Lessons Learned,
A Project Manager's Perspective

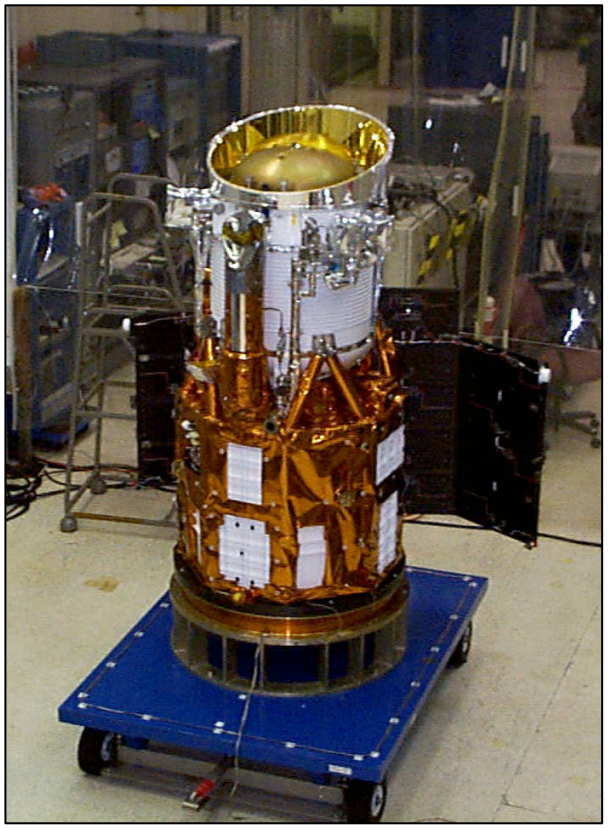
Bryan Fafaul

November 8, 2011

WIRE Case Study / Glory Experience

Do NOT Launch on March 4th

WIRE
March 4, 1999



Glory
March 4, 2011

WIRE MRR

January 28, 1999

Mission Description

- The Wide-field Infrared Explorer (WIRE) will be used to conduct a deep infrared, extra galactic science survey 500 times more sensitive than the Infrared Astronomy Satellite (IRAS) Faint Source Catalog. The WIRE instrument is provided by the Jet Propulsion Laboratory and teaming partner, the Space Dynamics Laboratory of Utah State University. The instrument consists of a cryogenically-cooled, 30 cm telescope which will detect faint astronomical sources in two infrared wavelength bands. The WIRE spacecraft bus is provided by the GSFC and is based on the SMEX SWAS spacecraft bus design. The spacecraft bus utilizes an all composite structure and the first of the SMEX•Lite modular solar arrays as part of the Explorer Project's technology infusion program. The WIRE spacecraft will be placed into a 540 km Sun-synchronous orbit using OSC's Pegasus XL launch vehicle in late February, 1999

WIRE MRR

January 28, 1999

Instrument Development Organization

SCIENCE TEAM

Nick Gautier, JPL
Paul Graf, BASG
Terry Herter, Cornell
Jim Houck, Cornell
Carol Lonsdale, IPAC
Harvey Moseley, GSFC
David Shupe, IPAC
Tom Soifer, Caltech
Gordon Stacey, Cornell
Mike Werner, JPL

WIDE-FIELD INFRARED EXPLORER

Perry Hacking, JSE, Principal Investigator
Tom Luchik, JPL, Project Manager
Carol Lonsdale, IPAC, Deputy Project Manager
JET PROPULSION LABORATORY

GSFC/SMEX WIRE TEAM

Jim Watzin, Project Manager
Bryan Fafaul, Mission Manager
Dave Everett, Spacecraft System Engineer
Leroy Sparr, Instrument Systems Engineer/COTR

SCIENC AND ENGINEERING STAFF

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Data Analysis — Tim Conrow, IPAC
R L h IPAC
Olga Pevunova, IPAC
Science St dies — Fan Fang, NRC
Cong Xu, IPAC

Virginia Yoshioka, ADMINISTRATION
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Teresa Alfery, PROCUREMENT
Steve Giacoma, COST ANALYSIS

ENGINEERING ASSURANCE

Bob Axsom, PRODUCT ASSURANCE
Darrell Schmit, SYSTEM SAFETY

WIRE INSTRUMENT

Harry Ames, Instrument Program Manager
John Kemp, Instrument Engineer
UTAH STATE UNIV/SPACE DYNAMICS LABORATORY

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John Kemp, SDL

CRYOGEN SYSTEM
Scott Sch ck, SDL

OPTICAL SYSTEM
Duane Miles, SDL

ELECTRONICS
Wally Gibbons, SDL

CRYOGENIC OPERATIONS
Scott Schick, SDL

INSTRUMENT ENGINEERING
John Kemp, SDL

BOEING
NORTH AMERICAN
Bill Armstrong

LOCKHEED MARTIN
ADVANCED TECH CENTER
Brenda Co stanzo

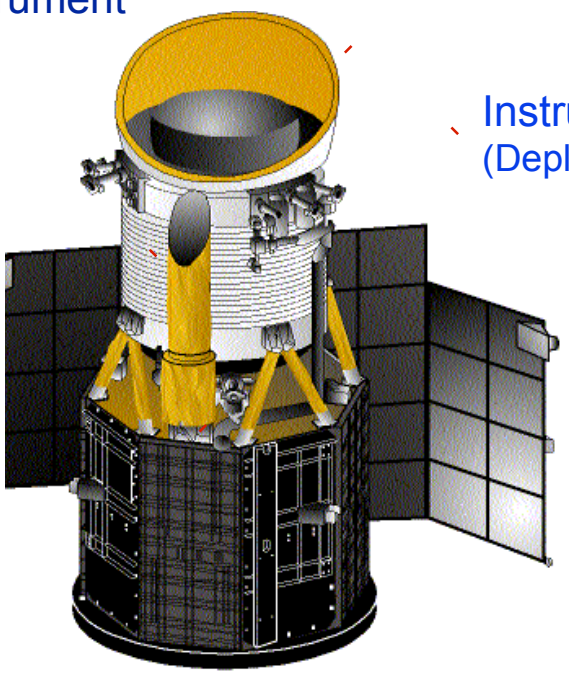
MECHANICAL SYSTEMS
Mehrdad Roosta, SDL

WIRE MRR

January 28, 1999

Instrument

- Dual stage cryogenically cooled infrared telescope
- Solid hydrogen cryogen - 4 to 6 month useful life
- Cassegrain optics



Spacecraft

- 3-axis stabilized fine pointer
- Autonomous on-orbit operations
- IPAC provided target observation plan
- Avionics identical to TRACE
- SMEX•*Lite* modular solar arrays
- All composite spacecraft bus
- Software system TRACE/SWAS pedigree
- ITOS ground system same as TRACE and SWAS

WIRE MRR

January 28, 1999

Mission Historical Summary

- SMEX Mission Set #2 selections announced 9/93
- Competitive Definition Phase followed, resulting in WIRE being selected as the fifth SMEX mission in 12/94
- Development Phase started in 10/95 after a one year mission phasing delay (cost saving measure)
- Spacecraft bus integration began 10/97 with the delivery of the flight qualified primary structure and was completed in 1/98 with the integration of the flight instrument electronics
- Cryostat assembly underwent separate environmental test program at LMATC/SDL prior to delivery to GSFC. High fidelity thermal and mass simulators were used with spacecraft prior to cryostat delivery
- Cryostat arrived at GSFC 5/98, was integrated with the spacecraft, and completed remaining observatory environmental testing

WIRE MRR

January 28, 1999

Mission Historical Summary (continued)

- The WIRE spacecraft successfully conducted environmental test program (3/98-6/98)
  - EMI/EMC testing
  - Vibration testing
  - Thermal balance/thermal vacuum testing
  - Acoustics testing (with cryostat)
  - Magnetic calibration (with cryostat)
  - Comprehensive performance testing (with cryostat)
  - Numerous L&EO and nominal science mission operations simulations
- Extensive functional testing after each environmental test has been performed to insure proper function of the spacecraft

WIRE MRR

January 28, 1999

Mission Historical Summary (continued)

- Mission followed traditional GSFC review cycle with additional instr. reviews
  - Detailed instrument reviews -- conducted by JPL
    - FPA and Electronics 2/28/96
    - Science 3/1/96
    - SO&DA 3/4/96
    - Cryostat 3/6-7/96
    - Safety 3/8/96
    - Electronics 3/12/96
    - Optics 3/12/96
    - Instrument I&T 3/13/96
    - Instrument Single Design Review 3/19-20/96
    - Instrument Pre-Environmental Review 5/29/97
  - Instrument Pre-Ship Review 5/6/98
- Mission reviews -- conducted by GSFC
    - Single Design Review 5/21-23/96
    - Pre-Environmental Review 2/23/98
    - Flight Operations Readiness Review 7/21/98
    - Pre-Ship Review 7/22/98

WIRE MRR

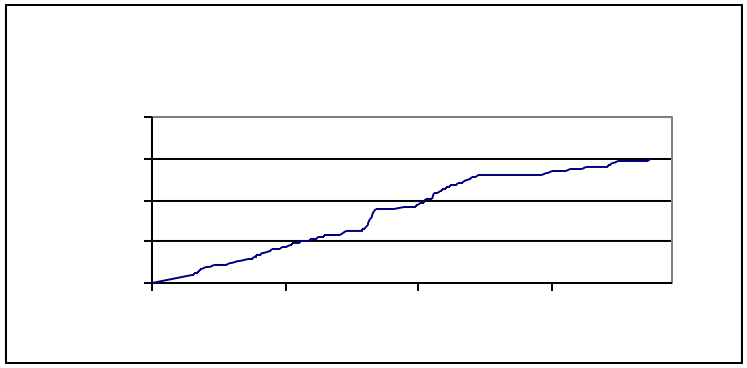
January 28, 1999

Observatory Status

- All observatory electronics now have accumulated ~1500 hours of trouble-free testing
- There are NO open anomalies against observatory, GSE, or ground system
- There are NO critical safety verifications open
- All launch site safety documentation and procedures are signed-off by all parties, including the range
- Spacecraft and GSE shipped on January 15, 1999, arrived at VAFB, California January 18, 1999, using standard SMEX practices
  - Air ride, environmental controlled tractor trailer
  - Shock mounted, enclosed, instrumented, N2 purged shipping container

Operating Hours as of January 22, 1999

Component	Total Hours Prior to PSR	Total Hours Since PSR	Total Hours
SPE/Shunt Box	1100	384	1484
SCS	1100	384	1484
ACE	861	321	1182
Receiver	650	384	1034
Transmitter	300	209	509
A Wheel	580	226	806
B Wheel	592	227	819
C Wheel	511	170	681
Y Wheel	829	298	1127
Gyro 1	416	97	513
Gyro 2	422	175	597
Gyro 3	465	231	696
WIE	450	244	694
Pyro Box	120	5	125
Star Tracker	100	5	105
WAES	550	224	774



Internal / External Lessons Learned

There are six key lessons learned from the WIRE failure:

1. Proper application of FPGAs
2. Proper Peer Reviews
3. Effective closed-loop tracking of actions
4. Managing across organizational boundaries
5. Extra vigilance required when deviating from full system end-to-end testing
6. System design must consider both nominal and off nominal scenarios

United States General Accounting Office

GAO

Report to the Subcommittee on Space and Aeronautics, Committee on Science, House of Representatives

January 2002

NASA

Better Mechanisms Needed for Sharing Lessons Learned

Table 1: Reasons for Spacecraft Failures

Reasons for Failure	Major Program Reviews			Major Mishap Reviews							
	Broad Area Review	Lockheed Martin Independent Assessment Team	Faster, Better, Cheaper Task Force	WIRE[a]	Mars Climate Orbiter	Mars Polar Lander	Lewis	SOHO[b]	Mars Observer	DC-X[c]	Challenger
Cost and Schedule Constraints	•			•			•		•		•
Insufficient Risk Assessment and Planning		•	•		•	•	•	•	•	•	•
Underestimation of Complexity and Technology Maturity	•		•				•	•	•		
Insufficient Testing			•	•	•		•		•	•	•
Poor Team Communication	•	•	•	•	•	•	•	•			•
Inattention to Quality and Safety	•	•	•		•						•
Inadequate Review Process	•	•	•	•	•	•	•	•		•	•
Design Errors	•			•	•	•			•	•	•
Inadequate System Engineering	•	•	•	•	•	•	•	•	•		
Inadequate or Under Trained Staff	•	•			•	•		•	•	•	•

GAO – Lessons Learned Report

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Inadequate or Under Trained Staff	•	•			•	•		•	•	•	•

Common Findings / Observations

- Cost / Schedule Constraints
- Insufficient Testing
- Poor Team Communication
- Inadequate Review Process
- Design Errors
- Inadequate Systems Engineering

Summary

- The Scientist needs to get involved and stay engaged
- Everyone is a Systems Engineer like it or not
- Success / Protection comes in layers
- Listen to every opinion, especially the tough ones
- Make the good technical decisions first
- Understand programmatic trades / risks
- Recognize “Management Anomalies” and do something
- Don’t be afraid to speak-up
- Be proactive, make a positive difference