rethink how spacecraft are designed, launched and operated.

The company has already built eight flight demonstrators, completed 250 test flights, and conducted 49 aerospike engine hot-fire tests. Those lessons are now fed into the development of the next generation of spaceplanes capable of Mach 10 flight, aerial refuelling and two-stage-to-orbit missions. Beyond commercial spaceflight, POLARIS is also applying its technology to advanced defence platforms, including autonomous aerial refuelling systems designed to support both hypersonic aircraft and allied defence operations. The company's approach also reduces the environmental impact of launch operations by eliminating space debris and using eco-friendly propellants such as synthetic kerosene and liquid oxygen.

"Our vision is to give Europe independent access to space from anywhere," said Jonas Bruemmer, Structural Design and Analysis Engineer at POLARIS. "Europe urgently needs sovereign access to orbit, and our technology is designed to deliver exactly that. We are building the world's first airline to space."

Challenge: Rapid Growth Outpacing Engineering Infrastructure

As POLARIS accelerated development of increasingly sophisticated hypersonic spaceplanes, engineering complexity began growing faster than the company's early-stage processes could support. What had worked for a startup team was no longer sufficient for an organization supporting more than 100 engineers across structures, propulsion, software, manufacturing and autonomous systems. Maintaining visibility, configuration control and cross-disciplinary collaboration became increasingly difficult as every new demonstrator introduced additional complexity.

POLARIS's development strategy compounded that challenge. Rather than designing a single vehicle, the company builds a series of increasingly capable demonstrators, with each generation relying on the engineering knowledge, flight-test data and design decisions captured from the previous one. Losing control of that information would slow future innovation and increase program risk.

Like many rapidly growing startups, POLARIS initially relied on shared folders to manage CAD models, engineering documentation and design data. As projects became more sophisticated, that approach became increasingly difficult to manage. Engineers struggled to identify the latest versions, changes were difficult to trace, and disconnected information made collaboration slower and less reliable. These issues were amplified by the unique demands of spaceplane development. POLARIS develops and flight-tests demonstrators while certification is addressed simultaneously, meaning that design, manufacturing and regulatory documentation must evolve in parallel. Without robust traceability and configuration control, preparing certification evidence became increasingly time-consuming and introduced unnecessary program risk.

"We were developing and building demonstrators while still waiting for the direct permission to operate them," said Bruemmer. "Tracking our own approaches precisely was essential, but the way we worked made it difficult. It was becoming more challenging every month."

Design iteration itself was also inefficient. When engineers needed to abandon a design path, they often had to manually remove changes and reconstruct assemblies, creating unnecessary engineering effort and increasing the risk of introducing new errors.

The disconnected environment also affected collaboration. Without a shared engineering backbone, teams worked largely within their own disciplines, relying on meetings, emails and

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Partner Spotlight

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institutional knowledge to coordinate work. As the organization expanded, that approach became increasingly difficult to sustain.

As the company advances toward Mach 10 flight, aerial refuelling capabilities, and two-stage-to-orbit operations, increasing product complexity exposed the limitations of disconnected tools and manual processes.

"It became clear that we needed a scalable, connected digital environment," Bruemmer explained. "We needed a single source of truth to support the complexity of what we are building."

Solution: A Unified Digital Backbone for Hypersonic Innovation

"To support its long-term vision for reusable hypersonic spaceflight, POLARIS set out to create a single digital engineering environment capable of connecting design, simulation, product data and engineering change across the entire organization. The objective was not simply to replace disconnected tools, but to establish a scalable foundation that could preserve engineering knowledge, support rapid iteration and maintain configuration control as both the company and its vehicles became more sophisticated.

After evaluating several approaches, POLARIS selected PTC because of its deep aerospace expertise and integrated digital engineering portfolio. The company partnered with PDSVISION to implement and optimize the solution, ensuring the new environment could be deployed quickly while supporting future growth.

> **"We've moved from managing complexity to mastering it. By unifying our engineering truth, we now innovate at a velocity that matches our ambition, turning what once felt impossible into a repeatable, scalable reality."**
>
> **Jonas Bruemmer, Structural Design and Analysis Engineer, POLARIS Raumflugzeuge GmbH**

"Designing a hypersonic spaceplane demands partners who can operate with the same ambition and speed," said Bruemmer. "PTC's technology and PDSVISION's expertise gave us the foundation we need to move fast without losing control."

The first step was modernizing product development with Creo. Engineers gained a collaborative 3D design environment where they could develop complex assemblies, evaluate design alternatives and validate structural performance much earlier in the engineering process. Integrated simulation provided immediate insight into how components would perform under load, helping teams make better design decisions before investing in physical testing.

The move also transformed day-to-day engineering workflows. Instead of manually reconstructing assemblies when designs changed, engineers could safely explore alternatives, compare revisions and roll back unsuccessful iterations without losing work

"There are basically no limitations to what you can do," Bruemmer said. "We can directly see how loads affect the design before going into deeper analysis."

POLARIS then established Windchill as the company's enterprise-wide engineering backbone. Shared folders and disconnected documents were replaced with a governed environment that connected product data, engineering changes, configuration history and design traceability within a single source of truth. Engineers across propulsion, structures, software, manufacturing and flight testing could now work from the same trusted information while maintaining complete visibility into every design decision.

Guided by PDSVISION, the implementation was structured to support both current development programs and the company's long-term roadmap for increasingly complex reusable spaceplanes.

"Now everyone has direct access to everything," added Bruemmer. "We can work simultaneously on assemblies without worrying about overwriting each other."

Together, Creo and Windchill established a connected digital thread that now links every stage of product development, from concept and design through simulation, manufacturing and flight testing. Rather than treating each demonstrator as a standalone project, POLARIS can continuously capture engineering knowledge and apply it to future vehicle generations.

"Tracking our approaches precisely is essential," Bruemmer said. "Now we can gather all the data from every demonstrator and feed it directly into the next."

Today, POLARIS is developing its newest-generation spaceplane entirely within this connected digital engineering environment. Design, simulation, product data and engineering changes are managed together from the beginning of the program, providing the traceability, scalability and engineering discipline needed to support increasingly ambitious flight objectives.

More importantly, POLARIS has shifted from managing engineering information as individual files to managing it as connected product knowledge. That transformation enables the company to move faster, collaborate more effectively and build each new generation of spaceplanes on a trusted digital foundation.

Benefits: Faster Engineering, Greater Confidence and a Foundation for Growth

The adoption of a unified digital engineering foundation has transformed POLARIS's ability to design, certify and scale its hypersonic spaceplane programs. With Creo and Windchill in place, the company now operates with a level of speed, precision, and cross-disciplinary coordination that was previously out of reach.

"Time and efficiency definitely went up," said Bruemmer. "We know we're a lot faster, even if we haven't quantified it yet. Starting with a PLM system was key. You need a single source of truth, standardized workflows, and a culture of cross-disciplinary collaboration. That's how you scale ambitious engineering programs like ours."

One of the most immediate improvements has been engineering confidence. Teams no longer question whether they are working from the latest design or whether critical changes have been captured. Engineers across multiple disciplines can collaborate simultaneously on complex assemblies with complete visibility into revisions, design intent and configuration history, reducing manual coordination and enabling faster decision-making.

"We can now directly roll back if a design isn't working," Bruemmer added. "In the past, that meant manually deleting changes and risking mistakes. Now it's simple and safe."

The company's certification process has also become significantly more structured. Engineering changes, product configurations and supporting documentation are now captured as part of normal development activities rather than assembled manually at the end of the process. For a company simultaneously advancing flight demonstrators while preparing for future certification, this traceability provides a far more predictable foundation for regulatory compliance.

Earlier engineering insight has improved design quality throughout development. By evaluating structural performance earlier in Creo, engineers can identify potential issues sooner, validate design decisions with greater confidence and reduce the likelihood of costly redesigns later in the program. This supports POLARIS's rapid design-build-fly development model while strengthening overall engineering discipline.

As POLARIS has grown, its digital engineering foundation has scaled with it. New engineers can quickly understand existing programs through complete design histories, standardized workflows and centralized product information. Engineering knowledge is no longer dependent on individual teams or institutional memory, making collaboration more consistent as the organization continues to expand.

"It's made scalability much simpler," Bruemmer said. "We can integrate new colleagues easily and keep track of every change."

Most importantly, the digital foundation ensures that POLARIS never loses critical test data. Every flight, every demonstrator, and every iteration feeds directly into the next generation of spaceplanes, including the company's newest spacecraft. This continuity allows the organization to build on proven knowledge rather than reinventing it, strengthening both engineering quality and long-term program reliability.

"We're not losing any test data," Bruemmer said. "Everything we gather throughout the process is preserved and used to move us forward. We've moved from managing complexity to mastering it. By unifying our engineering truth, we now innovate at a velocity that matches our ambition, turning what once felt impossible into a repeatable, scalable reality."

Looking Ahead: Advancing Toward Mach 10 and Operational Spaceflight

With eight demonstrators already completed and hundreds of successful test flights behind it, POLARIS is entering an even more ambitious phase of development. Future programs will introduce higher Mach flight, aerial refuelling capabilities and reusable two-stage-to-orbit missions, significantly increasing both engineering complexity and the volume of data generated throughout development.



Because every vehicle builds directly on the lessons learned from its predecessor, preserving engineering knowledge has become a strategic advantage. The digital engineering foundation established with Creo and Windchill will continue to connect design, simulation, manufacturing and flight-test data as each new generation of spaceplanes pushes the boundaries of performance.

"Our next projects aim for Mach 2, Mach 4 and Mach 10," said Bruemmer. "We're developing reusable spaceplanes that take off horizontally, operate from airports and transform access to space. The digital foundation is key to achieving that vision."

As POLARIS expands its portfolio of reusable spaceplanes and advanced defence platforms, its digital engineering foundation will continue to support every stage of growth, from concept and design through manufacturing, flight testing and future certification. And as Europe seeks sovereign access to space, POLARIS is positioned to play a pivotal role in delivering secure, sustainable and strategically independent spaceflight capabilities.

Benefits

- **Unified Engineering Backbone** – Single, governed environment replaced fragmented folders, ensuring every engineer works from the same authoritative data set.
- **Cross-Disciplinary Collaboration** – Engineers across structures, propulsion, software, manufacturing and flight testing collaborate from the same product baseline with complete visibility into engineering changes.
- **Configuration Control at Scale** – Automated version management and configuration control eliminated uncertainty around design revisions and engineering changes and solves the "last person who saves win" problem.
- **Faster Engineering Iteration** – Engineers can safely evaluate alternatives, compare revisions and roll back unsuccessful designs without manual rework. Accelerated Design Cycles - Integrated simulation in Creo enables early structural validation, reducing late-stage redesigns and speeding up design-build-fly iteration.
- **Certification-Ready Traceability** - Every change, decision and dependency is captured automatically, simplifying regulatory documentation and reducing approval risk.
- **Scalable Organizational Growth** – New engineers gain immediate access to standardized workflows, complete design histories and centralized engineering knowledge. Continuous Engineering Knowledge – Every flight test, demonstrator and design iteration becomes part of a reusable engineering knowledge base that strengthens future vehicle programs.

Customer Overview | POLARIS Raumflugzeuge GmbH

Industry	Aerospace / Hypersonic Spaceplane Development
Headquarters	Bremen, Germany
Employees	100+
Website	polaris-raumflugzeuge.de
PTC Products	Creo, Windchill