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NASA's LoFLYTE™ Program Flown

Flights Demonstrate Airworthiness of "Waverider" Shape

During the week of June 23, 1997, LoFLYTE™ made three successful flights at Edwards Air Force Base under the direction of the 445th Flight Test Squadron. In the next stage of the program, a neural network flight control system will be installed and tested.

The LoFLYTE™ (Low Observable Flight Test Experiment) program is a joint NASA Langley Research Center/U.S. Air Force Research Laboratory ground and flight test program that has resulted in a demonstration aircraft. LoFLYTE™ passed an important milestone in 1997 with a series of successful flights. This was the first flight of a true waverider aircraft configuration. The LoFLYTE™ prototype, a 100-inch-long jet-powered remotely-piloted vehicle (RPV), has demonstrated the subsonic airworthiness of the "waverider" shaped aircraft.

The LoFLYTE™ program is designed to provide a technology testbed for many emerging aerospace technologies with initial emphasis on neural network controls. The LoFLYTE™ jet completed its first flight on December 16, 1996, at Mojave Airport after completing design, airworthiness, and flight safety reviews required by NASA and the U.S. Air Force. LoFLYTE™ is flown at Edwards Air Force Base in California. Flight testing using neural network controls will begin in late 1997. This small jet-powered aircraft will demonstrate neural network control and sensing technology. The LoFLYTE™ concept was first tested at NASA Langley Research Center as a wind tunnel article with 191 runs in both the 12-Foot Low Speed Tunnel and 30 x 60 foot wind tunnels. The present LoFLYTE™ shape is the same size as the wind tunnel article. In addition, the Naval Postgraduate School in Monterey,

LoFLYTE™ banks after take-off.

California, did water tunnel flow visualization tests and tested a 72-inch-long drop model.

Accurate Automation Corporation, of Chattanooga, Tennessee, was selected as the contractor for LoFLYTE™ under the NASA and U.S. Air Force Small Business Innovation Research (SBIR) Programs. The LoFLYTE™ RPV will eventually become an unmanned autonomous vehicle (UAV). The shape of LoFLYTE™ is based upon a high lift/drag Mach 5 configuration. The actual shape takes advantage of engine/body integration and was derived from a Mach 5 conical flowfield. The LoFLYTE™ vehicle demonstrates clearly how rapid prototyping can build flight-quality hardware inexpensively. It also features onboard subsystems, including an advanced real-time airborne data acquisition and control system with 16 channels of analog sensor input as well as 14 channels of control telemetry, GPS for position, retractable landing gear, video and spread spectrum communications to the ground.

LoFLYTE™ will eventually fly the Accurate Automation Neural Network Processor and Neural Air Data Subsystem. This 72 pound aircraft is powered by a 38 pound thrust jet engine built by SWB Turbines. An advanced engine controller will be tested for future use with this miniature JP-8 fueled engine.

The LoFLYTE™ Mobile Ground Control Station provides the flight test team with all of the facilities needed to conduct flight testing, including all aircraft maintenance and safety equipment, computers for telemetry and data recording, and a weather station.

Some of the technologies that will be tested with the LoFLYTE™ aircraft include:

- Rapid Aircraft Prototyping and Design Concepts
- Aircraft Instrumentation
- Fault Diagnosis and Isolation Techniques
- Real-time Airborne Data Acquisition, Control System and Video
- Miniature Spread Spectrum Telemetry
- Antenna Placement
- EMI Minimization
- Tiperons
- Neural Network Flight Controls
- Interface for the Neurocontrol With Flight and Propulsion Control
- Neural Air Data Subsystem for Determining Angle of Attack, Sideslip, and Velocity
- Advanced Nozzle Concepts
- Various TitaniumAlloy Parts With Subsequent Non-destructive Evaluation
- Adaptive Compensation for “Pilot-induced Oscillations”
- Trajectory Control
- Advanced Landing Concepts

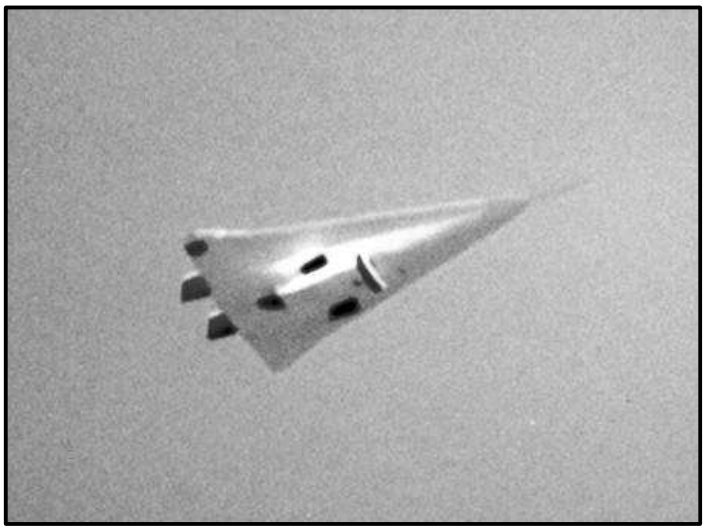
Neural Network Flight Controls

The LoFLYTE™ Neural Network Flight Control System is an important advance in aerospace technology because of the adaptive nature of the control system. The controller is designed to learn as it flies, so the control system, not the pilot, determines the most effective commands to give the plane for a particular situation.

During normal flight, the neural controller will use the data it receives from the telemetry system to compute the most efficient flight characteristics and adjust the control surfaces accordingly. However, where the neural control system has an enormous advantage over traditional control systems is during abnormal and unexpected flight conditions. For example, if the control system determines that the rudder is not responding, it will adjust quickly to control the aircraft using the remaining flight surfaces. Neural network control is necessary in hypersonic vehicles where the center of gravity of the vehicle can change significantly throughout the flight. The neural network can adjust to changing flight conditions faster than a human pilot, greatly enhancing the safety of the aircraft.

The neural network control system, designed and manufactured by Accurate Automation Corporation, is based on the company's successful Neural Network Processor (NNP®), also funded under the SBIR program. The NNP® is a multiple instruction/multiple data (MIMD) system that can be used in personal computers as well as aircraft.

Accurate Automation's Neural Network Processor.



LoFLYTE™ flying over the pilot's position on the flight of June 23, 1997.

The LoFLYTE™ fiber-optic "Fly-by-Light" communications offer lighter weight, increased transmission capability and safety from electrical system short circuits and EMI problems.

The LoFLYTE™ telemetry captures the data from the instrumentation in real-time and displays it for operational decisions during flight and transmission to remote sites.

Future Versions of LoFLYTE™

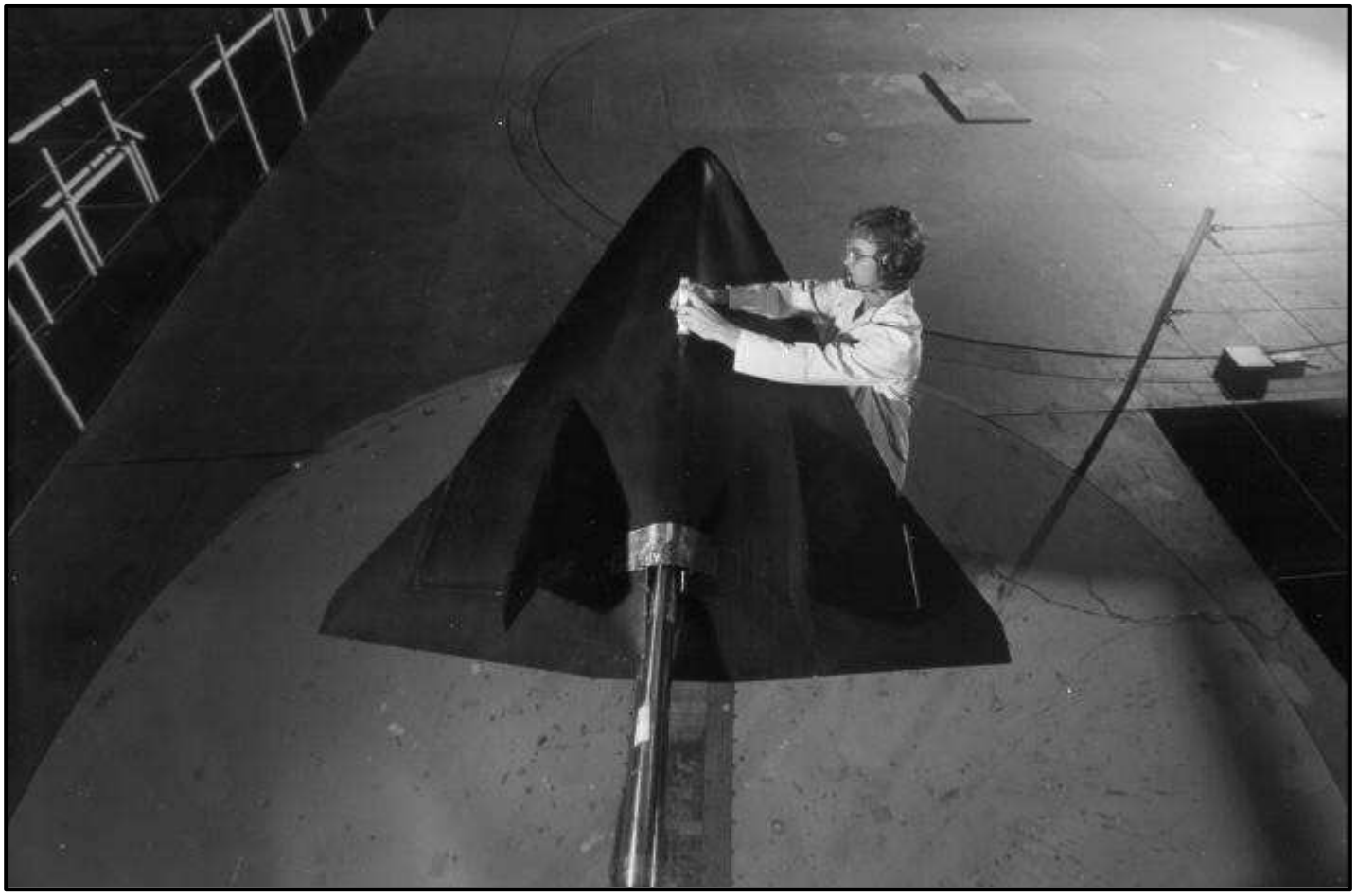
Once testing of the 100-inch version of LoFLYTE™ is concluded, a larger transonic version may be developed to explore supersonic flight characteristics of the waverider shape. This larger version will include a unique hypersonic flowpath configuration. Other hypersonic aerodynamic shapes will be tested using the LoFLYTE™ subsystems.

An advanced engine controller is being developed for ramjets under NASA Lewis Research Center's SBIR program. This controller will be tested on the LoFLYTE™ vehicle with the current turbine.

An advanced autolanding system is being developed for NASA Ames Research Center, under SBIR, that may be tested with LoFLYTE™.

Small Business Innovation Research

The objective of NASA's Small Business Innovation Research Program is to stimulate technological innovation in the United States by using small business, including minority and disadvantaged firms, to help meet Federal research and development needs.



One of 191 wind tunnel tests conducted at NASA Langley Research Center to test the airworthiness of the LoFLYTE™ waverider shape.

This is the 15th year of the NASA SBIR program, which allocates 2.5 percent of NASA's research and development budget to support SBIR.

NASA Langley Research Center, the U.S. Air Force and LoFLYTE™ were awarded the Small Business Administration's National Tibbetts Award in 1996.

Glossary of Terms

conical flowfield. The cone-shaped shockwave generated by a supersonic or hypersonic vehicle.

hypersonic. Operation at Mach numbers exceeding 4.

neural network. A class of computational methods that loosely imitate the function of the brain. Among the benefits of neural networks are that they learn from experience, can generalize from their data set, are fault tolerant, and can exploit parallel systems for rapid processing.

pilot-induced oscillations. A condition of aircraft uncontrollability caused when pilot's intent and the control system get out of sequence, forcing the plane to swing back and forth, often with disastrous results.

supersonic. Operation between Mach 1 and Mach 4.

waverider. A type of supersonic or hypersonic aircraft where the vehicle takes advantage of the shockwave flowfield, instead of cutting through it, increasing lift and reducing drag.

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