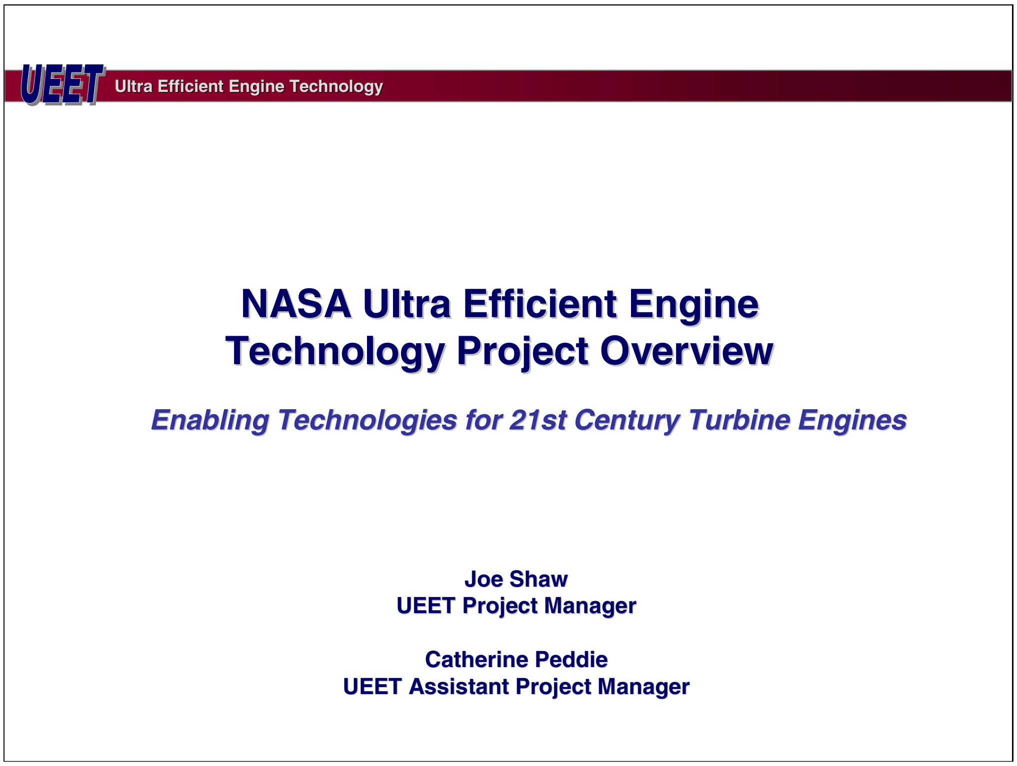
NASA ULTRA EFFICIENT ENGINE TECHNOLOGY PROJECT OVERVIEW

Catherine L. Peddie and Robert J. Shaw
National Aeronautics and Space Administration
Glenn Research Center
Cleveland, Ohio



UEET Ultra Efficient Engine Technology

NASA Ultra Efficient Engine Technology Project Overview

Enabling Technologies for 21st Century Turbine Engines

Joe Shaw
UEET Project Manager

Catherine Peddie
UEET Assistant Project Manager

Outline

- Overview of current UEET Project
- Re invention of UEET as part of the Vehicle Systems Program

Current UEET Project

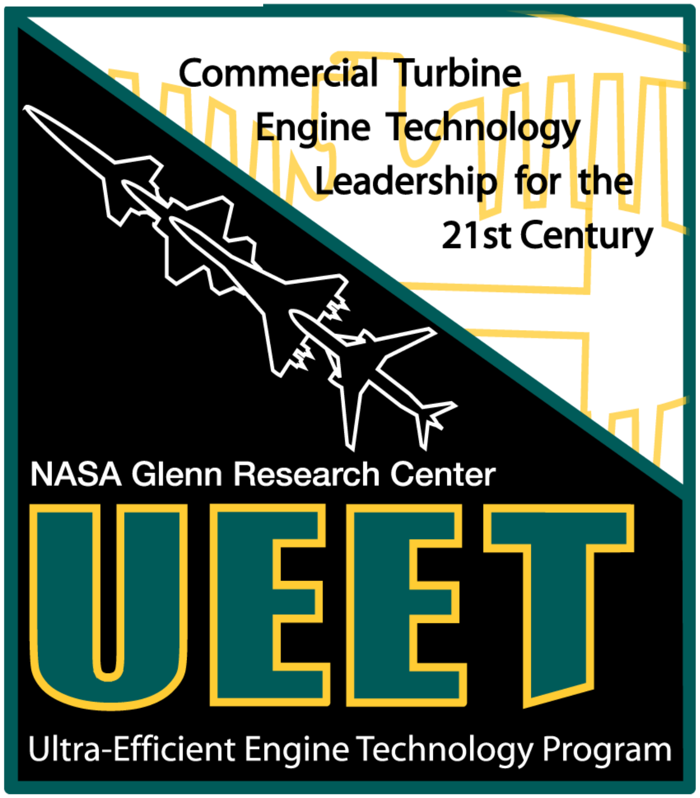
The NASA Mission

To understand and protect our home planet

To explore the Universe and search for life

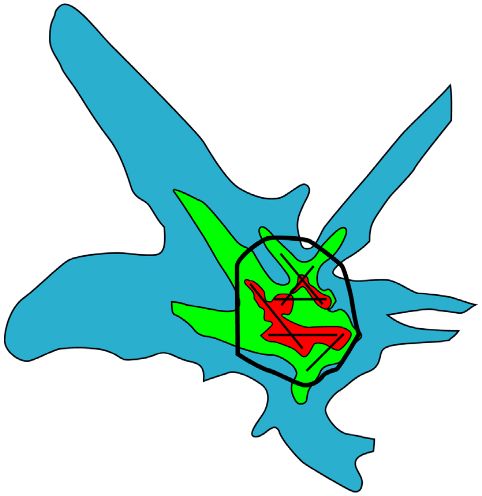
To inspire the next generation of explorers

… as only NASA can.



The UEET Program will develop and transfer to the U. S. industry critical gas turbine engine technologies which will contribute to "enabling a safe, secure, and environmentally friendly air transportation system".

Environmentally Friendly Aircraft

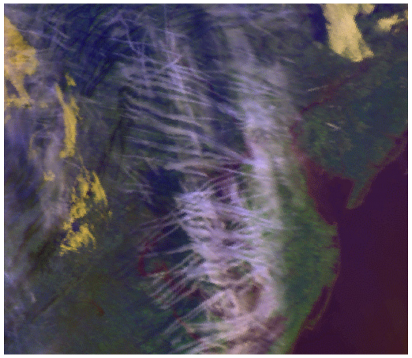


Noise within airport boundaries

Constrain objectionable noise to within airport boundaries

Smog-free

Minimize the contribution of air vehicles to the production of smog



No impact on global climate

Minimize the impact of air vehicles on global climate

Revolutionize Aviation Goal Emissions Objective

UEET **Ultra Efficient Engine Technology**

Reduce emissions of future aircraft by a factor of three within 10 years (2007), and by a factor of five within 20 years.

NASA Three Pillars for Success-1997

Reduce NOx emissions of future aircraft by 70 percent within 10 years, and by 80 percent within 25 years (using the 1996 ICAO Standard for NO_x as the baseline. Reduce CO_2 emissions of future aircraft by 25 percent and by 50 percent In the same timeframes (using 1997 subsonic aircraft technology as the baseline).

NASA Aerospace Technology Enterprise Strategic Plan-2000

UEET will be the responsible propulsion program for delivering on this objective!

Vision: *Develop and hand off revolutionary turbine engine propulsion technologies that will enable future generation vehicles over a wide range of flight speeds.*

Goals:

Propulsion technologies to enable increases in system efficiency and, therefore, fuel burn reductions of up to 15 % (equivalent reductions in CO_2)

Combustor technologies (configuration and materials) which will enable reductions in LTO NO_x of 70% relative to 1996 ICAO standards.*

** LTO - Landing/Take-off*

Vision

UEET Ultra Efficient Engine Technology

Develop and hand off revolutionary propulsion turbine engine technologies that will enable future generation vehicles over a wide range of flight speeds.

We support the vision and are committed to the success of NASA's Ultra Efficient Engine Technology (UEET) Project.

William E Koop

William Koop, Air Force Research Laboratory

Gerald L. Brines

Gerald Brines, Allison-Rolls Royce

Mahmood Naimi

Mahmood Naimi, Boeing Commercial Airplane Company

Fred H. Krause

Fred Krause, General Electric Aircraft Engines

Dimitri Mavris

Dimitri Mavris, Georgia Tech

Timothy R C

Tim Conners, Gulfstream

Vinod Nangia

Vinod Nangia, Honeywell

Tom Hartmann, Lockheed-Martin

Robert J. Shaw

Robert J. Shaw, NASA Glenn Research Center

Robert D Southwick

Robert D. Southwick, Pratt & Whitney

Scott Cruzen, Williams International

Gulfstream A GENERAL DYNAMICS COMPANY Honeywell LOCKHEED MARTIN NASA Williams International

Last Update-April 2003

Baseline Vehicles for UEET Technology Application Studies

UEET Ultra Efficient Engine Technology

Commercial Vehicles

Subsonic

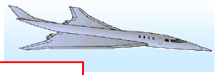
300 PAX
Large Subsonic Transport

50 PAX
Regional Jet Transport

500-600 PAX
Blended Wing Body (BWB)

Supersonic

300 PAX
High Speed Civil Transport (HSCT)



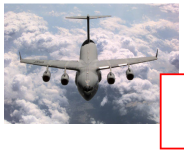
10 PAX
Supersonic Business Jet (SBJ)

Hypersonic

These vehicles drive the technology investment strategy

Non-Commercial Vehicles

4 PAX
General Aviation Aircraft (GA)



Military Transport (C-17)

Unmanned Aerial Vehicle (UAV)

Advanced Fighter

Access-to-Space/High Mach Platform

These vehicles determine the technology synergies

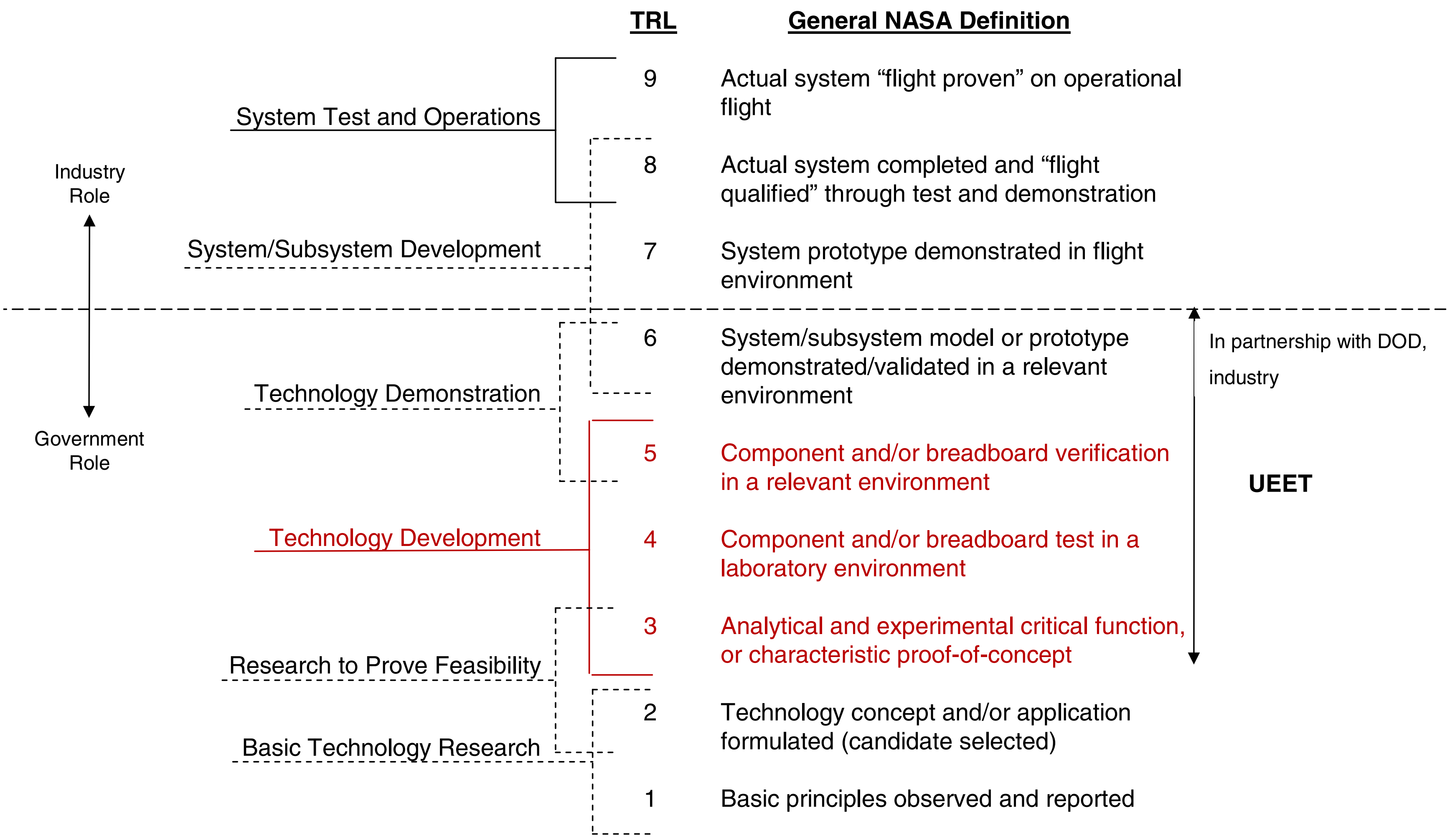
Program Technical Objectives

UEET Ultra Efficient Engine Technology

	Goal	Minimum Success Criteria
CO_2 Goal	15% fuel burn reduction for large subsonic aircraft	12% fuel burn reduction for large subsonic aircraft
	8% fuel burn reduction for small subsonic, small / large supersonic	4% fuel burn reduction for small subsonic, small / large supersonic
NO_x Goal	70% N0x reduction (below ICAO 96) for subsonic (large/ regional) combustors over the LTO cycle	65% N0x reduction (below ICAO 96) for subsonic (large/ regional) combustors over the LTO cycle

NASA's Technology Readiness Level (TRL) Scale

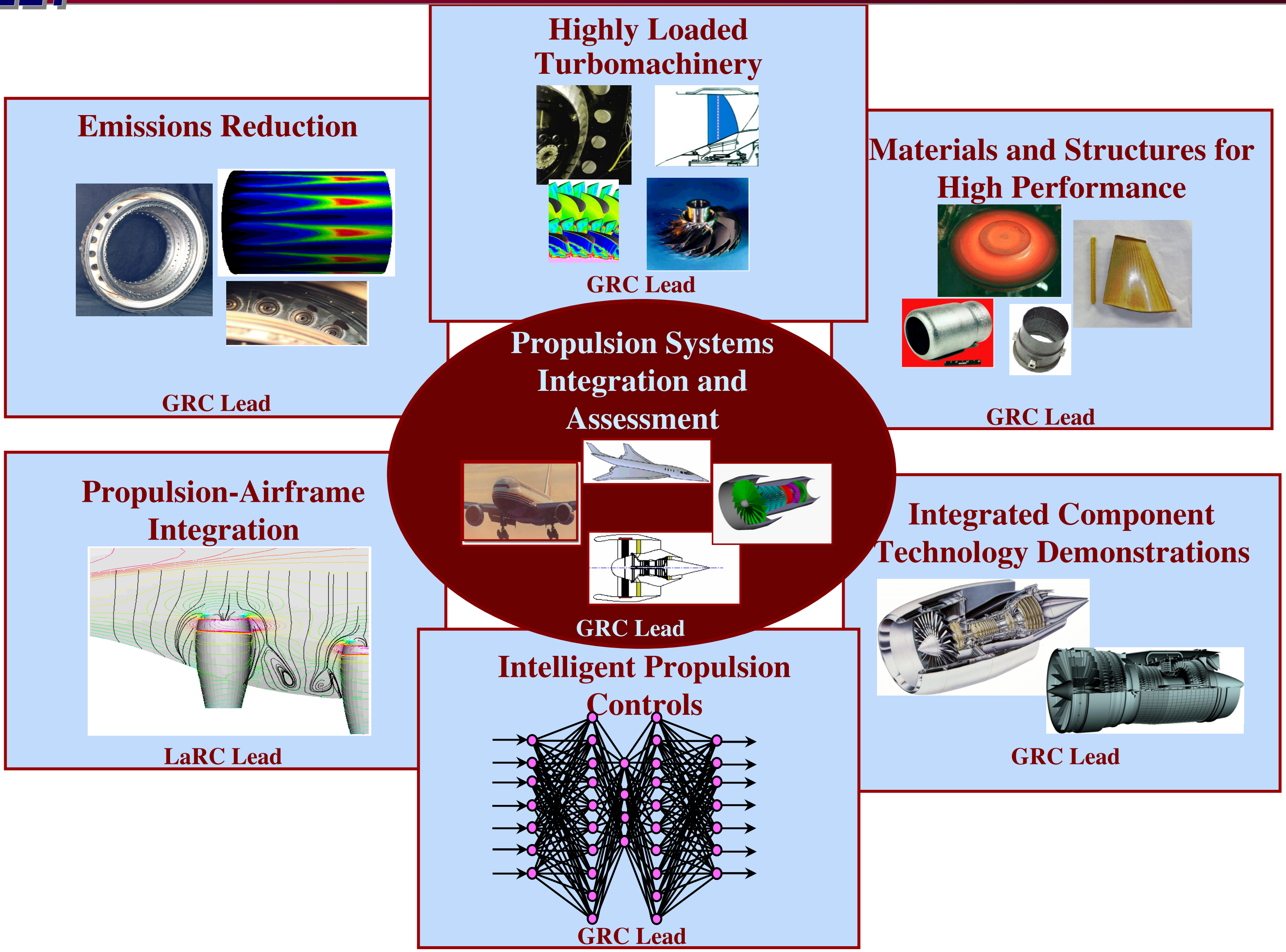
Ultra Efficient Engine Technology



TRL	General NASA Definition
9	Actual system "flight proven" on operational flight
8	Actual system completed and "flight qualified" through test and demonstration
7	System prototype demonstrated in flight environment
6	System/subsystem model or prototype demonstrated/validated in a relevant environment
5	Component and/or breadboard verification in a relevant environment
4	Component and/or breadboard test in a laboratory environment
3	Analytical and experimental critical function, or characteristic proof-of-concept
2	Technology concept and/or application formulated (candidate selected)
1	Basic principles observed and reported

UEET Elements

UEET Ultra Efficient Engine Technology



Highly Loaded Turbomachinery

GRC Lead

Emissions Reduction

GRC Lead

Materials and Structures for High Performance

GRC Lead

Propulsion Systems Integration and Assessment

GRC Lead

Propulsion-Airframe Integration

LaRC Lead

Integrated Component Technology Demonstrations

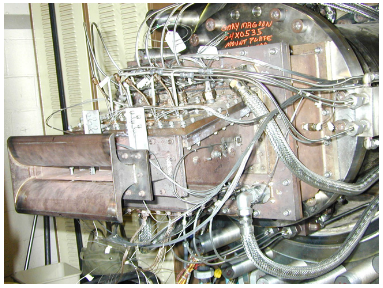
GRC Lead

Intelligent Propulsion Controls

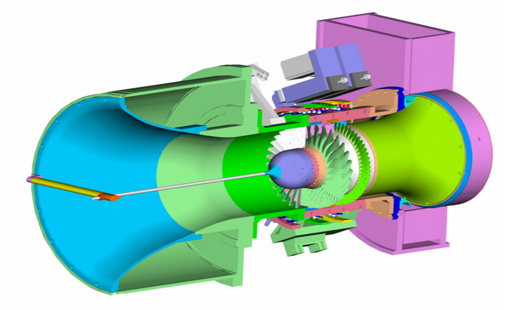
GRC Lead

Selected Technical Highlights

UEET Ultra Efficient Engine Technology

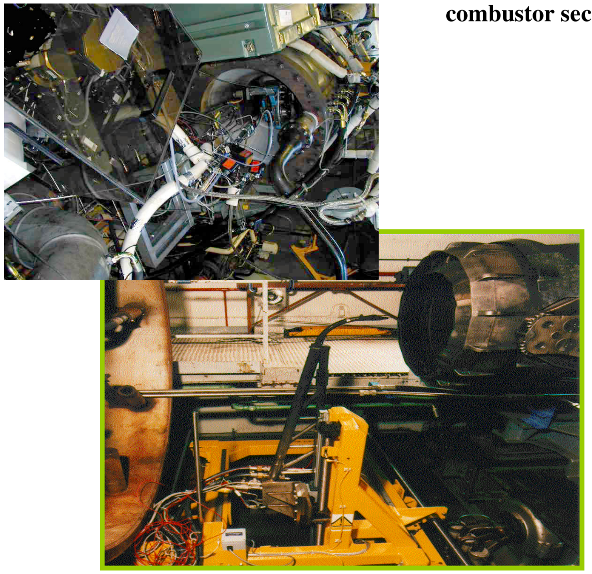


70% LTO NO_x
combustor sector tests

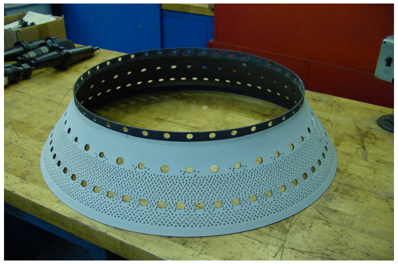


2 stage POC compressor rig design

Turbomachinery disk material
temperature limit



Rig/engine tests to measure
particulates, aerosol emissions

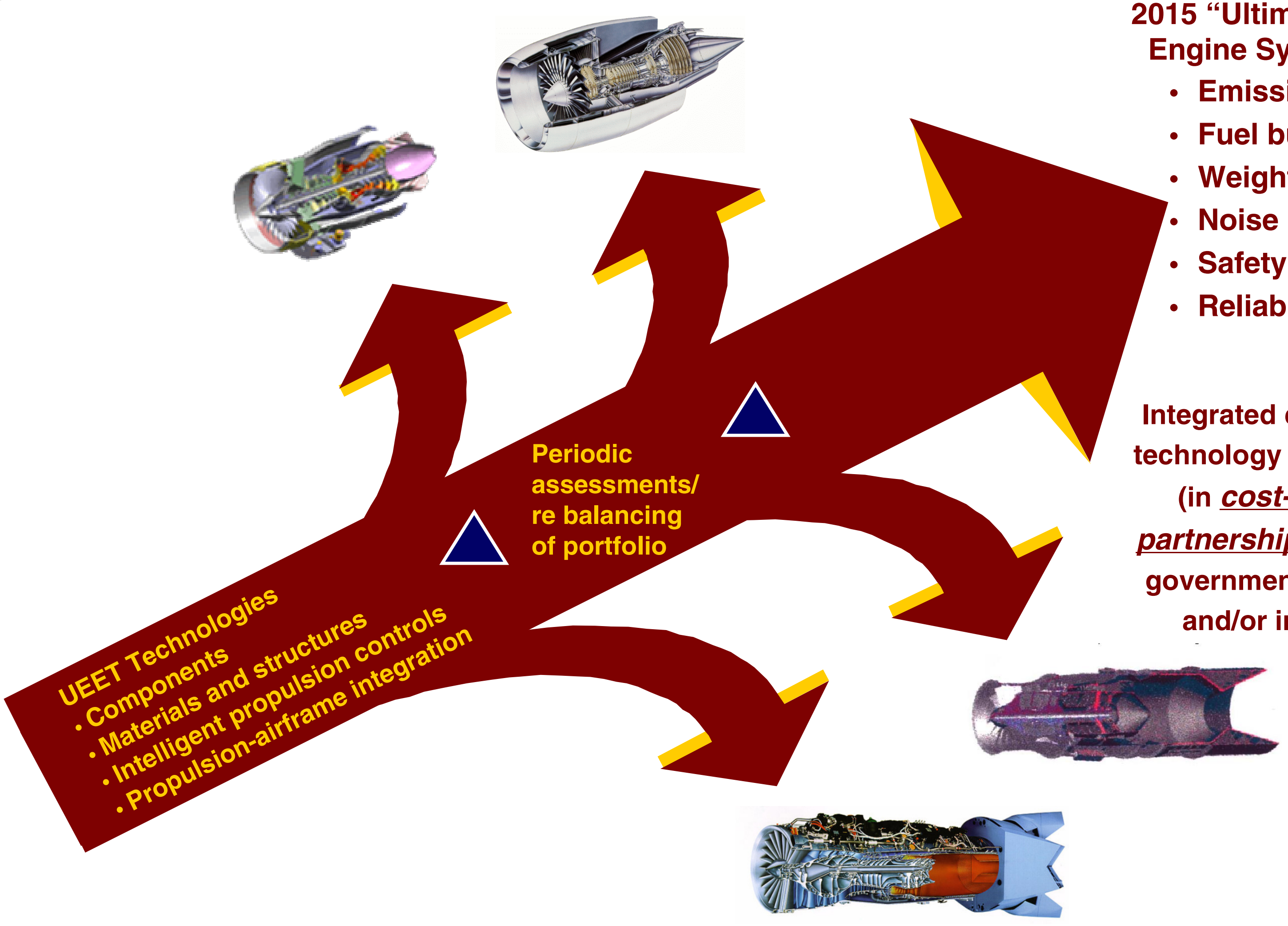


CMC combustor liner
for engine test

Active flow control
to reduce inlet distortion

The UEET “Roadmap”

UEET Ultra Efficient Engine Technology



UEET Technologies
- Components
- Materials and structures
- Intelligent propulsion controls
- Propulsion-airframe integration

Periodic assessments/ re balancing of portfolio

2015 “Ultimate” Turbine Engine Systems
- Emissions
- Fuel burn
- Weight
- Noise
- Safety
- Reliability

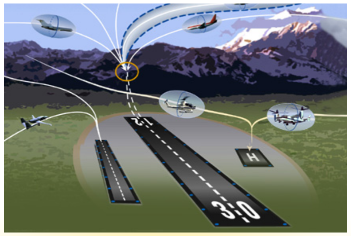
Integrated component technology validations (in ***cost-sharing partnership*** with other government agencies and/or industry)

The Path to
Re Invention
of the UEET Project

VehicleSystems

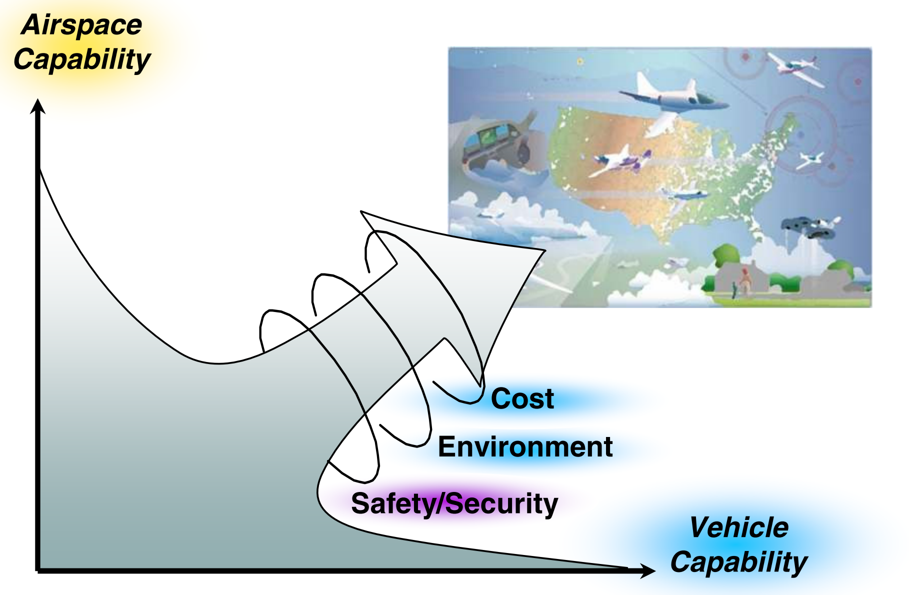
where innovation soars.

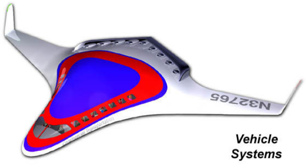
Aeronautics Technology – Three Integrated Programs



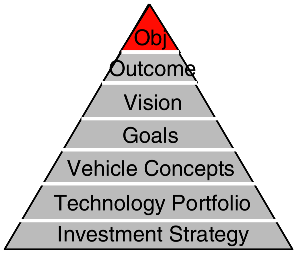
Airspace Systems

Aviation Safety & Security

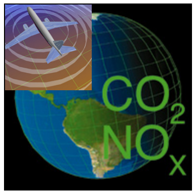




Vehicle Systems


Obj
Outcome
Vision
Goals
Vehicle Concepts
Technology Portfolio
Investment Strategy

Aeronautics Theme Objectives for the Public Good

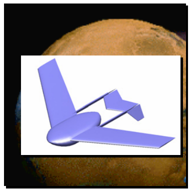


Protect the Environment

Protect local environmental quality and the global climate by reducing aircraft noise and emissions.

Increase Mobility

Enable more people and goods to travel faster and farther, anywhere, anytime with fewer delays



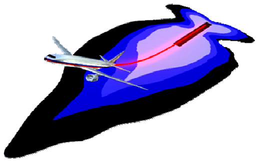
Explore New Aerospace Missions

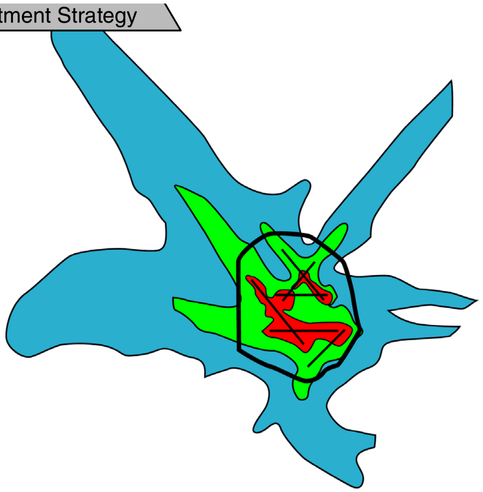
Pioneer novel aerospace concepts to support earth and space science missions

Support National Security

Leverage NASA aeronautics technology investments in partnership with DOD to support their role of protecting the Nation

Environmentally Friendly Aircraft



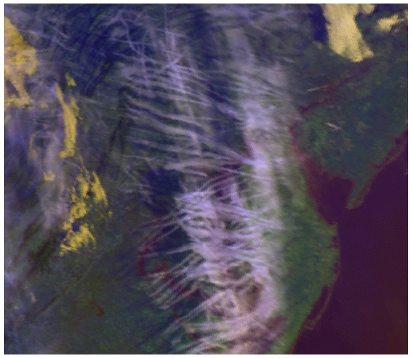


Noise within airport boundaries

Constrain objectionable noise to within airport boundaries

Smog-free

Minimize the contribution of air vehicles to the production of smog



No impact on global climate

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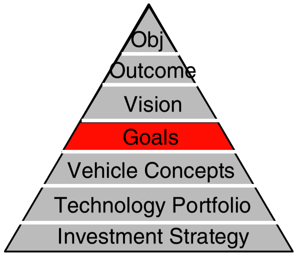
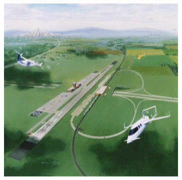


Aircraft for Public Mobility



More Convenient

Expand access to aviation to more locations and make it available on-demand

More Affordable

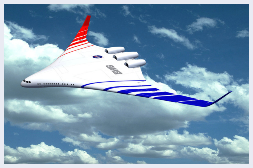
Make air travel available to the entire population

Faster

Increase the speed of air travel

…without compromising safety

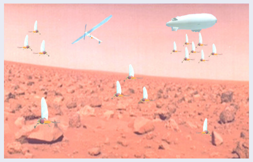
Innovative Vehicle Concepts to Identify Key Technology Requirements


Minimum environmental impact, maximum efficiency

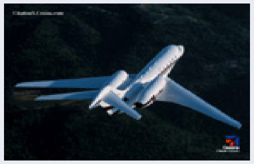
Clean Transport


Strengthen national security through rapid deployment and global reach

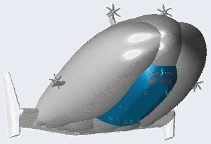
Global Strike


Conduct extended science and exploration missions

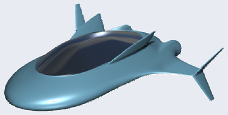
Planetary Flight Vehicles


All hour access to any location without noise disturbance

Santa Monica at Midnight


Global reach and on-demand delivery

Global Reach Transport


Rural, regional, and intra-urban transportation

Personal Air Vehicle


Rural and regional economic growth, time critical transport

Heartland Express


Automated refueling capability, ultra-long endurance, wide speed range

Tanker


Enables city center access in all weather

V/STOL Commuter


Expands the use of existing airport infrastructure

Extreme STOL Transport

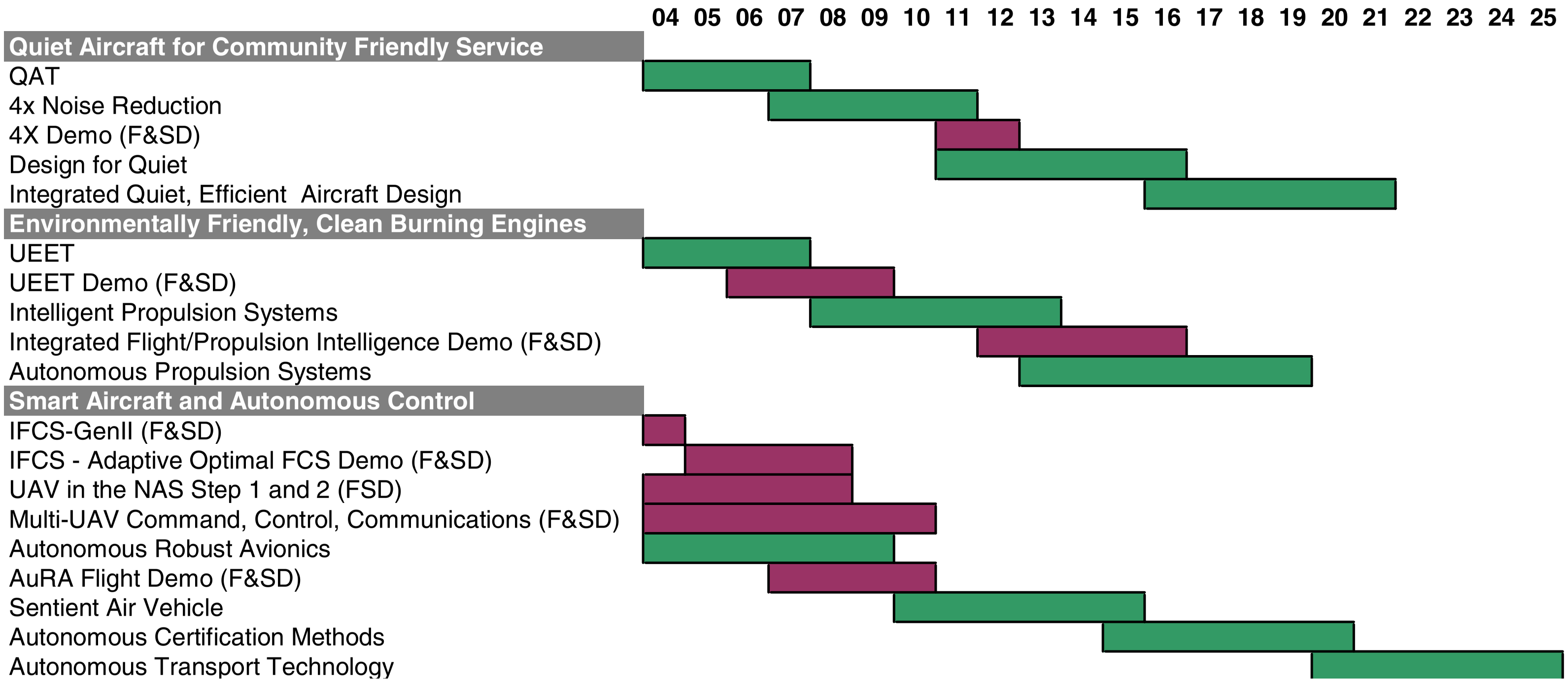

Reduce passenger flight time by at least a factor of 2

Supersonic Overland


High altitude observations for science and defense

High Altitude Long Endurance

Project Evolution within Replanned Vehicle Systems Strategic Focus Areas



Factors Driving Change

- Administration/OMB drivers that are not going away
  - Be more competitive (outhouse and in house) to get “best product”
  - Right size the NASA institution (people and facilities)
  - Proper role of government programs in aerospace R&D food chain

- Increasing stress on Federal budget
  - Growing Federal deficits for foreseeable future
  - Administration priorities (Homeland security and anti terrorism)
  - Aerospace priorities (National and Agency)

Opportunities

Opportunity to:

-significantly strengthen UEET in the eyes of our customers/partners/stakeholders

--increase the support of key decision makers for UEET

-make major technology impacts on next generation gas turbine engine propulsion systems

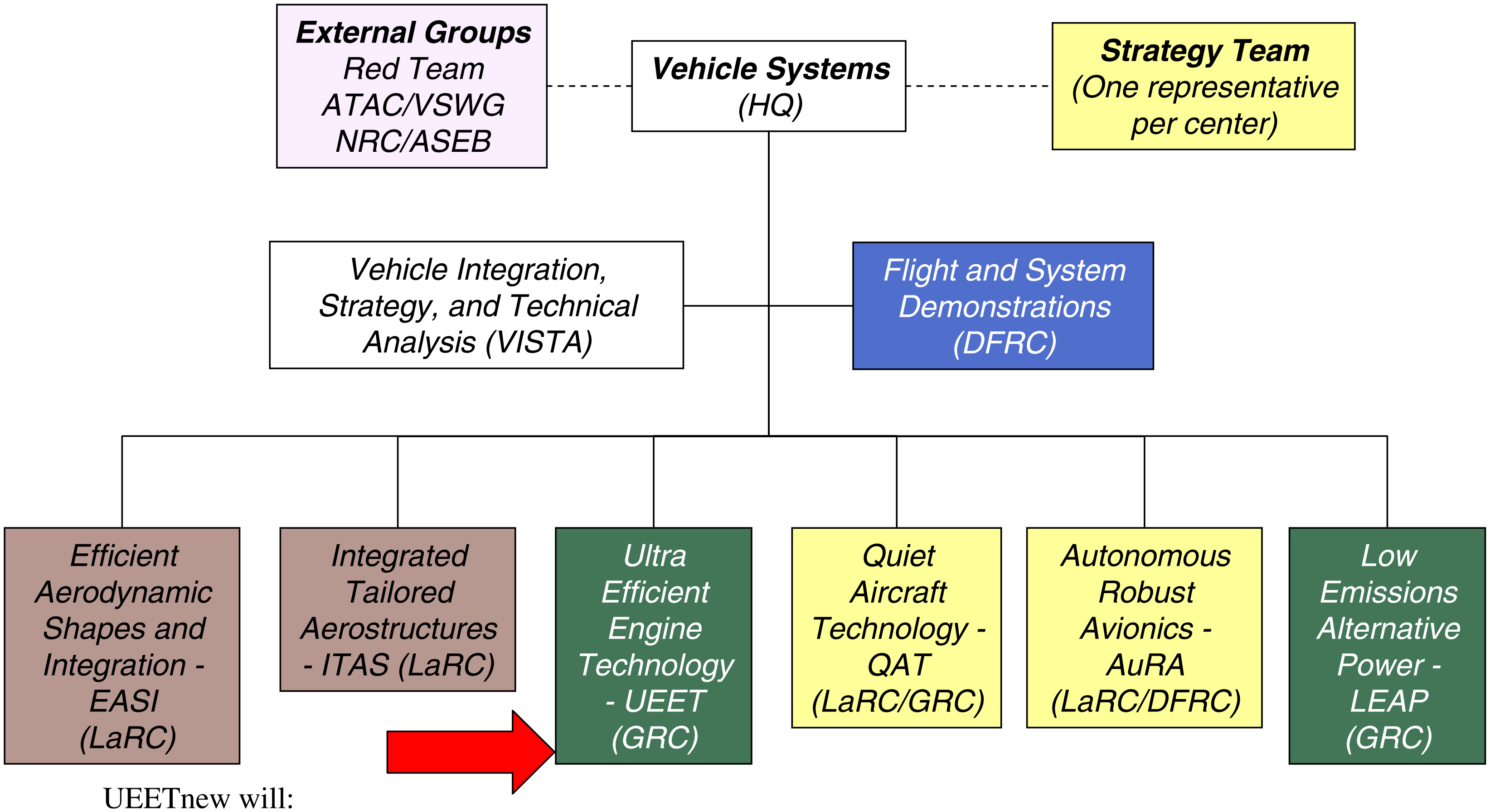
- carry our relationship with DoD (IHPTET/VAATE) to the next level

-forge a partnership with NAI, NGLT

-be a leader in developing an new NASA/other government agencies/industry/university partnership model for aerospace R&T

How do we do it?

Vehicle Systems Program Structure



External Groups
Red Team
ATAC/VSWG
NRC/ASEB

Vehicle Systems
(HQ)

Strategy Team
(One representative per center)

Vehicle Integration, Strategy, and Technical Analysis (VISTA)

Flight and System Demonstrations (DFRC)

Efficient Aerodynamic Shapes and Integration - EASI (LaRC)

Integrated Tailored Aerostructures - ITAS (LaRC)

Ultra Efficient Engine Technology - UEET (GRC)

Quiet Aircraft Technology - QAT (LaRC/GRC)

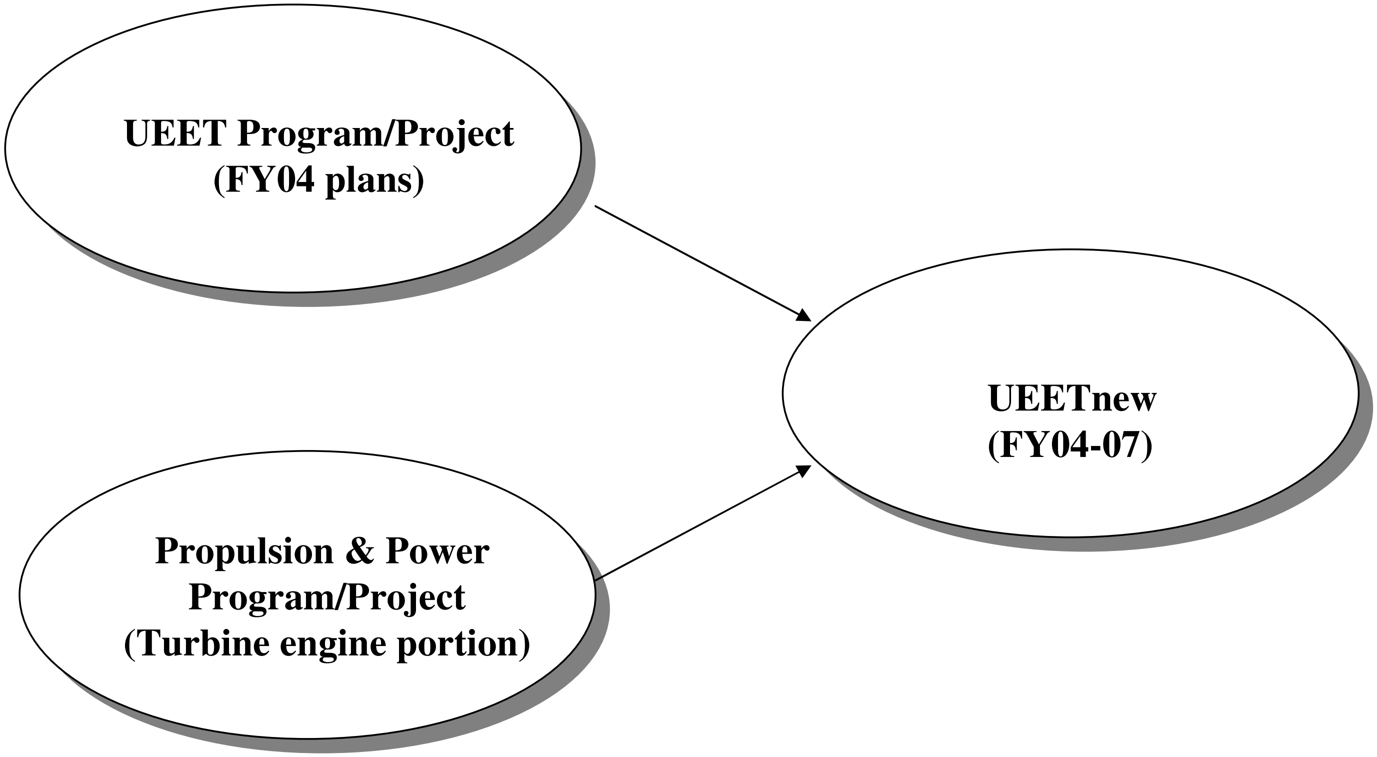
Autonomous Robust Avionics - AuRA (LaRC/DFRC)

Low Emissions Alternative Power - LEAP (GRC)

UEETnew will:
- Be a TRL 1-6 project.
- The **only** project in the Vehicle Systems Program **focused entirely on turbine engine propulsion systems.**
- Invest approximately 20% of resources into developing a technology foundation for the follow on project.

The FY04 Challenge

Ultra Efficient Engine Technology



UEET Program/Project
(FY04 plans)

Propulsion & Power
Program/Project
(Turbine engine portion)

UEETnew
(FY04-07)

Vision: ***Develop and hand off revolutionary turbine engine propulsion technologies that will enable future generation vehicles over a wide range of flight speeds.***

Goals:

Propulsion technologies to enable increases in system efficiency and, therefore, fuel burn reductions of up to 15 % (equivalent reductions in CO_2)

Combustor technologies (configuration and materials) which will enable reductions in LTO* NO_x of 70% relative to 1996 ICAO standards.

**** LTO - Landing/Take-off***

These will remain the same!

UEETnew "Characteristics"

- UEETnew will focus on technologies for subsonic and supersonic commercial systems.
  - The subsonic systems will be regional jets though large wide bodies
  - The supersonic systems will be SSBJ through commercial transports (10 -100 PAX)
- UEETnew will do selected rotorcraft technologies that are dual use technologies which benefit our prime customer base.
- UEETnew will continue to emphasize partnership efforts with DoD that emphasize collaborative efforts to develop dual use technologies.
- UEETnew will use systems studies results as a prime factor in prioritizing and selecting technology efforts. Expert opinion will be employed wherever appropriate (e.g. areas where systems studies cannot currently model technology impacts).

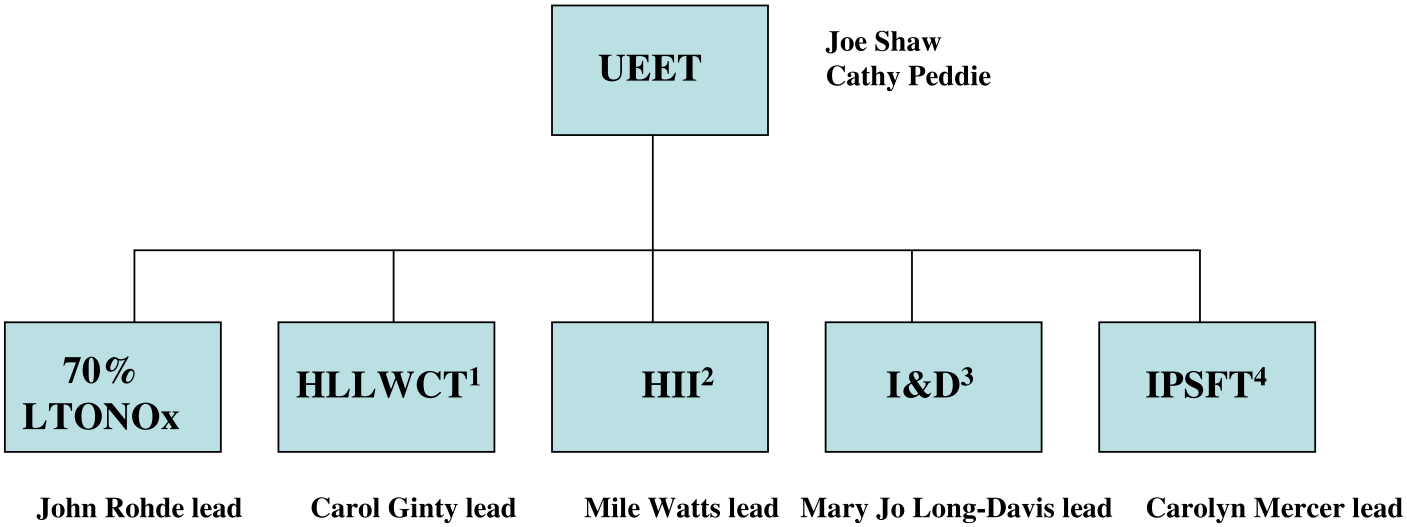
Critical aspects of UEET Re invention

Lower TRL efforts
-Lay foundation for follow on project-Intelligent Propulsion Systems
-All efforts openly competed and selected
-Partnerships encouraged

Higher TRL efforts
-Contribution to achievement of UEET goals
-Appropriate for NASA investment
-Possible dual use technology with partnering with DoD
-Up front commitments by cost sharing partner
    Cost sharing amount and type
    Technology transition/insertion plan
    Approach to utilizing NASA personnel, facilities

UEETnew Sub Project Structure

UEET Ultra Efficient Engine Technology



UEET

Joe Shaw
Cathy Peddie

70% LTONOx

John Rohde lead

HLLWCT[1]

Carol Ginty lead

HII[2]

Mile Watts lead

I&D[3]

Mary Jo Long-Davis lead

IPSFT[4]

Carolyn Mercer lead

[1] HLLWCT-Highly Loaded, Low Weight Compressor and Turbine

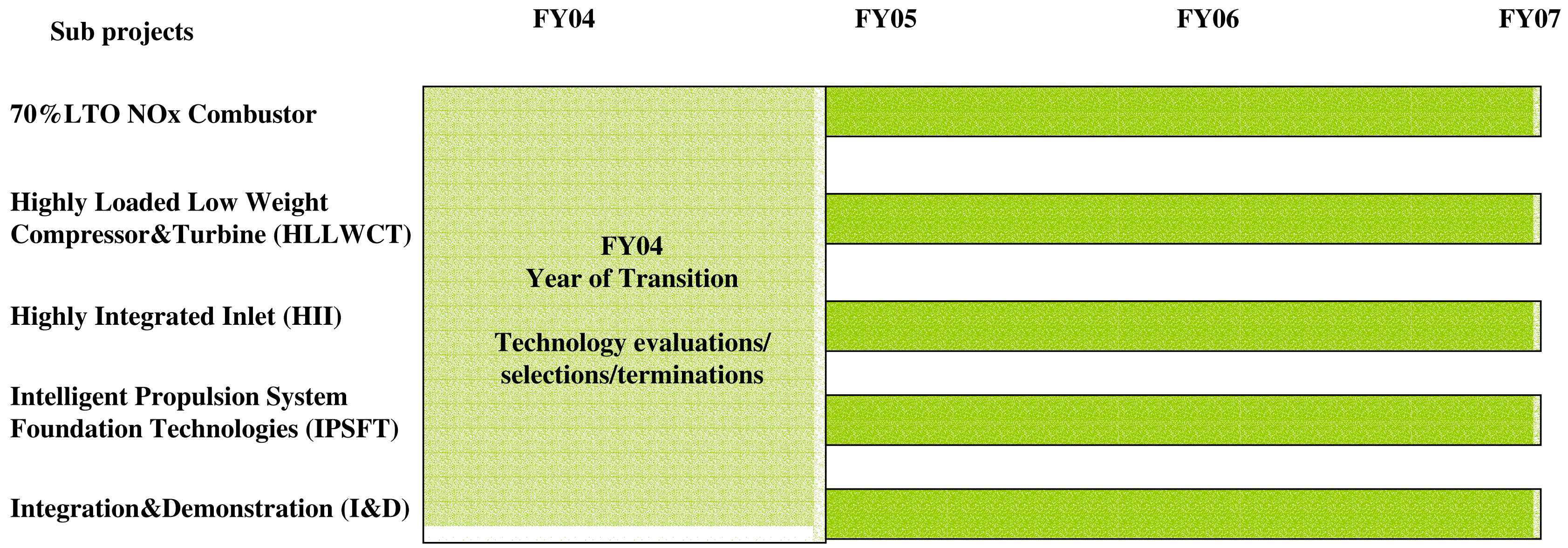
[2] Highly Integrated Inlet

[3] Integration and Demonstration

[4] Intelligent propulsion System Foundation Technologies

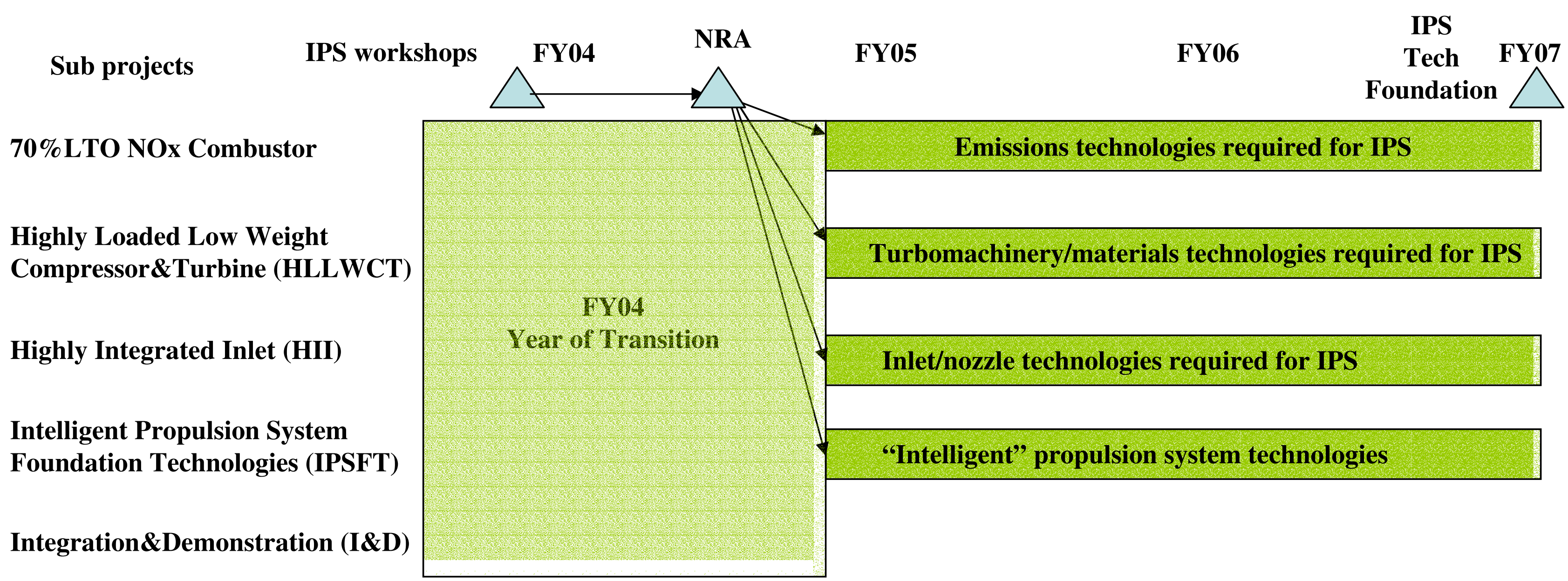
Approach to Re inventing UEET

UEET Ultra Efficient Engine Technology



Approach to Re inventing UEET-Lower TRL

UEET Ultra Efficient Engine Technology



Approach to Re inventing UEET-Lower TRL

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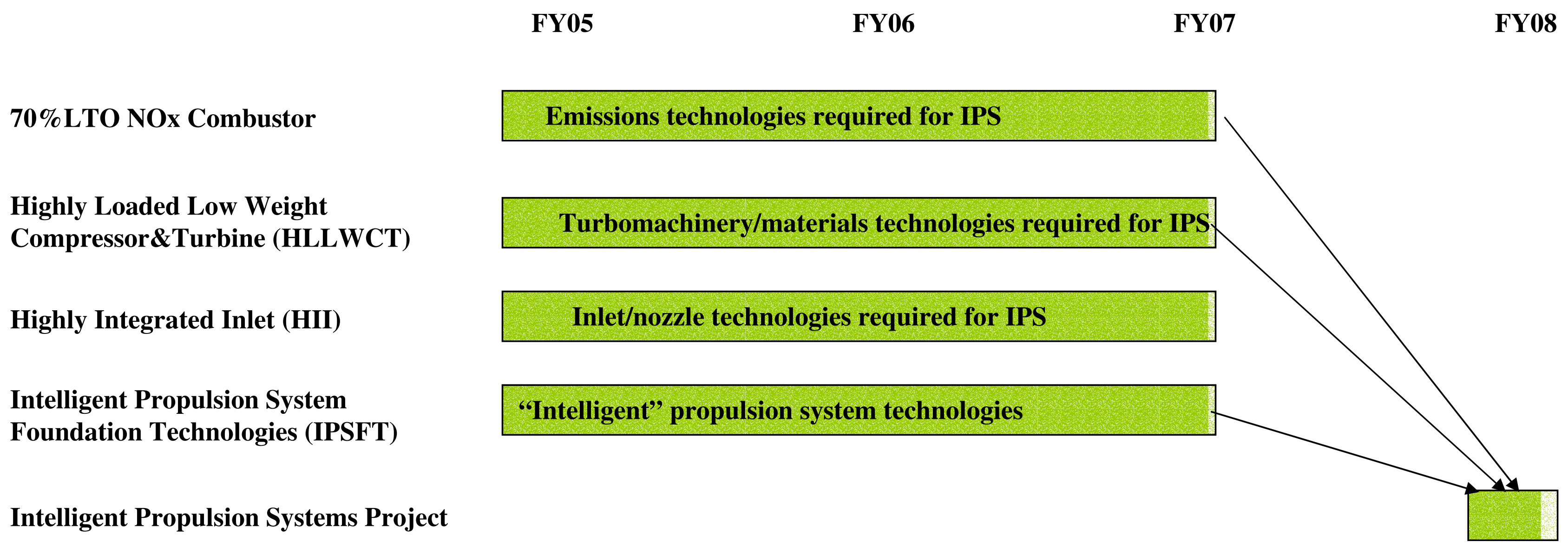


Developing Higher TRL Technology Partnerships/Transitions

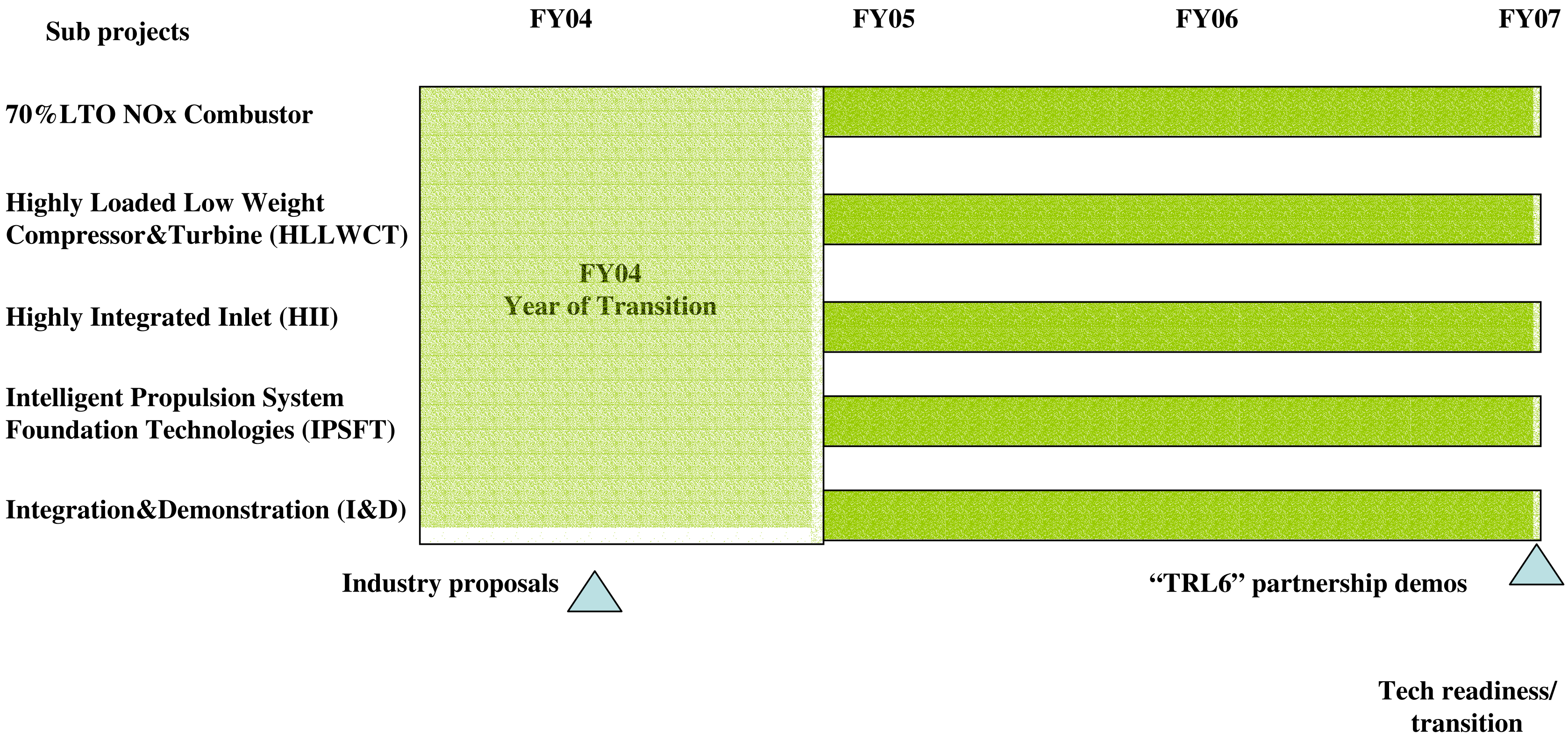
A key part of the new UEET Project will be the selection and transition of UEET technologies with industry/ DoD partners to a sufficiently high level so that our partners can use them in future “product designs’ after further technology efforts that go beyond NASA’s charter (i.e. TRL6).

The success of this effort will be one measure as to how UEET will be graded both by the government (e.g. NASA HQ, OMB, Congress) and our partners.

But we must address “corporate welfare” concerns and doing DoD’s job.

Approach to Re inventing UEET-Higher TRL’s

UEET Ultra Efficient Engine Technology



Sub projects

FY04

FY05

FY06

FY07

70%LTO NOx Combustor

Highly Loaded Low Weight Compressor&Turbine (HLLWCT)

Highly Integrated Inlet (HII)

Intelligent Propulsion System Foundation Technologies (IPSFT)

Integration&Demonstration (I&D)

FY04
Year of Transition

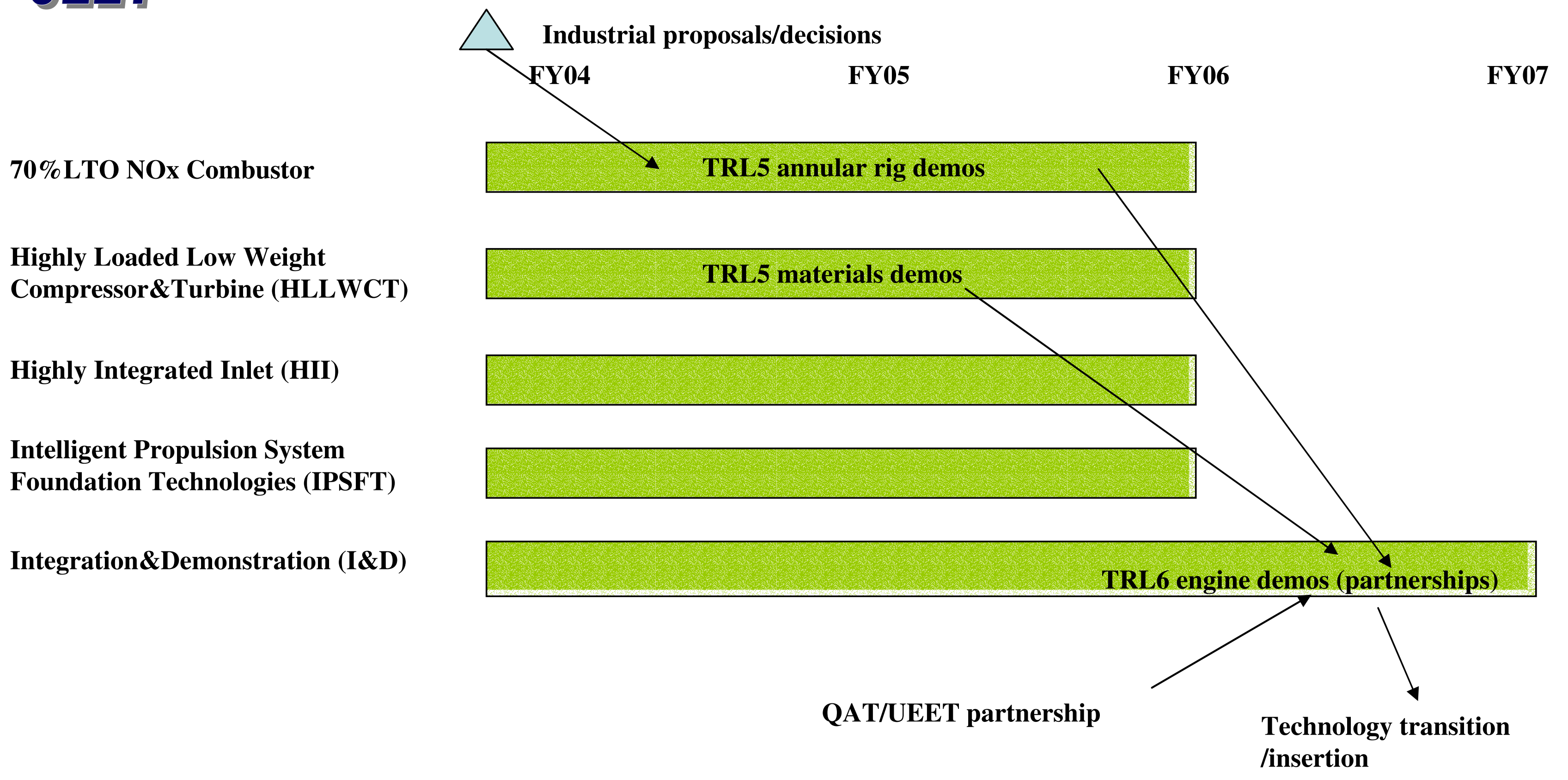
Industry proposals

“TRL6” partnership demos

Tech readiness/
transition

Approach to Re inventing UEET-Higher TRL’s

UEET Ultra Efficient Engine Technology



Industrial proposals/decisions

FY04 FY05 FY06 FY07

70%LTO NOx Combustor

Highly Loaded Low Weight Compressor&Turbine (HLLWCT)

Highly Integrated Inlet (HII)

Intelligent Propulsion System Foundation Technologies (IPSFT)

Integration&Demonstration (I&D)

TRL5 annular rig demos

TRL5 materials demos

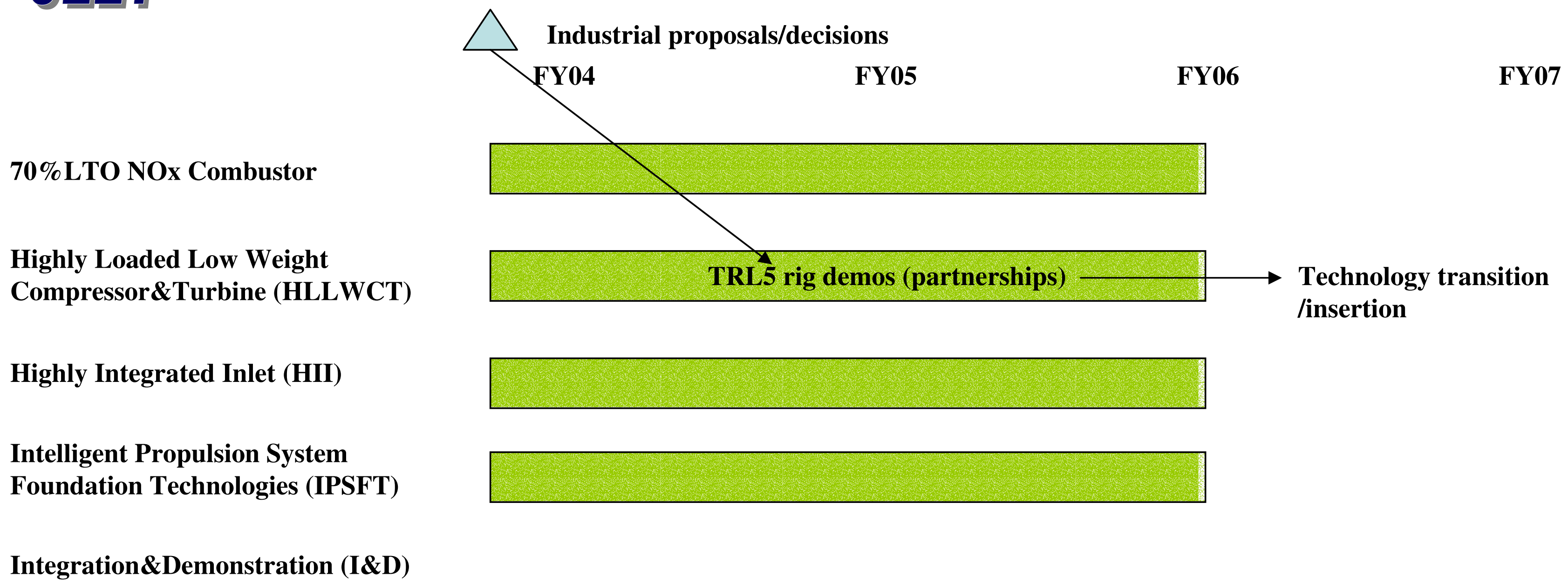
TRL6 engine demos (partnerships)

QAT/UEET partnership

Technology transition /insertion

Approach to Re inventing UEET-Higher TRL's

UEET Ultra Efficient Engine Technology



Industrial proposals/decisions

FY04 FY05 FY06 FY07

70%LTO NOx Combustor

Highly Loaded Low Weight Compressor&Turbine (HLLWCT)

TRL5 rig demos (partnerships)

Technology transition /insertion

Highly Integrated Inlet (HII)

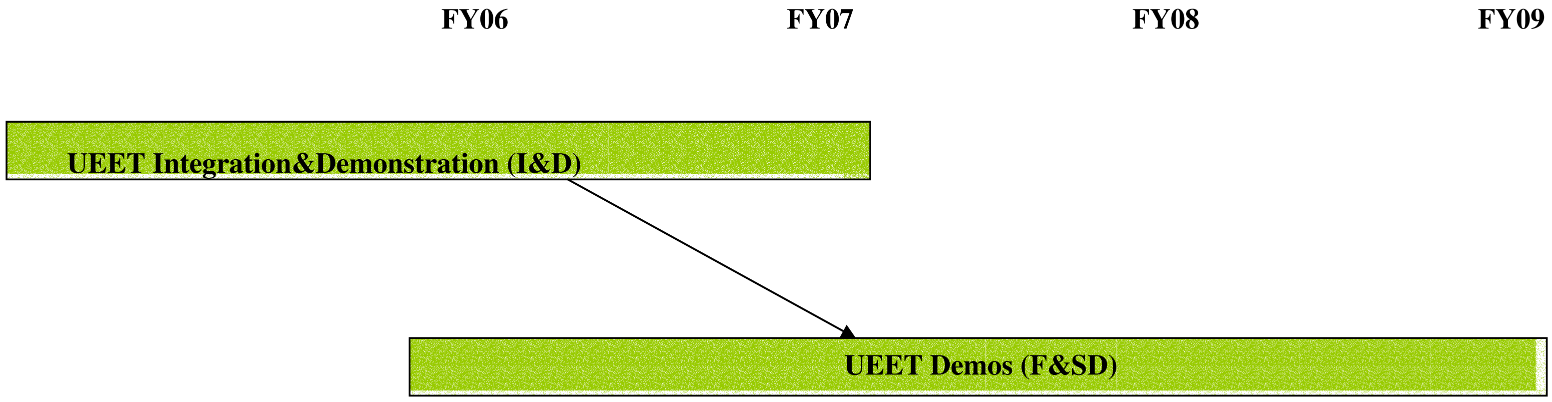
Intelligent Propulsion System Foundation Technologies (IPSFT)

Integration&Demonstration (I&D)

Some technologies will not require engine tests to successfully transition.

Approach to Re inventing UEET-Higher TRL’s

UEET Ultra Efficient Engine Technology



FY06 FY07 FY08 FY09

UEET Integration&Demonstration (I&D)

UEET Demos (F&SD)

UEET and F&SD projects will TOGETHER proactively work with the customers to define and conduct the required flight demonstrations!

Some things won’t change!

Baseline Vehicles for UEET Technology Application Studies

UEET Ultra Efficient Engine Technology

Subsonic

Supersonic

Hypersonic

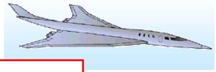
Commercial Vehicles

300 PAX
Large Subsonic Transport

50 PAX
Regional Jet Transport

500-600 PAX
Blended Wing Body (BWB)

300 PAX
High Speed Civil Transport (HSCT)

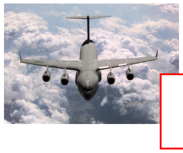


10 PAX
Supersonic Business Jet (SBJ)

These vehicles drive the technology investment strategy

Non-Commercial Vehicles

4 PAX
General Aviation Aircraft (GA)



Military Transport (C-17)

Unmanned Aerial Vehicle (UAV)

Advanced Fighter

Access-to-Space/High Mach Platform

These vehicles determine the technology synergies

Vision

UEET Ultra Efficient Engine Technology

Develop and hand off revolutionary propulsion turbine engine technologies that will enable future generation vehicles over a wide range of flight speeds.

We support the vision and are committed to the success of NASA's Ultra Efficient Engine Technology (UEET) Project.

William E Koop

William Koop, Air Force Research Laboratory

Gerald L. Brines

Gerald Brines, Allison-Rolls Royce

Mahmood Naimi

Mahmood Naimi, Boeing Commercial Airplane Company

Fred H. Krause

Fred Krause, General Electric Aircraft Engines

Dimitri Mavris

Dimitri Mavris, Georgia Tech

Timothy R C

Tim Conners, Gulfstream

Vinod Nangia

Vinod Nangia, Honeywell

Tom Hartmann, Lockheed-Martin

Robert J. Shaw

Robert J. Shaw, NASA Glenn Research Center

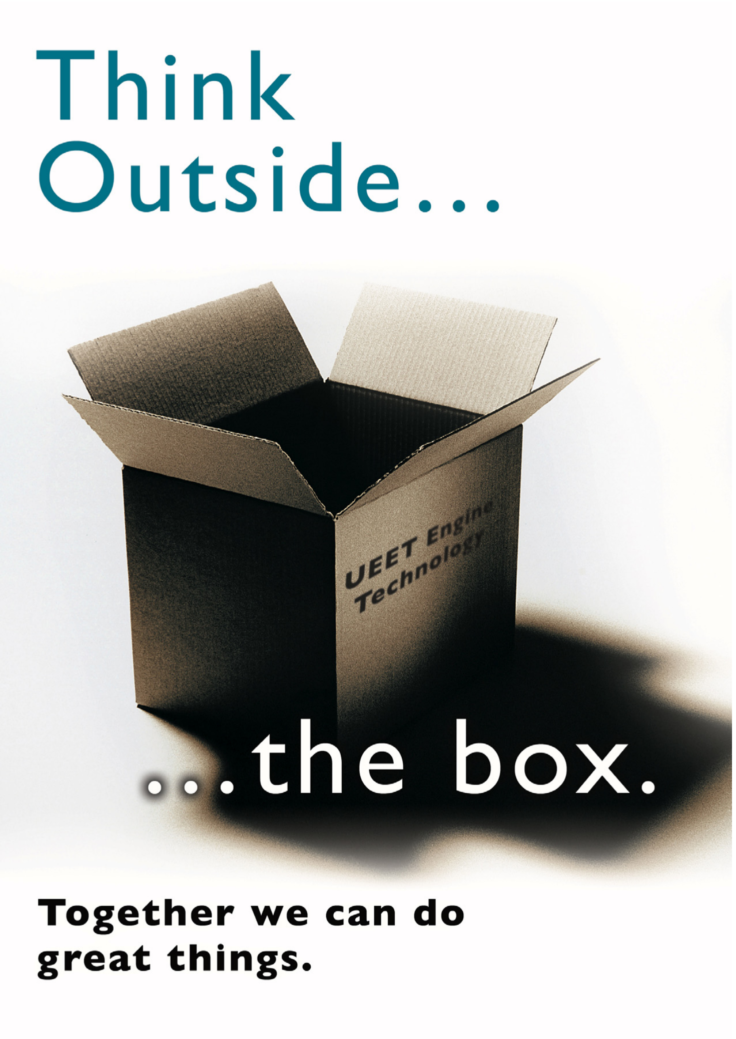
Robert D Southwick

Robert D. Southwick, Pratt & Whitney

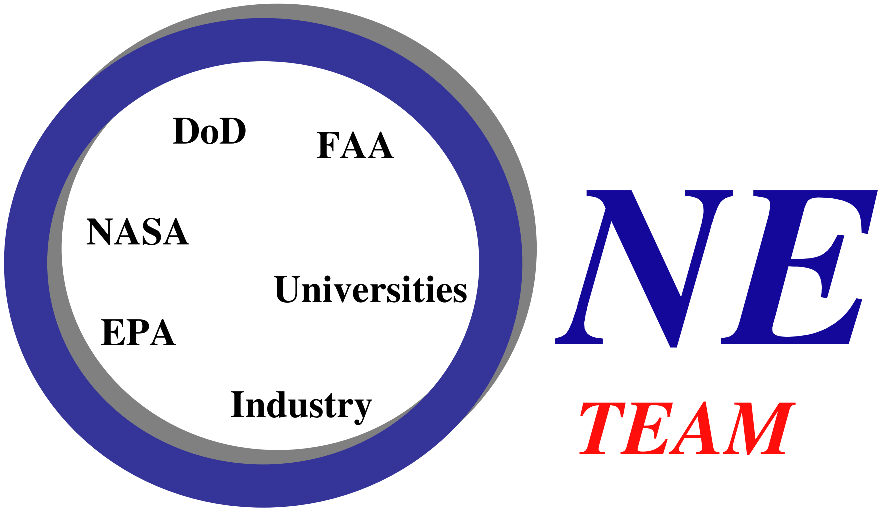
Scott Cruzen, Williams International

Gulfstream A GENERAL DYNAMICS COMPANY Honeywell LOCKHEED MARTIN NASA Williams International

Last Update-April 2003



We are committed to working together in partnership to actively seek out opportunities for the transfer of appropriate technologies both into and out of UEET.



DoD FAA

NASA

Universities

EPA

Industry

ONE TEAM

Addressing the key national agenda areas that will contribute to 21st Century U. S. aerospace leadership

Back-up

Program Status

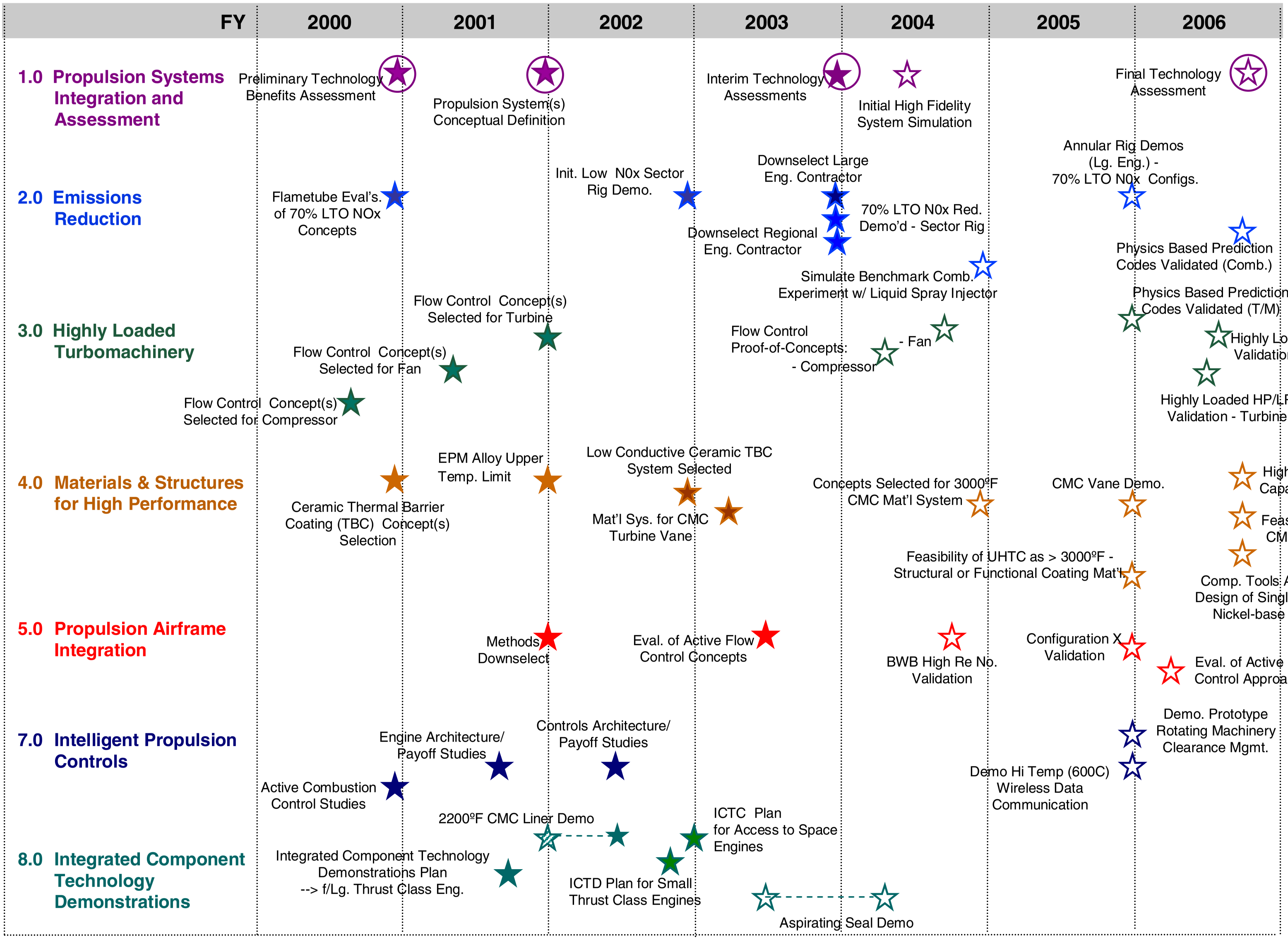
UEET Ultra Efficient Engine Technology

October 2003

Goal	Status	Remarks
15% fuel burn reduction for large subsonic	21% projected for 300 PAX 25% projected for BWB	Systems studies projections of combined impacts of UEET technologies using available (limited) test data in TRL2-3+ range. Initial probabilistic assessment results indicate 94% probability of meeting UEET goal for 300 PAX Benefit projections less than previous years' projections due to technology portfolio changes and refined technology projections.
8% fuel burn reduction for small subsonic, small / large supersonic	21% for 50 PAX 18% for 10 PAX SSBJ	
70% N0x reduction (below ICAO 96) for subsonic (large regional) combustors over the LTO cycle	NASA/industry partnership tests of sector configurations (TRL4) give confidence that target objective will be reached. 79% reduction projected for 300PAX 83% reduction projected for 50 PAX	Sector tests completed in 4Q of FY03

UEET Level I Milestone Schedule

May 2002 Rebaseline



Notes: 1) PCA milestones are denoted by ☆
2) WBS 6.0 reserved for Program Mgmt. functions