

# **An Introduction to the 2012 NASA FM Workshop: Background, Logistics, Scope, Goals**

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Jet Propulsion Laboratory  
California Institute of Technology

April 10, 2012

## Acknowledgements

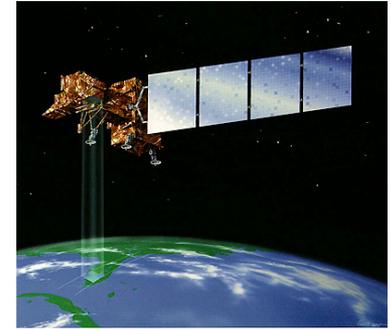
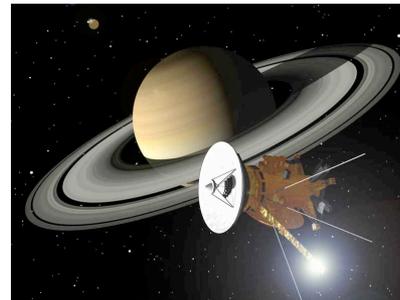
- Venue arrangements: Pauline Burgess and Michelle Hensen, NRESS
- Steering Committee
  - Lindley Johnson, HQ/SMD – sponsor for this workshop and FM Handbook
  - Neil Dennehy, GSFC/NESC – co-sponsor of FM Handbook
  - Steve Scott, GSFC/OCE
  - Brian Muirhead, JPL/OCE
  - George Cancro, APL
  - Pat Martin, HQ/OSMA
  - Tim Crumbley, MSFC/OCE and Standards Office Manager
  - Ken Ledbetter, HQ/OCE
  - Carlos Garcia-Galan, JSC/MOD
  - Jeri Briscoe, MSFC/DNF
  - Frank Groen, HQ/OSMA
- FM Architecture Trade Session Leads: Kevin Barltrop (JPL), David Garlan (CMU), John Day (JPL)
- FM Capabilities Roadmap Session Leads: Ken Costello (IV&V Facility), Mitch Ingham (JPL)
- Facilitators: Daria Topousis, Chris Eng, Alex Kadash (JPL)

# Welcome to the 2012 NASA Spacecraft Fault Management Workshop!

- ~120 attendees
- >30 organizations from government, industry, academia
- 4 NESC Technical Fellows and members of the SE TDT
- Media
  - Photos by NESC
  - Video capture by NSC, to be posted on NASA Engineering Network ([nen.nasa.gov](http://nen.nasa.gov))
  - Webcast by NSC (welcome, NSC STEP participants and ESA colleagues!)
- Now, a word from our Sponsor, Lindley Johnson, NASA SMD/PSD Discovery Program Executive

## 2012 Scope

- FM, ISHM, FP, IVHM, SHM, FDIR, RM, HUMS
- HSM and OSMA focus this year
- Aeronautics, GS, MS next on the list



# Recent FM Developments

**Jul '08:** Constellation (CxP) identifies FM as potential risk; forms **FM Assessment/Advisory Team (FMAAT)** (B. Muirhead)

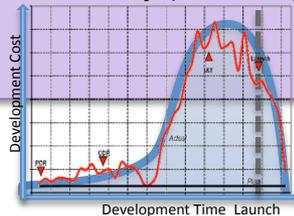
**Dec '09:** CxP publishes **FMAAT Position Papers** addressing key FM issues

**Jan '10:** CxP **establishes FM Team** within Level 2 SE org (M. Goforth)



**2006-2008:** FM causes cost overruns and schedule slips on multiple missions

**Apr '08:** SMD/PSD sponsors **S/C FM Workshop** (J. Adams)



**Mar '09:** FM Workshop **White Paper** published



**Jul '09:** NASA OCE endorses white paper; directs to **"Coalesce the field"** (M. Ryschkewitsch)

**Apr '10:** NESC/SMD launch **FM Handbook** – robotic focus (L. Johnson/N. Dennehy)

**Oct '10:** **FM CoP** established on OCE's NEN website – [nen.nasa.gov](http://nen.nasa.gov) (L. Fesq)

**Jul '11:** **FM Handbook Draft** delivered to NESC/SMD and NTSP and Centers for review. OCE directs to "coordinate robotic, HSF and OSMA concepts next"

**Apr '12:** SMD/PSD sponsors **2<sup>nd</sup> S/C FM Workshop** (L. Johnson)



# FM Handbook: Draft 2 – 4/9/12

[http://www.nasa.gov/offices/oc/documents/2012\\_fm\\_workshop.html](http://www.nasa.gov/offices/oc/documents/2012_fm_workshop.html)

1. SCOPE
  2. APPLICABLE DOCUMENTS
  3. ACRONYMS AND DEFINITIONS
  4. PROCESS
  5. REQUIREMENTS DEVELOPMENT
  6. DESIGN AND ARCHITECTURE
  7. ASSESSMENT AND ANALYSIS
  8. VERIFICATION AND VALIDATION
  9. OPERATIONS AND MAINTENANCE
  10. REVIEW AND EVALUATION
  11. APPENDIX A: REFERENCES
- APPENDIX B: FM CONCERNS WITHIN NASA
- APPENDIX C: FM FUNDAMENTAL CONCEPTS AND PRINCIPLES
- APPENDIX D: CONTENT GUIDE FOR MANAGEMENT STRUCTURE
- APPENDIX E: WORK TEMPLATE (TBS)
- APPENDIX F: RELEVANT NASA LESSONS LEARNED
- APPENDIX G: ACKNOWLEDGMENTS

 <b>NASA TECHNICAL HANDBOOK</b> National Aeronautics and Space Administration Washington, DC 20546-0001	<b>NASA-HDBK-1002</b> Approved: MM-DD-YYYY Superseding
	<b>FAULT MANAGEMENT HANDBOOK</b>
<b>DRAFT 2 – APRIL 9, 2012</b> This official draft has not been approved and is subject to modification. <b>DO NOT USE PRIOR TO APPROVAL.</b> <b>MEASUREMENT SYSTEM IDENTIFICATION: NOT MEASUREMENT SENSITIVE</b>	

# A community of practice is...



A group of people who “share a concern, a set of problems or a passion about a topic, and who deepen their knowledge and expertise in this area by interacting on an ongoing basis.”

-Etienne Wenger

# 2012 NASA SPACECRAFT FAULT MANAGEMENT WORKSHOP

April 10-12 2012  
New Orleans, Louisiana

## NASA Communities of Practice on the NEN website

The screenshot shows the NASA Engineering Network (NEN) website. At the top right, there are links for Sign In, Support, Feedback, Site Map, and About. The main header features the NASA Engineering Network logo and a navigation bar with links for HOME, OCE, LESSONS LEARNED, COMMUNITIES, and TOOLS & RESOURCES. Below the navigation bar, there are two columns of technical disciplines: TECHNICAL DISCIPLINE and MANAGEMENT DISCIPLINE. The TECHNICAL DISCIPLINE column lists: Aerosciences, Autonomous Rendezvous and Docking, Avionics, Electrical Power, Environmental Test & Verification, Fault Management, Flight Mechanics, Guidance, Navigation and Control, and Human Factors. The MANAGEMENT DISCIPLINE column lists: Life Support/Active Thermal Loads and Dynamics, Mechanical Systems, Nondestructive Evaluation, Passive Thermal Control and Protection, Propulsion, Software Engineering, Structures, and Systems Engineering. The MANAGEMENT DISCIPLINE column also lists: Customer Advisory Committee, Earned Value Management, Knowledge Management, and Product Data and Life-Cycle Management (PDLM) Program/Project Management. Below the navigation bar, there is a section for the 2012 NASA Spacecraft Fault Management Workshop, featuring a video player and a "Live Online Streaming of the Fault Management Workshop" announcement by Christopher Eng at JPL, 4/4/12. The announcement text states: "The 2012 NASA Spacecraft Fault Management Workshop will take place 4/10 - 4/12. All parts of the Workshop not limited to 'US Persons Only' will be available for live online streaming. Follow the link to find out about how to register!" and includes links for "Read More" and "Learn More". Below the announcement, there is a "WELCOME" section with a video player featuring Mike Ryschkewitsch, NASA Chief Engineer. The "WELCOME" text says: "Welcome to the NASA Engineering Network, where engineers may access Lessons Learned; interact with their discipline's Technical Fellow, subject-matter experts, and practitioners through Communities of Practice; search many NASA repositories of interest, and find tools and resources." Below the "WELCOME" section, there is a "SPOTLIGHT" section with "OCE Events: April 2012" and "Case Studies". The "OCE Events" section lists: "19 - Baseline Performance Review" and "28 - Taurus 2 Demo C-1". The "Case Studies" section includes a video player and text: "Case studies illustrate the decisions and dilemmas managers face daily. They capture a project's complex nature and identify key decision points, allowing an inside look from a practitioner's point of view." Below the "SPOTLIGHT" section, there is a "FEATURES" section with "Associations & Societies" and "Inventions & Contributions Board". The "Associations & Societies" section includes a video player and text: "Access professional associations and societies from the American...". The "Inventions & Contributions Board" section includes a video player and text: "The ICB has distributed millions of dollars for thousands of...".

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### NASA ENGINEERING NETWORK

HOME OCE LESSONS LEARNED COMMUNITIES TOOLS & RESOURCES Search Options

#### TECHNICAL DISCIPLINE

- Aerosciences
- Autonomous Rendezvous and Docking
- Avionics
- Electrical Power
- Environmental Test & Verification
- Fault Management
- Flight Mechanics
- Guidance, Navigation and Control
- Human Factors

#### MANAGEMENT DISCIPLINE

- Life Support/Active Thermal Loads and Dynamics
- Mechanical Systems
- Nondestructive Evaluation
- Passive Thermal Control and Protection
- Propulsion
- Software Engineering
- Structures
- Systems Engineering
- Customer Advisory Committee
- Earned Value Management
- Knowledge Management
- Product Data and Life-Cycle Management (PDLM)
- Program/Project Management

CLOSE

### 2012 NASA SPACECRAFT FAULT MANAGEMENT WORKSHOP

1 2 3 4 ▶

#### Live Online Streaming of the Fault Management Workshop

By Christopher Eng at JPL, 4/4/12

The 2012 NASA Spacecraft Fault Management Workshop will take place 4/10 - 4/12. All parts of the Workshop not limited to "US Persons Only" will be available for live online streaming. Follow the link to find out about how to register!

+ Read More  
+ Learn More

View All Announcements

#### WELCOME

Welcome to the NASA Engineering Network, where engineers may access Lessons Learned; interact with their discipline's Technical Fellow, subject-matter experts, and practitioners through Communities of Practice; search many NASA repositories of interest, and find tools and resources.

Mike Ryschkewitsch  
NASA Chief Engineer

00:00 00:00

#### COMMUNITY OF PRACTICE

##### Wireless Avionics Connections

The Wireless Avionics Connections sub-Community seeks to mature NASA Wireless Avionics Connections technology and applications through an agency-wide forum to share information and capture knowledge. It's scope is limited to On-Vehicle and Vehicle Proximity RF Wireless.

George Studor

#### SPOTLIGHT

##### OCE Events: April 2012

- 19 - Baseline Performance Review
- 28 - Taurus 2 Demo C-1

##### Case Studies

Case studies illustrate the decisions and dilemmas managers face daily. They capture a project's complex nature and identify key decision points, allowing an inside look from a practitioner's point of view.

#### FEATURES

##### Associations & Societies

Access professional associations and societies from the American

##### Inventions & Contributions Board

The ICB has distributed millions of dollars for thousands of

## Communities

Engineering 

Management 



### Customer Advisory Committee

Contact: Michael Ryschkewitsch



### Product Data and Life-Cycle Management (PDLM)

Contact: Harold (Hal) Bell



### Earned Value Management

Contact: Jerald Kerby



### Program/Project Management

Contact: Sandra Smalley



### Aerosciences

Contact: Dave Schuster



### Life Support/Active Thermal

Contact: Hank Rotter



### Autonomous Rendezvous and Docking

Contacts: Neil Dennehy



### Loads and Dynamics

Contact: Curtis Larsen



### Avionics

Contact: Oscar Gonzalez



### Mechanical Systems

Contact: Joseph Pellicciotti



### Electrical Power

Contact: Denney Keys



### Nondestructive Evaluation

Contact: William Prosser



### Environmental Test & Verification

Contact: Ed Strong



### Passive Thermal Control and Protection

Contact: Steve Rickman



### Fault Management

Contact: Lorraine Fesq



### Propulsion

Contact: Roberto Garcia



### Flight Mechanics

Contact: Dan Murri



### Software Engineering

Contact: John C. Kelly



### Guidance, Navigation and Control

Contact: Neil Dennehy



### Structures

Contact: Ivatary Raju



### Human Factors

Contact: Cynthia Null



### Systems Engineering

Contact: Joe Smith

# 2012 NASA SPACECRAFT FAULT MANAGEMENT WORKSHOP

April 10-12 2012  
New Orleans, Louisiana

## NASA FM Community of Practice

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### NASA ENGINEERING NETWORK

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#### FAULT MANAGEMENT

Fault Management

EXPLORE THE COMMUNITY

- Community Home
- Best Practices
- Conferences
- Contact List
- Document Library
- Forums
- Lessons Learned
- NASA Fault Management Handbook Wiki
- References and Links
- Suggestions

#### Cassini Spacecraft Enters Safe Mode

By Daria Topousis at JPL, 11/8/10



Engineers at NASA's Jet Propulsion Laboratory, Pasadena, Calif., are working to understand what caused NASA's Cassini spacecraft to put itself into "safe mode," a precautionary standby mode. Cassini entered safe mode around 4 p.m. PDT (7 p.m. EDT) on Tuesday, Nov. 2.

+ Read More

TOP STORIES: ALL ANNOUNCEMENTS

- Focused Session at AIAA InfoTech@Aerospace Conference - 10/16/10

#### WELCOME



Fault Management (FM) is an engineering discipline addressing the need for operational systems to prevent, detect, contain, isolate, diagnose, and respond to anomalous and failed conditions that would otherwise interfere with intended operations or threaten crew safety. In operation, FM increases system reliability, availability, and robustness by actively preserving system functionality. In NASA missions, the operational aspect of FM is realized by hardware and software on-board a spacecraft/aircraft, by crew members/pilots, and by ground-based systems and operators.

Contact: Lorraine Fesq (Blo)  
Facilitator: Daria Topousis

#### COMMUNITY LINKS

-  **Best Practices**  
Best practices, NPRs, etc.
-  **Lessons Learned**  
Official Lessons Learned related to FM
-  **Conferences**  
Conferences, workshops, events
-  **NASA Fault Management Handbook Wiki**  
Fault Management Handbook
-  **Contact List**  
Practitioners working in Fault Management
-  **References and Links**  
Relevant handbooks, NPRs, etc.
-  **Document Library**  
Papers, articles, other documents
-  **Suggestions**
-  **Forums**  
Online discussions

NASA National Aeronautics and Space Administration

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NEN v3.0

Editor: **Manson Yew**  
NASA Official: Gregory Robinson  
+ Contact NEN

# 2012 NASA SPACECRAFT FAULT MANAGEMENT WORKSHOP

April 10-12 2012  
New Orleans, Louisiana

Day 1 - April 10, 2012		Day 2 - April 11, 2012		Day 3 - April 12, 2012	
7:00 AM	QB Registration			8:00 AM	QB Invited Speaker: Dr. Algirdas Avizienis
8:00 AM	Introductions, Purpose, Goals - Lorraine Fesq	8:00 AM	QB Invited Speaker: Dr. Werner Dahm	8:00 AM	QB Distinguished UCLA Emeritus Professor
8:15 AM	Welcome - Lindley Johnson		Director, Security and Defense Systems Initiative	8:45 AM	"Terminology Issues in Dependable Computing"
8:30 AM	Agenda, Logistics, FM Handbook Status		Ira A. Fulton Schools of Engineering, Arizona State University		JPL/CalTech - Steve Jenkins, "FM Ontology"
8:45 AM	JPL/CalTech - Brian Muirhead, "Coalescing NASA's Views of Fault and Health Management"	9:00 AM	FM Capabilities Roadmap Session Overview - Ken Costello, Session Chair (IV&V Facility) and Mitch Ingham (JPL)	9:15 AM	NASA/ARC - Peter Robinson, "FM as a Control System"
	JHU/APL - Kris Fretz, "Recent Progress in FM"	9:30 AM	Architecture Evaluation Session Overview - John Day, Session Chair (JPL) and David Garlan (CMU)	9:45 AM	NASA/OSMA - Frank Groen, "FM in an Objectives-Based/Risk-Informed View of Safety and Mission Success"
9:45 AM	Break	10:00 AM	Breakout Sessions: Logistics	10:15 AM	Break
10:00 AM	QB Focus Area: "Assessing FM architectures"	10:15 AM	Break	10:30 AM	QB Panel Discussion: "Integrating FM: How Does It Fit?"
10:15 AM	NASA/MSFC - Jon Patterson, "Analytical Approaches to Guide Space Launch System FM Development"	10:30 AM	BC Architecture Evaluation Session - <u>US Persons only</u>	10:30 AM	QB Panel Moderator: Marilyn Newhouse, MSFC/CSC
10:45 AM	NASA/JSC - Carlos Garcia-Galan, "FM for Crewed Missions"		QP Breakout Session		Panelists: Michael Aguilar, NESG; Michael Brieden, JSC;
11:15 AM	Aerospace Corp - Phillip Schmidt, "Independent Assessment of NASA Fault Management System Architectures"		US Breakout Session		George Cancro, APL; Stephen Johnson, MSFC/UCCS;
11:45 AM	AFRL/W-P - Mark Derriso, "State Awareness and Decision-Making Architecture"				Bob Rasmussen, JPL; Jonathan Wilmot, GSFC
12:15 PM	QB Lunch - Invited Speaker: Michael Aguilar	12:30 PM	LN Lunch	12:00 PM	LN Lunch
	NASA GSFC, NESG Software Tech Fellow		LN Steering Committee Meeting		LN Steering Committee Meeting
	"Fault Management using MBSE Tools and Techniques"	1:15 PM	BC Architecture Evaluation Session - <u>US Persons only</u>	1:00 PM	QB Architecture Evaluation Report & Discussion - <u>US Persons only</u>
1:15 PM	QB Focus Area: "Developing a FM Capabilities Roadmap"		QP Breakout Session		John Day (JPL) and David Garlan (CMU)
1:30 PM	NASA/ARC - Mark Schwabacher, "Human Spaceflight ISHM Technology Development"		US Breakout Session	2:00 PM	QB Capabilities Roadmap Report & Discussion - <u>US Persons only</u>
2:00 PM	NASA/ARC - Robert Mah, "System-Wide Safety Assurance Technologies"				Ken Costello (IV&V Facility) and Mitch Ingham (JPL)
2:30 PM	JPL/CalTech - Mitch Ingham, "No more Band-Aids: Integrating FM into the Onboard Execution Architecture"	2:45 PM	Break	3:00 PM	QB Closing Remarks
3:00 PM	JPL/CalTech - Dan Dvorak, "Model-Based Systems Engineering (MBSE) and Goal-Based FM"	3:00 PM	BC Architecture Evaluation Session - <u>US Persons only</u>	3:00 PM	QB Steering Committee Meeting
3:30 PM	NASA/JSC - Lui Wang, "Modeling Failure Modes with SysML"		QP Breakout Session		
4:00 PM	Break		US Breakout Session		
4:15 AM	QB NASA/MSFC, UCCS/Jacobs - Stephen Johnson, "FM Technical Performance Metrics"				
4:45 PM	AFRL/W-P - Mark Derriso, "AFRL's ISHM Journey and Future Plans"	5:00 PM	RS Steering Committee Meeting		
5:15 PM	QP Steering Committee Meeting				
5:30 PM	IB Reception				
7:30 PM	Iberville and Bienville Rooms - Second Floor				

Room Legend	
Mezzanine	QB Queen Anne Ballroom
	BC Bonnet Carre Room
	OR Orleans Room
	QP Queen Anne Parlor
	LN La Nouvelle East
	IB Iberville/Bienville Rooms
Second Floor	US Ursaline Salon
	PR Pontalba Room
	GS Gallier Salon
	RS Royal Salon B

# Logistics

- Agenda is color-coded to indicate locations
- Every day, start in Queen Anne Ballroom
- Day 1 schedule is tight – I will be holding speakers to their allotted time.
- Day 1 presentations prepare us for Day 2 activities
- Day 2 plan: Split into 2 parallel Breakout Sessions
  - Go to one Session and stay there for the day. Discourage traveling
  - Introductions to each Session will be provided on Day 2
- Day 3 focuses on FM Handbook issues

## Day 3: Handbook Issues

- Terminology!
- What is the “science” that lies beneath FM?
- Confusion about FM vs OSMA responsibilities
- How does FM fit within a mission?
  - Part of SE’s responsibilities?
  - Separate subsystem like power, ACS and thermal?
  - Additional duty for subsystem engineers?

# Goals

- Bring FM LL and BP alive to benefit future missions
- Establish a vision for FM technology development
- Expose the different views/roles of FM on current missions
- Work toward consensus on key issues
- Plans for the next 3 days
  - Collect and Assess past FM Architectures
  - Develop a FM Capabilities Roadmap
  - Discuss via a panel the role of FM on a Mission
  - Mature the contents of the NASA FM Handbook

## Final announcements

- Online survey for you to take at the end of this Workshop
- Workshop presentations & FM handbook posted on public NEN website --  
[http://www.nasa.gov/offices/oce/documents/2012\\_fm\\_workshop.html](http://www.nasa.gov/offices/oce/documents/2012_fm_workshop.html)
- At the end of today, all FM architecture session Case Study leads please meet with John Day