# From Zero to Formalizing Requirements in 10 weeks

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Thanks to:

NASA

The West Virginia Space Grant Consortium

and

The NASA Faculty Fellowship Program

# Starting Point:

- Physics professor – PhD 1986
  Surface Physics/Electrochemisty
- Fortran and Basic experience (years ago)
- Teaching professor at a small/medium state college in West Virginia (6500 students) since 1994
- Enticed by $13k and a change of scenery rather than $4k for one summer course.

# Questions at the start:

#1 What does IV&V stand for? (4 and 5?)

#2 Would I have to get a degree in computer programming to make a contribution?

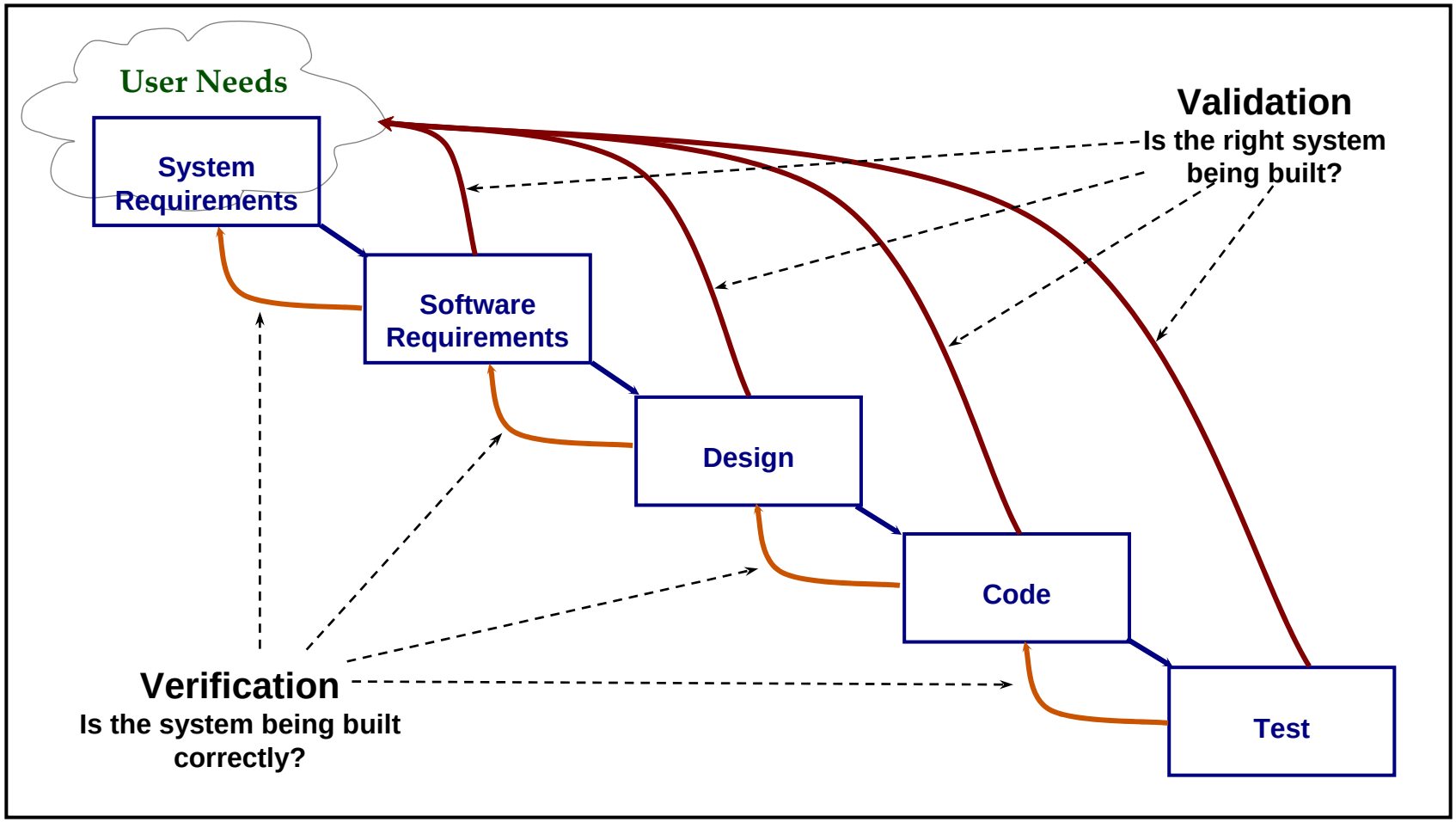
#3 What can a physicist with very little software background do at a government facility that focuses on software?

# Answer to #2:

V&V stands for Verification and Validation

Software engineering is basically problem solving

Software engineering is basically problem solving – it involves much more than just computer programming



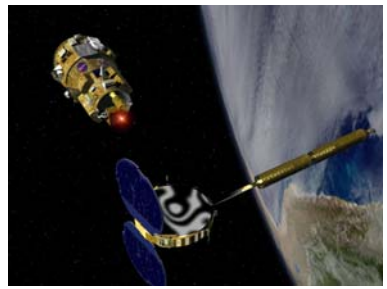

Themis presentation by David King, UCB liason

# JSC, MSFC, ARC, HQ
# Supported Missions

## I. Overview of IV&V Facility

Space Shuttle

International Space Station

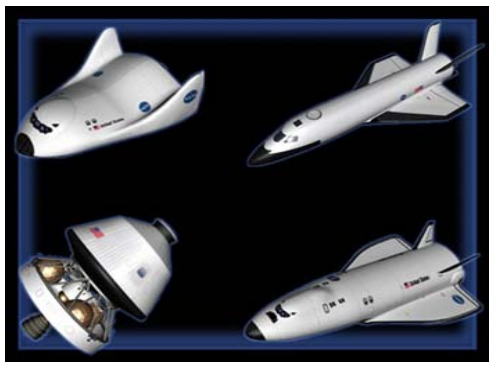
DART

X-37

Johnson Space Center

Marshall Ames Headquarters

Gravity Probe B



Orbital Space Plane

AATT

Advanced Air Transportation Technologies

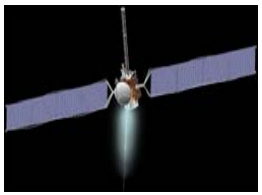
ifm PROGRAM

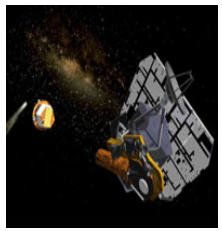
# JPL, LaRC, DFRC, GRC Supported Missions

## I. Overview of IV&V Facility

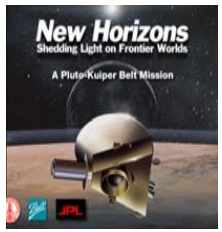
Deep Impact

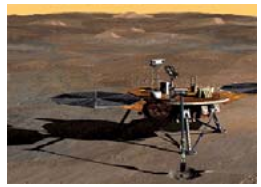
DAWN





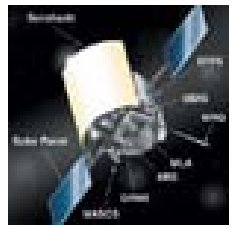
PKB



Mars Phoenix

MER



MESSINGER

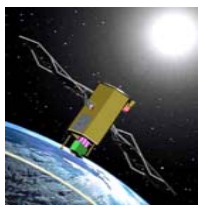
MRO

Jet Propulsion Lab

Langley Dryden Glenn

SIM


X-43C



OCO

Intelligent Flight Control System

Active Aeroelastic Wing

Fluids and Combustion Facility

# Discussions with Stephanie Ferguson Project Manager for DAWN

- DAWN includes instruments from several countries, USA government labs and academic institutions
- The instruments are proprietary, secret “black boxes” to the other countries and organizations
- The specifications of instrument interfacing with the platform satellite is described only in “interface documents”

# DAWN Mission: Study the physical structure and evolution of asteroids Ceres and Vesta

- A framing camera provided by the German Aerospace Center (DLR), Institute of Space Sensor Technology and Planetary Exploration
- A mapping spectrometer provided by the Italian Institute for Space Astrophysics in Rome
- A laser altimeter provided by the NASA Goddard Space Flight Center
- A gamma ray spectrometer from the Department of Energy's Los Alamos National Laboratory
- A magnetometer provided by UCLA

# ***My First Attempt at a proposal during my summer fellowship at the NASA IV&V facility in Fairmont, WV***

Title: "V&V of Software Interfaces between 'Secured' Mission Components"

**SOFTWARE IV&V**
**RESEARCH INITIATIVE PROPOSAL**
**for the**
**NASA SOFTWARE IV&V FACILITY**

# Abstract

V&V tools and techniques will be reviewed and developed in the context of case studies and current projects to deal with the risks of misinformation passed across the interface between “secured components” (SC) of a mission where the sharing of specific component information is prohibited.

# I became familiar with issues of system and software requirements

- Most problems in software are traced back to the requirements (>60% of industrial fails or works poorly when first tested)
- The cost of fixing a fault increase >100 x when found after coding, verse when found in the requirements phase
- Writing good requirements w/ tracing matrix (RTM) for V&V are not welcomed tasks;  not emphasized in UG programs and research

# and…Nobody WANTS to Trace!

- Particularly "after the fact" (IV&V analysts)
- Why?
  - ⇦Tedious
  - ⇦Error prone
  - ⇦Time consuming
  - ⇦Arduous
  - ⇦Booooorrrrriiiinnnggggggggg…… zzzzzzzzzzz...

(Jane Hayes: Dept. of Computer Science, U of K)

# A fundamental question:

Is it worth the time and cost to Verify and Validate software requirements?

"Return on Investment (ROI) of IV&V"

James Dabney
NASA IV&V Research Initiative

A common argument against IV&V is that the expenses exceed the value added.

Another fundamental question that can be addressed by undergraduate students at FSU:

Is it worth the time and cost to write requirements “formally” so they can be traced by computer program?

# Back to the Questions at the start:

#3 What can a physicist with very little software background do at a government facility that focuses on software?

# Answer to #3:

1) Augment problem-solving skills with principles of Software and Systems Engineering to tackle issues of requirements writing and V&V in science and technology applications;
2) Develop project-based curriculum at FSU to teach SE / Problem Solving to students of several majors

# Why apply formal methods?

## (such as Software Cost Reduction (SCR))

- Proven to be effective in almost every other engineering discipline
- Formal modeling and verification can provide very strong evidence that an embedded system satisfies critical safety, scheduling and synchronization properties
- Unambiguous proofs can be performed in order to demonstrate the correctness of a property
- Existing techniques with high degree of discipline are experiencing “quality ceilings”

# Return on Investment (ROI) of Formalizing Requirements

Galen J. Hansen - PI

- This project will examine the ROI of formalizing requirements for computer automated V&V, compared to traditional V&V.
- Groups of FSU students will perform V&V on a set of requirements with seeded faults using:
  (1) Software Cost Reduction (SCR) tools;
  (2) basic software engineering design;
  (3) traditional IV&V tracing
- The project will be modeled after the V&V ROI project of Arthur, et.al. performed by students at Georgia Tech.
  (Arthur, J.D., Groener, M.K., Hayhurst, K.J., Holloway, C.M., Evaluating the effectiveness of independent verification and validation, IEEE Computer, October 1999, pp. 79 83.)

# Phase 1: Curriculum Development

Fall 2005 and Spring 2006 Semesters

- Takes two SE courses from WVU's SENG program

- Develop two undergraduate prototype courses:
  Software Engineering and V&V

# Phase 2 (if funded): ROI Project

Summer 2006 – Spring 2007

- Develop appropriate requirement set with injected faults

- Teach Software Engineering and V&V courses to selected students

- Student groups perform respective V&V tasks on ROI requirements set

Trying to find and teach students who will become interested in majoring in a STEM discipline, becoming a STEM teaching in secondary education, or working at NASA is like looking for gamma-ray bursts in space.

- Random – in which schools does one look?
- Fundamental Underlying Principles – Personal Experiences; Expectations; Environment (family, communities, opportunities)
- A continual wide-angle sweep of space is needed to locate interest before narrowing our view (solicitations aren't good enough)

# Brainstorm: A Project-based Multi-discipline Systems Engineering Four-Year Program at FSU

- Four year program to build a rocket with a science mission
- Program students major in various Engineering Technologies, Sciences, Computer Science, and Business/Information Systems
- Freshmen take a Systems Engineering/Problem Solving course introducing SE principles
- Principles of SE emphasized as program students come together in seminars and workshops over the four years to design, build, and test their rocket

Thanks to those who have taken the time to talk with me, give me advice, and share resources with me:

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