

## SpaceX delivers outer space at bargain rates

At SpaceX, a managed development environment provides critical infrastructure for development of low-cost launch vehicles that will slash the cost of space access

### Business challenges

Develop rockets that reduce the cost of space access by a factor of 10

### Keys to success

Employ a managed development environment built on NX software and Teamcenter software

Create virtual mockups of entire rockets

Leverage design data for shop-floor guidance and marketing

Control the lifecycle of all rocket components

### Results

50 percent productivity improvement

More effective collaboration between design groups

Two Falcon 1 rockets successfully launched

## SPACE EXPLORATION TECHNOLOGIES (SPACEX)

SpaceX aims to revolutionize the commercial space industry with rockets that cut the cost of a launch by a factor of 10.

### Low-cost rockets set to change the rules

Space Exploration Technologies (SpaceX) is a privately-held launch vehicle developer and launch services provider with an ambitious goal: to revolutionize the commercial space industry. The company was founded by Elon Musk, whose previous businesses (PayPal and Zip2 Corp.) gave him the wherewithal to get into the space-for-hire market. Musk started SpaceX in 2002 and to date the company has launched two of the Falcon 1 rockets.

The two-stage, liquid oxygen and kerosene-powered rocket can lift a half ton into low-earth orbit for a price of about \$6 million. This is one-third the cost of other currently available options. The rockets have all been launched from the Kwajalein Atoll in the South Pacific.

SpaceX has also been developing the Falcon 9 rocket, which supports the medium- to heavy-class launch market. SpaceX was recently awarded the NASA COTS contract. SpaceX was specifically selected by NASA to demonstrate delivery and return of cargo to the International Space Station (ISS). At the option of NASA, the agreement can be extended to include demonstrating transport of crew to and from the International Space Station. If successful, NASA will have the ability to use the demonstrated capability to resupply the ISS after the 2010 retirement of the Space Shuttle.

Originally, designs at SpaceX tried using a mid-range computer-aided design (CAD) program to develop the Falcon 1. After about a year of frustration with assemblies that took more than an hour to load (or worse, wouldn't open after they were created), the company began looking for more powerful software. Chris Thompson, vice president of Development Operations at SpaceX, knew that in addition to needing more capable design software, the company had gotten to the point where it needed a solution for managing the growing amount of design data, specifications, CNC programs, processes and so on that were part of the Falcon 1 project. Although Thompson and his colleagues evaluated CAD, finite element analysis (FEA) and product data management (PDM) solutions separately, they ended up choosing all of the technology from Siemens PLM Software to create a managed development environment. The product lifecycle management (PLM) solution included NX™ software (including NX



# PLM Software

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Nastran), Femap™ software, and Teamcenter® software. “Everyone liked the functionality and user interface of NX,” says Thompson. “Then we did a standalone evaluation of PDM software and Teamcenter won hands-down. In our opinion there was no comparison between it and the competition. On the analysis front Femap and Nastran were the clear winners, not only due to wide industry acceptance but also from an ease of use and support standpoint.”

#### **NX handles the entire rocket**

SpaceX has modeled the entire Falcon 1 and Falcon 9 rockets and the Dragon capsule in NX. The software has no trouble handling more than 25,000-part assemblies. “Having the ability to work with an assembly of such size in a timely manner is very important,” says Thompson. “The entire assembly takes only five to 10 minutes to load.” Once loaded, a virtual mockup of the rocket enables designers to readily find interferences. A major benefit in working with large assemblies is “designing in context,” which allows various component parts to be developed and completed all while working in the assembly. Designing in context means immediate feedback relative to fit and feasibility. Conversely, without the ability to load all the relevant components around the area of concern, designing the components to fit precisely is a much more difficult and time-consuming task. In addition to NX’s assembly strengths, SpaceX designers use NX to simulate motion, such as the separation between the first and second stages, to further check their work.

SpaceX leverages its NX data in other ways as well. Technicians on the shop floor look at NX models as they build the rocket to better understand a rocket’s inner workings. This is particularly helpful for seeing the routes of tubes and wires within the rocket, for instance. SpaceX has machined metal scale models that it uses for marketing purposes and has also fabricated SLA models. The company that makes these models works directly off the NX geometry. In addition, SpaceX has a video that simulates the launch of the Falcon 1. The company that made the video imported a wireframe model of the rocket in native NX format into its animation software.

#### **Managed development environment boosts collaboration**

Teamcenter is the repository for all documentation related to the design and manufacture of the Falcon – CAD models, specifications and so on. “Having the ability to associate a Word document or a machine program with a part is helpful,” says Thompson. “For example, if I have a system specification for a particular part, that document is now under revision control with that part. We’re not working off multiple databases to manage product information.” Teamcenter is also used to control processes such as engineering change and design release. “We use Teamcenter to manage the lifecycle of the part,” Thompson adds.

SpaceX’s managed development environment has enhanced collaboration at the company. Designing a rocket takes the coordinated effort of three different engineering teams: propulsion, structures and avionics. At SpaceX these teams are located in different buildings. Because everything related to the rocket design is managed by Teamcenter, the teams can each work on different parts of the rocket



**Solutions/Services**

NX

[www.siemens.com/nx](http://www.siemens.com/nx)

Femap

[www.siemens.com/plm/femap](http://www.siemens.com/plm/femap)

Teamcenter

[www.siemens.com/teamcenter](http://www.siemens.com/teamcenter)**Client's primary business**

Space Exploration Technologies (SpaceX) is a privately-held launch vehicle developer and launch services provider.  
[www.spacex.com](http://www.spacex.com)

**Client location**

El Segundo, California  
United States

***"We now have total team collaboration and it's a huge advantage."***

*Chris Thompson  
Vice President,  
Development Operations  
Space Exploration  
Technologies*

without worrying about interfering with each other. "If a structures designer is doing work on a part, an engineer in another building can look at that part and make sure it doesn't interfere with what he's doing. Or they can discuss any potential problems early on. We now have total team collaboration and it's a huge advantage," says Thompson.

Between the significantly better process control made possible by Teamcenter and the higher productivity resulting from the move to NX, SpaceX has experienced a 50 percent productivity improvement. Leveraging a fully digital managed

development environment built on NX and Teamcenter, SpaceX's Falcon 1 rocket has moved from development into production and launch, while its Falcon 9 rocket and Dragon capsule are in development, with qualification testing well under way.



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