This presentation is an overview of basic Research & Development at the AFRL Propulsion Directorate, given to the National Research Council Research Associateship Programs.
Air Force Research Laboratory
Edwards Air Force Base, CA

Intro & Basic R&D Overview for NRC RAP Administrator

13 July 2011

Lt. Col. LaDonna Davis
Division Technical Advisor
Space & Missile Propulsion Division

Distribution A: Unlimited Distribution
Create and Transition Propulsion and Power Technology for Military Dominance of Air and Space

Space & Missile Propulsion

Hypersonics

Energy, Power & Thermal

Turbine Engines
AFRL People & Facilities

- 10 Major R&D sites across US
- 40 Locations around the World
- 10 Technical Directorates
  - Air Vehicles (RB)
  - Directed Energy (RD)
  - Human Effectiveness (RH) (711 HP Wing)
  - Information (RI)
  - Space Vehicles (RV)
  - Munitions (RW)
  - Materials & Manufacturing (RX)
  - Sensors (RY)
  - Propulsion (RZ)
  - AF Office of Scientific Research (AFOSR)

- 5,400 Gov’t Employees
- 3,800 On-site Contractors

Distribution A: Approved for Public Release; Distribution Unlimited
Resources: Land
Total Area: 65 Square Miles

- Air quality constraints do not inhibit research activities
- Noise abatement not a problem
- Wind/population corridor does not inhibit research
- Environmental monitor/control systems in place
- Flight Test Center relation/support ongoing

Distribution A: Approved for Public Release; Distribution Unlimited
# Resources: People

**Total Personnel : 468**

<table>
<thead>
<tr>
<th>Category</th>
<th>Total</th>
<th>M.S.</th>
<th>Ph.D.</th>
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<td>Scientists and Engineers</td>
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Joint government and industry effort focused on developing affordable technologies for revolutionary, reusable and/or rapid response military global reach capability, sustainable strategic missiles, long life or increased maneuverability spacecraft capability and high performance tactical missile capability.
Space and Missile R&D Building Block Process

6.1 EXPLORATORY RESEARCH

Materials
Turbomachinery
Thrust Chambers & Nozzles
Preburners

6.2 APPLIED RESEARCH

Cases/Tanks
Controls

6.3 ADVANCED DEVELOPMENT

Reusable
Strategic
Expendable
Tactical
Spacecraft
Space and Missile Integrated Rocket Demonstrators

TECHNOLOGY TRANSITION

Space and Missile Component Technology Demonstrators
Branch Expertise

- **RZSA – Aerophysics**
  - Characterize, model, and analyze propulsion fluid and energy flow processes
  - Non-equilibrium flows, combustion devices, plumes

- **RZSP – Propellants**
  - Liquid, solid rocket propellant modeling, synthesis, characterization, & development

- **RZSM – Materials Applications**
  - Basic & Exploratory research into application of materials to rocket propulsion components
  - Areas of research: High Temperature Components, Polymers, Propellant Fracture Mechanics

- **RZSO – Experimental Demonstrations (test facilities)**

- **RZST – Payoff Studies**
  - Provide unbiased analysis and assessment from component level through system level in support of internal and external customers

- **RZSB – Motors**
  - Exploratory and Advanced development of solid propulsion technologies

- **RZSE – Engines**
  - Exploratory and Advanced development of liquid rocket engine technologies

- **RZSS – Spacecraft**
  - Exploratory and Advanced development of spacecraft propulsion technologies

Distribution A – Public release, unlimited distribution
Designing Superoleophobic Surfaces

• Goal: a design framework for constructing super-repellent surfaces

• Demonstrated two embodiments:
  – electrospun mats (single step process)
  – μ-hoodoos (model lithographic surfaces)

• Three key ingredients

- Roughness \( (r) \)
- Surface Chemistry \( (\theta_e) \)
- Surface Geometry \( (\psi) \)
Green Propellants

- Eliminate highly toxic propellants
  - Hydrazine
  - NTO/MMH
- Ionic Liquid as energetic propellants
  - Liquid salts
  - Non-toxic, higher density Isp
  - Monopropellants (yes), Bipropellants??
- Technical Challenges
  - Higher operating temperature – consumes catalyst bed
  - Ignition delay
- Numerous applications
  - Spacecraft propulsion
  - Missile Defense

EMIM cation
(1-ethyl-3-methylimidazolium)

Distribution A: Approved for Public Release; Distribution Unlimited
Multi-mode Propulsion

• Mission need
  – Increased mission flexibility with limited apriori knowledge of mission profile
  – Same propulsion system for multiple different mission profiles

• Technical Challenge
  – High Thrust $\neq$ High Efficiency
    • Electric propulsion synonymous with high efficiency, low thrust propulsion
    • Chemical propulsion synonymous with high thrust, low efficiency
  – Difficult for single propulsion type to handle both
Resources: Facilities

Bench-level Labs

High Thrust Facilities
- 19 Liquid Engine stands, up to 8,000,000 lbs thrust
- 13 Solid Rocket Motor pads, up to 10,000,000 lbs thrust

Altitude Facilities
- From micro-newtons to 50,000 lbs thrust
Current R&D Thrusts

- Hydrocarbon Boost
- Multi-mode Satellite Propulsion
- Advanced Solid Motors
- Upper Stage Engine Tech
- "Green" Monopropellants
- All-electric Orbit Transfer
Questions?

Propulsion - the technology that enables the warfighter to reach out and touch anyone, anywhere in the world - and beyond. The Air Force Research Laboratory's Propulsion Directorate - the nation's premier organization to create and transition technology for military propulsion and power systems since the dawn of powered flight.