Pratt & Whitney
Propulsion Vision for the Future

NASA Turning Goals Into Reality

Simeon Austin
June 12, 2003
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

Program Goals

- 15 – 25% Lower CO₂
- 70 – 85 % Lower NOₓ, CO, and HC
- Increased Thrust / Weight
- 30 – 40 db Noise Reduction
- Reduction in IFSD’s
- 15 – 25% Lower Fuel Burn

Deliverables

- Green Engines
- Noise Technologies
- Advanced Combustion Concepts
- Integrated Total Aircraft Power Systems
- Intelligent Propulsion Systems
- Propulsion Health Management
- High Temperature Materials
- Lightweight Structural Materials
- Advanced Aerodynamic Designs

Quieter, Cleaner Environment

Lower Greenhouse Gases

Greater Safety Reduced COC
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)

**High BPR Cycles** (Noise, Capacity)

**All-electric Engine** (Fuel Burn / CO2)

**Ceramic Hot Section Structures** (Fuel Burn / CO2)

**Single Fluid Engine** (Affordability)

**Common Core** (Affordability)

**Intelligent Controls** (Safety, Affordability)

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

**Advanced Thermal Management System** (Fuel Burn / CO2)

**Light Weight, High Performance, Military Derivative Cores** (Weight / 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

- Manufactured in Green Factories
- Material Efficient (Metal Buy-to-Fly, Propellant Yield)
- Contains Green Materials
- Involves Green Suppliers and Partners
- Designed For Serviceability, Reusability, Recyclability
- Has the lowest possible emission impact during use
- Has lowest possible noise impact
- Designed with Human Factors In Mind
- Energy Efficient During Use (Fuel Burn)
- Maintained with Green Overhaul and Repair Processes
UTC INTEGRATED TOTAL AIRCRAFT POWER SYSTEMS (ITAPS™)

Total Power Architectures Yielding Significant Level Values Through Integration

Today

Future

Integrated Aircraft Networks
- Distributed Electric
- Aircraft Information
- Control and Protection
- Data Management, Diagnostics, Programming

Integrated Engine/Airframe Thermal Management System

Integrated Auxiliary Power/Tail Cone

Certified Engine Build Units

Local Primary Hydraulics and Electrical Secondary

Integrated Engine/Airframe Actuation/Structure

ITAPS

Total Power Architectures Yielding Significant Level Values Through Integration

- Electric Power Distribution Systems
- Auxiliary Power Systems
- Secondary Actuation
- Engine Actuation
- Engine Boost Pumps
- Lube & Scavenge Pumps
- Airframe Accessory Transmissions
- Engine Gearboxes
- Fans
- Air Turbine Motors
- OBIGGS Compressor
- Temperature Control
- Cabin Pressure Control
- Ram Air Turbines
- ECS Packs
- Engine Main Fuel Pumps
- FADEC Valves
- Pneumatic Starters
- Engine Main Fuel Pumps
- ITAPS
- Certified Engine Build Units
- Local Primary Hydraulics and Electrical Secondary
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Today

Future
ITAPS™ POWER MODULE CONCEPT

Vehicle-level Energy Management Approach To Integration

Features
- Integrated
  - Inlet
  - Powerplant
  - Exhaust
- Structural Moldlines
- Module Health Management
- Power Module
- UAV’s
- Environmental Control System
- Integral Generators

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

Services:
- Electric
- Hydraulics
- Pneumatic

Structural Moldlines
Self-contained Thermal Sink
Vehicle-mounted Control
Cooling Air

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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

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*

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- **C-17 T-1** Technology System Validation
- **PHM System Technology Validation**
- **Intelligent Propulsion System Technology Validation**
- **Data Fusion Algorithms**
- **HM/IVHM**
- **Autonomous Vehicles**

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HIGH SPEED TECHNOLOGY ROADMAP

Demonstrator Plan Supports Product Application

- Advanced Materials
- Integrated Diffuser/Combustor/Vane
- Advanced Cooling
- Active Clearance Control
- Ultra-High Work Aerodynamics
- Ceramic Airfoils
- Boundary Layer Control
- No Leakage Blade Attachments
- Erosion Coatings
- Low Noise Exhaust
- CMC Combustor
- Swept Fan
- Active Stability Control
- Intra-Stage Combustion

Engine/Core Demonstrators

Increasing Technology Base

Increasing System Capability

VAATE 1

UEET Follow On

JSF Growth

IHPTET Phase III Demonstrator

F119 / JSF
J58

F-22
Mn

SR-71
2+

LM JSF
Mn 1+

X-43B

3rd Gen RLV

LRSA

ATT

VAATE 2

High Speed Propulsion

"Commonality"
SUPERCORSSIC 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

- Accelerator/Missile
  - Mn 0.7-7+
  - TBCC / RBCC
- Fighter
  - Mn 2-3
  - High FN/Wt
- Strike
  - Mn 1.5-2.5
  - Cost
- Cruiser
  - Mn 0 – 7
  - Turboramjet / TBCC
- LRS
  - Mn ~2 Sustained
  - 5000 nmi Range
  - 4000 Hot Hours
- SSBJ
  - Mn 1.0-2.5
  - TSFC / Range
- Transports / Commercial
  - Low TSFC
  - 7500 nmi Range
- UCAV / UAV
  - Long Loiter (TOS)
  - Power Extraction
AERONAUTIC SPACE SYNERGY

Fundamental Technologies Apply Across Spectrum

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

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

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

Supersonic

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

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

Inlet/Nacelle/Nozzle
Lightweight Structures
Fluidic Vectoring

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

Hypersonic

Space

Subsonic

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P&W TECHNOLOGY VALIDATION APPROACH

Demonstrators Needed to Speed Transition To Product

Increasing Capability

Individual Technology Programs

Current Engines

Current Airplanes
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