National Aeronautics and Space Administration

Cover Blown:
WIRE SPACECRAFT MISHAP

Leadership ViTS Meeting

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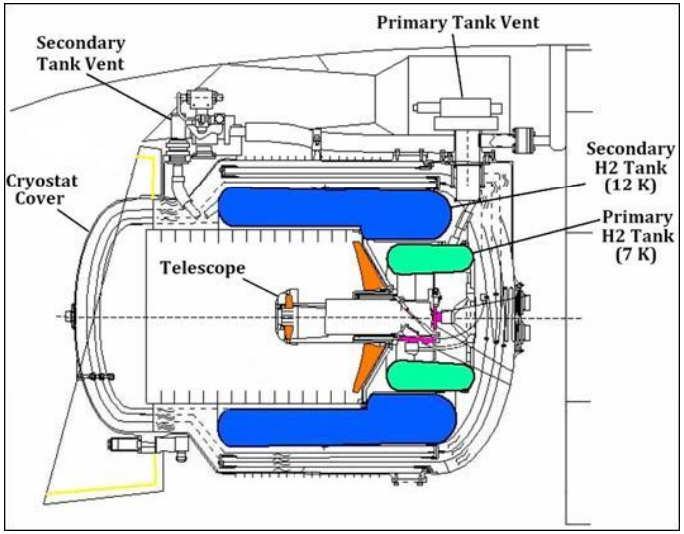
THE MISHAP

The Wide-Field Infrared Explorer (WIRE) spacecraft was part of NASA's Small Explorer Program (SMEX). Its primary mission was a four month infrared survey of starburst galaxies and luminous protogalaxies. Scientists hoped to use data collected by WIRE to measure starburst galaxy growth rates and gain a better understanding of how these galaxies form and evolve.

- WIRE's design included **two tanks of frozen hydrogen** to keep equipment cool and eliminate interference with faint infrared signals.
- A "**pyro box" controlled pyrotechnics** that would open onboard hydrogen tank vents, then jettison the cryostat cover later in the mission to allow telescopic observations.



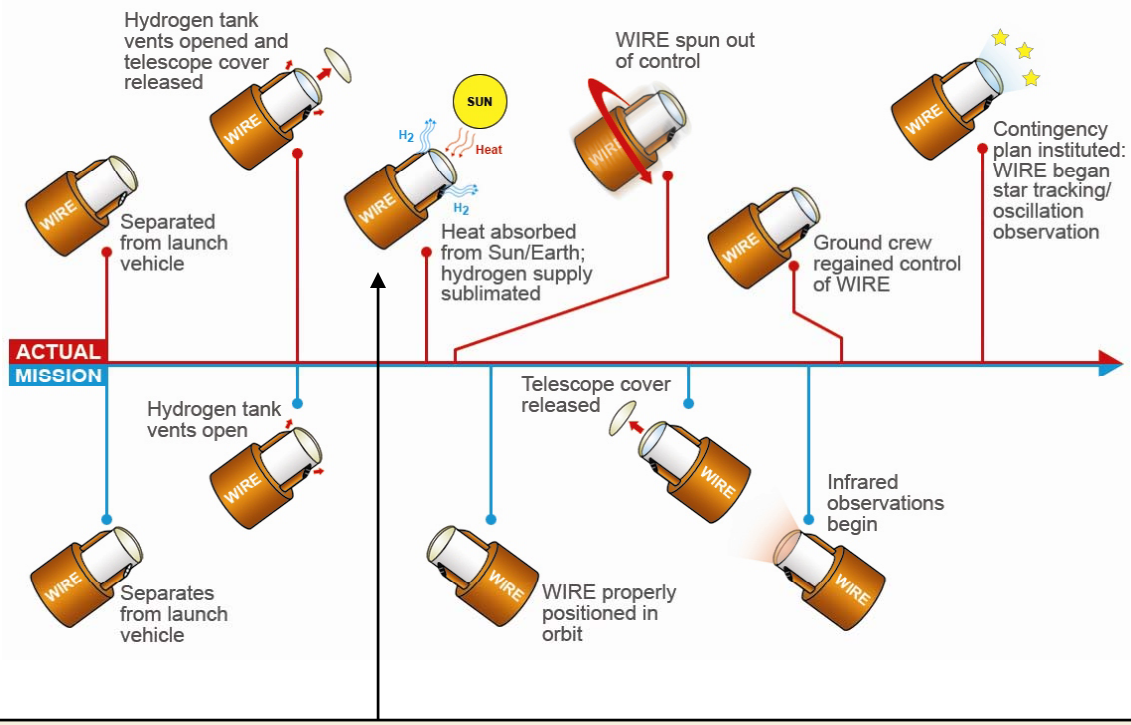
After WIRE attained orbit on March 4, 1999, a transient signal prematurely fired pyrotechnic devices that released the cryostat cover, exposing the spacecraft interior to solar heating. All onboard frozen hydrogen supplies for the four-month mission sublimated within thirty-six hours of launch. This coolant loss disabled telescope function and sent the spacecraft into an uncontrolled spin.

WHAT HAPPENED?

Planned Mission Timeline vs. Actual Events

Early Warnings

Transient signals had improperly fired the pyro devices during testing. After analyzing the set-up, the team incorrectly concluded that false signals from the test simulator triggered firing, not signals from the pyro box itself.



The Transient Signal

•**Components within the pyro box had variable power-on (rise) times**, which increased as the components' unpowered time interval increased. Until all of these components were fully powered on, pyro box outputs were unpredictable and not controlled. When the WIRE spacecraft separated from its launch vehicle and began its mission, the pyro box had been unpowered for two weeks.

•As the pyro box powered on, **a transient electronic signal fired the pyrotechnic devices** and released the cryostat cover prematurely.









PROXIMATE CAUSE

As the pyro box started up, its internal components were uncontrolled for several milliseconds. During this time a transient electronic signal prematurely fired the pyro device which released the cryostat cover. Without a cover, the interior of the cryostat was exposed to heat loads 100 times larger than anticipated, causing the frozen hydrogen to sublimate. Without the hydrogen coolant, the infrared telescope could no longer distinguish between signal and noise.

ROOT CAUSE / UNDERLYING ISSUES

Failure to Consider Off Nominal Conditions:

- The pyro box did not adequately account for the transient performance of its components.
- Designers assumed that pyro box components would always function per steady-state characteristics.
- Circuitry design lacked barriers to block uncontrolled, transient outputs to the pyrotechnics.

Lack of Peer Review Due to Communication Failures and Management Turnover

- No pyro box design review was done due to miscommunication during a management turnover.
- Professing a motto of “insight, not oversight,” neither organization ensured peer reviews took place.

Incomplete Test Procedures and Analysis:

- Low-fidelity tests did not adequately simulate live pyro configuration.
- During testing, the pyro box was powered on almost every day, never allowing residual charges to fully bleed off. Before launch, the pyro box had been powered off for nearly 2 weeks.
- Test irregularities were attributed to the simulator, which was considered unreliable during start up.

“The underlying theme of this mishap is that the ideal models of components do not match their actual behavior.” - WIRE MIB, 1999

FOR FUTURE NASA MISSIONS

Project Management

- Consider all mission activity sequences, including non-steady-state operations and start-up/shut-down procedures.
- Require detailed, independent technical peer reviews; hold reviews as often as necessary.
- Ensure that action items are tracked to closure.
- Take extra steps to prevent miscommunication and conflict when multiple, complex interfaces exist over major organizational boundaries.

Testing & Design

- "Test as you fly; fly as you test."
- Do not assume that devices will perform per designed logic at all times, especially given contrary evidence. Account for all possible anomaly causes.
- Consider off-nominal conditions and worst-case scenarios during testing and design.
- Build margin into designs and understand how to prevent deviating conditions from causing mission failure.