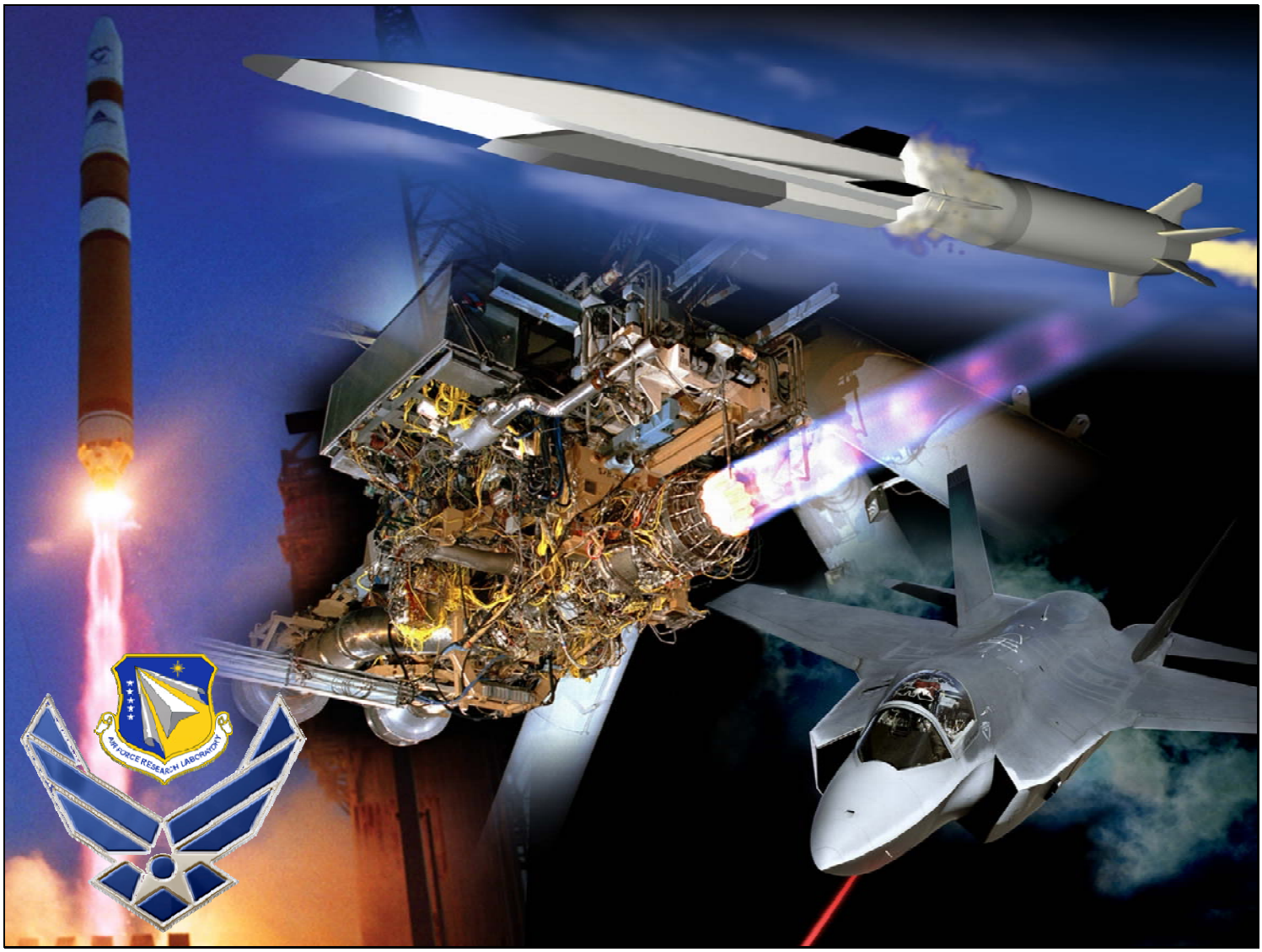
Introduction to

Air Force Research Laboratory

Propulsion Directorate

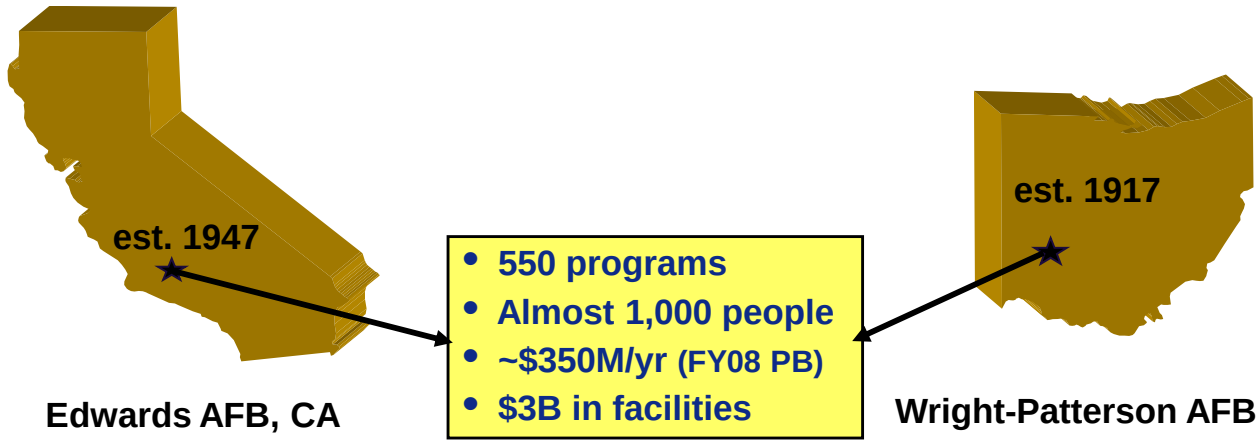


Propulsion Directorate
Mission and Vision

MISSION: To create and transition propulsion and power technology for military dominance of air and space

VISION: Maintain world leadership in military propulsion and power technology

AFRL's Propulsion Directorate

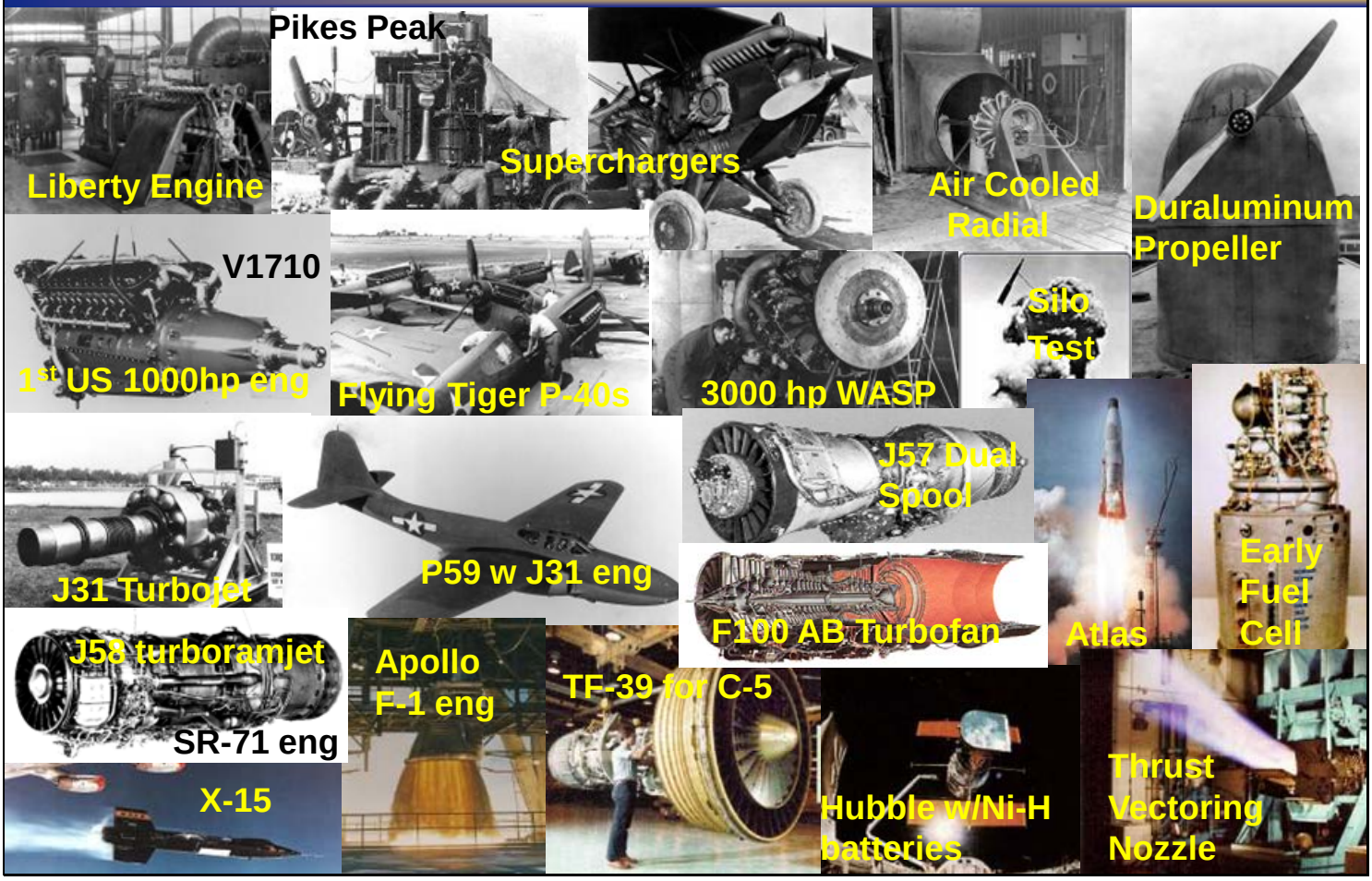


Product Line
• Liquid Engines
• Solid Rocket Motors
• Spacecraft Propulsion
• Propellants, Combustion, Nozzle Plumes, Materials Applications

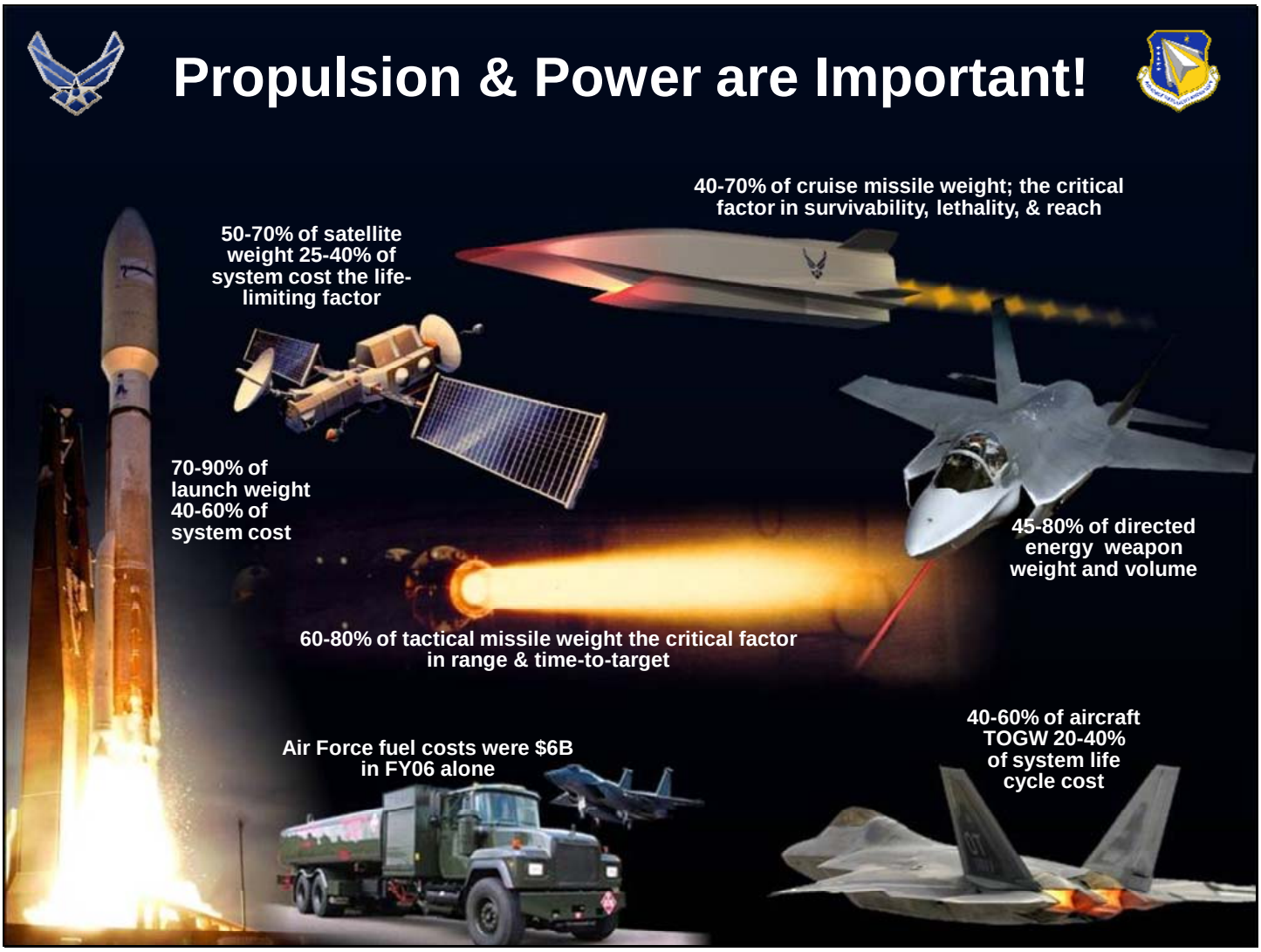
Product Line
• Gas Turbine Engines
• Power/Thermal Subsystems
• Hypersonic Propulsion
• Fuels, Lubricants, Mechanical Systems, Combustion

With the formation of AFRL, the Propulsion Directorate was formed from our Wright-Patterson site and our Edwards site; both teeming with heritage in the development of propulsion and power technologies for the war-fighter. Our "East" site has its roots in McCook Field just north of Dayton and was established in 1917. Our "West" site, which emerged from Wright-Patterson technical developments in rocket propulsion was established in 1947 for rocket hardware, and then another "trek" occurred in 1959 when rocket propellant work also moved to Edwards. The directorate consists of almost 1,000 people running approximately 550 R&D programs from basic research to advanced technology development. Our FY08 President's Budget is $350M, and our combined facilities at the two locations represents approximately $3B in plant replacement costs. Product lines at the Edwards site include everything having to do with rocket and spacecraft propulsion from the boost engines for space launch to solid rocket motors for our ICBM fleet. Spacecraft propulsion includes both chemically and electrically-based forms, and our efforts in advanced high energy density materials, propellants and nozzle plumes is world class. Here at the Wright site, we lead the Nation's turbine engine technology and are responsible for all aircraft electrical power and thermal management technologies. We conduct hydrocarbon-fueled hypersonic propulsion research and development, and our fuels research includes SECAF's goals in the development and qualification of synthetic aerospace fuels and blends with conventional fuel.

Rich History of Propulsion & Power

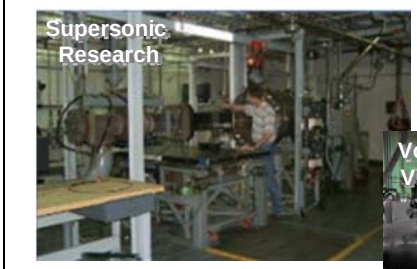


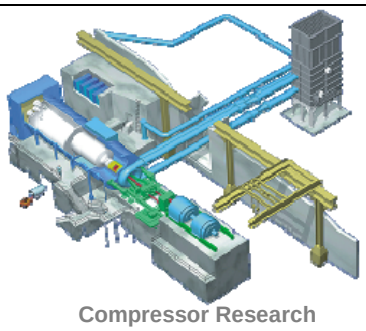
The Propulsion Directorate has been involved in the research and development of military aviation propulsion and power technologies since the beginnings of military flight at McCook Field near Dayton Ohio. The original organization, the Power Plant Section, was formed in May, 1917. Since that time, engineers and scientists of the Propulsion Directorate have been involved in establishing ever-increasing propulsion capabilities, the pacing item, for every new US Army Air Corp and the US Air Force aircraft. From the Liberty engine that powered the DH-4 to the thrust vectoring nozzle development for the F-119 engine powering the next generation air superiority fighter, the F-22 Raptor….the Propulsion Directorate leads the nation in future propulsion.

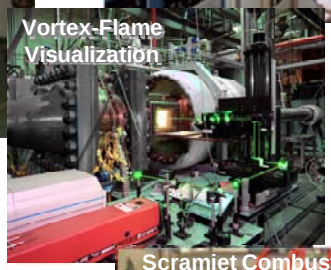


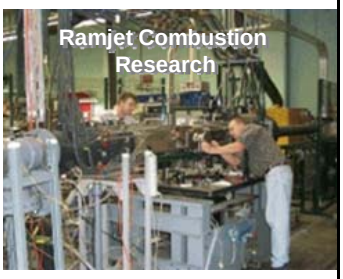
The Propulsion Directorate has long been the largest directorate within AFRL because our technologies have significant performance impact on USAF weapon systems. Here are some quantified examples of that impact. Turbine engine propulsion and the fuels that are employed represent 40-60% of an aircraft's Take-off Gross Weight and 20-40% of the system life cycle cost. Air Force fuel costs are soaring right along with the rest of the Nation, and our efforts there are leading the DoD into the future of advanced fuels. A large weight fraction and half the system cost for space launch (excluding the payload) are associated with our propulsion technologies. Our scramjet development represents a 40-70% weight fraction of an advanced hypersonic cruise missile weapon and is the main contributor to survivability, time-to-target, and range. The rest of these provide similar impact and reflect why the Propulsion Directorate's technologies have such enabling contributions to new weapon systems.

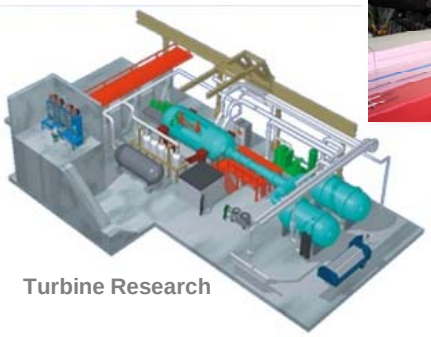
AFRL's PR-East Facilities




Compressor Research



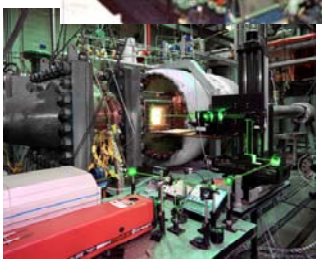



Turbine Research

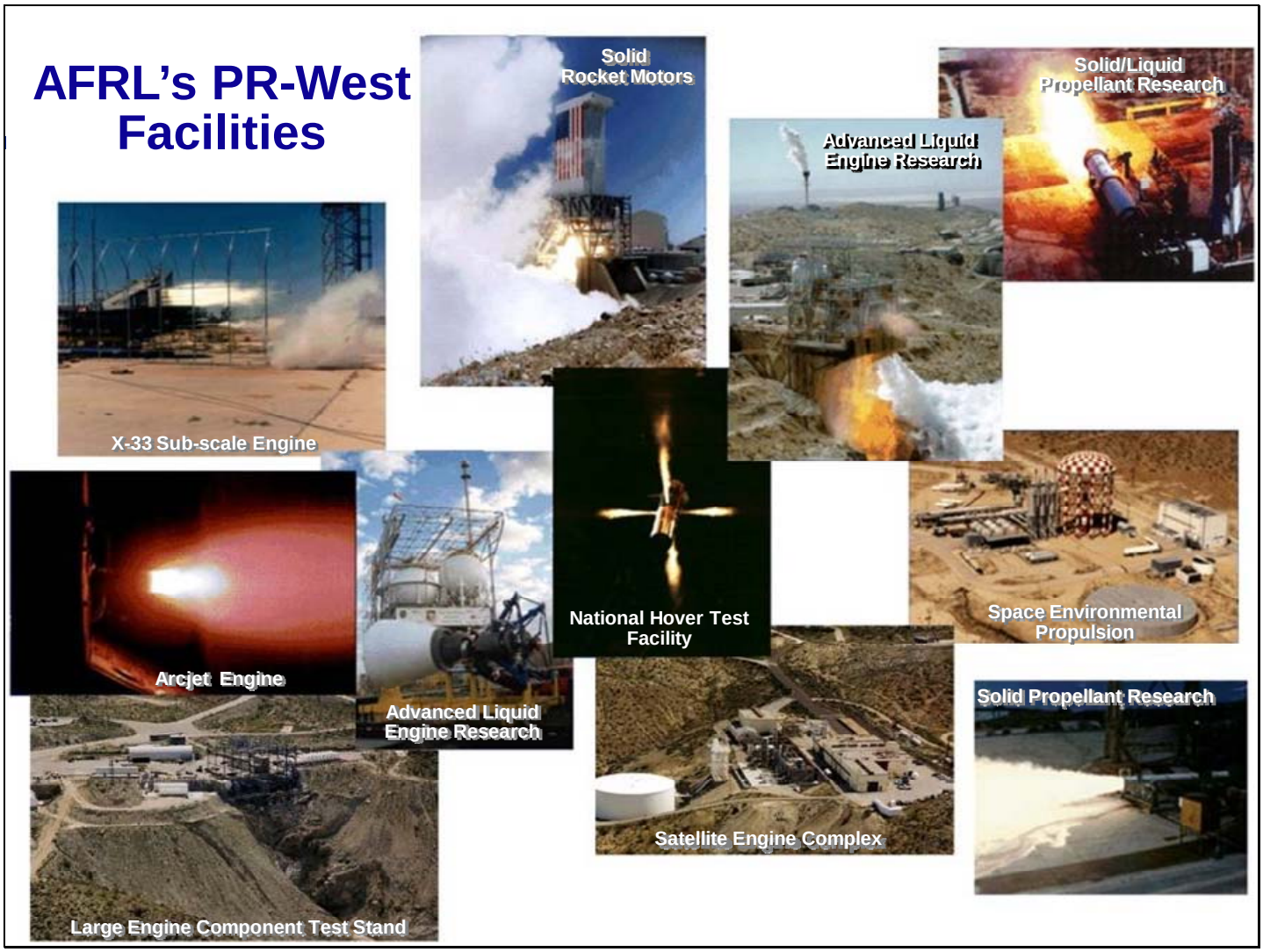

Altitude Simulation Compressor


High Temperature Combustor


Lubricant Qualification


High Pressure Combustion Research

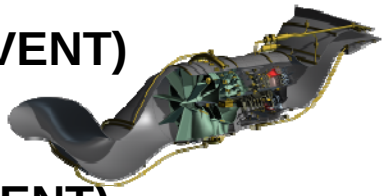
The Propulsion Directorate's world-class facilities here at the Wright site include a variety of state-of-the-art laboratories to support our line technology developments. Collectively, they represent approximately $1B in plant replacement costs. Our National Aerospace Fuels Research Complex (NAFRC) leads the way to achieve Secretary Wynne's goals in synthetic fuels. Our high pressure combustion facilities are world-unique in that the low pressure aspects and continuous operation allows us to simulate long duration, high altitude flight. We have three world-class facilities for developing hypersonic propulsion. Test cell 19 is used to develop advanced hypersonic instrumentation and diagnostic techniques as well as fuel injectors while test cell 18 scales these advanced components up from the research rig. Test cell 22 then represents full-scale scramjet combustors. Our battery labs have led Air Force research and helped bring about the currently used lithium rechargeable batteries that are on Mars and the Moon.



The Propulsion Directorate's Edwards site is also home to a host of world-class and unique facilities dedicated to space launch and spacecraft propulsion. Interestingly, we cover the range from facilities to test nano-newtons of thrust for micro-satellites to 1 million pounds of thrust for tomorrow's space access vehicles. The "Rock" covers 65 square miles of California desert and represents approximately $2B in plant replacement costs. Witnessing full engine tests at the Edwards site of AFRL is truly an exciting experience.

Major Propulsion Programs

- **Adaptive Versatile Engine Technology (ADVENT)**
  - **$350M effort (SECAF-directed)**



- **Integrated Vehicle Energy Technology (INVENT)**
  - **$150M effort**
- **X-51 Scramjet Engine Demonstrator**
  - **$200M effort (including DARPA)**

- **Highly Efficient Embedded Turbine Engine (HEETE)**
  - **$130M effort**
- **Hydrocarbon Boost - First stage boost engine development and demonstration**
  - **$275M effort**

There are several major development and demonstration efforts currently ongoing within the Propulsion Directorate. The largest entitled Adaptive Versatile Engine Technology (ADVENT) represents a truly game-changing concept whereby the efficiency of a high-bypass turbine is being coupled with the ability to provide the dash capability of a fighter-class engine. This concept was specifically identified by CSAF Moseley and Secretary Wynne as the propulsion system of choice for the next generation long range strike capability.

The Propulsion Directorate's X-51 program is the culmination of many years of supersonic combustion ramjet (called the "scramjet") development and is planned for first flight in AUG09. This test vehicle will represent the first flight of a hydrocarbon fueled scramjet which will lead to the world's first hypersonic cruise missile weapon.

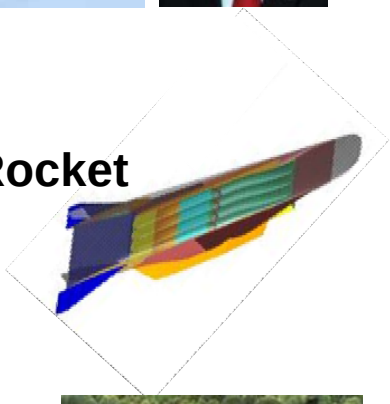
The Highly Efficient Embedded Turbine Engine (HEETE) is another turbine-based game changer with the performance goal of dramatically reducing the specific fuel consumption of next generation turbines for future mobility and ISR air platforms. If successful, the concept should significantly lower Air Force fuels cost as well as increase range or time-on-station.

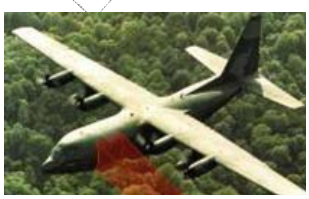
The Hydrocarbon Boost program represents the next generation in US first stage boost engines. It is an essential component in the Air Force "Operationally Responsive Space" initiative.

What's Hot

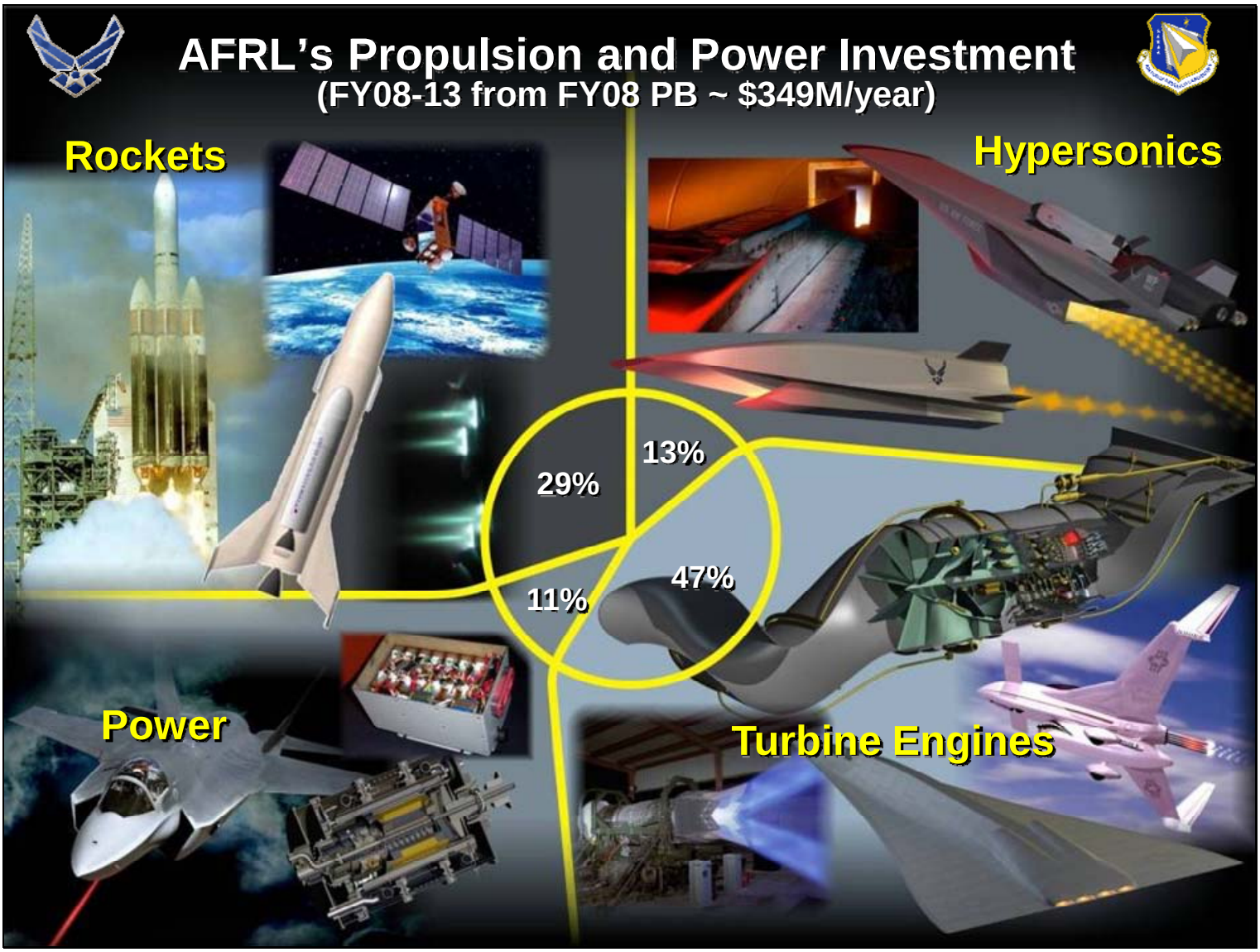
- **Alternate Fuels – Synthetic JP-8**
- **Efficiency**
- **Configurations**
  - **PDE – Pulse Detonation Engine**
  - **Combined Cycle – Turbine, Scramjet, Rocket**
  - **Adaptive Turbine Engine Cycle**
  - **Reusable Rockets**
- **Materials**
- **Power/Thermal**
  - **Aircraft – F-22, F-35, Next Gen Strike**
  - **DEW – laser gunship, high-power microwave**





Secretary Wynne has established aggressive strategic goals regarding the USAF's use of advanced synthetic fuels and blends with conventional fuels. Recently, our efforts rapidly and at greatly reduced cost qualified the B-1, B-52, and the C-17 on a 50/50 blend of JP-8 and synthetic fuel produced by the Fischer-Tropsch process. In this and all aspects of operations, efficiency has become a major driver in the propulsion arena. A variety of high payoff, new propulsion configurations have been identified to including the pulse detonation engine which could be highly fuel efficient and achieve high mach speeds, the ADVENT program discussed earlier and reusable rockets. In order to achieve future ops tempo goals for space access, combined cycle propulsion schemes such as the use of air-breathing systems in combination with rocket propulsion will be essential. The Propulsion Directorate maintains a high degree of technical coordination/collaboration with AFRL's Materials Directorate. New materials capabilities are directly related to dramatic increases in propulsion system performance. Between the F-22 and F-35, a paradigm shift occurred in that aircraft electrical power is now used to provide the motive force for flight control versus the use of fluid-based hydraulics. Management of the thermal energy within these systems has become an issue, and the Propulsion Directorate has accepted the challenge to fix these problems. Eventually, these same electrical power and thermal management technologies will enable future airborne electrically-driven directed energy weaponry including non-lethal high power microwave and lethal laser weapon systems.



The Propulsion Directorate's "core technical competencies" directly align with our organizational structure and our investment distribution is reflected here. Turbine engines including each of the critical subsystems as well as fuels represents the lion's share of the of the directorate's portfolio. Our Edwards site R&D in launch boost, spacecraft propulsion and associated propellants is approximately a third of the budget. The remainder of our budget is distributed between our hypersonics and power/thermal R&D.

Research Opportunities in Propulsion and Power

For one-year appointments through the NRC:

http://nrc58.nas.edu/pgasurvey/data/aobooks

For summer faculty appointments through the ASEE:

http://www.asee.org/sffp/

For summer faculty appointments through AFRL/RZ:

http://www.wpafb.af.mil/afrl/rz

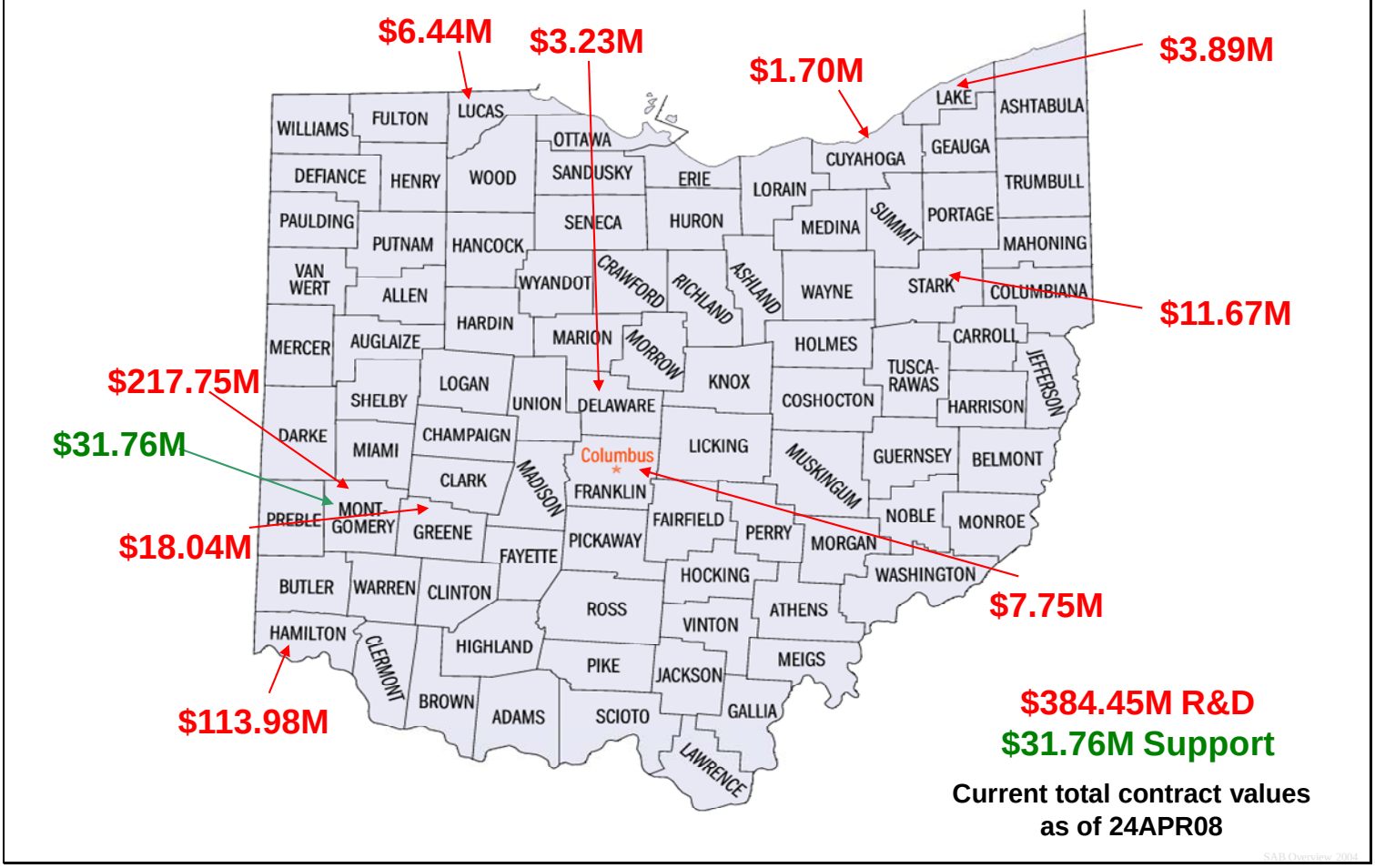
For a listing of research topics and advisors specific to propulsion and power:

http://www.asee.org/sffp/afrl_propulsion.cfm

Topics and advisors are the same for all programs.

There are a variety of venues for the conduct of propulsion and power research including appointment through the National Research Council, summer faculty positions with American Society of Engineering Education, an augmentation toward the ASEE through the Directorate.

Propulsion Directorate Active Contracts in Ohio



The Propulsion Directorate conducts a tremendous amount of business within the state of Ohio. Almost $400M is invested in Ohio industry and academia to conduct propulsion and power research and development. Approximately $32M is spent toward support.