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Air Force Research Laboratory Edwards Air Force Base, CA

Intro & Basic R&D Overview for NRC RAP Administrator

13 July 2011



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Division Technical Advisor

Space & Missile Propulsion Division



AFRL Propulsion Directorate

(AFRL/RZ)



**Create and Transition Propulsion and Power Technology
for Military Dominance of Air and Space**

**Space & Missile
Propulsion**

Hypersonics

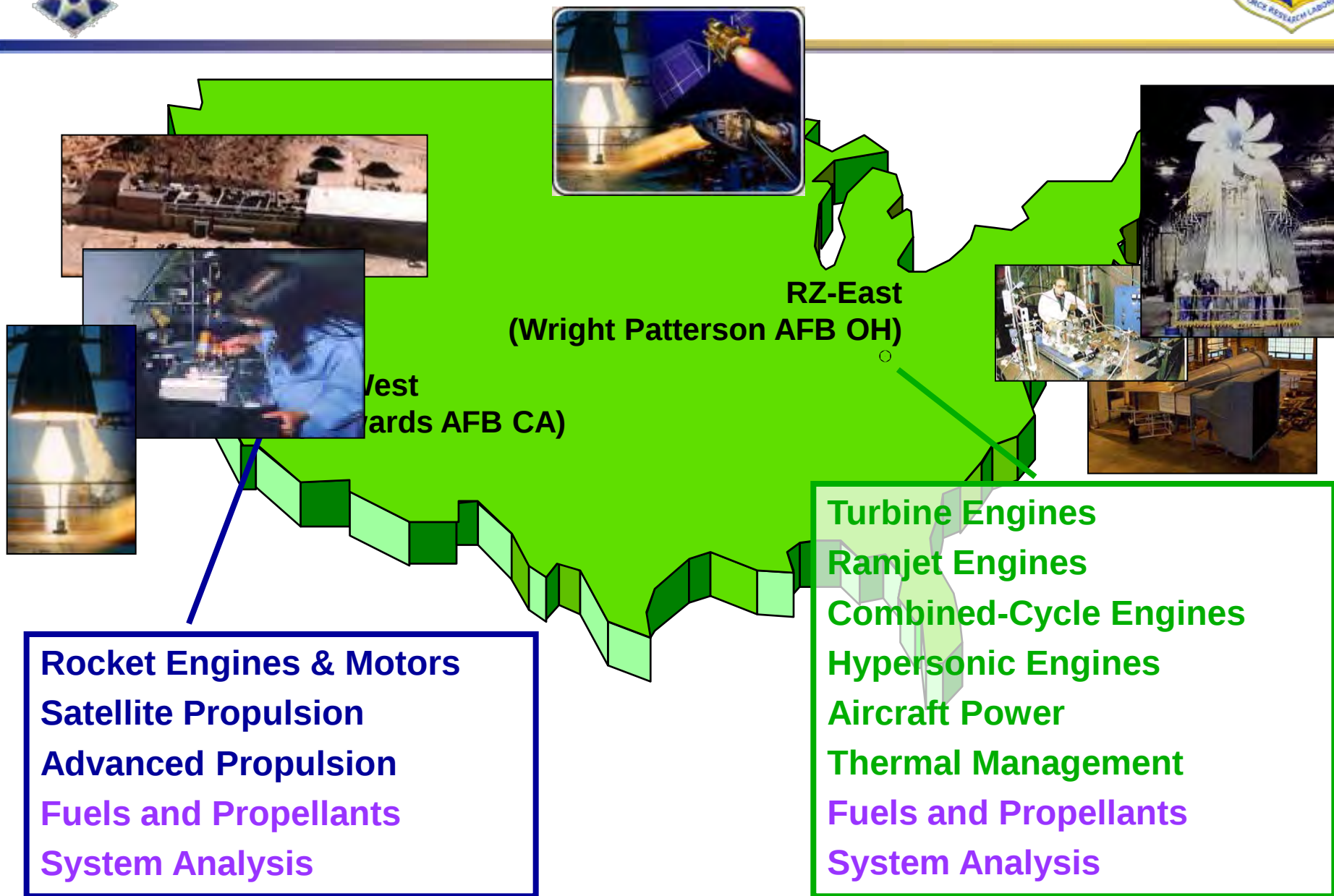


Turbine Engines

**Energy, Power &
Thermal**



AFRL Propulsion Directorate

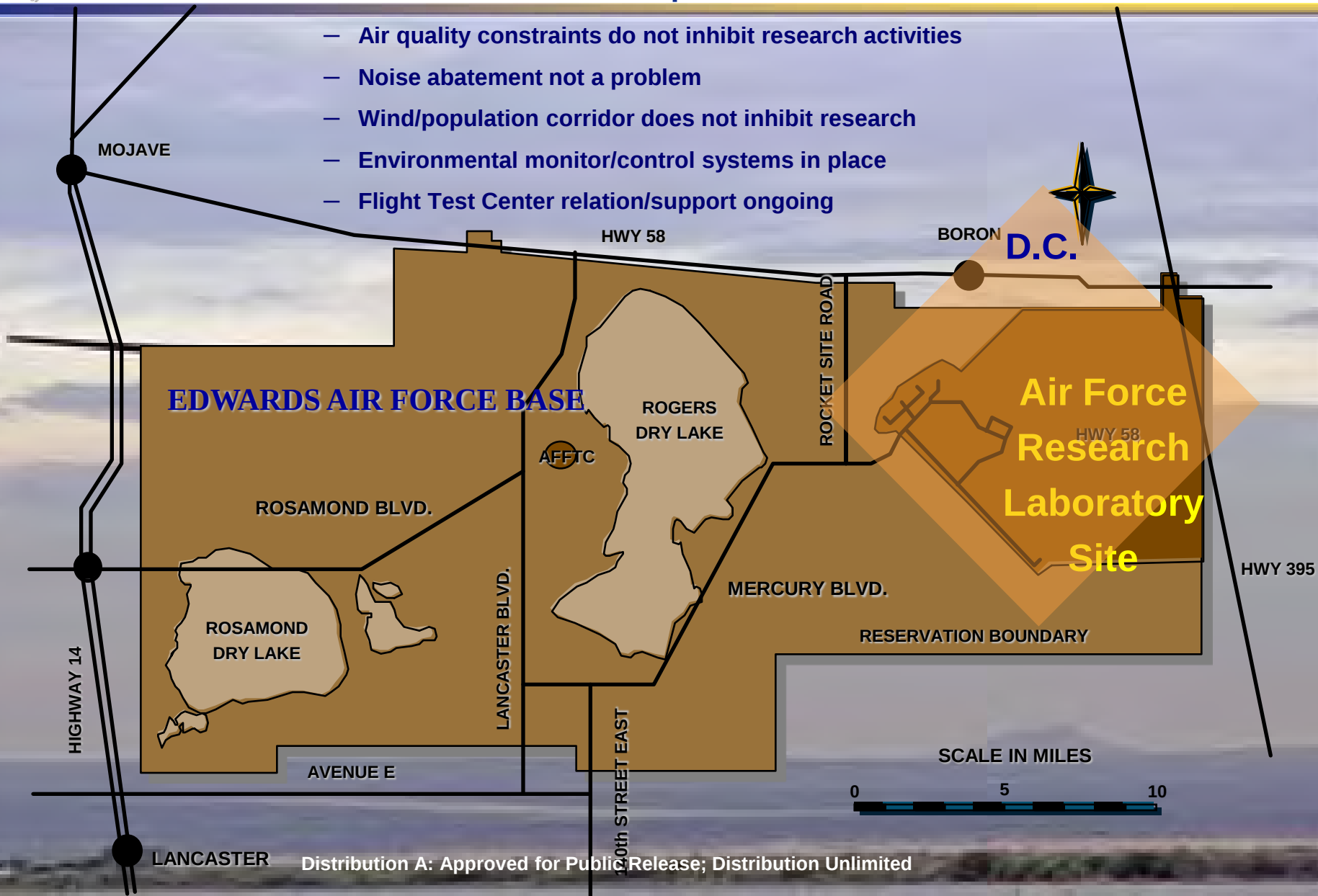




Resources: Land

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





Resources: People

Total Personnel : 468

CIVIL SERVICE	Total	M.S.	Ph.D.
Scientists and Engineers	109	21	46
Technicians	24	0	0
Administrative	29	0	0
CO-OPs	10	2	2
Student Support (S.T.E.P., etc..)	5	0	0
Palace Acquire	1	0	0
TOTAL CIVIL SERVICE	178	23	48

CONTRACTORS	Total	M.S.	Ph.D.
Scientists and Engineers	70	15	9
Technicians	156	0	0
Administrative	16	0	0
TOTAL CONTRACTORS	242	15	9

ACTIVE-DUTY MILITARY	Total	M.S.	Ph.D.
Scientists and Engineers	26	3	1
Technicians	15	0	0
Pgm mgrs/Admin	1	0	0
TOTAL ACTIVE DUTY MILITARY	42	3	1

IMAs	Total	M.S.	Ph.D.
Scientists and Engineers	4	0	1
Technicians	2	0	0
TOTAL IMAs	6	0	1



Integrated High Payoff Rocket Propulsion Technology (IHPRPT)



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

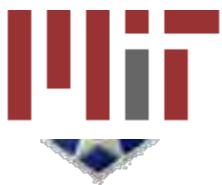




Branch Expertise



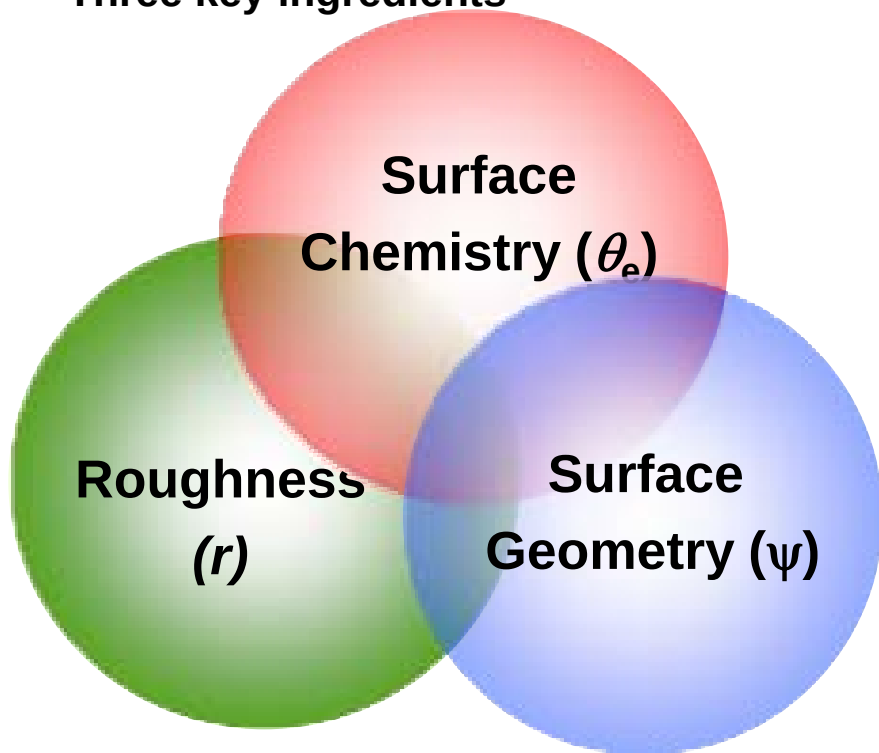
- **RZSA – Aerophysics**
 - Characterize, model, and analyze propulsion fluid and energy flow processes
 - Non-equilibrium flows, combustion devices, plumes
- **RZSP – Propellants**
 - Liquid, solid rocket propellant modeling, synthesis, characterization, & development
- **RZSM – Materials Applications**
 - 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



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



PMMA + 44 wt% POSS

electrospun coating (beads on a string)
morphology



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





Multi-mode Propulsion



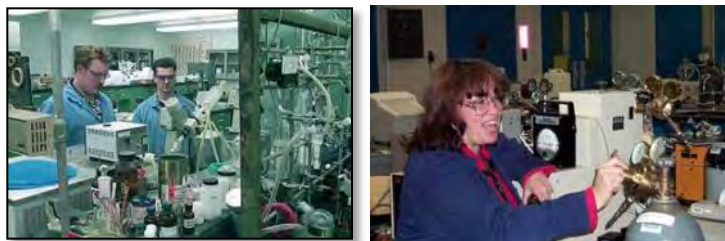
- **Mission need**
 - Increased mission flexibility with limited apriori knowledge of mission profile
 - Same propulsion system for multiple different mission profiles
- **Technical Challenge**
 - High Thrust $\neq$ High Efficiency
 - Electric propulsion synonymous with high efficiency, low thrust propulsion
 - Chemical propulsion synonymous with high thrust, low efficiency
 - Difficult for single propulsion type to handle both



Resources: Facilities



Bench-level Labs



Altitude Facilities

- From micro-newtons to 50,000 lbs thrust



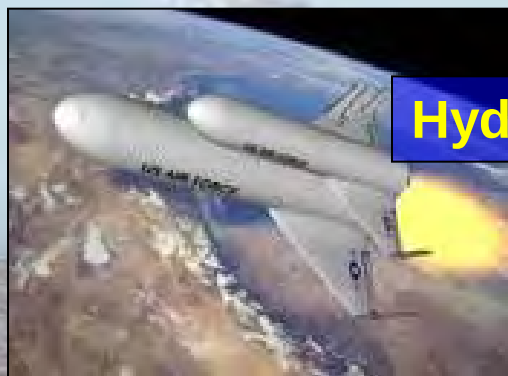
High Thrust Facilities

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





Current R&D Thrusts



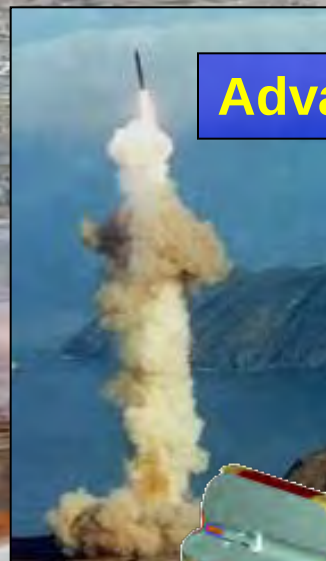
Hydrocarbon Boost



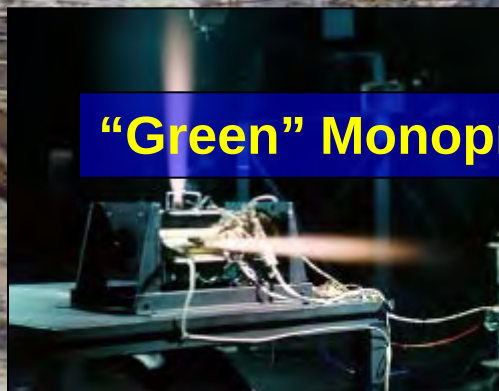
Multi-mode Satellite Propulsion



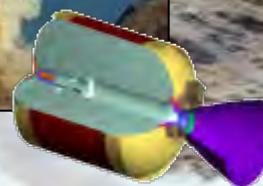
Upper Stage Engine Tech



Advanced Solid Motors



"Green" Monopropellants



All-electric Orbit Transfer





Questions?

