Teacher Enrichment Program
“Bite of Science”

Introduction to Aerospace Systems Engineering

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Agenda

• *My career in the Aerospace & Defense (A&D) industry*

• *Northrop Grumman; On the leading edge of…*

• *Aerospace Systems Engineering…*
  *architecting a whole that is > the sum of its parts*

• *Northrop Grumman’s commitment to STEM*
My career in the Aerospace & Defense industry
My desire to work in aerospace… all started with these jets!
So, I joined the Air Force when I was 19

Crew Chief/Flight Mechanic at 20

USAF Technical Training – Jets over 4 engines

My Airplane – well, MG Mullins’ KC-135A

4 years - Strategic Air Command, March AFB, Ca.

Plugging a B-1 over the Pacific
After the Air Force, I spent most of my career working on NASA’s two preeminent human space flight programs.
It was the Air Force that started me on my journey of academic learning.

- AAS Aircraft Maintenance Technology
- BS School of Technical Careers (Aviation Management)
- MS Technical Management
- Master of Business Admin.
- MS Space Systems
- Certificate - Project Engineering
- MS - Industrial Engineering
- Certificate Aerospace Project Mgmt.
- Certificate Financial Planning
With the Space Shuttle Program coming to an end at KSC, I accepted a position with Northrop Grumman as a Program Manager...
…working on Army/Navy Intelligence, Surveillance and Reconnaissance (ISR) Programs
Program Manager’s get to have some fun too…

Photo Credit: US Army
Northrop Grumman
On the leading edge of...
Missions that are Important to the Nation

Be the Leader in Preserving Freedom and Advancing Discovery

- Supply high value mission products to protect our national security
- Deliver earth and space science products to civil, science & military users
- Provide protected communications for the warfighter
- Protect the nation with reliable, global missile warning & defense

Providing Our Customers High Impact, Best Value Aerospace Products & Systems Through Enterprise Quality, Innovation & Superior Program Performance

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Northrop Grumman Today

• Leading global security company

• $24.7 billion sales in 2013

• $37 billion total backlog

• Leading capabilities in:
  – Unmanned Systems
  – Cyber
  – C4ISR
  – Logistics

Focus on Performance
Four Operating Sectors at a Glance

**Aerospace Systems**
- Airborne Ground Surveillance / C2
- C4ISR
- Directed Energy Systems
- Electronic Combat Operations
- Environmental & Space Science Satellite Systems
- Global / Theater Strike Systems
- ISR Satellite Systems
- Large Scale Systems Integration
- MILSATCOM Systems
- Missile Defense Satellite Systems
- Naval BMC2
- Strategic Space Systems
- Unmanned Systems

**Electronic Systems**
- Air Defense Systems
- C4ISR Networked Systems
- EO/IR Targeting & Surveillance
- Marine & Undersea Systems
- Navigation & Positioning Systems
- Propulsion & Power Generation
- Radar Sensors & Systems
- RF/IR Countermeasures
- Space Sensors

**Information Systems**
- Command & Control Systems
- Communications
- Cyber
- Enterprise Systems and Security
- Federal, State/Local & Commercial
- Health IT
- Homeland Security
- Intelligence
- Intelligence, Surveillance & Reconnaissance Systems
- IT/Network Outsourcing

**Technical Services**
- Aircraft Subsystem/Component Sustainment & Modernization
- Aircraft System/Platform Sustainment & Modernization
- Defense and Government Services
- Ground Vehicle Reconstitution
- Integrated Logistics and Modernization
- Irregular Warfare/Quick Reaction Capability
- Live, Virtual and Constructive Domains
- Nuclear Security Services
- Technical and Operational Training Support
- Training Solutions

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Northrop Grumman Centers of Excellence

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Manned Aircraft Design Center of Excellence
Current Landscape, 2013
Manned Aircraft Design Center of Excellence
New Building opening this year
Aerospace Systems Engineering…
Architecting a whole that is > the sum of its parts
Engineers… come in different sizes and shapes

- **Structural (Air Frame)**
- **Chemical (Aviation Fuel)**
- **Mechanical (Control Surfaces)**
- **Acoustic**
- **Electrical (Lights, Wiring)**
- **Computer (Flight Controls)**
- **Civil (Air Field)**
- **Electrical (Comm. & Nav.)**
- **Aeronautical (Body Shape)**
- **Materials**

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What exactly is a system?
A “system” is a construct or a collection of different elements that together produce results not obtainable by the elements alone. The elements include hardware, software, facilities, people, policies and information. The results include system level requirements, properties, characteristics, functions, behavior and performance ...

From INCOSE http://www.incose.org/

The International Council on Systems Engineering (INCOSE) is a not-for-profit membership organization founded in 1990. Its mission is to share, promote and advance the best of systems engineering from across the globe for the benefit of humanity and the planet.
Systems Engineering = Big Picture Thinking
Modern Aerospace Systems all have common characteristics

- Increasingly complex
- Requires human operator or monitor
- Requires S/W to provide desired functionality
- Has embedded computers/microprocessors
- Highly interactive and complex interfaces
- Limited resources utilized
- New technology may be required/desired
- High reliability and long life required
- Design/development requires “systems engineering”
System Engineering Genesis & Advancement

• Started with technical management by an outstanding individual or very small groups
  – e.g., Kelly Johnson – Lockheed Skunk Works…
  – Characterized by strong technical ability and driving personality

• Systems Engineering methods and tools were developed in the early 1960s to *decompose* and *breakdown* complex Aerospace Systems, e.g. Ballistic Missile, Launch Vehicles, Aircraft
  – Single designer not capable of total system knowledge
  – Engineering specialization “glued” together with Systems Engineering

• Current DoD Interoperability and Systems of Systems Integration is driving next advancement
Today’s Aerospace Systems Engineering

Systems Engineers...
“Engineer the System”

A structured process to ensure the system meets all of its requirements

Define the System
Design the System
(Build the System)
Integrate the System
Test the System
Support the System

A comprehensive, iterative Technical Management (TM) process that includes translating operational requirements into configured systems, integrating the technical inputs of the entire design team, managing interfaces, characterizing and managing technical risk, transitioning technology from the technology base into program specific efforts, and verifying that designs meet operational needs. It is a life cycle activity that demands a concurrent approach to both product and process development.

(11th Glossary of DoD Acqu Terms)

An inter-disciplinary approach and means to enable the realization of successful systems. (EIA 731.1)
In other words, Aerospace System Engineers bring it all together.
Aerospace System Engineering Roles

- **Technical leader** responsible for success of system

- Defines/manages requirement set that is comprehensive, validated, verifiable, and traceable

- Designs system solutions that are balanced across competing priorities (need, performance, risk, cost, and schedule)

- Decomposes system into individually implementable elements while ensuring requirements compliance when elements are integrated

- Integrates engineering effort across program; brings disciplines together and fills the gaps
The Systems Engineering Approach

- Systems engineering requires:
  1. An iterative “top-down/bottom-up” development approach,
     - Top-down to view the system as a whole
     - Bottom-up to determine trade balances, performance feasibility and allocations
  2. A life-cycle orientation to ensure decisions made consider impacts across all life-cycle phases
  3. Focus on system requirements and system performance baselines throughout the program
  4. Multi-domain experience - design/theory of operation level of depth across multiple, integrated domains
  5. Knowledge/experience of how to build up system functionality through lab integration techniques
  6. Knowledge and experience of knowing what to test and how to test it

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Mission Engineering to Customer/User Needs

System Engineering

Segment Engineering

Subsystem Engineering

Unit Design and Development (HW and SW)

Customer/User System Deployment and Operations

System Integration, Test and Verification

Segment Integration, Test and Verification

Subsystem Integration, Test and Verification

Feedback & Iteration

Requirements and Design

Integration and Verification

The Systems Engineer’s Model “V”
Aerospace Systems Engineering…
Helps Program Managers find the right balance
Future System Engineering Challenges

• Increasing system complexity
  – Multi-domain (e.g., ground, sea, air and space)
  – Complicated vs. Complex Systems*
  – Fluency in both hardware and software

• Broader range of missions
  – Cubesats to Large Scale Space Structures; LTA to Next Gen Long Range Strike
  – Short-lived demonstrations to 50-year operational

• Economic pressures demand increased cost/affordability focus
  – Innovation vs. invention
  – CAIV, DTC, should-cost, lowest price technically acceptable

• Consistent systems engineering implementation from system down through segment, element and subsystems

*Dekker, Sidney; “Drift into Failure, From Hunting Broken Components to Understanding Complex Systems”
What about “Systems of Systems”

“The global engineering environment drives a new worldview – systems of systems. Evolving needs, new approaches, and advances in technology are influencing the characteristics and the capabilities of emerging and future systems”

Dr. Donna H. Rhodes
Massachusetts Institute of Technology

- SoS are comprised of several autonomous embedded complex systems that can be varied in geography, operation, context, technology and conceptual frame
- A spacecraft is a System; a Launch Complex is a Systems of Systems
- Significant challenges:
  - Optimizing the mix of independent systems
  - The SoS operates in an uncertain environment
  - Interoperability between independent systems
What type of students... rise up as Systems Engineers

• Want a degree in Aero/Astro, ME, EE, math, or physics

• Are a “big” picture thinker and prefer to work in team environment

• Like science & engineering and enjoy working directly with customers

• Would like to work on cutting-edge aerospace & defense systems

• Would like to be sitting at the console at Cape Canaveral counting down the launch of a 4.5 million lb rocket!
Northrop Grumman’s Commitment to STEM
Why Are Kids Avoiding Engineering?

• They don’t know about it

• It is a difficult discipline
  – 41% of teens associate the word difficult with engineering

• They are not prepared for college engineering
  – Didn’t take advanced math/science in high school

• Ineffective messaging
  – Engineers solve problems using math and science
    Vs.
  – Engineering is essential to our health, happiness and safety
Aerospace Engineering... with benefits

1. Love your work, AND live your life too!
2. Be creative
3. Work with great people
4. Design things that matter
5. Never be bored
6. Make a good salary
7. Enjoy job flexibility
8. Travel
9. Make a difference
10. Change the world
NGC STEM Education Pipeline

Pre / Elementary School
- Early childhood STEM learning through the arts
- Camp Invention
- STEM Toolkits
- EWeek
- Class visits
- Teacher Professional Development

Middle School
- Space Camp
- Partners in Inspiration Programming
- STEM Toolkits
- VEX Robotics
- MATHCOUNTS
- EWeek
- Teacher Grants
- ECO Classroom
- Parent Engagement
- Teacher Professional Development

High School
- CyberPatriot
- HS Involvement Partnership/Intern programs
- Science Fairs
- VEX Robotics
- EWeek
- Innovation Challenge
- Career Days
- Nat’l Math and Science Initiative for Military Families
- ECO Classroom
- Teacher Professional Development

College
- Paid Internships and Coops
- School Partnerships
- University of MD, Cyber Security
- Career Fairs
- Executive Sponsors
- Curriculum Development
- Research and Development
- National Diversity Association Scholarships
- VEX Robotics
- Troops support

Northrop Grumman is Fully Engaged With K-16 STEM Pipeline
NGC National Programs
Do some of your students have it in them?

• Engineering can be a very meaningful and personally rewarding field
  – Our world has big problems and engineers will be expected to solve those big problems

• Engineering requires discipline and a good deal of effort
  – Edison was to have said, “Ingenuity is 1% inspiration, 99% perspiration.”
  – I think he was speaking about Engineering

• Engineering degrees are held by more CEOs than any other field
  – This is probably true of Chief Technical Officers (CTOs) as well
  – 62% of all CEOs have advanced degrees (MBA, PhD, Law degree, Master’s)
THE VALUE OF PERFORMANCE.

NORTHROP GRUMMAN
THE VALUE OF PERFORMANCE.

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