HIGH SPEED TRANSPORT AIRCRAFT RESEARCH

(FY89 NEW INITIATIVE)

3-6-87
VERSION
GOAL

PROVIDE TECHNOLOGIES TO ENABLE U.S. AEROSPACE INDUSTRY TO LEAD IN THE DEVELOPMENT OF LONG-RANGE HIGH-SPEED TRANSPORT SYSTEMS
SUPERSONIC AEROPROPULSION THRUSTS

MULTI-USE AEROPROPULSION TECHNOLOGIES

ONGOING BASE TECHNOLOGIES -
• PROPULSION
• MATERIALS & STRUCTURES

HIGH TEMPERATURE MATERIALS

VEHICLE-SPECIFIC TECHNOLOGIES

- HIGH-SPEED TRANSPORT
- SUPERSONIC STOVL
- SUPERMANEUVERABLE FIGHTER
NASA HIGH PERFORMANCE TURBINE ENGINE TECHNOLOGY PROGRAM ELEMENT FUNDING

TOTAL R&D $M
(FY88)

NASA ADVANCED CORE TECHNOLOGY (ACT) PROGRAM
(Planned FY89 Augmentation)

HI-TEMP MATERIALS & STRUCTURES

ONGOING R&T BASE

FISCAL YEAR

$225M

OVER GUIDELINE

$175M

WITHIN GUIDELINE
CONCEPT IDENTIFICATION AND ASSESSMENT

- SYSTEM BENEFIT STUDIES
  - SUPERCSONIC STOVL
  - SUPERMANEUVERABLE FIGHTER
  - SUPERCSONIC PERSISTENCE INTERCEPTOR
  - HIGH SPEED TRANSPORT

- ADVANCED ENGINE CONCEPT IDENTIFICATION
  - TURBORAMJET
  - AIR TURBORAMJET
  - SUPERCSONIC THROUGHFLOW
  - REGEN. CYCLES

- IN-DEPTH ASSESSMENT OF PROMISING CONCEPTS
  - SYSTEM LAYOUT
  - PRELIMINARY DESIGN
  - NEW TECHNOLOGY REQUIREMENTS
  - SUBSCALE CONCEPT VALIDATION EXPERIMENTS

- TECHNOLOGY PLANNING
  - PRIORITIZATION OF TECHNOLOGIES
  - DEVELOPMENT OF PROGRAM PLANS
## TARGET MISSION FOR HIGH-SPEED TRANSPORT

### TARGET MISSION

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<tr>
<th>Parameter</th>
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<td>RANGE</td>
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<tr>
<td>SPEED</td>
<td>MACH 3-5</td>
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<td>ALTITUDE</td>
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<td>SONIC BOOM</td>
<td>&lt; 1 psf</td>
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<tr>
<td>AIRPORT NOISE</td>
<td>FAR 36- III</td>
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<tr>
<td>FUEL</td>
<td>NON-CRYOGENIC</td>
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- BEIJING 6,000 N.M
- TOKYO 5,845 N.M
- SAN FRANCISCO 5,992 N.M
- NEW YORK 6,500 N.M
- HONG KONG
- SYDNEY
- LOS ANGELES
- WASHINGTON
- ...
WHY MACH 4 – 5?

TRIP TIME
6500 NM

13-1/2 hr. 6 hr. 2-1/2 hr. 1-3/4 hr.

DIMINISHING GAIN

SONIC BOOM

2-1/2 psf < 1 psf

TURBOMACHINERY & NON-CRYO FUELS POTENTIAL

FUELS POTENTIAL

Ozone

ALTIMETRY

100,000

50,000

EXISTING AIRCRAFT

CONCORDE

AVAILABLE TECHN.

TECHNICAL CHALLENGE
MARKET OPPORTUNITY

BIG STEP

FLIGHT MACH NO.
HI-STAR ROADMAP

- ENVIRONMENTALLY ACCEPTABLE
- ECONOMICAL
- SYSTEMS & ENVIRONMENTAL ANALYSES
- UNIQUE HIGH SPEED PROPULSION
- LONG LIFE THERMAL STRUCTURES
- TAILORED AERO

NASA

HI-STAR

COMMERCIAL TRANSPORT

2010 I.O.C.

FLIGHT MACH NUMBER


SR71

SCR/VCE

CONCORDE

NASA INDUSTRY
SYSTEMS & ENVIRONMENTAL ANALYSES
# SYSTEMS & ENVIRONMENTAL ANALYSES
## PHASE I - ENABLING TECHNOLOGIES

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- **Propulsion Concept Studies**
- **Airframe Configuration Integration Studies**
- **Infrastructure Economics**
- **Pollution**
- **Sonic Boom**
- **Community Noise**
PROPULSION CONCEPT STUDIES

OBJECTIVE:
IDENTIFY MACH 4-5 CONCEPTS PROMISING 40% BETTER PERFORMANCE THAN EXISTING POWERPLANTS WHILE COMPLYING WITH FAR 36 STAGE 3 NOISE RULES

SCHEDULE & FUNDING ($M)

FISCAL YEAR

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FUNDING
2 2 2 2 2 2 1 1 1
UNIQUE
HIGH SPEED
PROPULSION
Propulsion Concepts For High Speed Transports

TURBORAMJET

TJ ENGINE
OVER/UNDER TURBORAMJET
TURBORAMJET

TURBOFAN WITH SUPersonic Fan

REGENERATIVE AIR-TURBORAMJET (ATR)

SUPERSONIC THROUGH-FLOW TURBOJET/FAN
HIGH SPEED TRANSPORT AIRCRAFT RESEARCH

PROPULSION PROGRAM PLAN

FY 87 88 89 90 91 92 93 94 95 96 97

BASE R&T

STUDIES/CONCEPT ASSESSMENT

ENABLING TECHNOLOGIES

CONCEPT SELECTIONS

TECHNOLOGY INTEGRATION

SUPPORTING TECHNOLOGY

NASP

IHPTET/ACT/HTMI
(CORE ENGINE TECHNOLOGY)
## UNIQUE HIGH SPEED PROPULSION PHASE I - ENABLING TECHNOLOGIES

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SUPERSOIC INLETS AND DUCTING

OBJECTIVE:

ESTABLISH SUPERSOIC INLET & DUCTING TECHNOLOGY APPLICABLE TO MACH 3-5 TRANSPORT AIRCRAFT

- AERODYNAMIC PERFORMANCE
- ACOUSTIC CHARACTERISTICS
- STABILITY (UNSTART)
- SUPERSOIC & SUBSONIC THROUGH-FLOW
- INTEGRATION WITH PROPULSION SYSTEM AND AIRCRAFT

PARTICIPANTS & FACILITIES:

PARTICIPANTS:
- LeRC
- UNIVERSITIES/INDUSTRY

FACILITIES:
- LeRC TUNNELS (10x10, 8x6, 9x15, 1x1, HTF)
- IFM FACILITY (W1)
- LaRC & ARC TUNNELS

SCHEDULE & FUNDING ($M)

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SUPERSONIC THROUGH-FLOW AND ATR COMPRESSORS

SUPERSONIC THROUGH-FLOW FAN DESIGN PROCEDURE

AXISYMMETRIC DESIGN CODE

QUASI 3-D SHEAR LAYER NAVIER-STOKES CODE (MACH NO CONTOURS)

OBJECTIVE:

ESTABLISH SUPERSONIC THROUGH-FLOW COMPRESSION SYSTEM TECHNOLOGY APPLICABLE TO A BROAD SYSTEM OF MACH 3-5 ENGINE CONCEPTS

- DEVELOP/MODEL/VALIDATE ANALYTICAL CODES
- MODERATE LOADED/MODERATE TIP SPEED FANS
- HIGHLY LOADED/HIGH TIP SPEED COMPRESSORS
- COUNTER ROTATING COMPRESSORS
- COOLED COMPRESSOR BLADING

PARTICIPANTS & FACILITIES:

PARTICIPANTS:
- LeRC
- UNIVERSITIES/INDUSTRY
- IHPTET/ACT/HTMI

FACILITIES:
- LeRC MULTISTAGE COMPRESSOR FACILITIES (ERB)
- ROTOR DYNAMIC RIG (ERB)

SCHEDULE & FUNDING ($M)

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HIGH SPEED DESIGNER FUELS

AIRCRAFT FUEL CANDIDATES

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MACH NUMBER

0 1 2 3 4 5 6 7 8 9 12 15

OBJECTIVE:

RAISE NON-CRYOGENIC FUEL SPEED BARRIER FROM MACH 3 TO MACH 5 TO ENABLE HIGH SPEED TRANSPORTS TO USE EXISTING INFRASTRUCTURES

- NEAR TERM EMPHASIS ON CONVENTIONAL JP FUELS
- LONG TERM EMPHASIS ON ENDOFORMIC FUELS
- STUDY CRYOGENIC FUELS
- DEFINE & MINIMIZE ENVIRONMENTAL IMPACT ON THERMAL STABILITY

PARTICIPANTS & FACILITIES:

PARTICIPANTS:
- LeRC, ARC
- PROGRAM COORDINATION WITH AIRFORCE
- UNIVERSITIES/INDUSTRY

FACILITIES:
- LeRC CONCURRENT EXPTS. WITH COMBUSTION RESEARCH
- LeRC EXISTING THERMAL STABILITY TEST RIGS
- ARC CENTRAL COMPUTING

SCHEDULE & FUNDING ($M)

FISCAL YEAR

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**ADVANCED HYDROCARBON COMBUSTORS**

**FUEL-RICH CATALYTIC OXIDATION**

**OBJECTIVE:**

ESTABLISH COMBUSTION AND HEAT TRANSFER TECHNOLOGIES FOR MACH 3.5 TRANSPORT ENGINES

- COMBUSTION MACH NUMBERS: 1.5 TO 3
- EMPHASIS ON LIQUID HYDROCARBON FUELS

**PARTICIPANTS & FACILITIES:**

**PARTICIPANTS:**
- LeRC
- PROGRAM COORDINATION WITH AIRFORCE
- UNIVERSITIES/INDUSTRY

**FACILITIES:**
- HTF
- CE-9B & CE-5B, E.R.B.
- CELL 23, C.R.L.

**SCHEDULE & FUNDING ($M)**

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**H2 MODEL**

- MODEL VERIFIED
- UNSTEADY FLOW MODEL

**HYDROCARBON MODEL**

- MODEL VERIFIED
- UNSTEADY FLOW MODEL

**CATALYTIC HEAT EXCH. BURNING**

- STAGED DUCT BURNING

**TECHNOLOGY VERIFICATION**

- PLATE/SHELL LAB
- HTF COMBUST. TEST
### Objective:

Develop turbine enabling technologies for high speed transport propulsion systems.

- Investigate unconventional concepts to reduce stages (ATR)
  - COUNTER-ROTATION TURBINES
  - PARTIAL ADMISSION TIP TURBINES
  - DOUBLE-PASS TURBINES
- BLADING & COOLING OF SUPERSONIC THROUGH-FLOW TURBINES
- Develop, model, validate analytical codes

### Participants & Facilities:

**Participants:**
- LeRC
- Program Coordination with Airforce
- Universities/Industry
- IHPTET/ACT/HTMI

**Facilities:**
- Warm Turbine Test Facility (ERB)
- Counter-Rotating Turbine Facility (ERB)
- Rotor Dynamic Rig (ERB)

### Schedule & Funding ($M)

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LOW NOISE EXHAUST NOZZLES

OBJECTIVE:

IDENTIFY PROPULSION/EXHAUST NOZZLE CONCEPTS ENABLING FAR 36-III COMPLIANCE AND ESTABLISH ASSOCIATED TECHNOLOGIES

- AEROTHERMAL & ACOUSTIC PERFORMANCE PREDICTIONS
- NOVEL, LOW-JET VELOCITY DUAL CYCLE ENGINES
- NOZZLE NOISE SUPPRESSION CONCEPTS
- SIMULATION AND EXPERIMENTAL VALIDATION

PARTICIPANTS & FACILITIES:

PARTICIPANTS:
- LeRC
- UNIVERSITIES/INDUSTRY

FACILITIES:
- LeRC TUNNELS (10x10, 8x6, 9x15, 1x1, HTF)
- NOZZLE TEST FACILITIES (CE22, CW17)
- JET ACOUSTICS FACILITIES (10x10 APRON, W2, 9x15)
- LaRC AND ARC TUNNELS

SCHEDULE & FUNDING ($M)

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FUNDING: 1.9 6.7 7.2 7.2 8.7 8.7 8.7 8.7 5.5 3.0
THERMAL MANAGEMENT/HEAT EXCHANGER SYSTEMS

OBJECTIVE:

- IDENTIFY THERMAL MANAGEMENT CONCEPTS ENABLING MACH 3-5 TRANSPORTS AND ESTABLISH RELATED TECHNOLOGIES
- HEAT LOAD VS. ENGINE FUEL FLOW RATE MATCHING
- LIGHTWEIGHT HEAT EXCHANGERS
- COOLANT DISTRIBUTION SYSTEMS

PARTICIPANTS & FACILITIES:

PARTICIPANTS:
- LeRC
- PROGRAM COORDINATION WITH AIRFORCE
- UNIVERSITIES/INDUSTRY

FACILITIES:
- HOT SECTION TURBINE AND COMBUSTION COMPONENT FACILITIES
- HTF (PLUMBROOK FACILITY)

SCHEDULE & FUNDING ($M)

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PROPULSION/FLIGHT SYSTEMS CONTROL INTEGRATION

OBJECTIVE:

DEVELOP AND VERIFY INTEGRATED CONTROL TECHNOLOGY FOR ENGINE PROPULSION SYSTEM AND FLIGHT CONTROLS TO BE USED ON HIGH-SPEED TRANSPORT AIRCRAFT

PARTICIPANTS & FACILITIES:

PARTICIPANTS:
- LeRC
- ARC
- UNIVERSITIES/INDUSTRY

FACILITIES:
LeRC: SIMULATION & CONTROL LAB
8 x 6, 9 x 15, 10 x 10, PSL, HTF COMPONENT TEST FACILITIES (PIGGY-BACK)

ARC: VMS/RSIS, MVRSF INTELLIGENT SYST. LAB

SCHEDULE & FUNDING ($M)

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DYNAMIC MODELING
INSTR. REQMTS.
INTELL. METH. SENSORS METH.

PROPULSION CONTROL
CONCEPTS DSN METH

FLIGHT CONTROL
VMS BREAD SYST VMS

CONTROL INTEGRATION
PERFORMANCE AND CONDITION MONITORING CONCEPT DEVEL. VALID TESTS

FUNDING TOTAL NASP 3.9 5.0 5.2 5.8 5.9 5.9 4.9 3.7
AIRFRAME/PROPULSION INTEGRATION

OBJECTIVE:

- DEVELOP THE TECHNOLOGY TO ANALYZE THE COMPLEX SYSTEMS INTERACTIONS INHERENT IN HIGH-SPEED AIRCRAFT
- PROVIDE THE KNOWLEDGE BASE ENABLING A WELL-INTEGRATED AIRCRAFT DESIGN CAPABILITY

PARTICIPANTS & FACILITIES:

PARTICIPANTS:
- LEWIS
- LANGLEY
- AMES

FACILITIES:
- LEWIS 10x10 SUPERSOIC TUNNEL
- LANGLEY 16-FOOT TRANSONIC TUNNEL
- AMES UNITARY & 3.5' HYPERSONIC TUNNELS

SCHEDULE & FUNDING ($M)

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INLET INTERACTIONS

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NOZZLE EFFECTS

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AIRFRAME/PROPULSION INTEGRATION

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COMPONENT INTEGRATION AND VALIDATION

OBJECTIVE:

CONFIRM SYSTEM PERFORMANCE AND OPERABILITY

- subsystem interactions
- control and system dynamics
- mode transitions
- scale effects

APPROACH

- design system based on results of component technology programs and concept studies
- utilize available large-scale hardware from component technology programs and "off-the-shelf" for conventional and/or non-critical components
- test over simulated flight environment
- utilize 10x10, PSL, HTF facilities @ LeRC 40x80 tunnel (low speed) @ ARC

SCHEDULE & FUNDING ($M)

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- concept selection
- design
- fab/assembly
- isolated installed

FUNDING

10 25 35 40 20 10