UAHuntsville Propulsion Research Center
Overview

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for

Raytheon Missile Systems
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Agenda

• PRC Background
• Example
• Future Collaborations
UAHuntsville Propulsion Research Center

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.
UAHuntsville Organization Chart

President
Robert Altenkirch

VP Academic Affairs and Provost
Vistasp Karbhar

Dean
College of Engineering
Shankar Mahalingham

Interim Chair
Mechanical and Aerospace Engineering
Keith Hollingsworth

VP Research
John Horack

Interim Director
Propulsion Research Center
R. Frederick

Director
Center for Systems Studies Director
M. Griffin

Other Research Centers

Other Engineering Departments
UAH NIRPS University Consortium
National Institute of Rocket Propulsion Systems

"Opportunity goes where the best people go, and the best people go where good education goes."
W. Von Braun
Grand Challenges in Propulsion Research
Workshop Chairs

Back Row: Robert Frederick, UAHuntsville, Mark Brandyberry, University of Illinois; Robert Santoro, Penn State, Alan Wilhite, Georgia Tech.; Vadim Smelyanskiy, NASA Ames; Shankar Mahalingam, UAHuntsville.

Front Row: Ken Yu, University of Maryland; Roy Hartfield; Auburn; C.P. Chen; UAH; Mitchell Walker; Georgia Tech; and Bill Anderson, Purdue University.

October 14, 2010,
Huntsville, AL
Current State of Academia in Propulsion

UAH NIRPS Worship Report

System Architecture and Cost  Fundamental Processes  Multi-Physics Modeling

- NEA
- 407 km
- OPTIMIZER
- INPUT & PARAMETER LIMITS
- OBJECTIVE FUNCTION
- AERODYNAMICS
- PROPULSION
- MASS PROPERTIES
- CONFLICTS
- GUIDANCE & CONTROL
- SIX DOF

- Time-averaged streamlines

- AP/HTPB
- HMX/HTPB

- 2D Slice of 3-D

- UAH Huntsville

The University of Alabama in Huntsville
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
Nationally Recognized Student Launch Initiative
National First-Place Design-Fab.-Build – R. Frederick, UAH Faculty Advisor

PHOTO GALLERIES

Gallery: 30 Awesome College Labs
Posted 9:00 at 1:12 pm 0 Comments

University of Alabama at Huntsville: Propulsion Research Center

John B. Carrnett
Career: Rocket scientist
Learn to: Make things that go very fast and very far.

Each year, 20 aeronautical- and mechanical-engineering students get eight months to design, construct, and fly a rocket to a height of exactly 5,280 feet. These aren’t hobby rockets, which typically fly to less than 1,000 feet (any higher requires an FAA permit). “Consider that an ‘A’ engine is half as strong as a ‘B’ engine, and so on,” says engineering professor Marlow Moser. “The rockets you shoot off in the park, A and B engines. Our rockets: L engines.”

Last year’s class built a 37-pound, 8.5-foot-long carbon-fiber projectile with advanced data-collection systems onboard. The nosecone carried a video camera and avionics to record the rocket’s flight path and other information; the attitude, temperature, and strain sensors. Students enter their rocket in a NASA-
UAH University Student Launch Initiative
State of the Art Laboratories

Approximately 15,000 ft² 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 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
  - Plume Characterization
  - Solar Propulsion

- **Numerical Analysis**
  - Sprays
  - Acoustics
Aerospace Systems Design
Guided Bullet Study
Guided Bullet Study

Student IPTs. – Competing Concepts

Selected Design – Army Contract.

Additional Research - Autopilot

Guided 2.75 Rocket – Graduate Class

Systems Engineering Trade Considerations During Development

- Avionics Case Composition
- Dimension
- Mass Management
- Launcher Interface
- Mass/dimensions
- Power
- Connectivity
- Data Characteristics
- Umbilical CONOPS
- Length, Mass Balance
- CG in Launcher
- Motor Case Length
- Avionics Length
- Flight Characteristics
- Mass/Range, CONOPS -Air/Ground
- Canard Axial Position
- CG - CP Management
- Response Moments
- Flight Process
- Initialization
- GPS/Algorithm
- Processor/Power
- CONOPS
- In Flight Processing
- Component Performance/Availability/Produceability/Cost
- Software Commonality/ Compatibility

Advanced Tactical Missile II

Systems Engineering Process

- CDD Requirements
- HTORA Risk - A Launcher Assessment
- Strategy
- Integration/Installation
- Mass & Structures
- Aerodynamics
- Propulsion
- Mission System Concept
- Missiles/ Components
- Within Budget
- NO
- YES

FY06
FY07
FY08
FY09
FY10

Program management: The University of Alabama in Huntsville

UAHuntsville
Propulsion Research Center
MDA – Innovative Propulsion Technology Support

UAH/MDA Charter

• Identify, Assess, and Prioritize Promising Technologies
• Establish Consortium of Propulsion Technical Experts
• Conduct Analytic and Laboratory-Scale Assessments of Promising Technologies as Independent Verification of Characterization
• Synthesize, Document, and Maintain Propulsion Technology Investment Strategy
Example – UAH Integrated Methodology

System Engineering

Cold-Flow Spray Facility

Low-Pressure Combustion Stability

High-Pressure Combustion Performance

New Component Technology

Modeling and Verification

Digital Database
Task Summary

Objective: To evaluate and improve a laboratory-scale injector test facility that provides fundamental combustion data and maps the stability boundaries of practical injectors.

Team: UAH Propulsion Research Center
- Dr. R. A. Frederick, PI, Dr. David Lineberry
- Numerous Graduate Students
- Mr. James Hulka; Jacobs [Technical Monitor]

Approach
- Evaluate single, full-scale liquid rocket injectors with method from Russia
- Simulate key scaling parameters (such as momentum ratio) using atmospheric gases
- Measure the spontaneous oscillations in the atmospheric resonance chamber
- Correlate the amplitude and mode of observed instabilities with scaling parameters
- Verify Scaling Criteria with instabilities observed in high pressure motor firings

Accomplishments

Year 1 - Demonstrated Spontaneous Instability
AIAA Paper 2006-4528

Year 2 - Mapped Stability of Three Injectors
AIAA Paper 2007-5587

Year 3 - Mode Analysis
AIAA Paper 2008-1655

Year 4 - Comparisons with Engines
AIAA Paper No. 2009-5493

Year 5 - Optical Diagnostics
(AIAA Paper 2010-6668, AIAA Paper 2010-6737)

Year 6 - Digital Analysis of Modes
PRC Statistics

PRC History
• Founded in 1991
• 30 Million in External Funding to Date
• 75 Refereed Publications to Date
• Over 25 Ph.D. degrees Advised
• Over 120 Masters Degrees Advised
• Over 125 Undergraduate Students Supported
• Numerous Government, Academia, and Industry Partners

FY10 Statistics
• 14 Active Research Projects
• 5 Full time Staff
• 8 Faculty Collaborators
• 5 Ph.D. Students
• 20 Masters Degree Students
• 5 Undergraduate Students Researchers
• 1.2 Million in Expenditures

Sponsors and Collaborators

Images of various logos and partnerships.
UAH PRC Affiliations

- AIAA Hypersonic Technical Committee
- AIAA Joint Propulsion Conference Organizing Committee [Propulsion Education]
- AIAA Solid Rocket Technical Committee
- Aerospace Consortium of Alabama (ACA), [UAH, Auburn, and Alabama]
- Air Force Educational Partnership Agreement, AFRL Edwards
- AMRDEC Standing Contracts
- ASEE Propulsion Education
- JANNAF Journal of Propulsion and Energy
- JANNAF Solid Performance Committee
- NASA Constellation University Institute Program (CUIP)
- NASA Educational Partnership Agreement, MSFC
- NASA MSFC Cooperative Agreement
- NASA Glenn RTAPS [Research and Technologies for Aerospace Propulsion Systems]
- ONERA France