Pratt & Whitney
Propulsion Vision for the Future

NASA Turning Goals Into Reality

Simeon Austin
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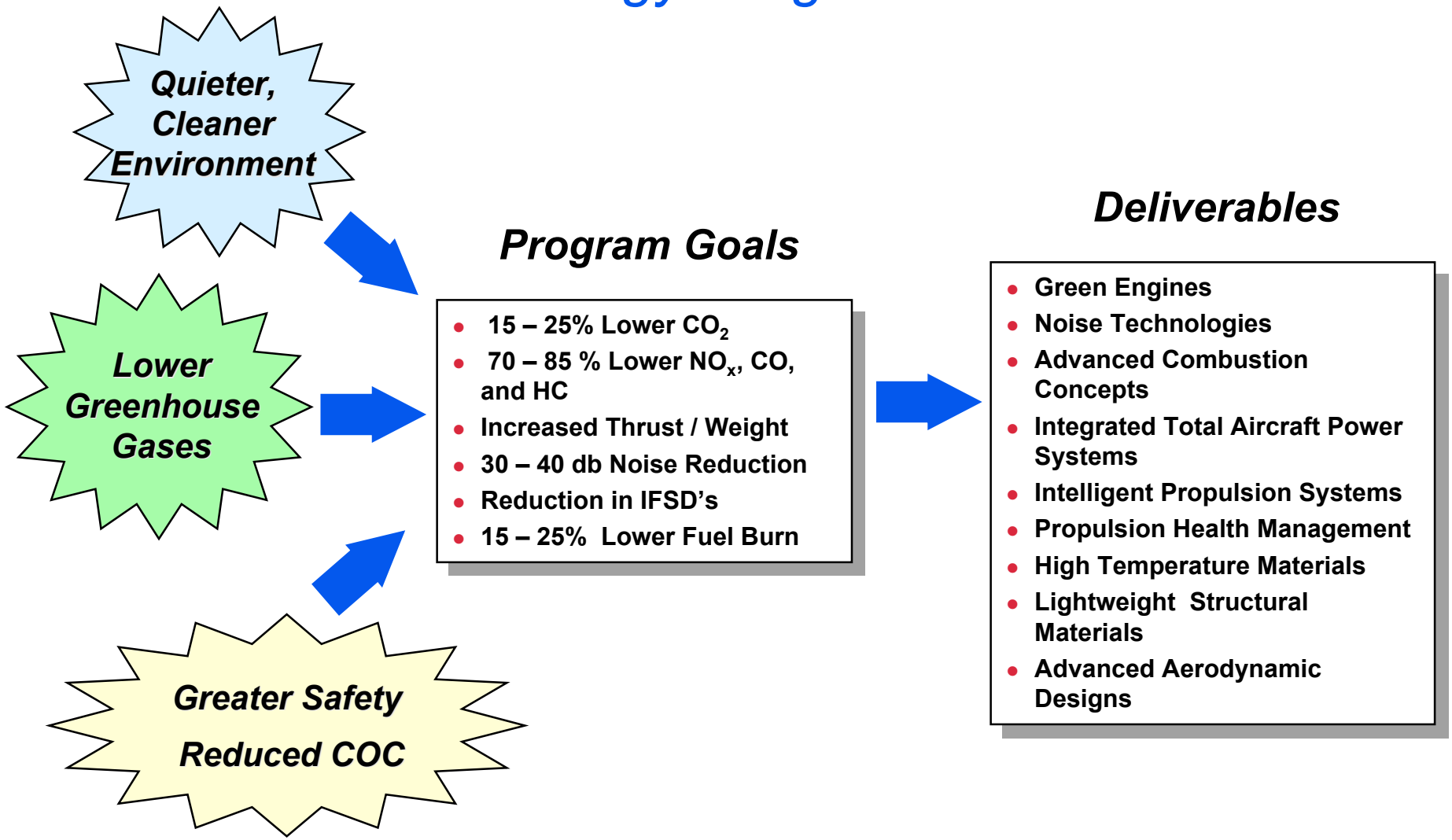
P&W NEW TECHNOLOGIES VISION

Propulsion and Power Outlook

- Green engines
- Integrated vehicle / propulsion designs
- UAVs / UCAVs
- Intelligent / adaptive systems
- Sustained high-speed flight
- Access to Space

ADVANCED COMMERCIAL ENGINE TECHNOLOGY PLANS

Issue Driven Technology Program



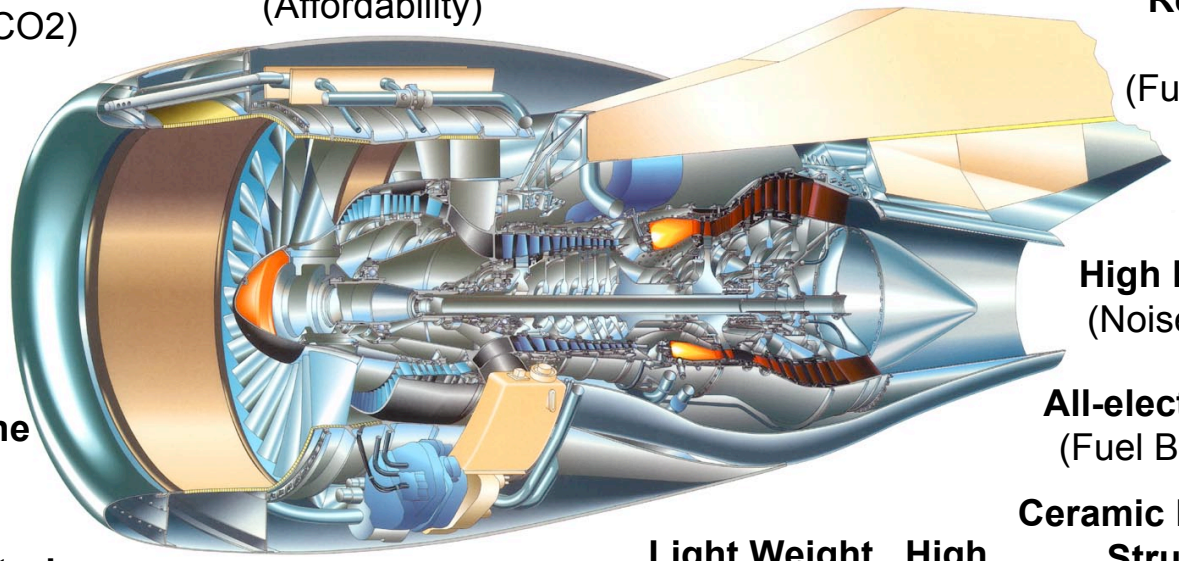
NEW COMMERCIAL ENGINE TECHNOLOGY CONCEPTS

Composite Cold Section Structures
(Fuel Burn / CO2)

All Blisk Compressor
(Affordability)

Variable Propulsion Cycles
(Fuel Burn/CO2, Emissions / NOx, Affordability)

Revolutionary Metallics
(Fuel Burn / CO2)



Common Core
(Affordability)

High BPR Cycles
(Noise, Capacity)

Single Fluid Engine
(Affordability)

All-electric Engine
(Fuel Burn / CO2)

Ceramic Hot Section Structures
(Fuel Burn / CO2)

Intelligent Controls
(Safety, Affordability)

Advanced Thermal Management System
(Fuel Burn / CO2)

Light Weight , High Performance, Military Derivative Cores
(Weight / Fuel Burn)

Geared Turbofan/Variable Fan Nozzle
(Acoustics / Fuel Burn)

Pulse Detonation Core
(Fuel Burn / CO2)

Aspirated Aerodynamics
(Fuel Burn / CO2)

P&W GREEN ENGINE PROGRAM

A Process To Tackle The Global Challenge

Has the lowest possible emission impact during use

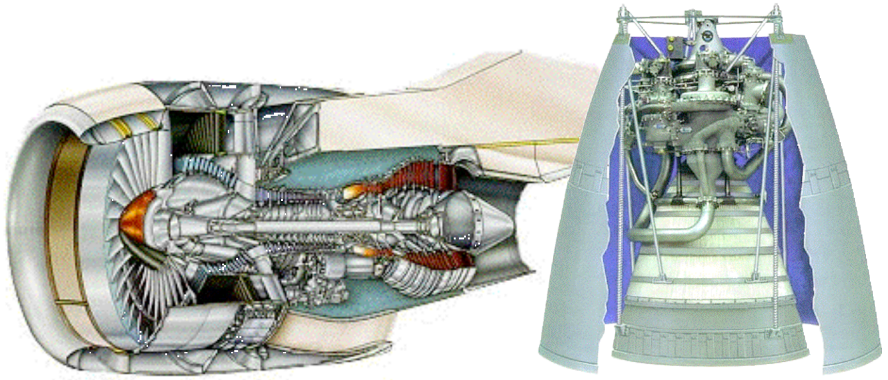
Has lowest possible noise impact

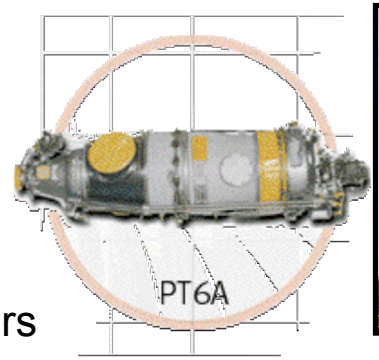
Manufactured in Green Factories

Material Efficient (Metal Buy-to-Fly, Propellant Yield)

Contains Green Materials

Involves Green Suppliers and Partners





Designed with Human Factors In Mind

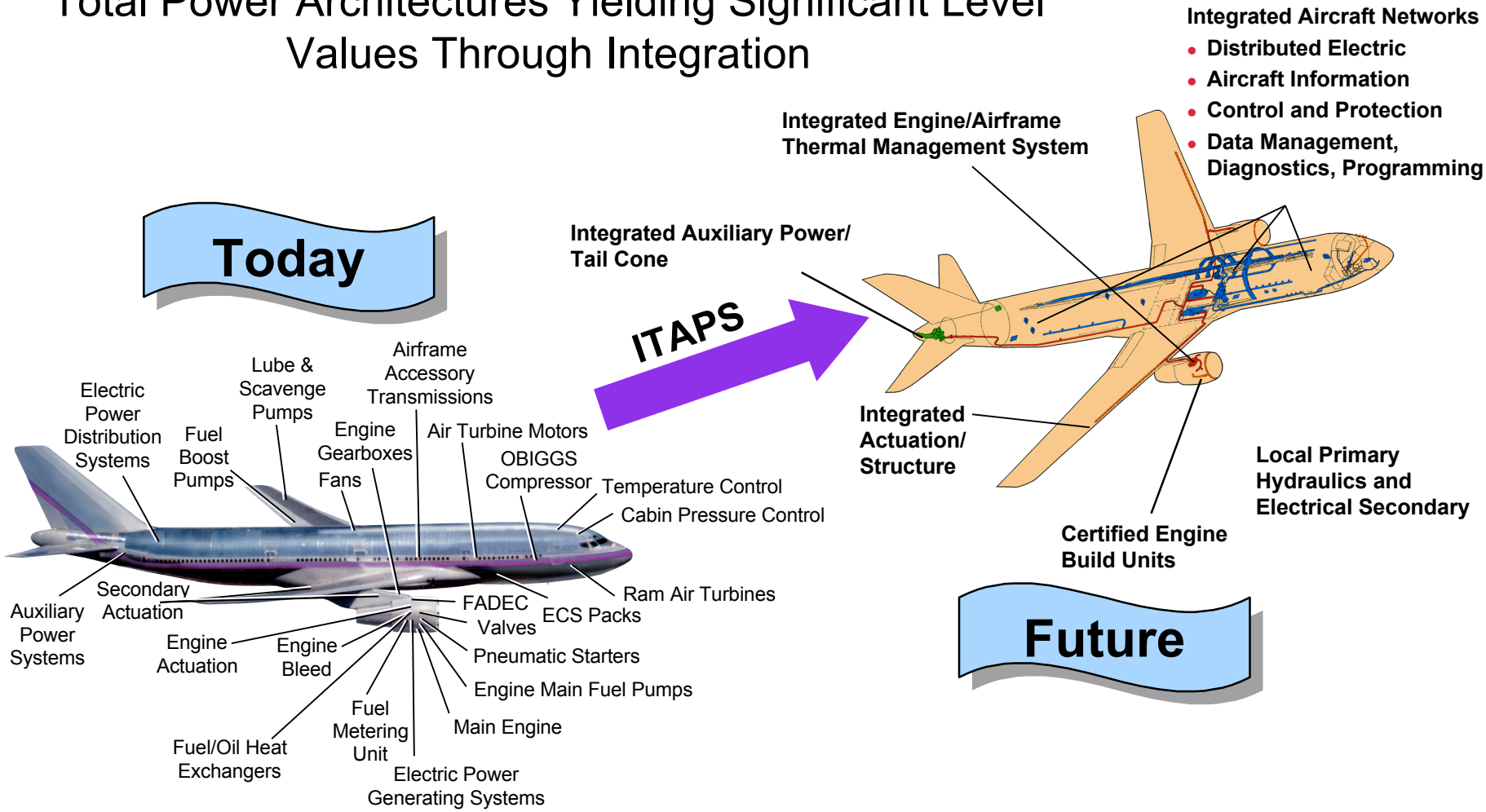
Energy Efficient During Use (Fuel Burn)

Maintained with Green Overhaul and Repair Processes

Designed For Serviceability, Reusability, Recyclability

UTC INTEGRATED TOTAL AIRCRAFT POWER SYSTEMS (ITAPS™)

Total Power Architectures Yielding Significant Level Values Through Integration

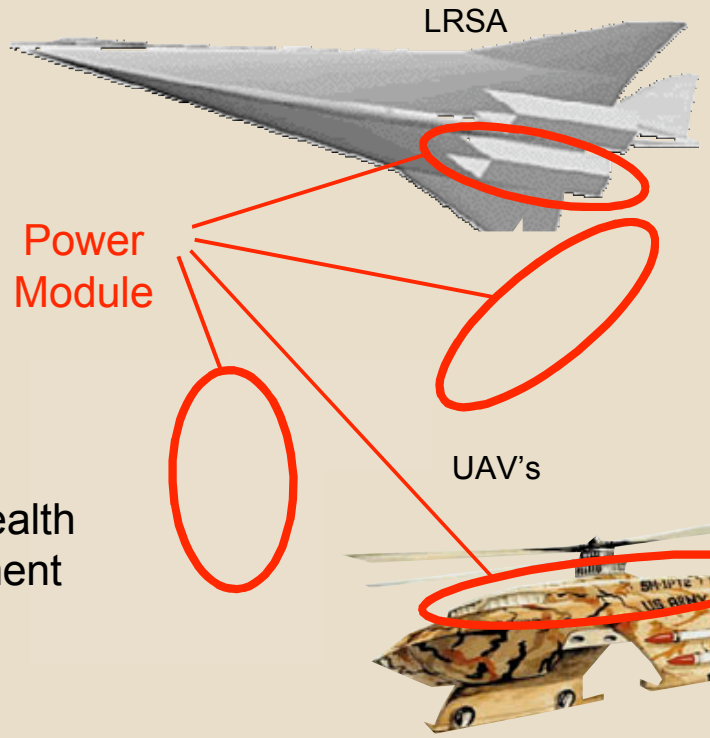


ITAPS™ POWER MODULE CONCEPT

Vehicle-level Energy Management Approach To Integration

Features

Integrated
- Inlet
- Powerplant
- Exhaust



Structural Moldlines

Module Health Management

Self-contained Thermal Sink

Environmental Control System

Integral Generators

Vehicle-mounted Control

Cooling Air

Services:
- Electric
- Hydraulics
- Pneumatic

Provides:
- Thrust/Shaft Power
- Vehicle Electric Power
- Vehicle Cooling
- Integrated Controls
- Health Management
- Thermal Management

HEALTH MANAGEMENT ON NASA C-17 T1 TESTBED

Developing Next Generation Health Management Technologies

Objective

- Develop and demonstrate technologies for next generation propulsion system health management

Benefits

- Reduced in-flight shutdown rate (safety)
- Fewer unplanned engine removals
- Minimize delays & cancellations

Approach

- Transition F119 / F135 HM technologies
- Introduce advanced sensors/algorithms
- Validate technologies using NASA C-17 T1 Flight Research Testbed

C-17 T1
Flight Research Testbed

Goal

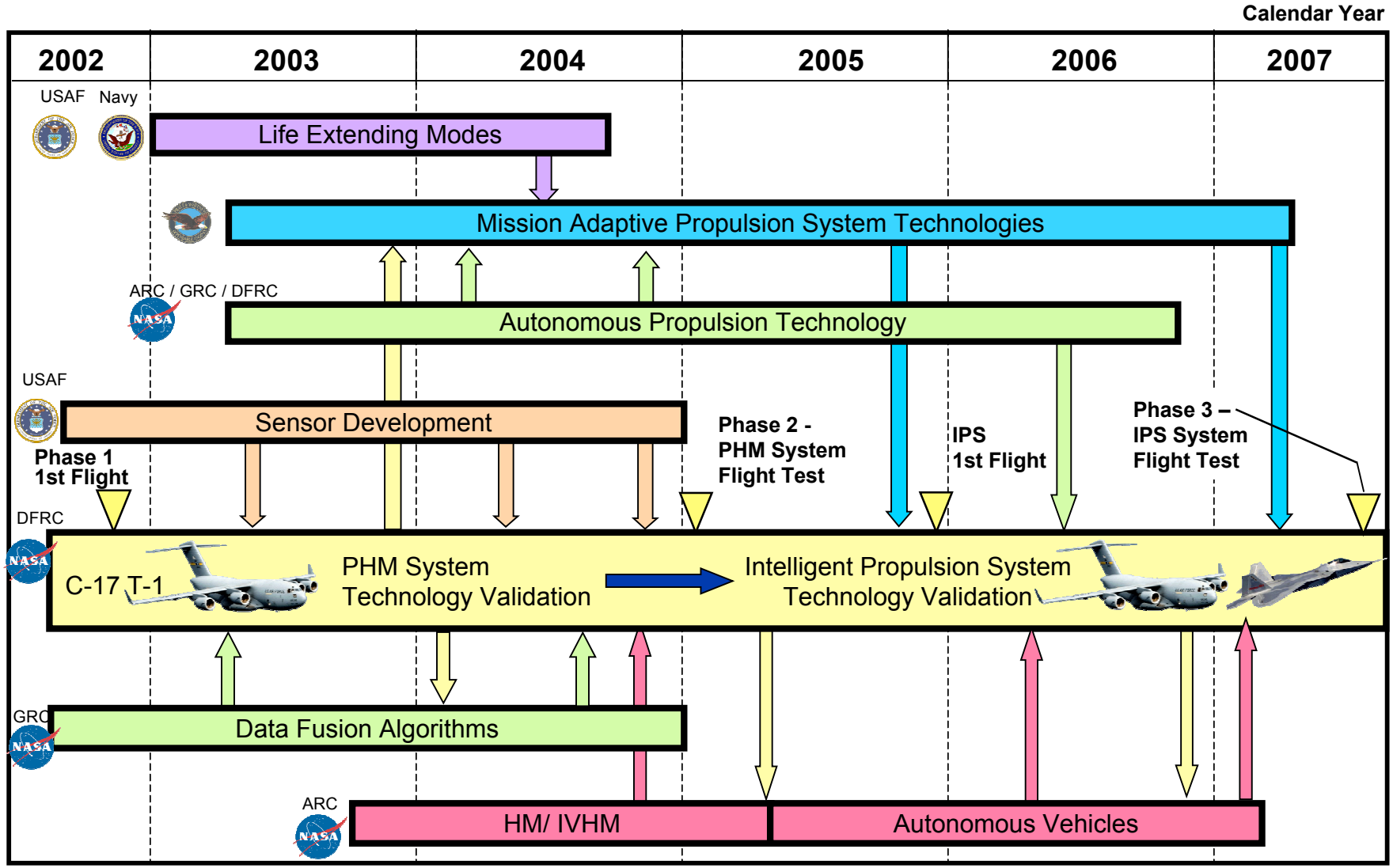
- Provide full suite of technology demonstration capabilities by end of 2004.

Status

- Advanced sensors being flown
- Algorithms being designed
- Processor host being planned

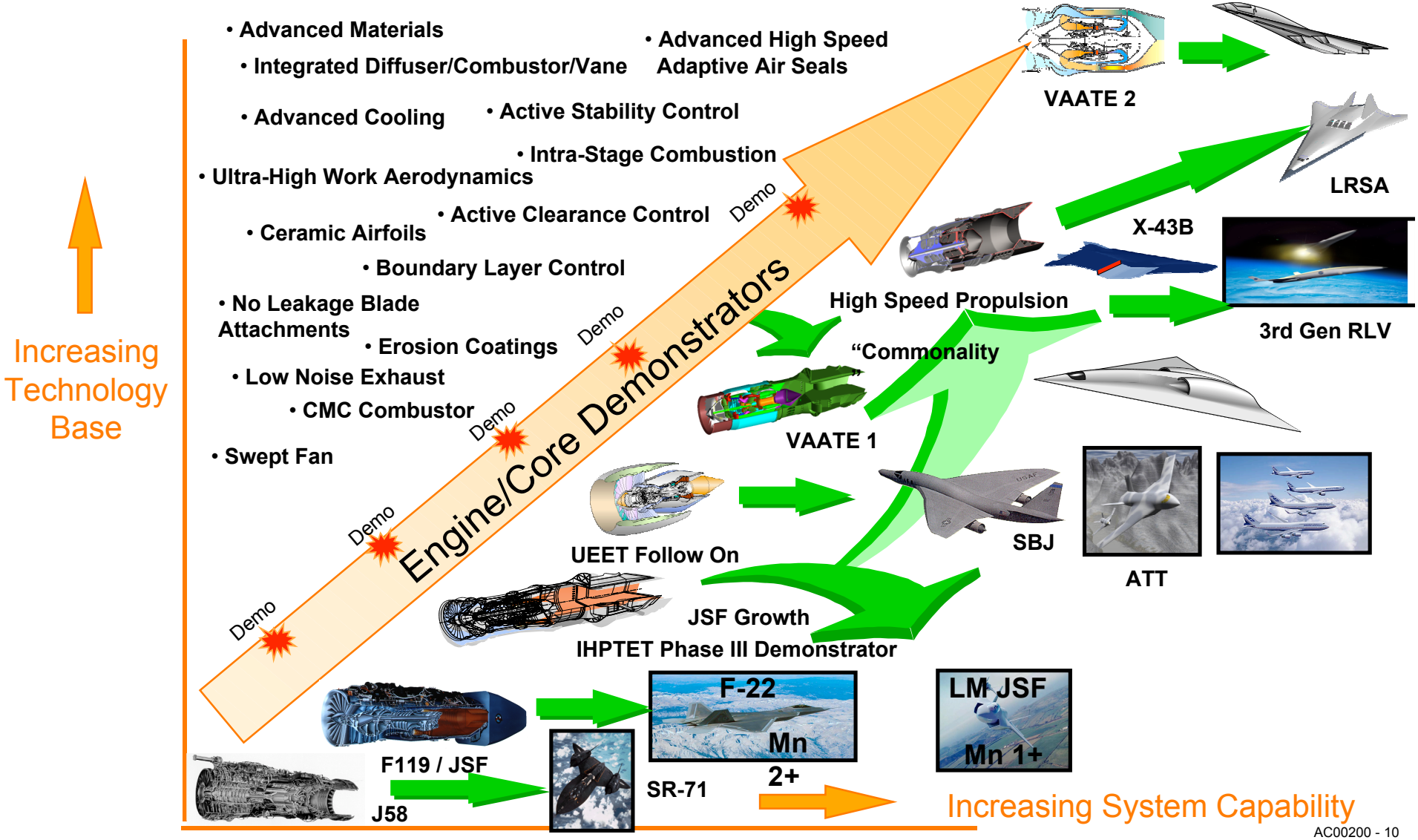
INTELLIGENT/ADAPTIVE SYSTEMS ROADMAP

Technology Partnership Key To Program Success



HIGH SPEED TECHNOLOGY ROADMAP

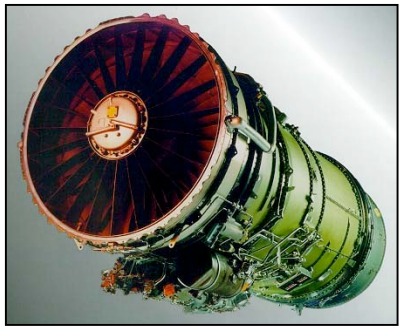
Demonstrator Plan Supports Product Application



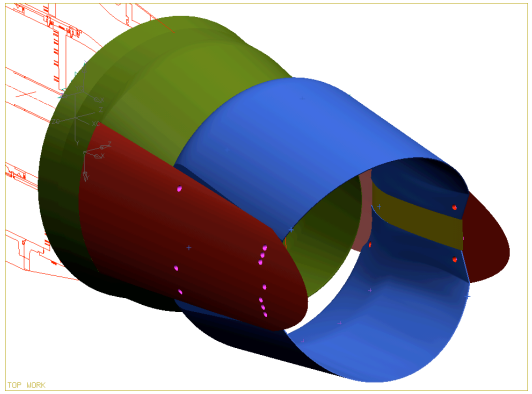
SUPERSONIC BUSINESS JETS

Likely Next Commercial Supersonic Application

- Economics and environmental compatibility
  - Supersonic SFC/range
  - Takeoff noise
  - Sonic boom mitigation
  - Cruise emissions

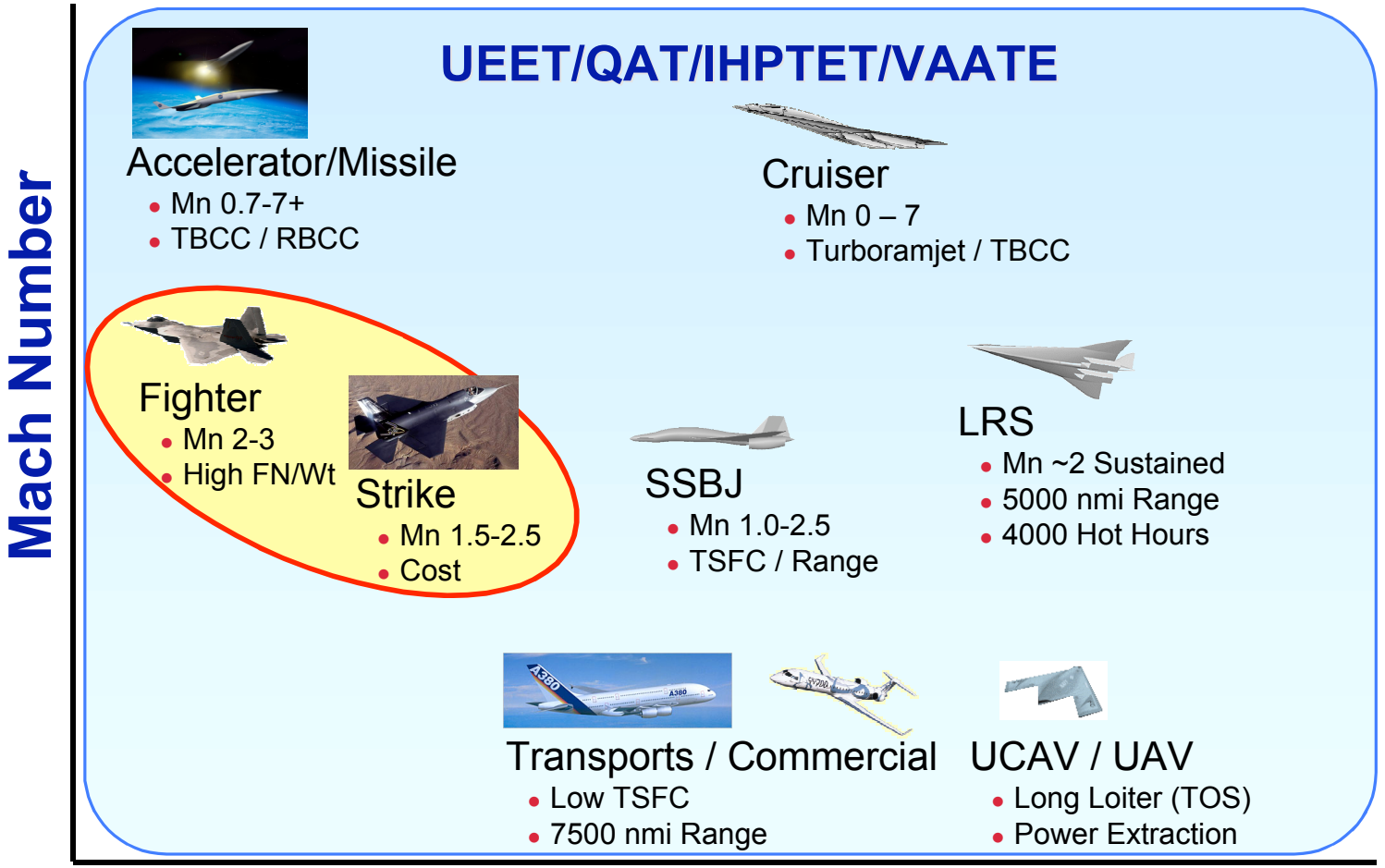


- Will require tailored propulsions response yielding optimum customer value
  - Upgrade to existing engines
  - Derivative engines (new low spool)
  - New centerline engines



P&W INTEGRATED GAS TURBINE PROPULSION PLAN

NASA/DOD Technologies Cross Thrust Classes & Missions Supported By Common P&W Tools and Processes



AERONAUTIC SPACE SYNERGY

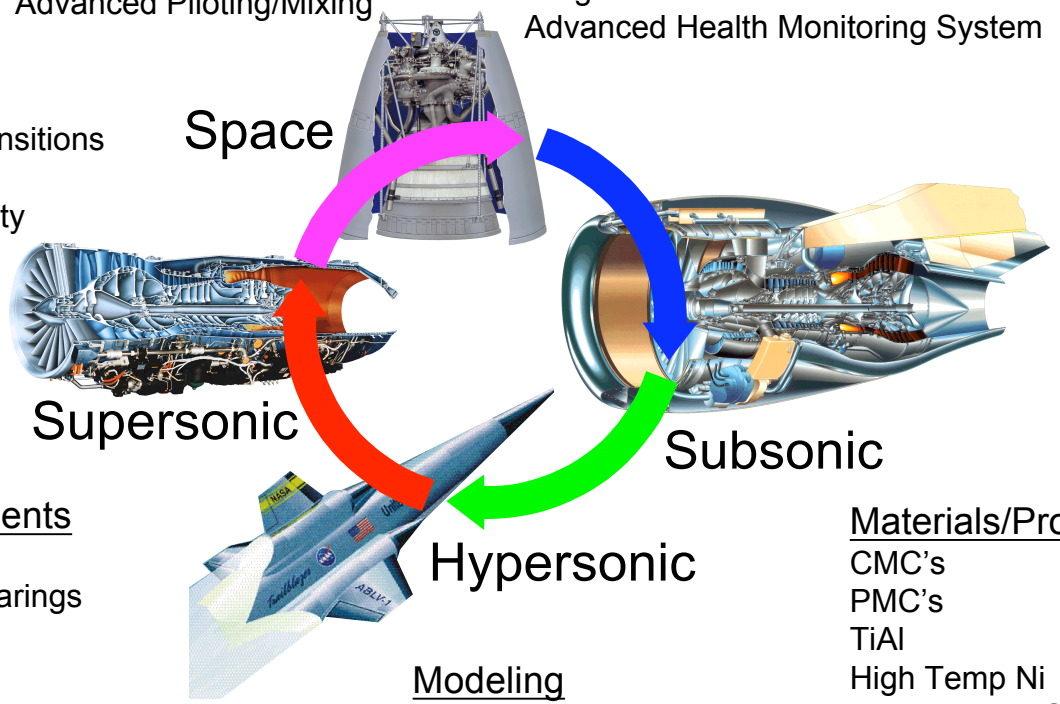
Fundamental Technologies Apply Across Spectrum

Combustion
CMC Liners
Full Authority Control
Advanced Fuel Injectors
Advanced Piloting/Mixing

Controls & Externals
Lightweight Components
Active Control System
Non-intrusive Instrumentation
Prognostic Sensors
Advanced Health Monitoring System

Compression
Advanced Materials
Highly Loaded Aero
Advanced Seals
Low Loss Flowpath Transitions
Clearance Mgmt
Passive & Active Stability

Turbines
CMC Components
Advanced Metallics
Advanced TBC's
Highly Loaded Aero
Advanced Seals
Low Loss Transitions
Clearance Mgmt
Advanced Cooling



Mechanical Components
CMC Components
High DN/High Temp Bearings
Low Wear Gears

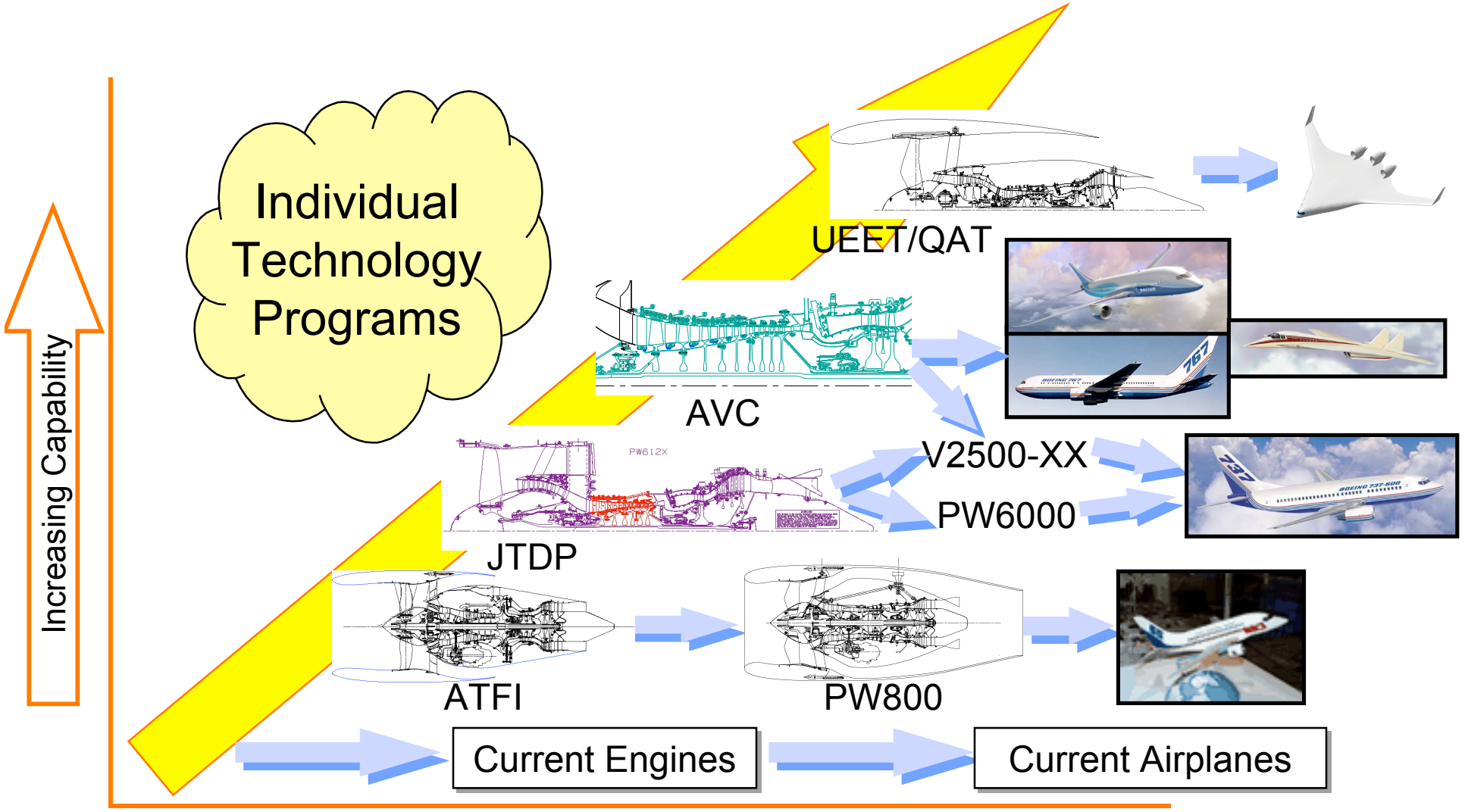
Inlet/Nacelle/Nozzle
Lightweight Structures
Fluidic Vectoring

Modeling
Physics-based Tools
CFD Modeling
Digital Engine Model
Manufacturing Modeling

Materials/Processes & Structures
CMC's
PMC's
TiAl
High Temp Ni
Advanced TBC's
Rapid Prototyping
High Speed Machining
High Speed Hole Drilling

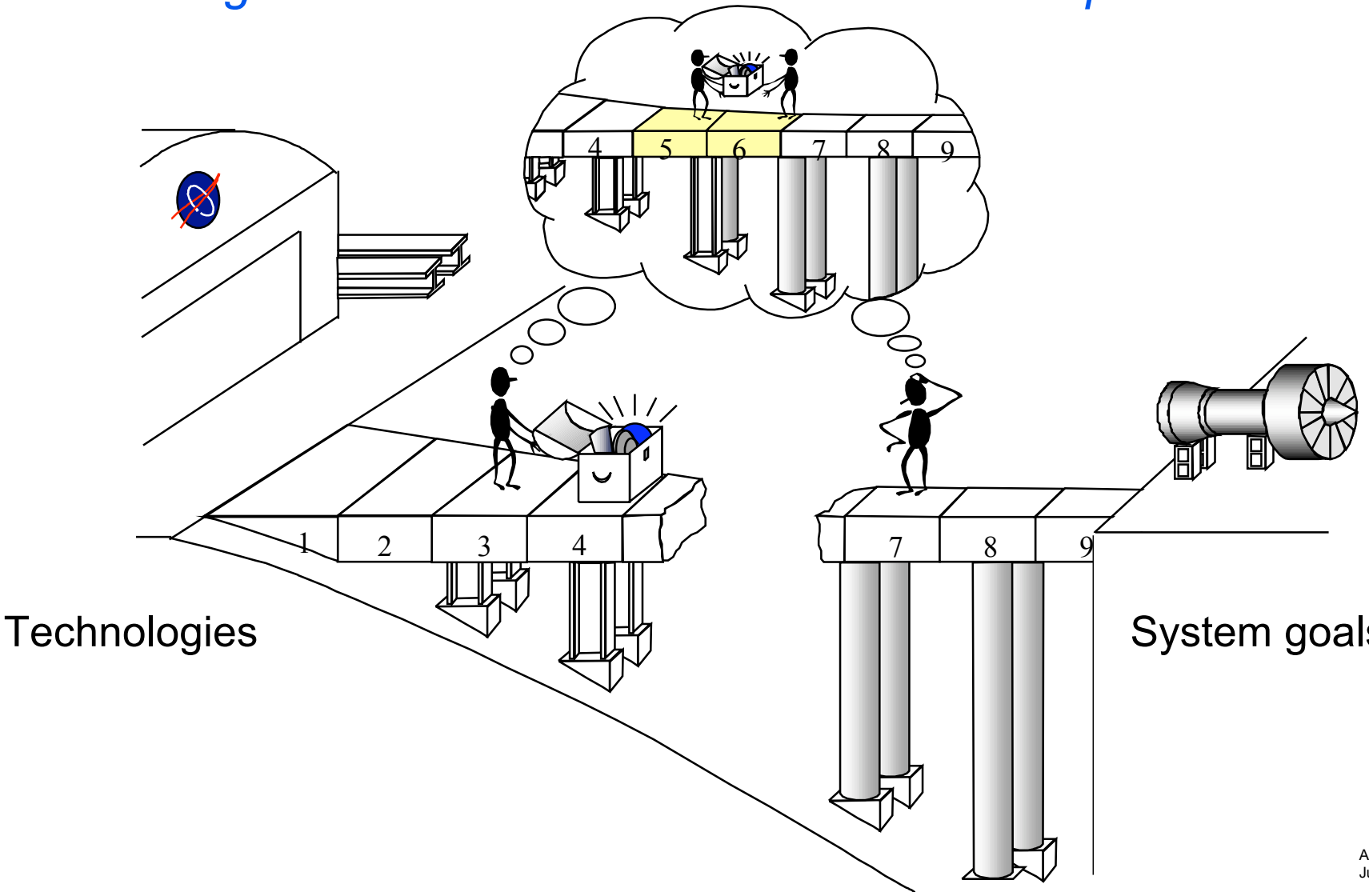
P&W TECHNOLOGY VALIDATION APPROACH

Demonstrators Needed to Speed Transition To Product



TECHNOLOGY READINESS “BRIDGE”

Validation Programs To TRL 6 Are Key To Maturing Technologies For Transition To Product Development



P&W VISION FOR THE FUTURE

Summary

- Emerging vehicle systems demand new solutions:
  - Integrated vehicle / propulsion design
  - Intelligent / adaptive systems
  - Sustained High Speed Flight
- Pratt & Whitney is aggressively pursuing advanced projects that will meet or exceed projected future propulsion requirements
- Pratt & Whitney is uniquely positioned in the Aeronautic market place to apply synergistic technologies to advanced commercial, military and space programs
- Demonstrator Vehicles are key to technology transition