Georgia Tech

Research News

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THREE, TWO, ONE, BLAST-OFF: NEW TECHNIQUE MAY IMPROVE SAFETY AND EFFICIENCY OF ROCKET DEPLOYMENT

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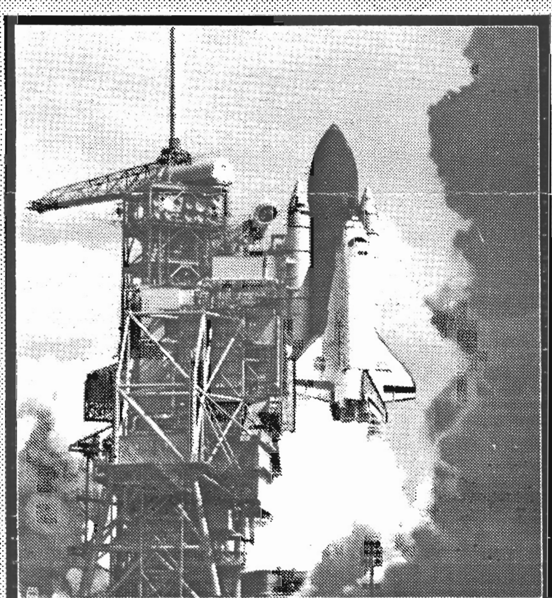
A new mathematical technique could soon make spacecraft deployment safer and more efficient while saving fuel after take-off by making realtime adjustments to keep a vehicle on track, scientists at the Georgia Institute of Technology have reported.

Theoretical results are promising, according to Dr. Dewey H. Hodges of Georgia Tech, and the National Aeronautics and Space Administration (NASA) hopes to implement the technique during an actual launch within the next two to three years.

"We're trying to make deployment less expensive and more routine," explained Hodges, a professor of aerospace engineering and director of Georgia Tech's Symbolic Computations Laboratory. "Right now, the launch vehicle sits on the ground and a big computer calculates the launch trajectory. The route is based on weather data collected from hot-air balloons and low-flying aircraft. Unfortunately, these techniques are rather slow."



Georgia Tech researchers have developed an algorithm for more efficient spacecraft deployment. *(Launch photo provided courtesy of NASA.)*

Weather conditions at lower altitudes often shift before balloon measurements have been completed in the upper atmosphere, Hodges said, and any change in the weather requires a lengthy reassessment of the launch trajectory. Meanwhile, the spacecraft continues to sit on the launch pad, racking up higher and higher costs.

But atmospheric data collection isn't the only problem. Existing calculations for determining the launch trajectory are complicated and time-consuming. "The computer programs that run these algorithms are quite slow," Hodges noted.

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"The weather data may be obsolete by the time it has been collected, analyzed, and incorporated into the calculations."

Hodges is optimistic, however, that the new Georgia Tech method for determining an "optimal trajectory" -- whatever path requires the least amount of fuel to reach a destination -- combined with recent advancements in weather data collection, such as the Light Detection and Ranging (LIDAR) system, will soon improve deployment efficiency. (By shooting an intense laser beam into the sky, a LIDAR system can rapidly gather weather information from scattered light molecules. In 1989, scientists with the Georgia Tech Research Institute successfully tested the largest LIDAR in the U.S. A year later, they developed a LIDAR that won't damage the human eye.)

New Life for an Old Principle?

While most predictive techniques are based on traditional Newtonian methods, Hodges decided to take another look at a physical principle which, until recently, hadn't enjoyed much popularity since its debut about 150 years ago.

What is Newton's law, and how is it different from Hamilton's principle? Newton's law, which leads to a system of differential equations, states that the rate of change of momentum is equal to the sum of all the forces acting upon a particular system, Hodges explained. Hamilton's principle deals, instead, with energy and work concepts. Scientists had begun to apply Hamilton's principle in computational mechanics to to directly solve problems of dynamics, but similar techniques did not exist for optimal control.

"I decided that if a direct use of Hamilton's principle works well for dynamics, an analogous method could also be used to solve optimal control problems," Hodges said. Based on this analogy of Hamilton's principle, Hodges' technique replaces intricate differential equations with sparsely coupled algebraic equations.

In the future, he believes an on-board computer system could run the new algorithms to re-optimize or re-adjust the path of a rocket every few seconds. "The original trajectory is based on a simplistic, idealized model of what the atmosphere is like and what the vehicle is like," he said. "When the real vehicle is flying, it only knows the real atmosphere, which may be different from the model So if you apply the thrust and control algorithms based on model conditions, you'll be off target."

Hodges' research collaborators include Aerospace Engineering Professor Dr. Anthony J. Calise of Georgia Tech. The group's latest findings were presented at the American Control Conference in San Diego, California May 23-25, 1990. In addition, a paper is expected to appear in the Journal of Guidance Control and Dynamics in January, 1991.

(This research, directed by Calise and Hodges, is supported by the NASA Langley Research Center of Hampton, Va.)

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