



# **Connecting Engineers to Online Experts and Knowledge**

Neil Dennehy (NESC) , Daria Topousis (JPL) &  
Kenneth Lebsock (OSC)

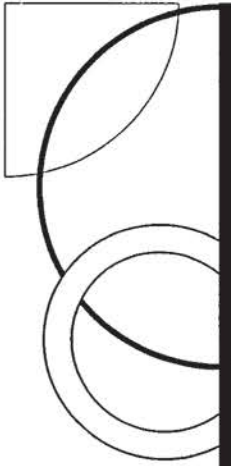
NASA Project Management Challenge 2010 9-10 February 2010  
Moody Gardens Hotel & Convention Center  
Galveston, TX



<http://nen.nasa.gov>

# Presentation Overview

- Why does NASA have a need for online engineering experts and knowledge sharing?
- Who is creating the online engineering Community of Practice sites?
- What do the Community of Practice sites provide?
- How does one access these online engineering Community of Practice sites ?
- How does one navigate these sites? (Live Demo)

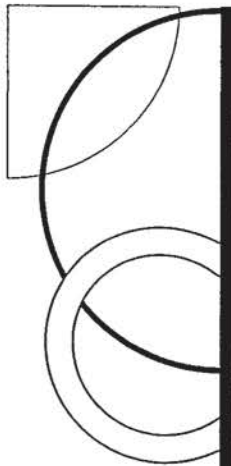


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# Observations on the NASA Workforce

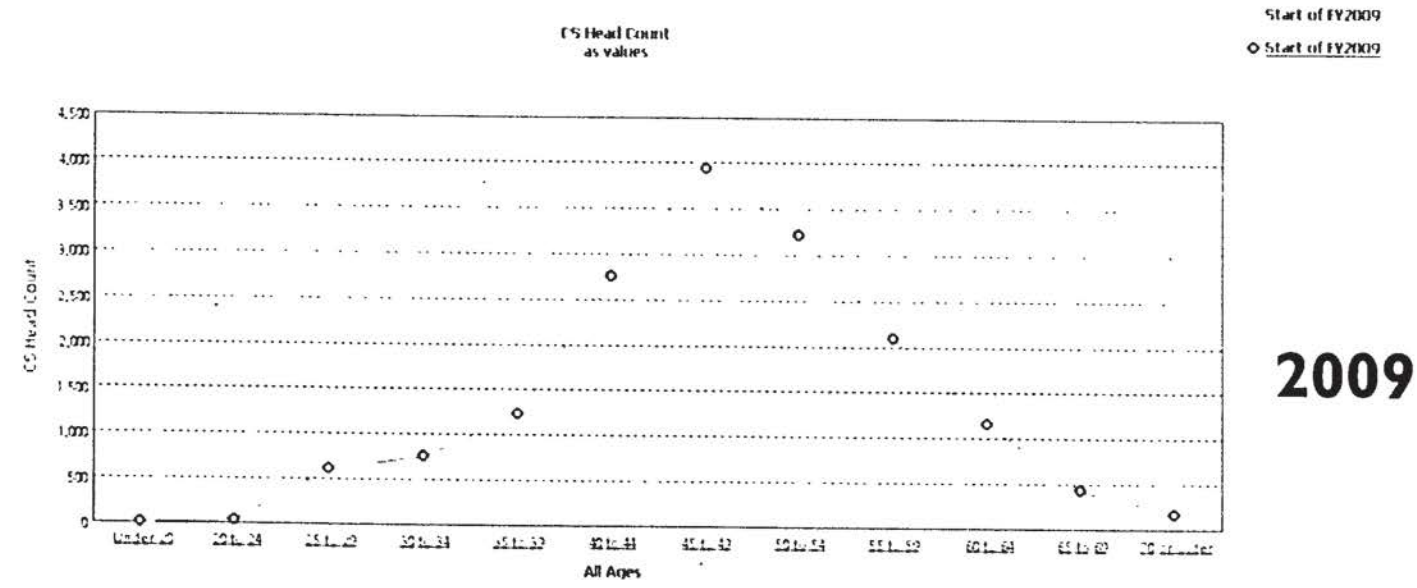
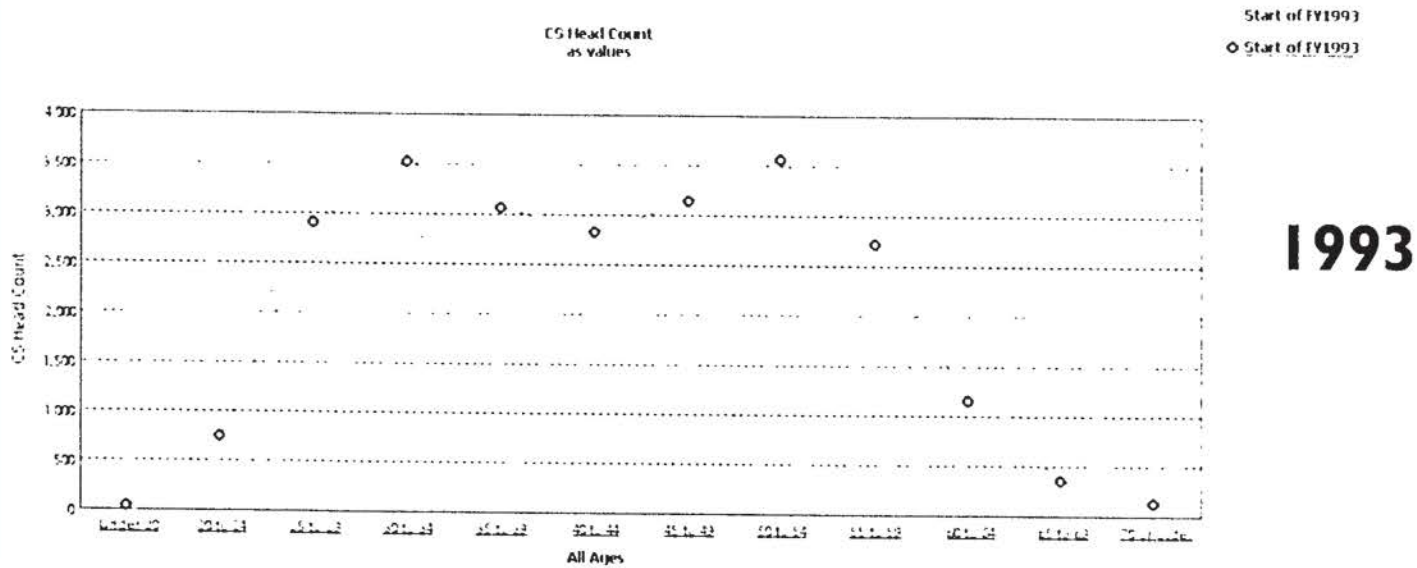
- NASA has an aging workforce population
  - Average age is 46
- Not enough engineers have worked up the ranks to compensate for those retiring\*
- Many early career engineers are still in the process of building requisite skills to assume mid-career leadership roles
- Have multiple generations in workforce that communicate and learn in different ways

\* Government Accounting Office (2003) NASA Major Management Challenges and Program Risks, Statement of Allen Li to the Columbia Accident Investigation Board, GAO-03-849T



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# NASA's Changing Age Distribution



Source: Workforce Information Cubes for NASA (WICN). <http://wicn.nssc.nasa.gov>





# Four Generations of Workers

Generation	Born	Characteristics
Traditionalists	1937-1945	Loyal to employer, like face-to-face communication
Baby Boomers	1946-1964	Idealistic, workaholics, first TV generation
Generation X	1965-1976	Value life/work balance, technologically savvy, not afraid to change jobs
Millennials	1977-1990	Using computers since children, comfortable w/instant messaging and texting

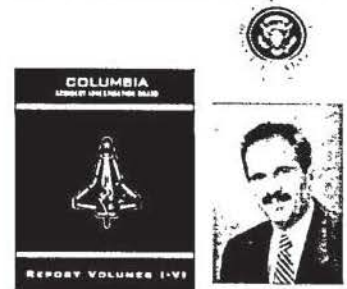
*According to a survey conducted by the Pew Research Center, 73% of respondents stated that younger and older people are very different in the way they use computers and new technology.\**

\* Pew Internet & American Life Project (2009). Generations Online in 2009 Report.

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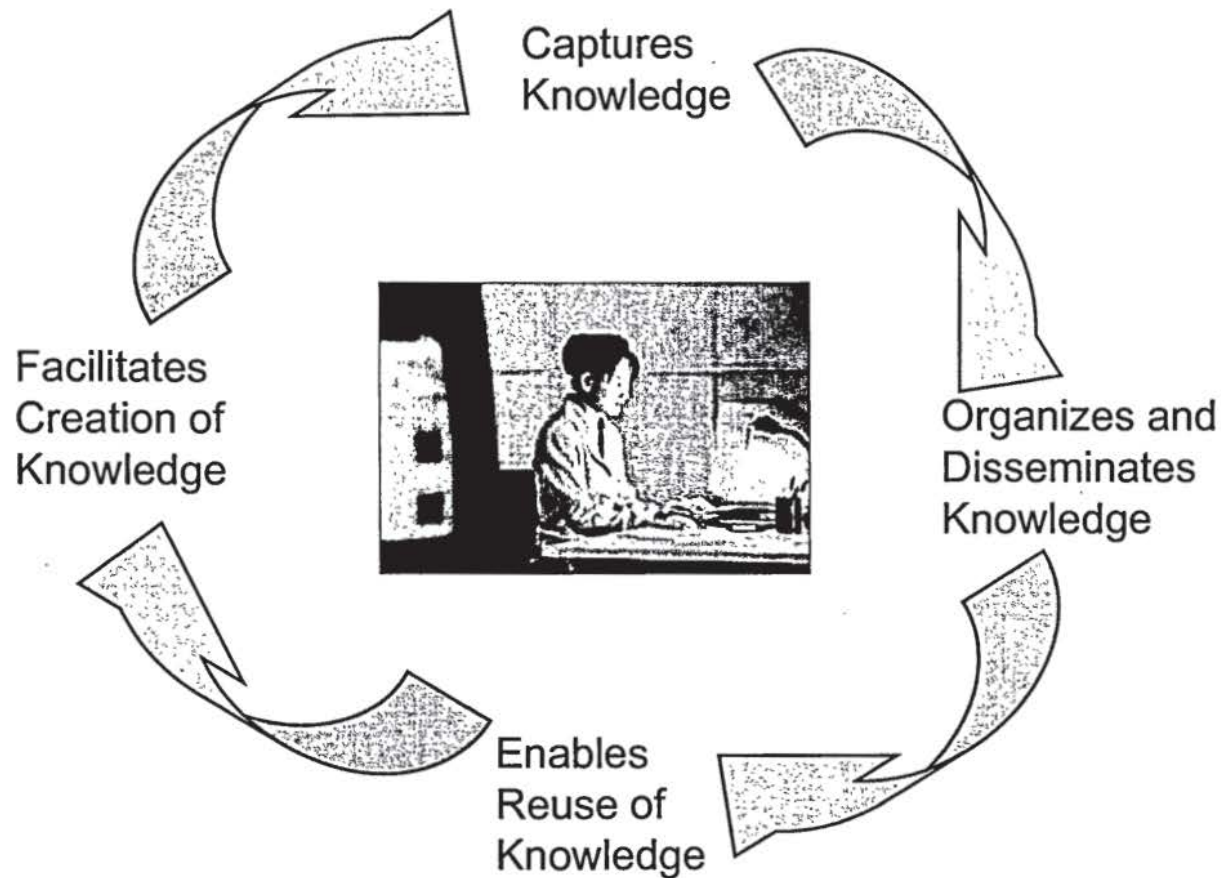
# Beyond the Age Gap: CAIB Findings

- Columbia Accident Investigation Board found NASA isn't a learning organization
- Knowledge of problems is contained within each center and not shared
- Diaz Report urged NASA to develop a system that would assure knowledge retention and use of lessons learned



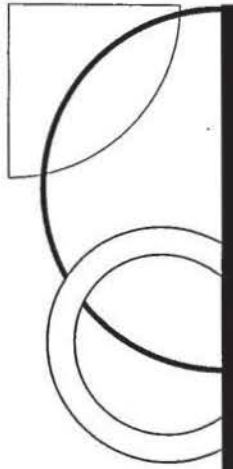
# Sharing Knowledge & Lessons

Every engineer needs access to all NASA engineering knowledge



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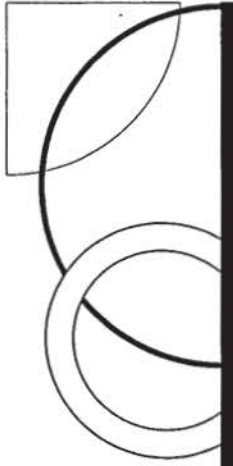


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# NASA Engineering Network

- Funded by the NASA Chief Engineer
- Online knowledge sharing system focused on engineering
- Access engineering org charts
- Search over one million documents in 40+ repositories
- Submit and/or browse NASA Lessons Learned
- Connect, collaborate, learn, and share ideas via Communities of Practice





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# Communities of Practice

A network of individuals who

- Have a passion for or level of experience in a given engineering discipline
- Want to share collective knowledge and learn from one another
- Identify common problems and explore solutions

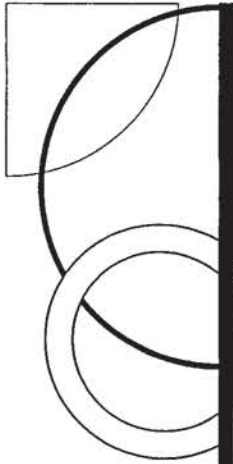




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## Why create the Communities of Practice?

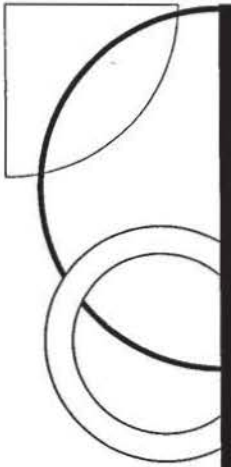
- Capture NASA's unique knowledge before brain drain hits
- Provide forum where engineers can learn, mentor/be mentored and collaborate
- Break down barriers between NASA's Centers
  - Stimulate cross-agency sharing of simulation tools, analytical methods, test facilities, etc.
- Welcoming to younger generation (communication, learning online communication vs. face to face)



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## CoPs at NASA are

- Built along key engineering disciplines based on NASA's core competencies
- Led by NASA Technical Fellows, recognized experts in their field. Tech Fellows are:
  - Appointed by the NASA Chief Engineer
  - Resident in the NESC
- Housed within the NASA Engineering Network
- Available to all personnel with NASA intranet access



# NASA Technical Fellow Roles & Responsibilities

- Serve as senior technical expert for the agency in support of the OCE, NESC, and NASA Programs
- Serve as an independent resource to the agency and industry to resolve complex issues
- Form, maintain, and lead Technical Discipline Team
- Lead agency-wide discipline working groups
- Foster consistency of agency-level standards and specifications and involved with levying standards & specs
- Promote discipline stewardship
- Ensure Lessons Learned are identified and incorporated into agency processes

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# Current Engineering CoPs

## Communities by Technical Discipline



**Environmental  
Test &  
Verification**  
Contact: Ed  
Strong



**Guidance,  
Navigation &  
Control**  
Contact: Neil  
Dennehy



**Loads &  
Dynamics**  
Contact:  
Curtis  
Larsen



**Mechanical  
Systems**  
Contact:  
Joseph  
Pellicciotti



**Nondestructive  
Evaluation**  
Contact: William  
Prosser



**Passive  
Thermal  
Control  
and  
Protection**  
Contact:  
Steve  
Rickman



**Propulsion**  
Contact:  
Robert Garcia



**Software  
Engineering**  
Contact: John  
C. Kelly

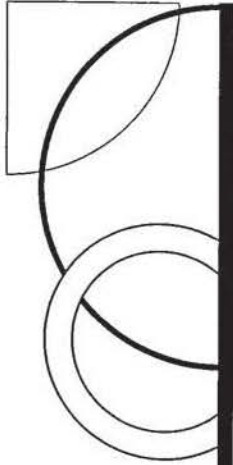


**Structures**  
Contact:  
Ivatury  
Raju



**Systems  
Engineering**  
Contact: Steve  
Kapurch

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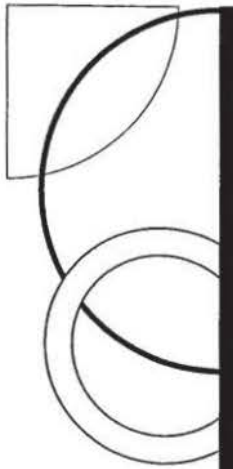
# Communities Under Development

- Life Support/Active Thermal
- Aerosciences
- Flight Mechanics
- Human Factors
- Avionics
- Electrical Power
- and more

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## What is on the Community Sites?

-  Standards and best practices
-  Ability to ask questions to experts
-  Lessons learned
-  Discussion boards/Forums
-  Facilities information for testing
-  Information on commonly used tools
-  Videos



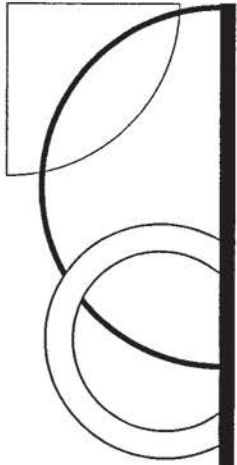
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## Live Demo

- Guidance, Navigation & Control
- Passive Thermal
- Mechanical Systems
- Propulsion

For those who missed the live presentation, see Slides 20-26 for screen captures from the live demo.

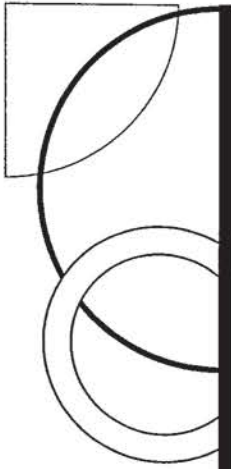




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## Conclusion

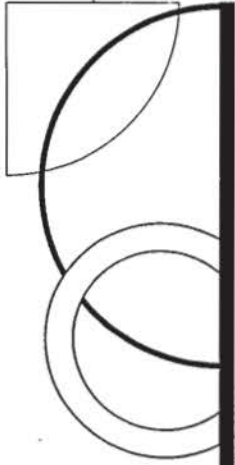
- Generational gap in NASA's workforce is a continuing issue that must be addressed
- Younger generations must have access to experienced engineers in order to grow technically
- Better technology will help attract and retain younger generations of workers
- CoPs provide one place to find authoritative documents and information
- Sites enable connections and collaboration



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## How to Take Part

- Join a community of practice
- Volunteer to serve as an expert
- Share lessons learned from projects
- Pose questions to experts
- Take part in a discussion
- Suggest content for the site
- Provide feedback on the site



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## Contact Us

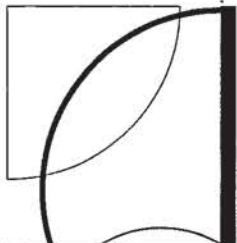
- Neil Dennehy
  - Leader, NESC Tech Fellow Office and Guidance, Navigation & Control Tech Fellow
  - GSFC Phone: 301-286-5696
  - [Cornelius.J.Dennehy@nasa.gov](mailto:Cornelius.J.Dennehy@nasa.gov)
- Daria Topousis
  - Leader, NEN Community of Practice Rollout & Maintenance
  - JPL Phone: 818-314-8794
  - [Daria.Topousis@jpl.nasa.gov](mailto:Daria.Topousis@jpl.nasa.gov)



# Screen captures from live demo

(for those who missed the live presentation)





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NASA Engineering Network | What's Hot

Home | About | Contact Us | Search

Search for

Home | About | Contact Us

Welcome to New NEN

Home | Site Map | Login | Register

NEN Home

Office of the Chief Engineer

Organization Charts

Lessons Learned (11)

Standards / Requirements

Communities by Technical Discipline

Communities by Signt. Discipline

Search

Tools / Resources

About

InsideNASA

### Release of New Chief Engineer's Case Study: The Gravity Probe B Launch Decision

#### Release of New Chief Engineer's Case Study: The Gravity Probe B Launch Decision

Making it through launch with a 100% probability of success is the ultimate objective of any launch. In addition, it takes a whole team of smart, competent people, a great approach, a few points that are grounded in hard data, agreements, and ability to interpret data, combined with the ability to make the call. The Gravity Probe B launch decision is a dramatic example of both. Check out the problem in greater detail.

Check out the new Case Study on the Gravity Probe B launch in the Chief Engineers Corner. Read more.

by [Nancy Yew](#)

### Science Magazines Honor Cutting-Edge NASA Programs

**SCHEDULED MAINTENANCE: Saturday, Nov 7, 2009, 9:00 a.m. - 9:00 p.m. EST**

**Mechanical Systems Experts Available to Answer Questions**

**APPEL Masters with Masters Event, October 29, 2009, NASA HQ**

View all [Case Studies](#) | [Lessons Learned](#) | [Archived Announcements](#) |

### NASA Twitter

#### Twitter / NASA

- NASA: Robotic lunar lander test, look promising for future space technology. Check it out at: <http://t.cn/xuncomvaznmt>
- NASA: Thanks for sharing about the Legend Meteor Shower. Learn more about it here: <http://bit.ly/04028>. Link up for night viewing!

## NASA Engineering Network



What's Happening at the Office

- APTT
- Case Studies
- NASA.gov with a Best of the Best
- TLE
- What's



NASA's Lessons Learned Repository

- Ask an Expert
- Community
- Share a Lesson
- What's Hot



Communities of Practice

- Mechanical Systems
- Thermal Systems



Search Repositories from Across NASA

- Apollo 13 Flight
- Earth Science
- Mechanical Systems
- What's Hot



### Chief Engineer's Corner

Chief Engineer's Corner

### Communities of Practice



Looking for a theme, test, or tool that will help you meet your needs, links to key data, tutorials, and reference documents?

- Mechanical Systems
- Earth Science
- Thermal Systems
- What's Hot

See Previous

See Next

### What's Hot

**November 03, 2009**

Ask an Expert has been rolled out to NEN. To learn how search for and ask experts from across NASA and engineering, questions you may have visit [Ask an Expert](#) to start getting answers to your questions.

**October 26, 2009**

White Paper Report: Spacemat 4.0 Management Work in Space. Under the Science Mission Directorate, Planetary Science Division, now available for download.

You can find this and many other documents on the [Library](#) page.

**September 24, 2009**

2009-09-24 10:00 AM



# CoP Home Page (GN&C)

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## NASA Engineering Network

NASA Engineering Network

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Home

Community for the Technical Discipline of Guidance, Navigation, and Control

Office of the Chief Engineer

Organization Charts

Lessons Learned (11)

Standards / Requirements

Communities by Technical Discipline

Guidance, Navigation, and Control

Best Practices

Conferences

Lore Discipline Team

Discussions / FAQ

Documents

GNC + NASA

Lessons Learned

Links for GNC

Reading Room

Environmental Test & Verification

Loads and Dynamics

Mechanical Systems

Nondestructive Evaluation

Passive Thermal Control and Protection

Propulsion

Software Engineering

Structures

Systems Engineering

Communities by Tqnt. Discipline

Search

Standards / Requirements

### Guidance, Navigation, and Control

#### Solar Activity Predictions for Solar Cycle 24

##### Solar Activity Predictions for Solar Cycle 24



The progress of this system for solar cycle 24 is being tracked and reported by the solar activity prediction team. The team consists of solar activity forecasters from the Space Weather Prediction Center, the National Oceanic and Atmospheric Administration, and the University of Colorado. The team is currently working on a report that will be published in the next few weeks.

Tau Hery

#### Relative Navigation Sensor for HST SNA

#### Acquisition, Pointing, and Tracking System Being Developed for Lunar Laser Communications Demonstration

#### Successful Attitude Control Motor (ACH) Test Firing

#### GNC Engineers Win NASA Honor Awards

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#### Community Links



Find best practices for links



Discussing and past events related to GNC



Have a question or need advice? Ask for help on our technical discussion forum.



Read frequently asked questions and participate in our discussion forum.



Find journal articles, workshop reports, and documents



Centering on the discipline and a list of interests



Find technical documents related to GNC



Links to sites of interest to GNC practitioners



List of recommended books and articles

### Welcome to Guidance, Navigation, and Control



As the GNC Technical Discipline CoP leader, Neil Dennehy is responsible for the overall direction and coordination of the GNC CoP. He is currently working on the development of the GNC CoP website and is looking for new members to join the community.

- + State of the Discipline
- + Summary IIEEG GNC

Discipline Assessment

Tech Fellow: Neil Dennehy

Facilitator: [Name]

### Updates to the CoP

Latest news from the Guidance, Navigation, and Control community.

- A new lesson in understanding the importance of the GNC CoP has been highlighted in the CoP newsletter. The newsletter is available on the GNC CoP website. Documents / IIEEG GNC / Publications and Reports / Aircraft GNC - Related Publications and Reports

### Suggestions (GNC)

Please enter your comment or suggestion in the field below and click Submit. To see the suggestions others have submitted, click View Suggestions.

More News

http://nen.nasa.gov





# Highlighting Lessons Learned

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## NASA Engineering Network

NASA Home

Home

Welcome to New NEN

NEN Home

Guidance, Navigation, and Control's Lessons Learned

Office of the Chief Engineer

Organization Charts

Lessons Learned (11)

Standards / Requirements

Communities by Technical Discipline

Guidance, Navigation, and Control

Best Practices

Conferences

Core Discipline Team

Discussions/FAQ

Documents

GN & NASA

Lessons Learned

Links for GN

Reading Room

Environmental Test & Verification

Loads and Dynamics

Mechanical Systems

Nondestructive Evaluation

Passive Thermal Control and Protection

Propulsion

Software Engineering

Structures

Systems Engineering

Communities by Mgmt. Discipline

Search

## Lessons Learned



## Guidance, Navigation, and Control

LESSONS LEARNED

### Lesson Learned in the Spotlight

#### X-43A Mishap, June 2001



The X-43A was the first flight attempt of NASA's hypersonic program with the purpose of achieving a hypersonic cruise capability for the next generation of vehicles. The X-43A stack was a combination of the Hyper-X booster, the Hyper-X launch vehicle, and the Hyper-X adapter, and the Hyper-X booster was the only one that was designed to be reusable. The X-43A stack was launched on June 21, 2001, from the B-52 bomber aircraft. The test was intended to demonstrate the ability of the X-43A stack to attain the required altitude and speed. The test was a failure because the stack diverged from its planned trajectory and was destroyed by range safety less than a minute after release from the B-52.

The flight attempt occurred in June 2001. The mission objectives of the flight were to demonstrate the ability of the X-43A stack to attain the required altitude and speed. The flight failed because the vehicle's flight control system (autopilot) design was deficient in several analysis modeling areas. These deficiencies were related to an overprediction of the autopilot stability margins. The most significant deficiencies were related to the autopilot's ability to maintain control during a sideslip divergence, followed by a full throttle maneuver. The autopilot's ability to maintain control during a sideslip divergence was deficient because the autopilot's stability margins were overpredicted. The autopilot's ability to maintain control during a full throttle maneuver was deficient because the autopilot's stability margins were overpredicted. The severe loss of control caused the stack to diverge significantly from its planned trajectory, and it was destroyed by range safety less than a minute after release from the B-52.

The NASA mishap investigation identified several deficiencies in the autopilot's design that caused the flight to fail. The flight failed because the vehicle's flight control system (autopilot) design was deficient in several analysis modeling areas. These deficiencies were related to an overprediction of the autopilot stability margins. The most significant deficiencies were related to the autopilot's ability to maintain control during a sideslip divergence, followed by a full throttle maneuver. The autopilot's ability to maintain control during a sideslip divergence was deficient because the autopilot's stability margins were overpredicted. The autopilot's ability to maintain control during a full throttle maneuver was deficient because the autopilot's stability margins were overpredicted. The severe loss of control caused the stack to diverge significantly from its planned trajectory, and it was destroyed by range safety less than a minute after release from the B-52.

The primary test goals for the flight were to demonstrate the ability of the X-43A stack to attain the required altitude and speed. The flight failed because the vehicle's flight control system (autopilot) design was deficient in several analysis modeling areas. These deficiencies were related to an overprediction of the autopilot stability margins. The most significant deficiencies were related to the autopilot's ability to maintain control during a sideslip divergence, followed by a full throttle maneuver. The autopilot's ability to maintain control during a sideslip divergence was deficient because the autopilot's stability margins were overpredicted. The autopilot's ability to maintain control during a full throttle maneuver was deficient because the autopilot's stability margins were overpredicted. The severe loss of control caused the stack to diverge significantly from its planned trajectory, and it was destroyed by range safety less than a minute after release from the B-52.

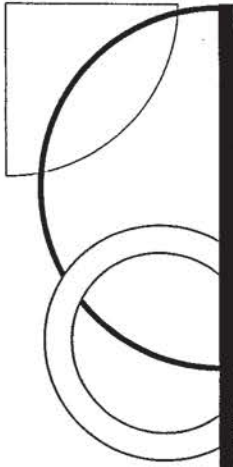
- Flight Test Findings (PDF)
- Spotlight on X-43A (PDF)
- MIT Final Report Summary and Conclusions
- Mission Report

### Lessons Learned Links

#### Search Queries and Links

- NASA Lessons Learned in the Spotlight (PDF)
- NASA Technical Report Server (TRS) Search on Guidance, Navigation, and Control
- See also Learning from Other People's Mistakes, Paul Cheng and Patrick Smith, *Aerospace Magazine*, The Aerospace Corporation
- [http://www.nasa.gov/pdf/12001main\\_x43a](http://www.nasa.gov/pdf/12001main_x43a) from the NASA Safety Center





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## How CoPs help engineers

- Engineer has a question on stability of a nonlinear control system
- He posts a question in the discussion board
- In this example two experts respond



# Discussion Board

Discussions/FAQ

Discussion Board (GNC) > Stability analysis for nonlinear systems

2009-08-31 12:00:49 PM

## Question on stability analysis for a highly nonlinear system

2009-07-10 14:56:00 PM

Author: [Scott Heathcote](#) Posted: 7/10/2009 1:47:56 PM

I am developing a controller (a thruster based controller) made for the GEM satellite. The controller scheme is fairly simple. Attitude and rate error for each spacecraft axis are fed through a set of gains which pass to a Schmitt Trigger (deadband with hysteresis) whose output is a -1, 0, 1. The output for all three axes are fed to a thruster selection algorithm which determines the thrusters that need to be on to provide that torque necessary for control.

The controller is a simple design and is stable, however proving stability has been an issue. Up to this point, GSFC has used describing functions for stability analysis of Schmitt Trigger controllers. However, in digging a little, I have determined that describing functions are inadequate for this problem. Lyapunov proofs don't work due to a discontinuous second derivative. Looking at a phase portrait, the system shows a stable limit cycle which indicates the system is stable. However, this method does little to indicate the margin for stability.

Up to this point, I have been doing a Monte Carlo style analysis to show that analytical predictions of system limit cycle amplitudes are accurate to show that the system is well behaved and stable. For margins, thruster forces have been increased in our HFI simulation to show gain margin and control commands have been delayed to show phase margin.

Currently, there is a requirement for a rigid body stability analysis to show 6 dB gain and 30 degree phase margin. This is possible for linear systems but for highly nonlinear systems, this does not hold very well.

Gain margin can be approximated through increases in control actuation force/torque. Phase margin is tougher since degrees of phase don't seem to fit a system where an input driving frequency will not be evident in the output. Delaying the controller commands is an approximate but determining the amount of delay needed to 'prove' robustness is hard to pin down and doesn't seem to capture what phase margin really is.

My question is what is the best method for proving robust stability for highly nonlinear systems?

## Re:Question on stability analysis for a highly nonlinear system

2009-07-31 12:00:49 PM

Author: [Robert Clarke](#) Posted: 7/31/2009 12:53:51 PM

I think you are on the right track with the finding the gain margin by increasing the loop gain until high frequency instability (limit cycle) is noted and then converting this to dB. If the system is conditionally stable then you also need to decrease the gain until you drive the system into low frequency instability (limit cycle). The frequency of each limit cycle would represent the crossover frequencies that you would have found in linear analysis (for a linear controller). Phase margin is equivalent to time delay, but you require a crossover frequency to do the conversion of time delay to phase margin. (Phase angle in radians = time delay in seconds \* frequency in radians per second). If you don't have anything else, I would recommend that you use the system bandwidth that you desire to be able to control. Typically this is much lower (3 to 5%) below the sensor and/or actuator bandwidths. This again goes back to the definition of phase margin for a linear system. The phase margin is measuring how far away the phase is from the critical phase angle. For negative feedback systems this is 180 degrees (+ or - are equivalent) when the gain is at the critical value of 0 dB. The 3 to 5% below the sensor and/or actuator bandwidths is to make sure that you really have good control of the phase characteristics of the system at this frequency. Too close to either of these bandwidths and you lose control of the systems phase (you become very sensitive to small changes in time delay and therefore become unstable).

## Re:Question on stability analysis for a highly nonlinear system

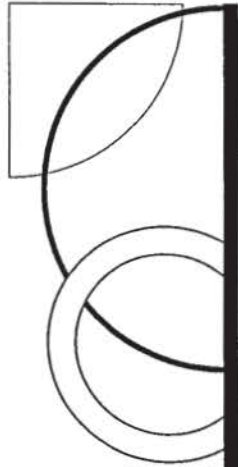
2009-08-31 12:00:49 PM

Author: [John Hanson](#) Posted: 8/31/2009 12:00:49 PM

I sent out your question and got two responses:

1. From Tamer Vanziwieri

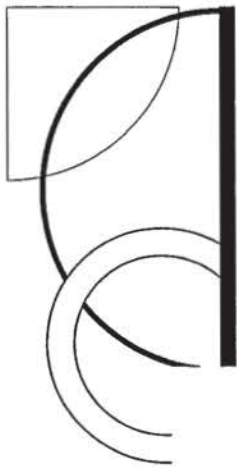
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## How CoPs help engineers (2)

- An engineer is looking for information about what thermal testing facilities are available
- He/she checks the list on the community of practice



# Thermal Facilities List

<http://nen.nasa.gov>

Facility Name or Designation	Center	Facility Type	Primary Use	Maximum Test Article Dimensions, Facility Characteristic Dimensions, Volume, Orientation (Note: In Units Provided by Facility Organization)
1 MW Power Test Facility	APC	Article	The 1-MW Power Test Facility is used to test aerodynamic heating in the thermal environment of the reentry module outer surface.	Standard configuration: max. test article length = 10 ft, max. test article diameter = 10 ft.
10 MW Transient Power Test Facility	APC	Article	The 10-MW Power Test Facility is used to test aerodynamic heating in the thermal environment of the reentry module outer surface.	Standard configuration: max. test article length = 10 ft, max. test article diameter = 10 ft.
100 MW Supersonic Turbulent Flow Device	ARC	Article	The 100-MW Supersonic Turbulent Flow Device is used to test high Mach number turbulent flow over a blunt body.	Standard configuration: max. test article length = 10 ft, max. test article diameter = 10 ft.
60 MW Aerodynamic Heating Facility (AHF)	ARC	Article	The 60-MW Aerodynamic Heating Facility is used to test aerodynamic heating in the thermal environment of the reentry module outer surface.	Standard configuration: max. test article length = 10 ft, max. test article diameter = 10 ft.
Aerodynamic Heating Facility (AHF)	ARC	Article	The Aerodynamic Heating Facility is used to test aerodynamic heating in the thermal environment of the reentry module outer surface.	Standard configuration: max. test article length = 10 ft, max. test article diameter = 10 ft.

## How CoPs help engineering (3)

- An engineer has a question
- He/she accesses the appropriate community of practice and asks the question
- Pre-identified experts are sent an email and answer the question
- Question and answer are stored online



http://nen.nasa.gov

# Ask an Expert

## Ask an Expert

Mechanical Systems

Search for questions

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## All Categories

Latest Questions

What is the best way to design a...

Have engineering questions?

ASK A QUESTION



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Categories

### Latest Questions

#### Archived Questions

- Electrical Systems (1/1/10)
- Fluid Dynamics (1/1/10)
- Structural Analysis (1/1/10)
- Control Systems (1/1/10)
- Electronics (1/1/10)
- Thermodynamics (1/1/10)
- Mechanical Design (1/1/10)
- Materials (1/1/10)
- Manufacturing (1/1/10)
- Software (1/1/10)
- Physics (1/1/10)