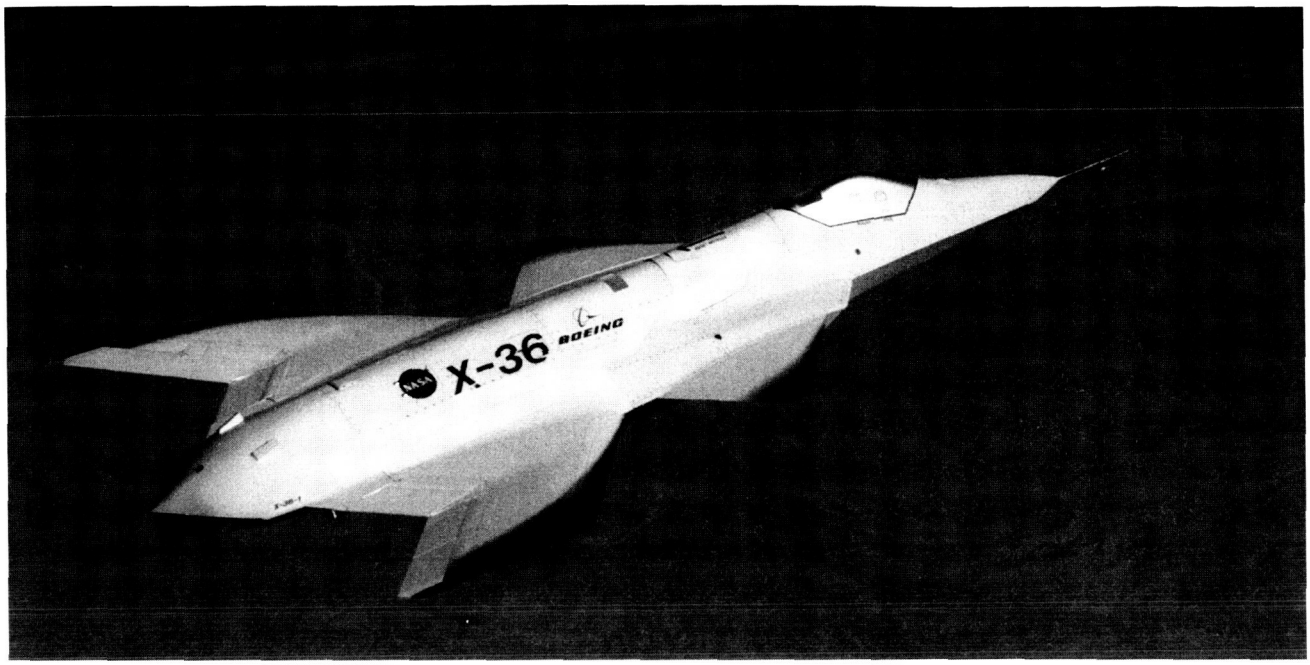

Fig. 1. The X-36 Tailless Fighter Agility Research Aircraft in flight over Rogers Dry Lake bed, Edwards Air Force Base, California.

show that the X-36 aircraft successfully demonstrated that a tailless aircraft can achieve levels of agility and maneuverability exceeding those of present-day fighters.

The X-36 is also an excellent example of how subscale, remotely piloted aircraft can demonstrate advanced technologies at a fraction of the cost and development time required by full-scale aircraft with the pilot aboard. The X-36 Project was a complete success and provides a preview of what fighter aircraft of the future will look like.

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Aeronautics Design/Test Environment Condition-Based Maintenance for the 12-Foot Pressure Wind Tunnel

Ann Patterson-Hine

In support of the Aeronautics Design/Test Environment effort to enhance operations at wind tunnel facilities, researchers collaborating with wind tunnel experts implemented a software application to monitor system performance and to diagnose anomalous behavior in the make-up air (MUA) compressor subsystem of the 12-Foot Pressure Wind Tunnel at Ames Research Center. This project combined the efforts of the System Health Management team, the Ames Fluid Mechanics Laboratory, and the Applied Research Laboratory at Pennsylvania State University. Condition-based maintenance (CBM) can increase facility efficiency by reducing or eliminating costly repairs required because of unnecessary maintenance and failures. CBM is a systematic approach that focuses on continuous monitoring of equipment combined with model-based reasoning software to indicate the need for maintenance that, if ignored,

could lead to failure. Unlike a traditional maintenance program based on manufacturers' time and performance statistics, the condition-based approach determines when maintenance is required based on actual conditions. It can provide advanced warning of possible failures by estimating "remaining useful life" for the component rather than warning only of imminent catastrophic failure. Such advanced warning allows efficient scheduling of downtime.

A Solatron data-acquisition system was installed in the MUA compressor subsystem of the Ames 12-Foot Pressure Wind Tunnel, along with a Rule-Based Expert System (RBES) constructed using RTWorks, an off-the-shelf application that simplifies the process of building complex mission-critical systems. The RBES was encoded with expert knowledge in vibrational analysis and other critical parameters, which then evaluated the monitoring data received and provided wind tunnel operators with alerts of off-nominal behavior. Once the system is tuned properly and the nominal behavior of the compressor is characterized, it will also be used to determine recommendations for system maintenance, including estimates of the remaining useful life of various system components, as shown in the figure. This system was successfully installed in September of 1997 and continues in operation, demonstrating the feasibility of condition monitoring of complex machinery such as that used in wind tunnels. This technology has widespread application not just to all of NASA's tunnels, but to aerospace vehicles at large.

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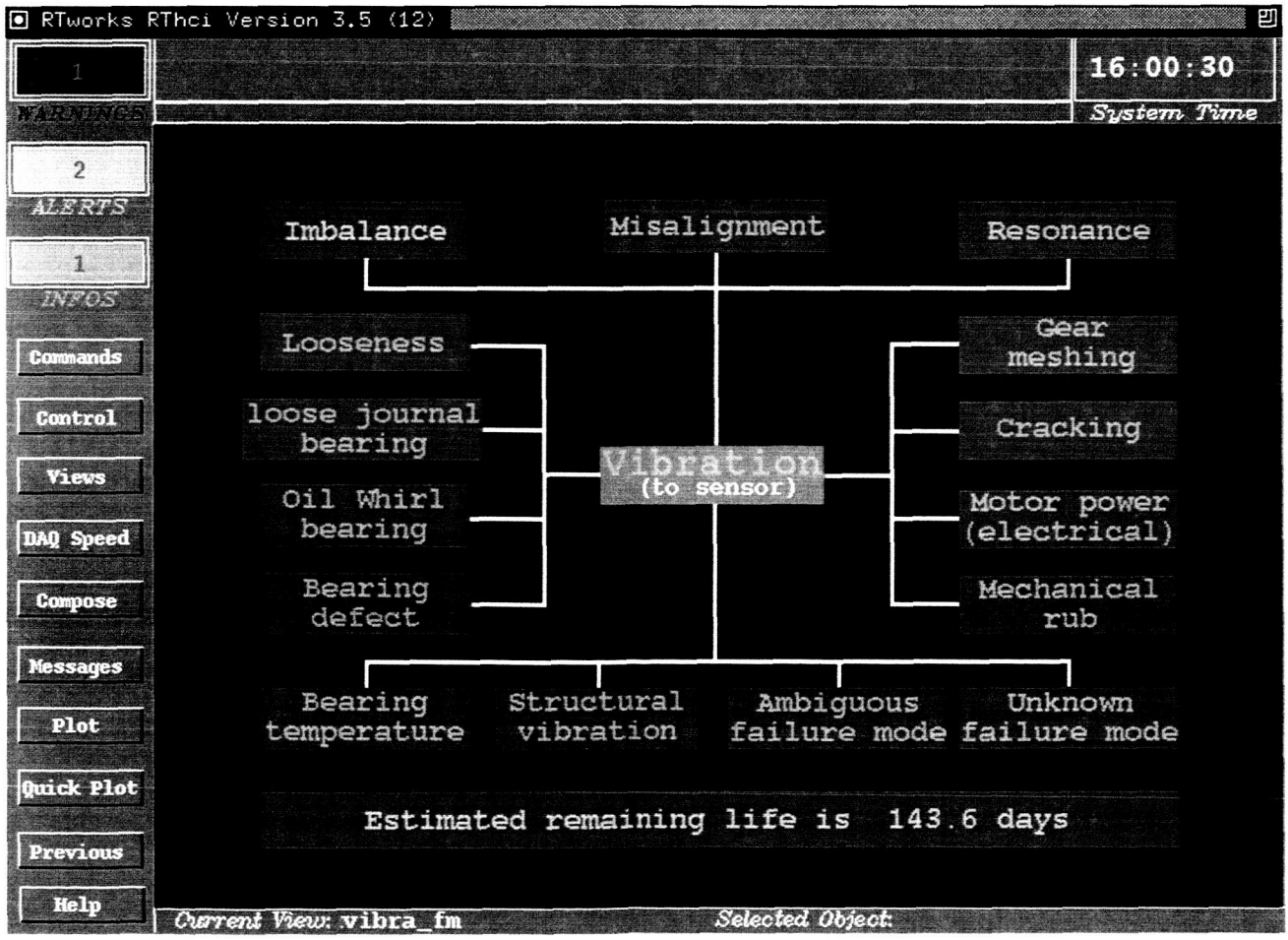

Fig. 1. Vibration monitoring system failure mode summary window.