

NASA's First Hypersonic Research Aircraft: The X-15's Lessons for GN&C, Safety, and Systems Engineering

Jeb S. Orr, Mclaurin Aerospace

This lecture provides an engineering-focused introduction to the X-15 research aircraft, a rocket-propelled spaceplane developed jointly by the United States Air Force, NASA, and the United States Navy and operated at the NASA Flight Research Center (now NASA Armstrong) from 1959-1968. Over the course of almost ten years, 199 flights were conducted in three X-15 aircraft, setting numerous records for winged vehicle speed and altitude. Numerous advancements in aerospace technology were the direct result of research and development performed in support of the X-15 program.

In the first part of this two-part lecture, a detailed introduction to the aircraft systems will be provided. In the second part, a discussion-based analysis of the fatal in-flight breakup of X-15 flight 3-65-97 will be presented. This incident remains the only departure from controlled flight of a single-pilot aircraft in a hypersonic flight regime. The interaction of the guidance, navigation, and control (GN&C) systems, the pilot, and the ground crew are given special focus. These and other engineering and programmatic factors have numerous implications in systems engineering and space safety.

Part I. The X-15 Research Airplane	Part II. The 1967 X-15 Accident
<ul style="list-style-type: none">• Mission profiles and research objectives• Structures, aerodynamics, and TPS• Propulsion, power, and life support• Instrumentation and flight control• Pilot factors• Range support and operations	<ul style="list-style-type: none">• Analysis of subsystem failures• Human factors and pilot performance• GN&C, autonomy, and adaptive control• Operational and cultural factors• Observations and recommendations• Major themes and insights

Target Audience

This lecture is targeted toward practicing engineers, operations personnel, and program managers. The material assumes a basic understanding of aircraft and spacecraft systems. However, fundamental insights are accessible to non-technical personnel. Useful background material for this lecture includes the text X-15: Extending the Frontiers of Flight by Dennis R. Jenkins, NASA SP-2007-9-001-HQ, which is freely available for download on the NASA website.

About the Speaker

Jeb S. Orr is a Principal Staff Engineer at Mclaurin Aerospace, where he performs analysis and design of flight control systems for launch vehicles and spacecraft. Dr. Orr serves as the Space Launch System (SLS) flight control Technical Specialist at NASA Marshall Space Flight Center. He holds a BSE in Computer Engineering and an MSE and PhD in Control from the University of Alabama in Huntsville. He is an instrument-rated private pilot with more than 1000 flight hours in 10 types of aircraft.

In 2014, Dr. Orr served as the technical lead for an independent assessment of the 1967 X-15 accident by the NASA Engineering and Safety Center (NESC).