Analyze this

Boeing Debris team analyzes millions of possible debris scenarios

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– Darby Cooper, integrated vehicle analysis manager

By Adam Morgan

M*ain engine start … 3 … 2 ... 1 … booster ignition … and liftoff of Space Shuttle* Endeavour. That's what you heard if you watched November's launch of *Endeavour* for mission STS-126. But what you probably didn't hear or see was the work of thousands of people behind the scenes to make the launch a success. Many of those unseen elements are orchestrated by Boeing Space Exploration employees, whose jobs require careful and constant precision from start to finish.

Boeing's Space Shuttle Debris team is one of the teams working behind the scenes to help ensure that each launch and landing goes as planned. Critical to the safety and success of each launch, the team is responsible for assessing ascent and re-entry debris—matter that may come loose from the space shuttle assembly, including ice and foam from the external tank—before these phases of flight. The team analyzes and predicts where and how hard debris might hit the shuttle (based on force, size and shape), documents the "what-ifs" for potential debris, and monitors the pieces that do separate to make sure they are within the expected size and trajectory range.

Although NASA and Boeing always assessed the potential for debris damage to the shuttle fleet, the team has been expanded and the effort intensified following the debris-related loss off Space Shuttle *Columbia* in 2003. During the return of *Columbia*, a chunk of fuel-tank insulating foam struck *Columbia*'s left wing during ascent to orbit, causing the craft's breakup on its descent from space.

The space shuttle is one of the most complex flying machines ever built. Designed to launch like a powerful rocket, maneuver in Earth orbit like a state-of-the-art spacecraft and then land like a glider, the shuttle consists of 2.5 million parts and has a gross liftoff weight of 4.5 million pounds (2 million kilograms). This extreme machine is propelled into Earth's orbit by 7 million pounds (31,138 kilonewtons) of thrust, accelerating to more than 17,500 miles per hour (28,164 kilometers per hour) in just 8.5 minutes. At that rate, it's not uncommon for small pieces of debris to fall off the shuttle.

The main source of debris is the external tank—85 feet (26 meters) tall and weighing 2 million pounds (907,185 kilograms)—which is attached to the orbiter. To keep the cryogenic propellant at optimum temperatures, the tank is encased in closed-cell foam. Small pieces of this foam occasionally dislodge from the tank during the shuttle's ascent. The extreme temperatures inside the tank lead to another source of debris: ice caused by the interaction of the cold tank and the warmer atmosphere.

"Our team is responsible for determining where debris will go once it releases from the space shuttle for both ascent and re-entry," said Darby Cooper, an integrated vehicle analysis manager and member of the debris team. "There's a certain amount of debris that is expected with each launch. Our team is very focused on the potential debris beyond what is expected."

PHOTO: Boeing engineers in Houston use the latest in technology, including computational fluid dynamics, to analyze more than 17 terabytes of data on debris and debris trajectories that could damage the space shuttle. ELIZABETH MORRELL/BOEING

The team works with NASA and other contractors to understand potential debris that could occur from design changes and anomalies. The Boeing team handles more than 17 terabytes of data to compute millions of potential debris trajectories and probabilistic risk assessments, integrating data from computational fluid dynamics, computer simulations, onboard cameras, sensors and various other tools to predict possible outcomes.

And the team doesn't stop at just analyzing debris. It has achieved at least a 50 percent reduction in debris analysis cycle times—from 12 weeks down to four to six weeks on average—by eliminating rework and standardizing input and output by using software that checks for errors before running or producing data. ■

adam.k.morgan@boeing.com

PHOTO: (LEFT) The space shuttle accelerates to more than 17,500 miles per hour (28,164 kilometers per hour) in 8.5 minutes on its way to orbit. Boeing engineers work behind the scenes to analyze where potential debris could strike and with how much force. NASA