Building Communities of Engineers to Share Technical Expertise

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PM Challenge 2012
Agenda

- Background
- What are communities?
- Examples of technical exchange
- Fault Management Community
- Autonomous Rendezvous & Docking Community
Driver: Distributed Geography
Driver: Columbia Accident

“NASA has not demonstrated the characteristics of a learning organization.”

-Columbia Accident Investigation Board, 2003
Driver: Evolving Mission
NASA Engineering Network

- Office of the Chief Engineer content
- Communities of Practice
- Lessons Learned
- Search
- Engineering Organization Charts

NASA Engineering Network (NEN)
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
Role of the NESC

The NESC performs value-added independent testing, analysis, and assessments of NASA's high-risk projects to ensure safety and mission success.

NASA Technical Fellows, appointed by the OCE, lead most of the communities of practice.
Developing Online CoPs

- 2003: CAIB Report
- 2004-2005: NEN Developed and Implemented
- 2006-2008: First 6 CoPs
- 2009-2010: 15 new CoPs
- 2011-present: Focus on growth
Establishing a New Community

**Phase 1**
- NASA’s core competencies
- NEN team and Tech Fellow collect key resources
- List center-by-center info
- Share papers

**Phase 2**
- Communication
- Encourage more user input
- Interactive online content
- Allow users to join a community

**Phase 3**
- Community-driven content
- Experts answer questions
- Tech Fellow champions, but not sole source of content
Getting Expert Input
Technical Exchange: MATLAB Scripts

```matlab
function [h, w, cg, wp, lp, hp, wn, zn] = slosh(R, L, bt, bb, rho, fill_ratio, nu, verbose)

% error checking of inputs and outputs:
if (nargin < 6 || nargin > 8)
    fprintf('Invalid number of inputs\n');
    error('slosh usage: [h, w, cg, wp, lp, hp, wn, zn] = slosh(R, L, bt, bb, rho, fill_ratio, nu, verbose)\n');
end

if (nargin < 7)
    nu = [];
end

if (nargin < 8)
    verbose = [];
end

if (isempty(nu))
    nu = 0;
end

if (isempty(verbose))
    verbose = 0;
end

if (nargout > 8)
    fprintf('Invalid number of outputs\n');
    error('slosh usage: [h, w, cg, wp, lp, hp, wn, zn] = slosh(R, L, bt, bb, rho, fill_ratio, nu, verbose)\n');
end

if (R <= 0)
    fprintf('Input parameter, R, must be positive\n');
    error('slosh usage: [h, w, cg, wp, lp, hp, wn, zn] = slosh(R, L, bt, bb, rho, fill_ratio, nu, verbose)\n');
end
```
Facilities Information

Facility Name or Designation

Pin-On-Disk Tribometer

Location

Glenn Research Center (GRC)

Facility Type

Bearing Systems and Tribology

General Description

Measures tribological properties with a pin-on-disk contact arrangement under controlled atmosphere (inert, oxidizing, etc) and temperature.

Maximum Test Article Dimensions/ Facility Characteristic Dimensions

Fins/Balls range from 1/8 to 1/2 in;

Operating Range/Parameters

Unidirectional sliding at 100 to 3000 rpm (0.27 to 8 m/s). Dead weights load a hemispherically-tipped pin against the disk. Friction force continuously measured with load cell. Low-frequency induction coil heats
Webcasts (Partnership with NESC)

WEBCASTS

The GN&C community, in conjunction with the NASA Engineering & Safety Center, is offering regular webcasts led by subject matter experts. They are held the third Wednesday of every other month at 2 pm Eastern. See below for the schedule, session abstracts, and speaker bios. If you are interested in attending the next webcast, please register in advance. Details about how to attend will be posted soon.

Upcoming Courses

<table>
<thead>
<tr>
<th>Course Title</th>
<th>Date</th>
<th>Speaker(s)</th>
<th>Abstract</th>
<th>Presentation</th>
<th>Bio</th>
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</thead>
<tbody>
<tr>
<td>Fundamentals of Spacecraft Attitude Control</td>
<td>July, 2012</td>
<td>Dave Mangus</td>
<td><a href="#">Abstract</a></td>
<td></td>
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Other Knowledge Sharing

- One of a kind documents
- Discussion Forums
- Blogs
FM CoP Domain

System Design

Hardware Components
Software

assessment results

ments, design solution

assessment results

V&V results
Recent FM Developments

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)

2008

2009

2010

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)

2011

2012

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 (L. Fesq)

Jul '11: FM Handbook Draft delivered to NESC/SMD and NTSPO and Centers for review

Apr '12: SMD/PSD sponsors 2nd S/C FM Workshop (J. Adams)
FM Handbook – Table of Contents

1. Scope
2. Applicable Documents
3. Acronyms and Definitions
4. Concepts and Guiding Principles
5. Organization, Roles and Responsibilities
6. Process
7. Requirements Development
8. Design and Architecture
9. Assessment and Analysis (TBS)
10. Verification and Validation
11. Operations and Maintenance (TBS)
12. Review and Evaluation
13. Conclusion
14. Future Directions (TBS)

Appendix A: References
Appendix B: Work Product Templates (TBS)
Appendix C: Relevant NASA Lessons Learned
Appendix D: Acknowledgements, historical background
Fault Management Products

- Lessons Learned
  - Process for developing FM systems
  - Guidance and options to address technical issues

- Hyperlinked list of all FM-related lessons
  - Robotic and human spaceflight lessons

- Contact list
  - Conferences with FM focus
  - Suggested training courses
  - 2nd FM Workshop: April 2012
Fault Management Blog

- Captures latest activities in FM community
- Allows CoP Lead to “get the word out” quickly
Fault Management Poll

- Solicit input from across the community
- Provide a forum for differing opinions
- Goal: move toward consensus on definitions of FM terms
Upcoming Workshop: April 2012

2nd NASA Spacecraft Fault Management Workshop

**FEE**
- View Event Summary
- View Event Agenda

**RSVP**
Monday, 03/12/12
Please respond by clicking one of the buttons below

**YES  NO**
Summary of FM Community Objectives

- Establish online forum for knowledge sharing
- NASA-wide consensus on FM nomenclature
- Capture FM approaches at NASA and other orgs
- Educate FM engineers
- Share latest developments
AR&D CoP Background

- Autonomous/Automated Vehicle Rendezvous and Docking (AR&D) was identified as an Agency-level technical cross-cutting issue at December 2007 BPR meeting at NASA HQ
  - Tech Cross-cutting Issue Description: “This a critical exploration technology in that it enables two vehicles to perform autonomous/automated docking with at least one vehicle without humans present. Supports cargo transport and robotic sample return. The US is behind where we need to be. Russia, Europe and Japan have operational systems. Internationally, the technology is still a high risk as has been demonstrated by the Issues/lessons learned from Progress/Mir docking (Russia), ETS-VII (Japan) and XSS-11, DART and Orbital Express (USA). A more robust development and validation strategy is needed.”

- To close this issue, the NESC, OCE, and the AR&D engineering organizations across the Agency jointly establish the AR&D CoP in May 2010.

- Active participants from ARC, DFRC, GRC, GSFC, JSC, JPL, LaRC, MSFC, NESC, and the HQ Office of the Chief Engineer (OCE)
Autonomous Rendezvous & Docking (AR&D) CoP

- Formed in May 2010 to enable collaboration across the Agency and develop the relationships to utilize the experience, expertise, and skills of each center.
- Established as a peer network of AR&D technical practitioners and subject matter experts.
- Hold monthly CoP telecons and an annual face-to-face meeting.

Formation driver was the need for cross-Agency collaboration on RFI responses and technology proposals.

- AR&D Systems engineering
- AR&D Systems integration
- Relative navigation sensor design and development
- Relative navigation algorithms
- 6 Degree-of-Freedom relative control algorithms
- Docking mechanisms

AR&D CoP Purpose

- Promote cross-directorate communication on AR&D in order to facilitate maximum leverage of agency resources for technology road-mapping and informal peer reviews
- Develop an Agency AR&D strategy
- Steer AR&D technologies and developments in the future
- Provide a source of independent technical expert support at formal design reviews and for anomalies
- Enable simple periodic sharing of data, lessons learned and best engineering practices
- Leverage Agency hardware and/or software/algorithms across directorates
- Increase awareness of partnership, collaboration, and cost-leveraging opportunities inside and outside the Agency
AR&D Community Products

**Strategy White Paper**
- NASA and U.S. space industry need to develop mainstream AR&D capability suite
- Proposes strategy
- Used to explain and promote AR&D

**Vision Navigation Sensor EDU**
- Goal was an in-space relative navigation sensor technology demonstration on ISS as part of DPP
- Initiated by CoP, sponsored by NESC
- Low-cost way to mature relative navigation sensor component technology

**Products & Tools**
- Relative navigation sensors database
- Catalog of AR&D algorithms to share
- AR&D test facility database
Developed by the core community to describe our vision of an approach to ensure a sufficiently technically advanced and affordable AR&D technology base is available to support future NASA missions.

The goal of this strategy is to create an environment exploiting reusable technology elements for an AR&D system design and development process which is:

- Lower-Risk
- More Versatile/Scalable
- Reliable & Crew-Safe
- More Affordable
AR&D Mainstream Capability Suite
(“Depot” Concept)

Warehouse also contains extensive documentation (design, history, risks, assumptions, etc.) for all above, plus Agency-wide contact information, lessons learned (design, testing, operations) and other expertise, facilities databases, sensor databases, etc.
Key Tenants of the AR&D CoP’s Strategy

- Focuses on development of an AR&D capability suite, which primarily involves four specific subsystems that can enable AR&D and its required integration for all these missions.

- The focus is not on the development of a single complete AR&D package capable of being wired into a spacecraft which supports all mission types (“AR&D-in-a-box”).

- The four subsystems most impacted by adding an AR&D requirement to a vehicle:
  - Relative navigation sensors and integrated communications
  - Robust AR&D GN&C & real-time FSW
  - Docking/capture mechanisms
  - Mission/system managers for Autonomy/Automation

- The AR&D capability suite would be populated with various solutions for each of these four areas, and all solutions would have standardized interfaces.
  - The recently agreed-to “International Docking System Standard” is an excellent example.

- Each mission would then pick-and-choose which solutions in the AR&D suite are most useful for implementing their design.
AR&D CoP Creates, Vets, and Disseminates Best Practices Products

Products like this “Navigation Filter Best Practices” report were initially created to capture expert knowledge for next generation of NASA GN&C engineers.

However the AR&D CoP has found that sharing products such as this with our NASA industry partners is an effective way to communicate our NASA design and development best practice “expectations”
Vision Navigation System (VNS) EDU for Ground Test/Flight Test

- Vision Navigation System (VNS) is the Relative Navigation Flash LIDAR rendezvous sensor baselined for Orion Multi Purpose Crew Vehicle (MPCV)
- The NASA AR&D Community of Practice led the cross-Agency effort to build, calibrate, and test an existing Orion “on the shelf” VNS EDU hardware at Ball
- A more advanced version of the STORRM VNS unit was flown on STS-134 in April 2011
- Will be a shared asset for the AR&D CoP
- Delivered on October 2011
- First use in GSFC’s Spacecraft Servicing Capabilities Program Argon ground testbed
- Currently searching for on-orbit flight test opportunity for VNS EDU
# AR&D CoP Formulated Multi-Program/Project Team Partnership for VNS EDU Effort

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<th>Group</th>
<th>Investment</th>
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| Orion                                      | • Provide existing “on the shelf” VNS EDU components  
• Allow use of VNS emulator and other GSE                                                                                                       |
| Satellite Servicing Capabilities Program   | • Provide integration of VNS onto DPP  
• Perform system testing (now ground testing)  
• Provide operations planning/ support                                                                                                           |
| Flagship Technology Development Program    | • Provide Civil Servant FTEs for AR&D “science”  
• Provide Civil Servant travel funding                                                                                                              |
| Ball Aerospace                             | • Early integration activities  
• Make components flight-ready                                                                                                                       |
| NASA Engineering and Safety Center         | • Provide funding to Ball to assemble, test and calibrate VNS EDU H/W and complete embedded flight software                                                                                       |
AR&D Community Success: Founded Upon A Common Strategy, Trusting Relationships, Communications, and Sharing

A Common AR&D Strategy

Team collaborates on proposals

Sharing knowledge across centers

Communication about importance of AR&D
Conclusion

- Engineers are sharing what they know
- Knowledge is captured and stored
- Center barriers are more porous
- Enabling key fields to coalesce