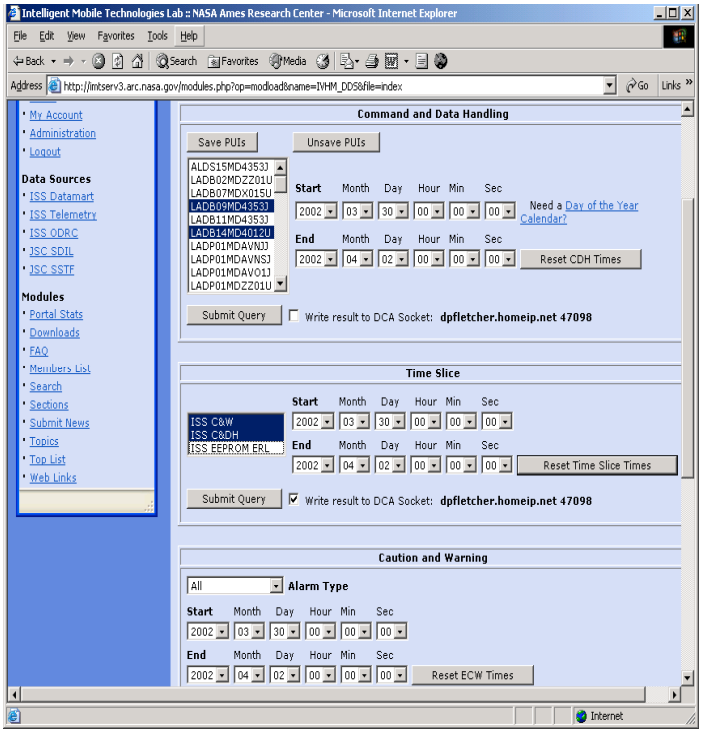

# Advanced Diagnostic Systems for ISS

NASA Ames and Johnson Space Center collaborate to develop next-generation capabilities for enhanced space vehicle management. The focus is on real-time subsystem monitoring, fault detection, advanced diagnosis and adaptive recovery for International Space Station (ISS) flight systems. The objective is to quantify the effort needed to develop such tools, and to demonstrate specific benefits by evaluating prototype tool suites during actual mission operations.

## Background

The Advanced Diagnostic System (ADS) project was an extension of earlier work for the development of the Databus Analysis Tool (DAT) for on-orbit ISS avionics databus monitoring for assisting Station assembly and checkout operations in low earth orbit. The ISS uses flight computers connected together using the Mil-Std 1553 avionics databus for critical control and monitoring of Station subsystems. Prior to the first Station assembly flight, the Program recognized the need for on-orbit diagnostic tools for contingency troubleshooting if problems were detected. DAT allows monitoring of Mil-Std 1553 databuses, the nerve system of ISS, allowing engineers to track the functions of the Command and Data Handling system. The DAT was employed during the successful checkout of the Control Momentum Gyros during STS-92 in October 2000. Astronauts Bill McArthur and Leroy Chiao used the DAT to power and spin-up each of the gyros on the Z1 truss prior to installation of the US Lab module that would ultimately control the gyros, used for stabilizing ISS attitude while orbiting the earth. The DAT is currently manifested aboard ISS for use should the need arise.

Another associated development, the Diagnostic Data Server (DDS) provides standard web-based access to a large, well-indexed repository of Station vehicle telemetry data. It has the capability to provide context-sensitive search for datasets meeting diagnostic developer's criterion for nominial and off-nominal telemetry specific to the Station subsystem being studied. DDS can provide streaming network data from historical archives, avionics testbeds and even from the real ISS vehicle. The DDS is intended to facilitate the work of Advanced Diagnostic System (ADS) researchers by providing facile access to a variety of high-fidelity vehicle datasets from disparate sources, significantly reducing the time and effort required to interface new applications to ISS telemetry.




## Research Overview

The ARC Computational Sciences Division is working with the International Space Station Program for the development and evaluation of Advanced Diagnostic Systems (ADS). The ADS project studies the process for the development of model-based reasoning tools for Space Station real-time fault detection, isolation and recovery systems (FDIR), providing support to researchers interested in vehicle system anomaly resolution, mission management and critical decision support. The ADS project collaborates with researchers developing tool suites for Station Operations by building computational models of Station subsystems which can provide enhanced insight into failure modes and states.

# Advanced Diagnostic Systems for ISS

A key element of the ADS project is interactive discussion, prototype development and demonstration involving domain experts from the ISS Program that have designed the systems being analyzed or are directly involved in the management of ISS subsystems, such as avionics software engineers, system engineers and flight controllers and crewmembers. One result has been that while the techniques being matured, such as model-based diagnostics, surely provide benefit, how these techniques are specifically applied within the context of current operational practice and current tools and mission control systems is critical to adoption and use by the flight programs. The development approach is truly collaborative by bringing algorithm and tool developers together with the actual users of these innovations during the operational concept development phase through to the prototype evaluation phase, yielding a much better match of product capability to user needs.

The ADS project has sponsored the development of several prototypes addressing different ISS subsystems such as Electrical Power System and Thermal Control System, each using a different diagnostic modeling approach. An ADS prototype is being developed for the International Space Station's Command and Data Handling system (C&DH), consisting of 30 computers in a three-tiered network responsible for the commanding and data acquisition of all other subsystems on ISS including propulsion, electrical, life support, and communications and navigation. The technology is designed to reduce ISS operations costs and increase safety by extending the current Caution and Warning system with model-based diagnosis methods to classify caution and warning events by root cause, which can be hardware and software. This will be accomplished by explicitly modeling the information flow between variables in memory and across computers in a similar manner of modeling the fluid flow in a network of components and pipes.

Other ADS prototypes include a physics model of the electrical power system, a logical model of interactions between power, command and thermal subsystems and a dependency model of the databus. The project continues to work with partners for development of diagnostic and mission management tools relevant to ISS and future space vehicles.

## Relevance to Exploration Systems

The ADS project uses ISS as a testbed for future vehicle health management technologies, which promise to significantly extend the capabilities for managing complex multi-element systems at lower cost while increasing safety and resource margins. Further alignment with mission management efforts will increase the potential benefits.

### *H&RT Program Elements:*

This research capability supports the following H&RT program elements:

ASTP/Software, Intelligent Systems & Modeling

TMP/Advanced Space Operations

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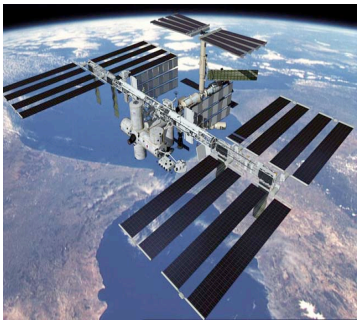

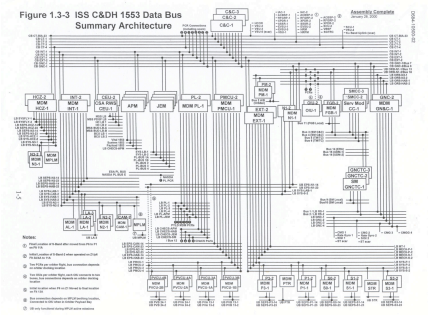


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