

# Academic Perspective on Benefits of NIRPS Solutions

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National Institute for Rocket Propulsion Systems (NIRPS) Workshop 2012  
Monterey California, December 6, 2012



# My Background

- 1 Year in Gas Turbine Industry
- Graduate CO-OP with Air Force Rocket Propulsion Laboratory
- PhD Purdue University, 1988
- 3 Years Advanced Diagnostics for Strategic Rocket Testing, AEDC
- 21 Years as Professor at UAH
  - 15 years as Director of Integrated Product Team Initiative
  - 4 years as Propulsion Research Center Director
  - 1 year as Interim Department Chair
  - 8 million in Research, 80 projects
  - 80 Advanced degrees
  - 100 classes



# Overview

- **Purpose:**
  - Provide one academic's perspective on NIRPS and what it can do to benefit universities and the STEP pipeline.
- **Outline:**
  - A) 2010 NIRPS Academic Workshop
  - B) UAH Propulsion Research FY12 Snapshot
  - C) Research Case Studies
  - D) Challenges and Opportunities



# A) 2010 NIRPS Academic Workshop



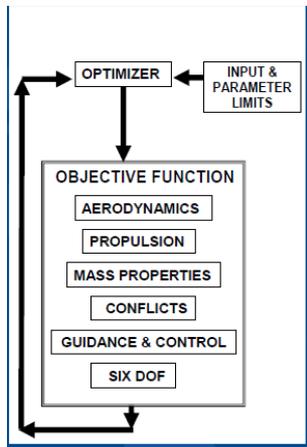
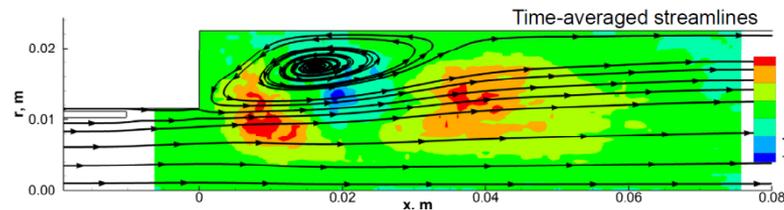
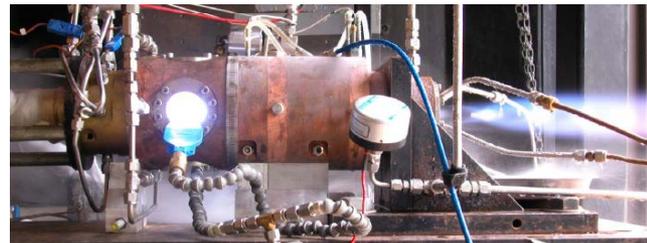
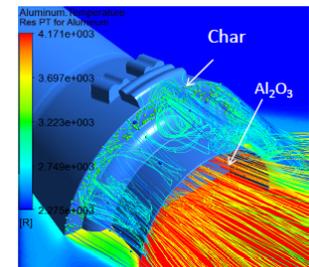
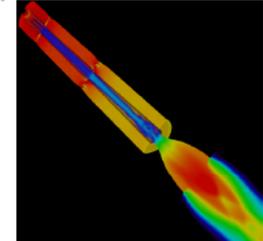
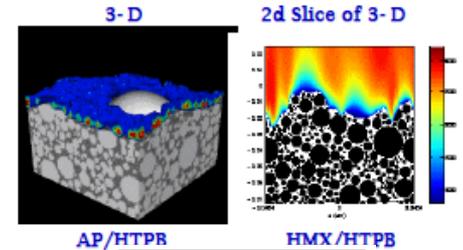
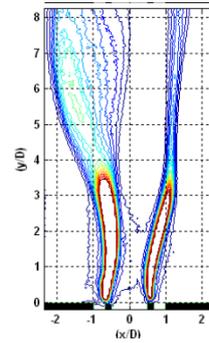
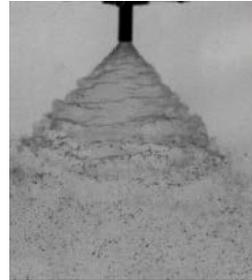
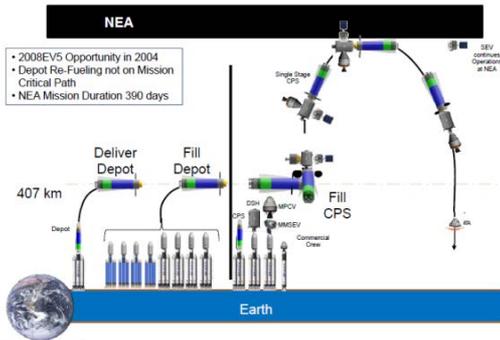
# 2010 NIRPS Workshop - Current State of Academia <sup>5</sup>

Sponsored and Hosted by The University of Alabama in Huntsville

System Architecture  
and Cost

Fundamental  
Processes

Multi-Physics  
Modeling



# 2010 NIRPS Workshop - Effective NASA /University Programs

(Bob Santoro)

- **Continuity over the graduate student's degree program (minimum 3 years).**
- **Do not tie academic research programs to current development programs.**
  - **Makes them compete for resources with mission critical elements.**
  - **Do not put their milestones in a critical path as research progress can not be scheduled.**
- **University research overall must be relevant to NASA near and long-term program goals**



# General Comments -2010 NIRPS Workshop

- Need a compelling mission
- Insure a proper mix of DoD and NASA Research
- Insure proper industry buy in for university research work (transition research and students into industry; understand pull)
- **Provide means for integrating government, industry, and academic researchers and engineers**
  - **NASA CUIP Program was a Model for Healthy Government/University Interactions**
  - **French-German collaborations on high pressure HO systems and combustion instability are sustainable and productive**
- Invest in High Risk High Payoff Technology in Foundational Research Now (i.e. Combustion Instability/Crosscutting Disciplines/Life Prediction)
- Affordability/Demand is Critical to the Future (NASA Cost Models do not Include University Research)
- **Focus on most difficult problems that *require* collaboration between multiple disciplines (but do not eliminate individual researcher contributions)**

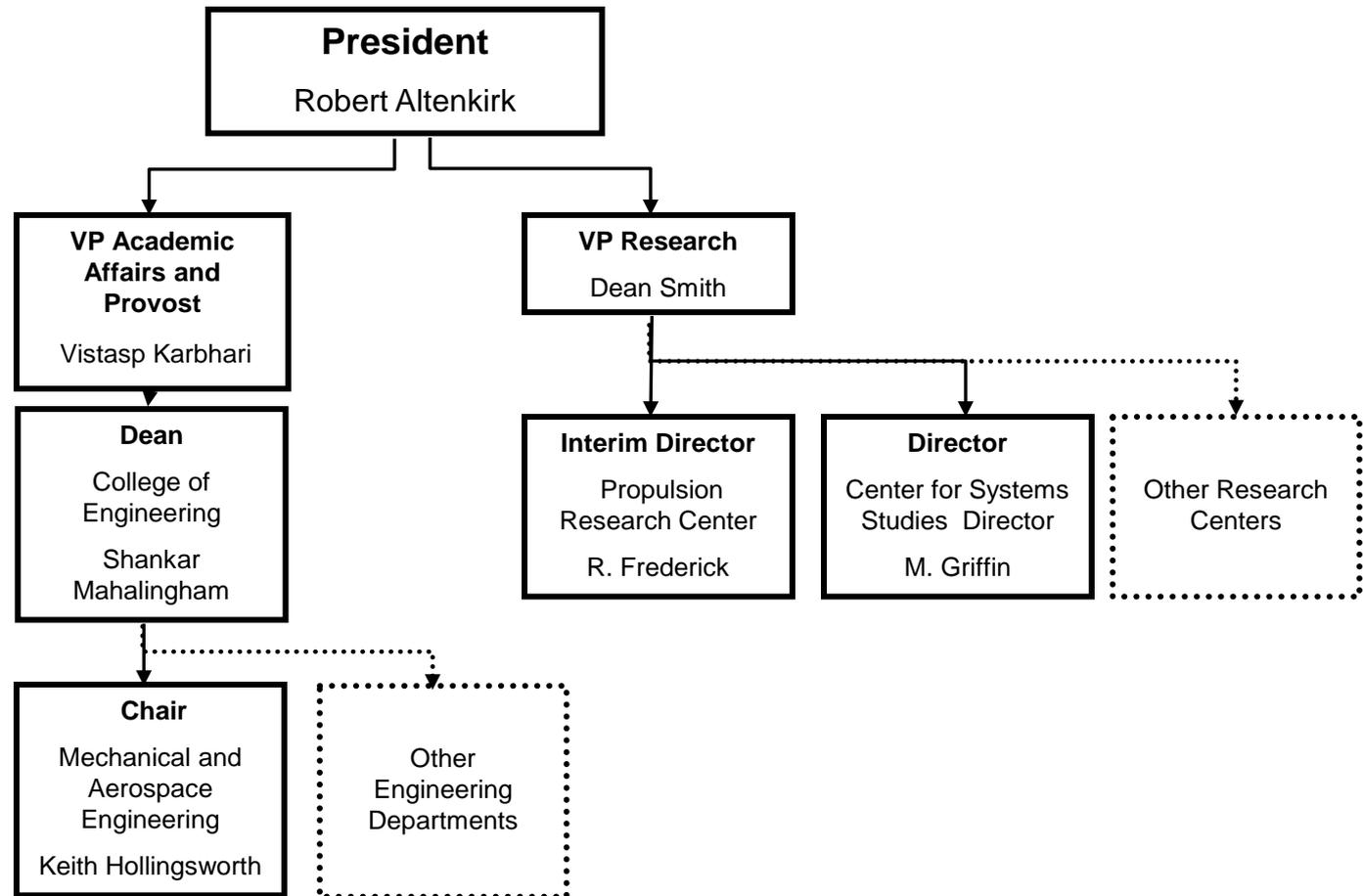


# B) UAH Propulsion Research FY12 Snapshot

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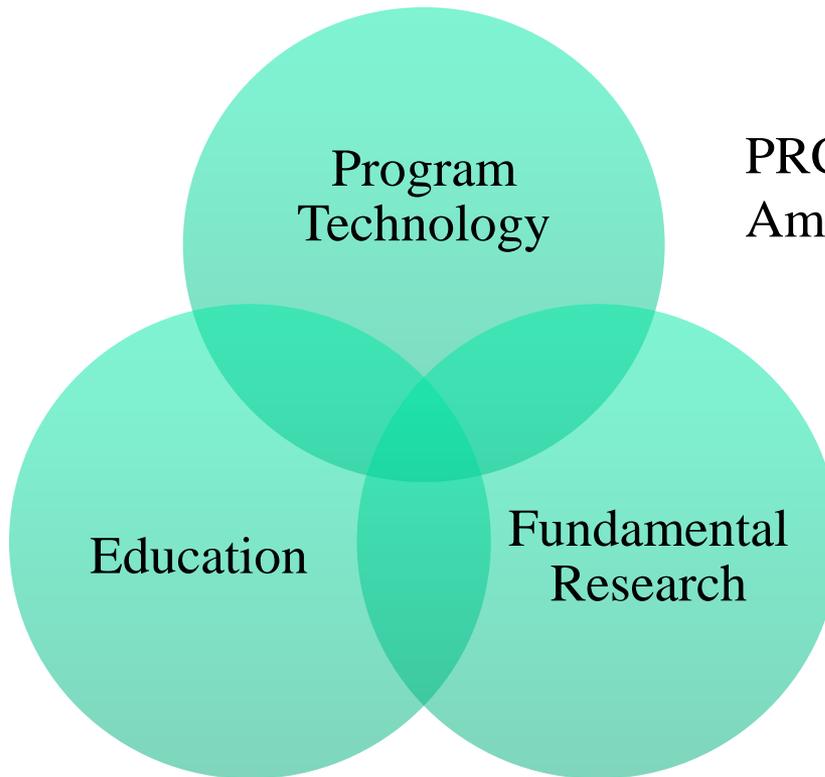


# UAHuntsville Organization Chart



# UAH Propulsion Research Center

PRC connects the Academic Research Community with Industry & Government to advance basic science and technology development related to propulsion and energy.



PRC Focuses on Creating Overlap  
Among Competing Goals

# UAHuntsville Propulsion Research Center

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## Mission

PRC connects the Academic Research Community with Industry & Government to advance basic science and technology development related to propulsion and energy.



## PRC Strategic Vision 2015

The PRC will be a major generator of talent and innovative solutions in propulsion and energy related technologies.



**MAE Faculty/Administration**



# UAH Department of Mechanical and Aerospace Engineering

Not Shown: 5 staff, 13 part-time instructors,  
Over 900 students, 143 degrees/yr. (Department)

**MAE Faculty**



**MAE Lecturers**

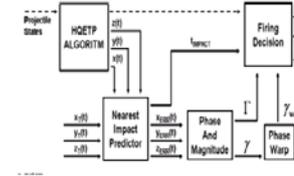
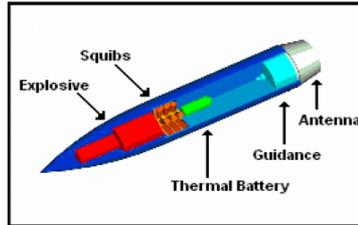


**Emeritus Faculty**

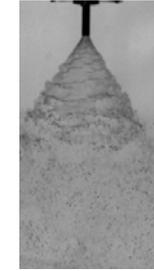
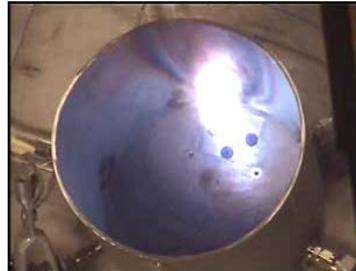


# PRC Core Competencies

- Aerospace System Design**  
 Systems Requirements  
 Technology /Assessment Integration  
 System Modeling/Evaluation



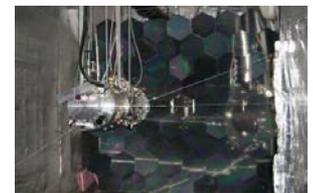
- Liquid Propulsion**  
 Integrated Methodology  
 Combustion Efficiency/Instability  
 Laboratory-Scale Rocket Engine  
 Advanced Diagnostics



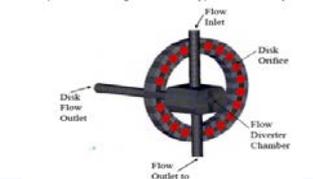
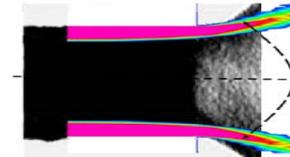
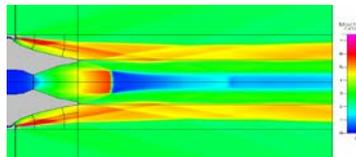
- Solid Propulsion**  
 Propellant Formulation  
 Burn Rate Determination  
 Motor Testing



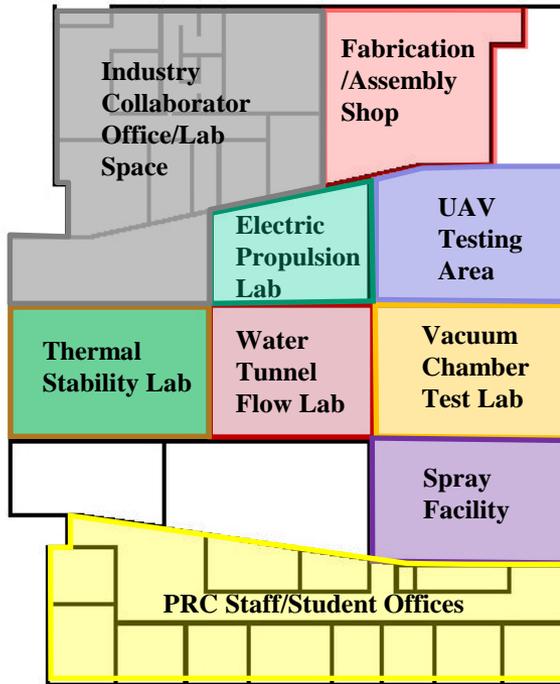
- Advanced Propulsion**  
 Plasma Modeling  
 Fusion Propulsion  
 Solar Propulsion



- Numerical Analysis**  
 Sprays  
 Acoustics  
 Reacting Flows



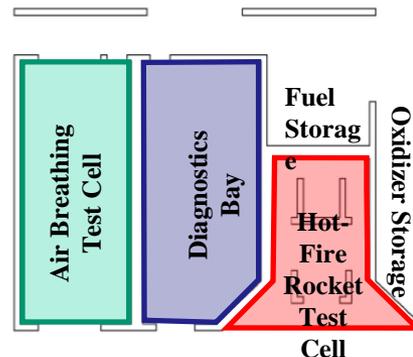
# State of the Art Laboratories



PRC Labs at the  
Johnson Research  
Center

Approximately 15,000 ft<sup>2</sup> of Laboratory Space

- Air-breathing Test Cell
- Hot-Fire Rocket Test Cell
- Thermal Stability Test Lab
- Solar Thermal Lab (not Shown)
- High-Pressure Solid Propellant Lab (not shown)
- Electric Propulsion Lab
- Gaseous Cold Flow Lab
- Water Tunnel Flow Lab
- Vacuum Chamber Test Lab



PRC's Propulsion Test Facility



# FY12 PRC NUMBERS

## FINANCIALS

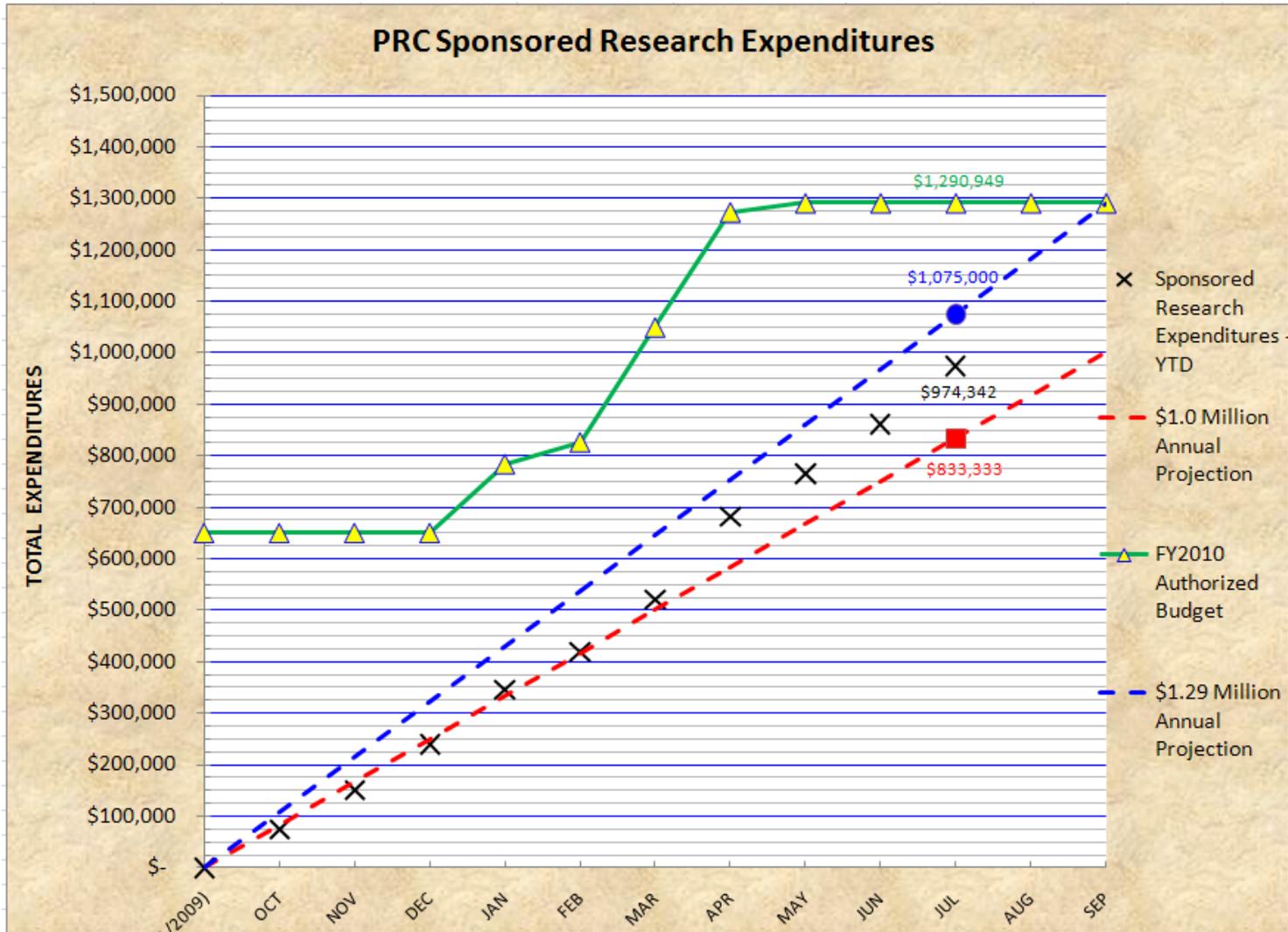
- \$2.3 Million Expenditures
- 25 Active Res. Accounts
- Top 5 Projects
  - 80% of Funds, Average \$370K
  - AMRDEC, MDA, Craft Tec, NSF, State of Alabama
- Bottom 20 Projects
  - 20% of Funds, Average \$23K
  - SBIRS, Company, DoE, etc.
- \$210K State Support

## Other

- Recognized as 3<sup>rd</sup> Most Awesome Laboratory in Nation by Popular Science
- Supported 12 Full Time Graduate Students
- Assisted 40 Graduate Students
- Published 12 Articles
- Participated in 7 Professional Societies
- Hosted NASA USLI Team



# EXAMPLE CENTER FUNDING PROFILE FY10



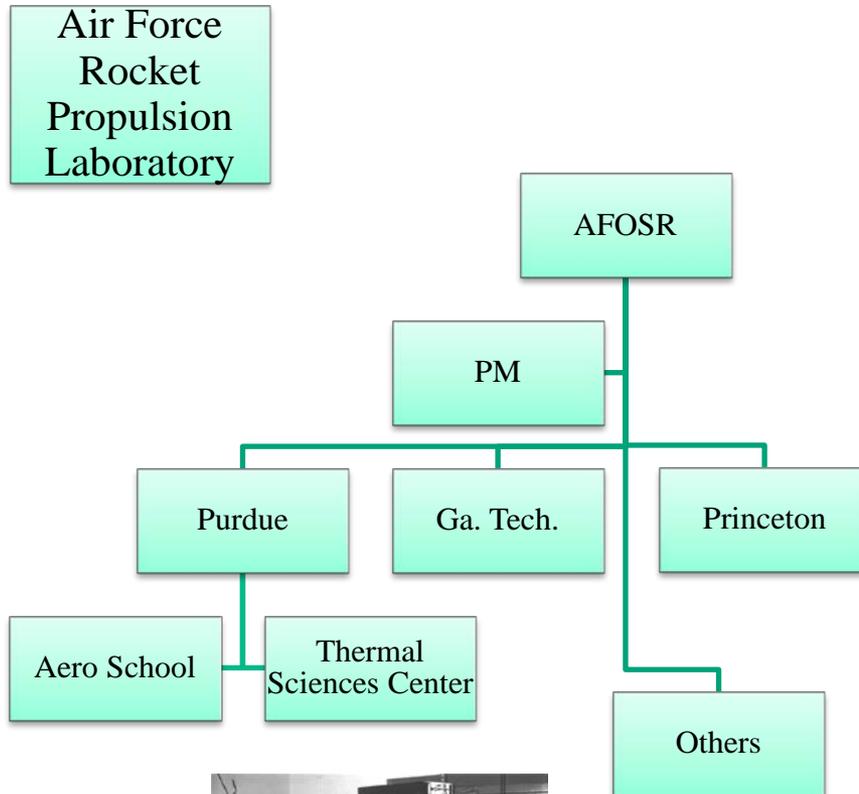
## C) Research Case Studies

Show Relationship Among Agencies  
Advantages/Disadvantages



# 1980's – Air Force/University

## Solid Propellant Development

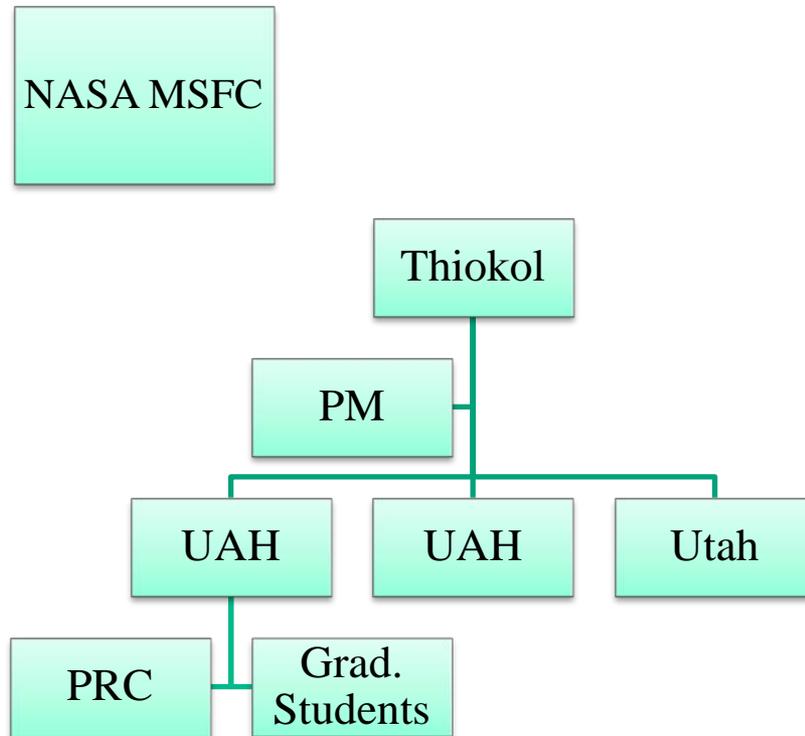


- Fundamental Research
- University Based
- Multi-Year
- Annual Contractor Meetings
- Research Coordinated with Air Force Rocket Propulsion Laboratory
- 8 years



# 1990's – Company Research IRAD

## Hybrid Propulsion

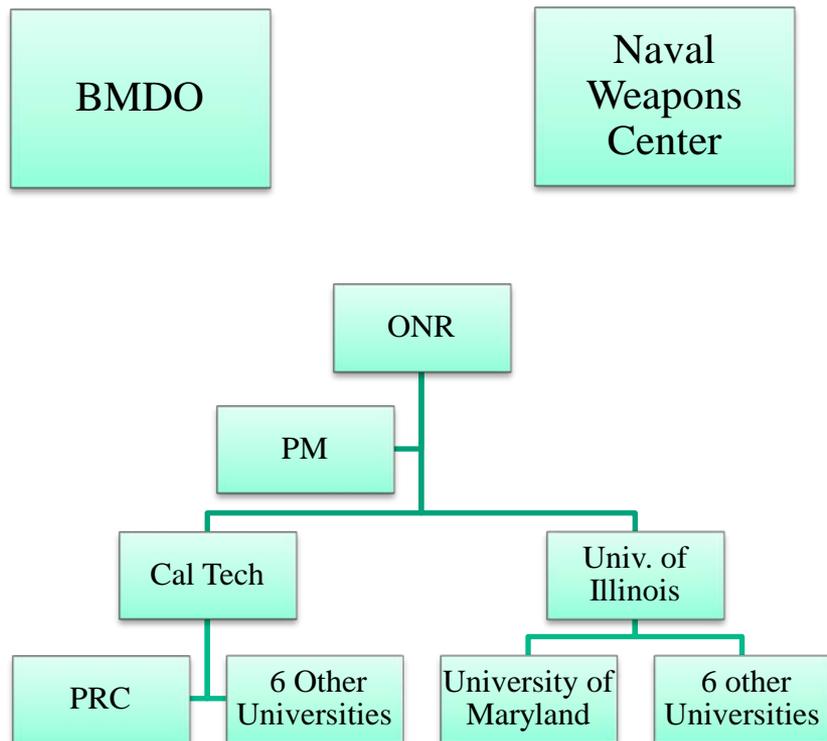


- Fundamental Research
- University Based
- Multi-Year
- Student Focused
- Annual Meetings
- Research Coordinated with In House Technology Projects and MSFC Tech. Projects

# 1990's – ONR MURI

## Novel Energetic Materials

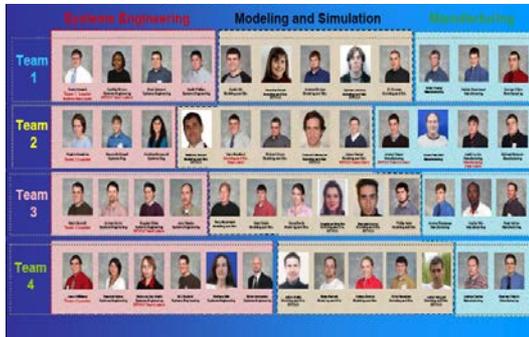
Office of Naval Research, Multi-University Research Initiative



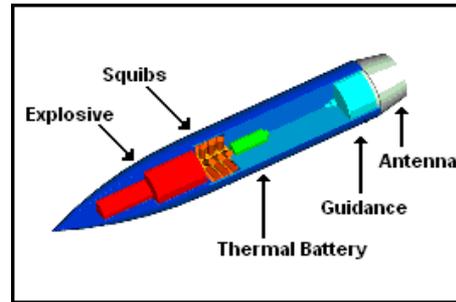
- Fundamental Research
- University-Assembled and Lead Teams
- Multi-Year
- Student Focused
- Annual Meetings
- Research Coordinated Among Universities
- 3 years

# 1990's System Concept Study- STEM

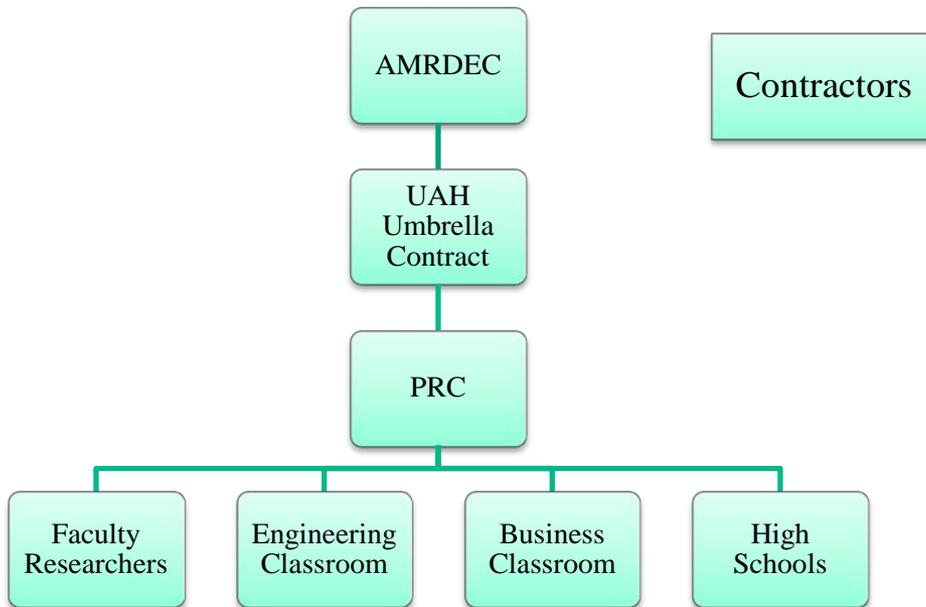
Student IPTs. – Competing Concepts



Selected Design – Army Contract.



- Advanced System Concepts
- Multi-Disciplinary Sr. Design Projects – Classroom Focused
- International University
- STEM Outreach
- External Reviews
- Annual Funding – 20 Years



Hahn, P.V., Frederick, R.A., Jr., and Slegers, N., "Predictive Guidance of a Projectile for Hit-to-Kill Intercept," IEEE Transactions on Control System Technology, Vol. 17, No. 4, 2009.

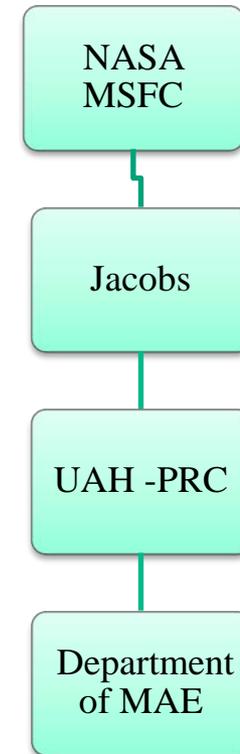
# 2000's Example Class - Adv. Solid Rocket Propulsion

Developed by Robert Geisler and Dr. Robert Frederick, Jr.

ITAR Cleared, UAH Graduate Course, UAH Professional Development Course, and AIAA Short Course



14 Industry Speakers  
Multi-Year (Recorded)

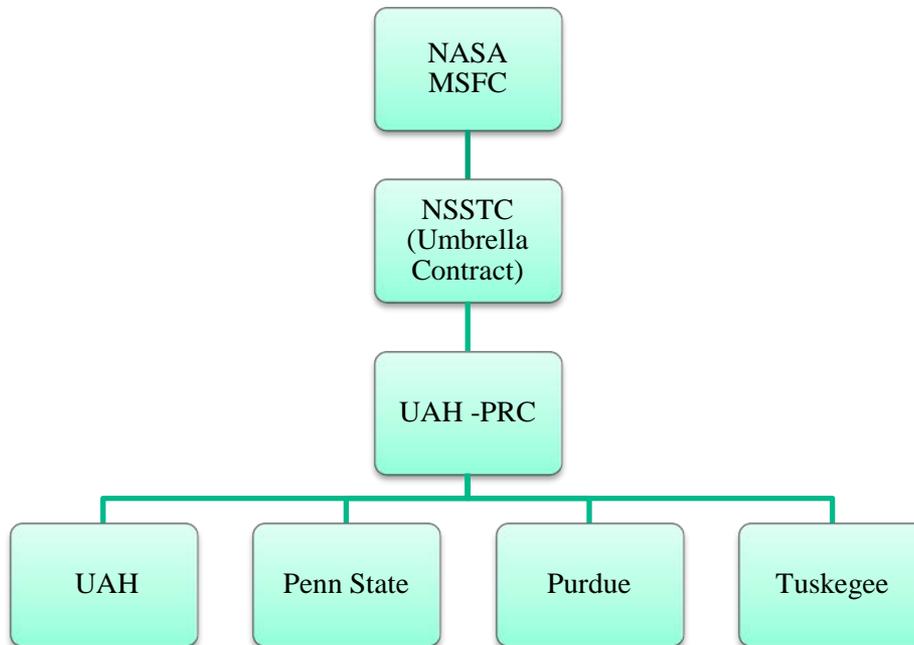


# 2000's –UAH NASA REAP

Combustion Instability and Thrust Chamber Cooling

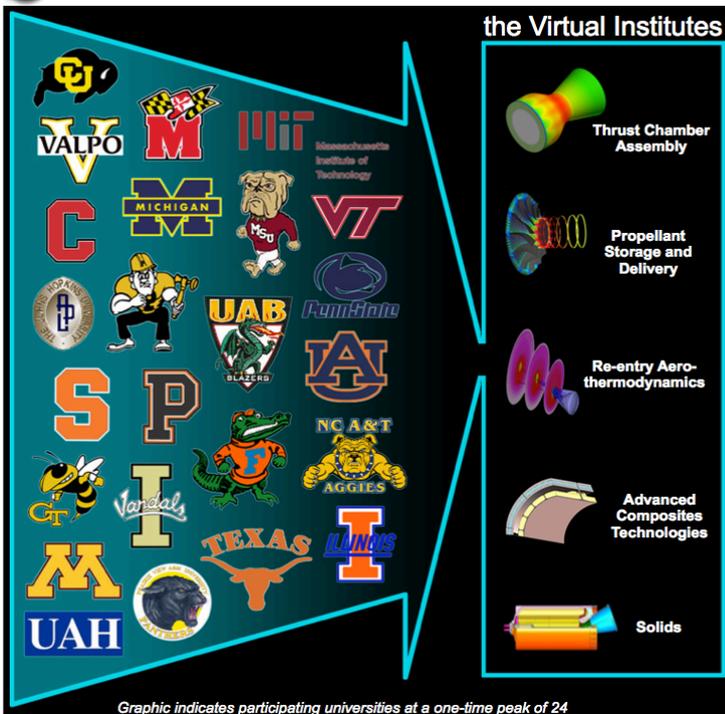


- Applied Research
- Host University Manage Subcontracts
- University Based
- Multi-Year
- Student Focused
- Research Associated with In House Technology Issues
- 3 years



# 2000's – NASA CUIP

## Constellation University Institutes Project



- Perform research and development that addresses critical Constellation needs.
- Enhance and broaden the ability of the nation's universities to meet the needs of NASA's programs.
- Expand the nation's talent base for NASA mission-related research and development and technology maturation.
- Strengthen NASA's ties to academia through long-term, directed, and sustained investment.

- University Based Applied Research
- Multi-Disciplinary
- Host University Manage Subcontracts
- Multi-Year Efforts
- Agency Technical Mentors
- Student Focused
- Annual Evaluations
- Over 7 years



# 2000 - Nationally Recognized Student Launch Initiative

National First-Place Design-Fab.-Build – R. Frederick, UAH Faculty Advisor

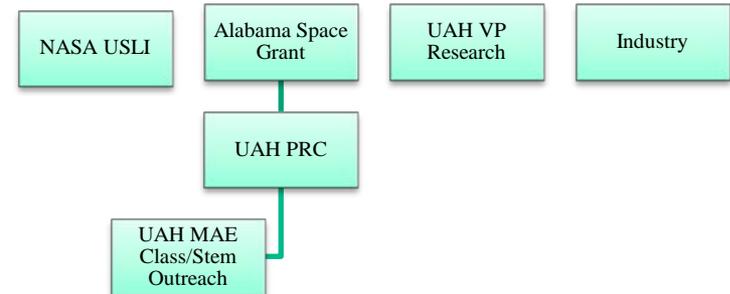
**POPSCI** THE FUTURE NOW

PHOTO GALLERIES

f FAC

## Gallery: 30 Awesome College Labs

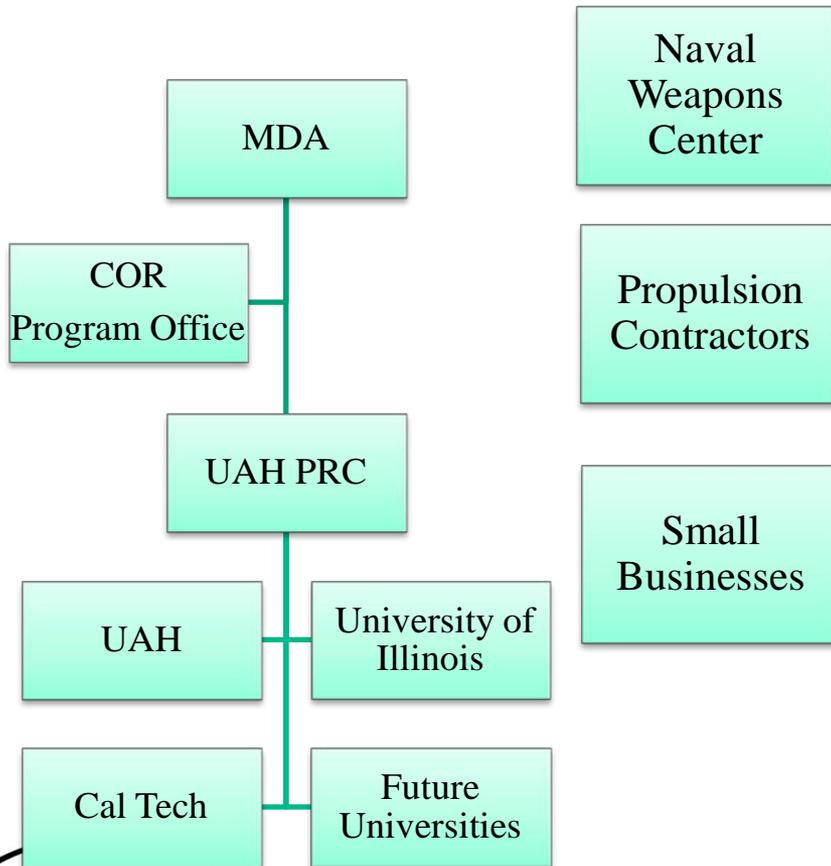
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- Basic Funds From Space Grant
- PRC Provides Laboratory/Safety
- VP Res. Augments Funding
- National Student Competition
- Annual Bids

# 2010's – MDA MSTAR

Missile Defense Agency, Science and Technology Advanced Research (MSTAR)  
*"Innovative Propulsion Technology Support"*



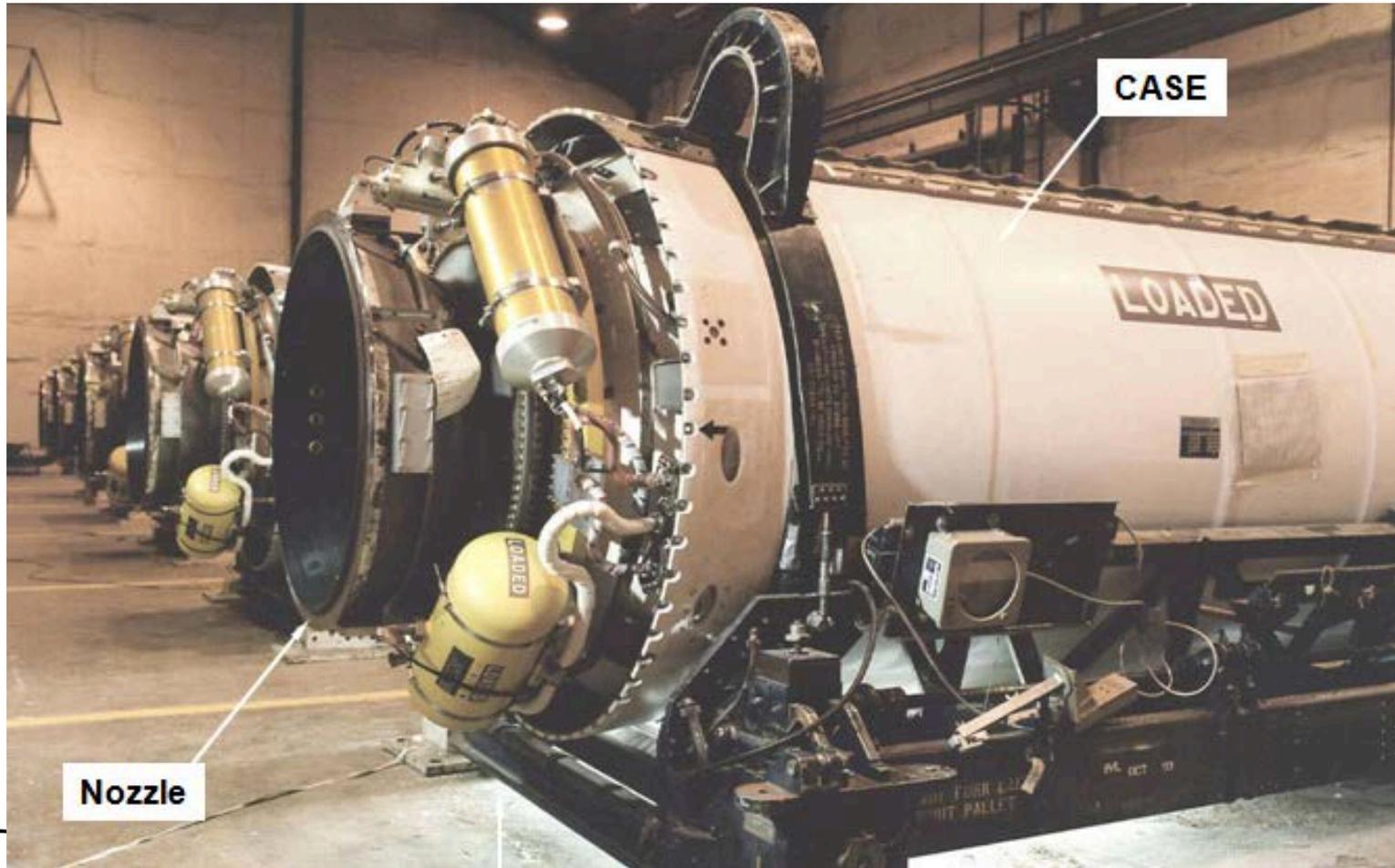
- Applied Research
- University-Assembled/Lead Team
- 1-3 year Contract
- Weekly Meetings, Monthly Reports, Quarterly TIM's, Annual Reports
- Faculty PI's
- Graduate Students
- Security Clearances, ITAR
- Multi-Party Non-Disclosure Agreements with Propulsion Companies and Small Business

## D) Challenges and Opportunities

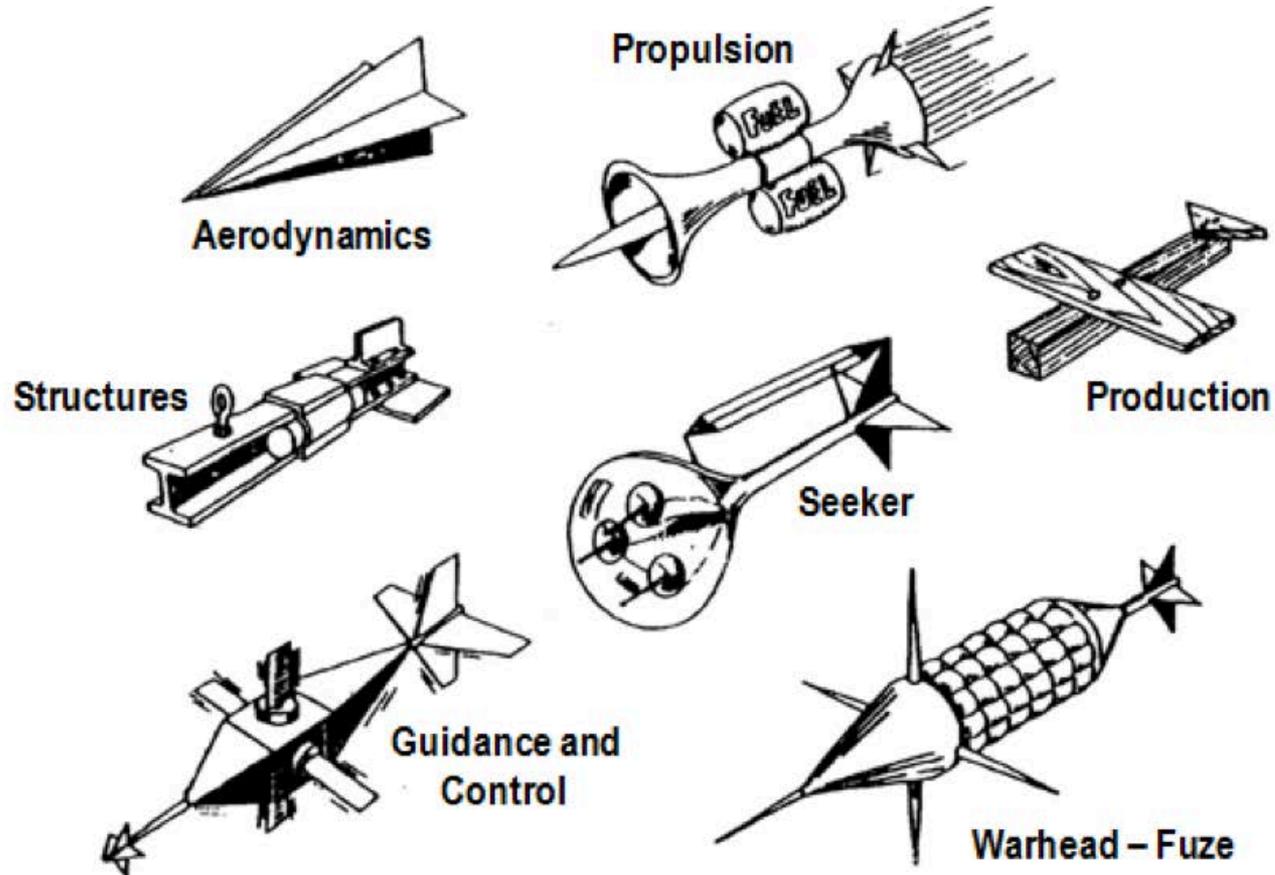
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# Program Orientation

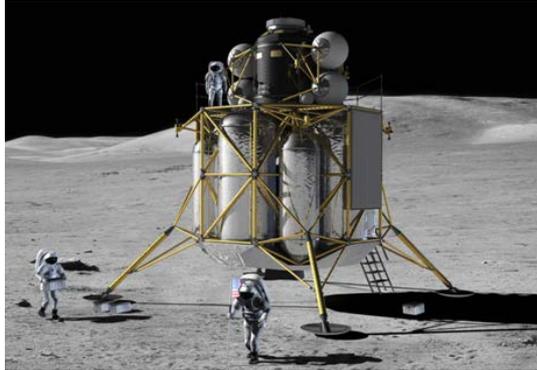


# Multi-Disciplinary

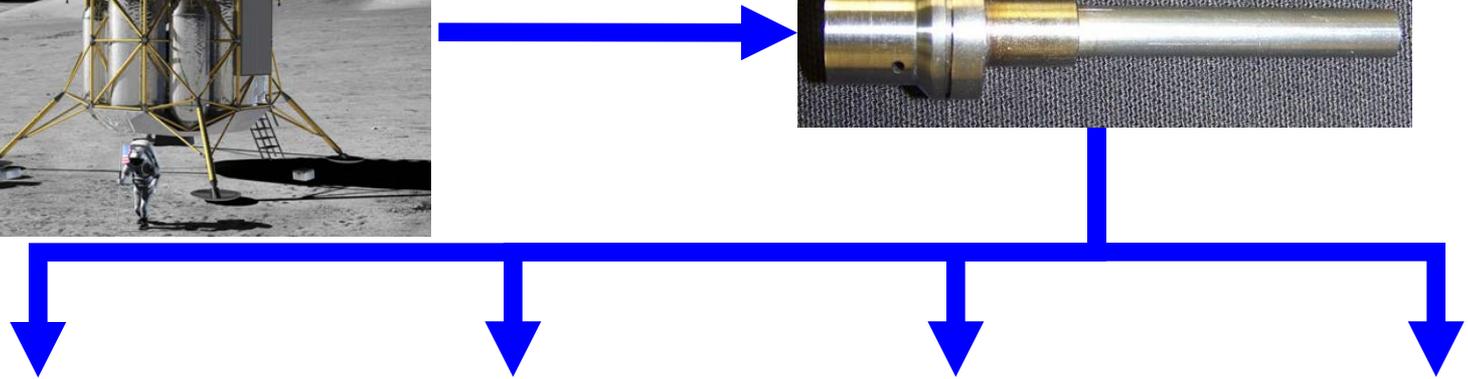


# Example – UAH Integrated Methodology

System Engineering



New Component Technology

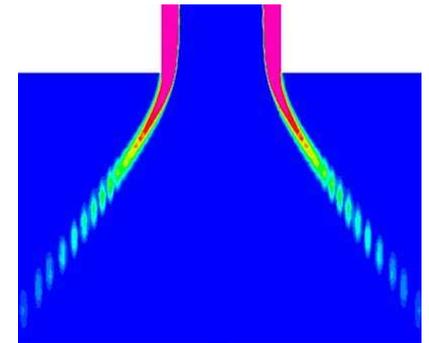
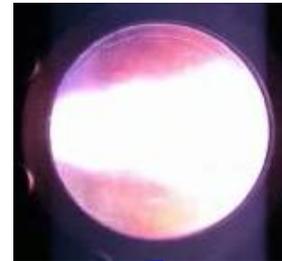
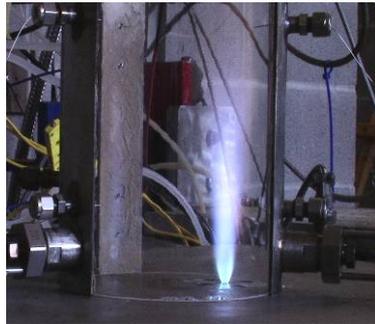


Cold-Flow Spray Facility

Low-Pressure Combustion Stability

High-Pressure Combustion Performance

Modeling and Verification



Digital Database



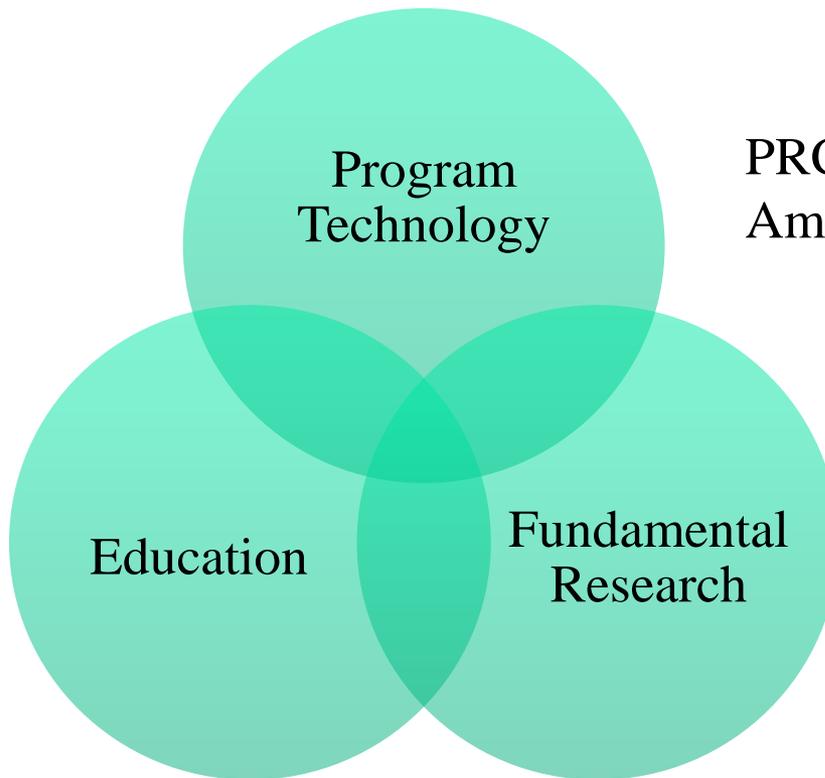
# Multi-Year Funding





# UAH Propulsion Research Center

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PRC Focuses on Creating Overlap  
Among Competing Goals

# Summary Thoughts – NIRPS University Strategies

- Relevance to Agency Needs
- Commitment to Basic Research
- Multi-Year University Programs
  - Carefully Contracted Umbrella Admin.
  - Technical Mentorship
  - Technical Review and Deliverables
  - Special Care on ITAR, Proprietary, Safety, and other Sensitive Information
  - Leverage the Professor's Assets
- CUIP is Model Program to Consider

