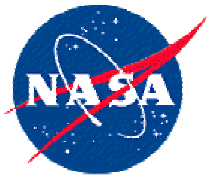






# Propulsion Test Technology:
# *Collaboration is Not a New Concept*

Wednesday, 5/18/2005

Robert Bruce
Chief, New Business Development Office
NASA John C. Stennis Space Center

# Agenda & Topics for Discussion



- SSC Mission Areas
- Rocket Propulsion Test (RPT) Program
  - Rocket Propulsion Test Management Board (RPTMB) Mission
  - National Rocket Propulsion Test Alliance (NRPTA) Mission
- Technology Development at SSC
- Technology Development at Centers within the RPT Programs
- Collaborative Test Technology Development Initiatives
- Dual Use Program for Technology Development
- Center Director's Discretionary Fund
- Summary

# SSC Mission Areas/Lines of Business



- Rocket Propulsion Testing
  - SSC Rocket Propulsion Test Directorate
  - NASA Rocket Propulsion Test Management Board
  - NASA-DOD National Rocket Propulsion Test Alliance
- Applied Sciences
  - Develops and enhances Earth Science products for advancement of earth system science and its application to societal concerns
  - Develops advanced tools to enhance the performance and the results of the Earth observation missions.
- SSC Institution
  - Environmental Office
  - Information Technology
  - Education
  - Manage a Federal City of more than 30 federal, state, academic, and private organizations, as well as numerous technology-based companies.

# Background

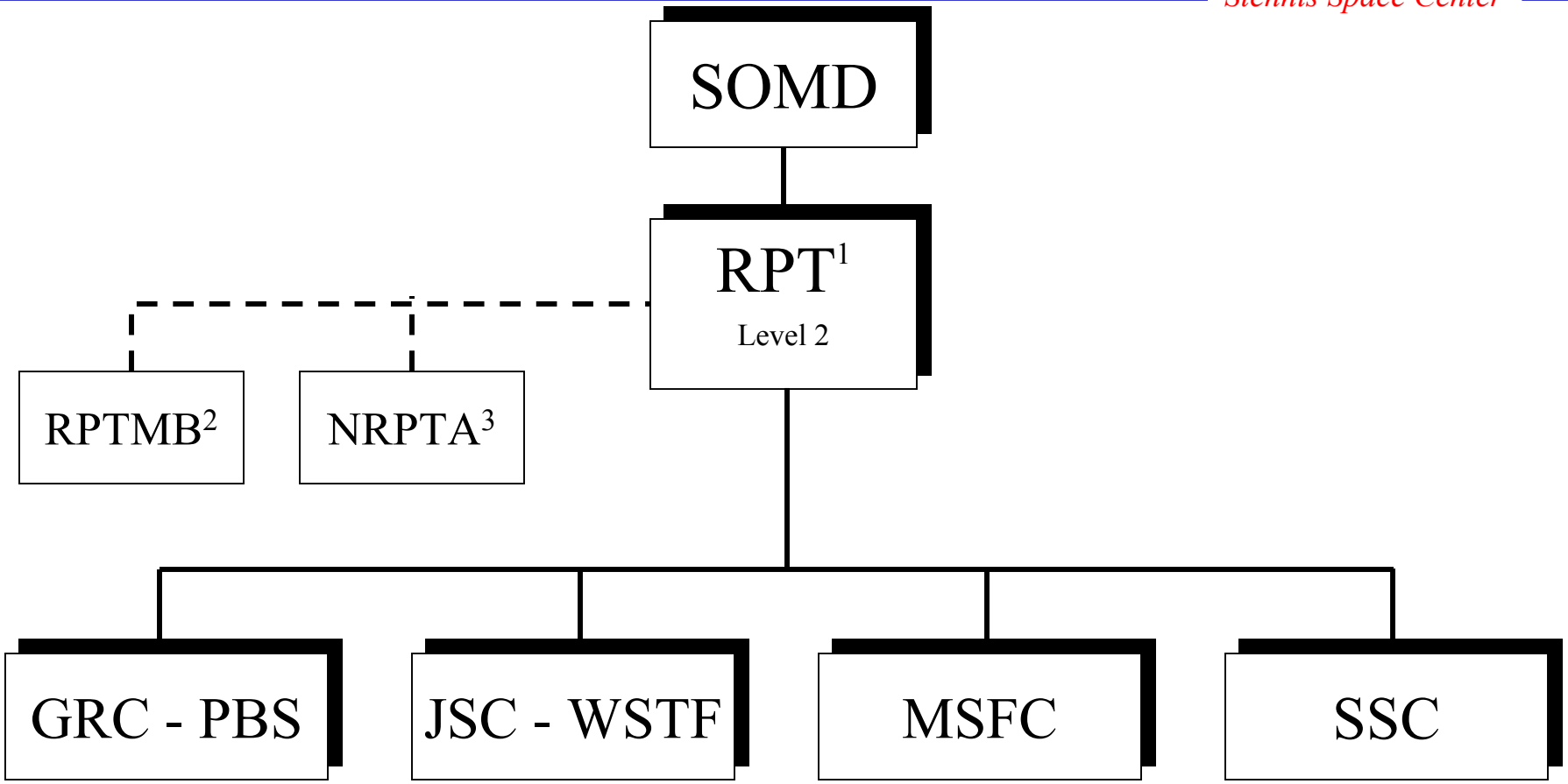
# Rocket Propulsion Test (RPT) Program Objectives

*Stennis Space Center*

- Manage NASA's rocket propulsion test assets, activities and resources
- Advance test technologies
- Reduce propulsion test costs through the safe utilization and efficient use of rocket propulsion test facilities in support of NASA Programs, Commercial Partners and the Department of Defense (DoD)

# Rocket Propulsion Test

*Stennis Space Center*




NOTES: 1. RPT Level 2 Program Manager resides at Stennis Space Center, but reports to the AA, SOMD.

2. RPT Program Manager is Chairman of the RPTMB.

3. RPT Program Manager is Co-Chairman of the NRPTA.

# Rocket Propulsion Test Management Board (RPTMB)

*Stennis Space Center*

**Mission: As the principal implementing activity for the Rocket Propulsion Test Program, the RPTMB serves as the NASA decision making body for rocket propulsion testing; and reviews, approves, and provides direction on the following:**

- All rocket propulsion test assignments.
- All capital investment recommendations for rocket propulsion test facilities and equipment.
- All facility modifications or refurbishments affecting NASA rocket propulsion test capability.
- All official documentation pertaining to multi-site test activities.

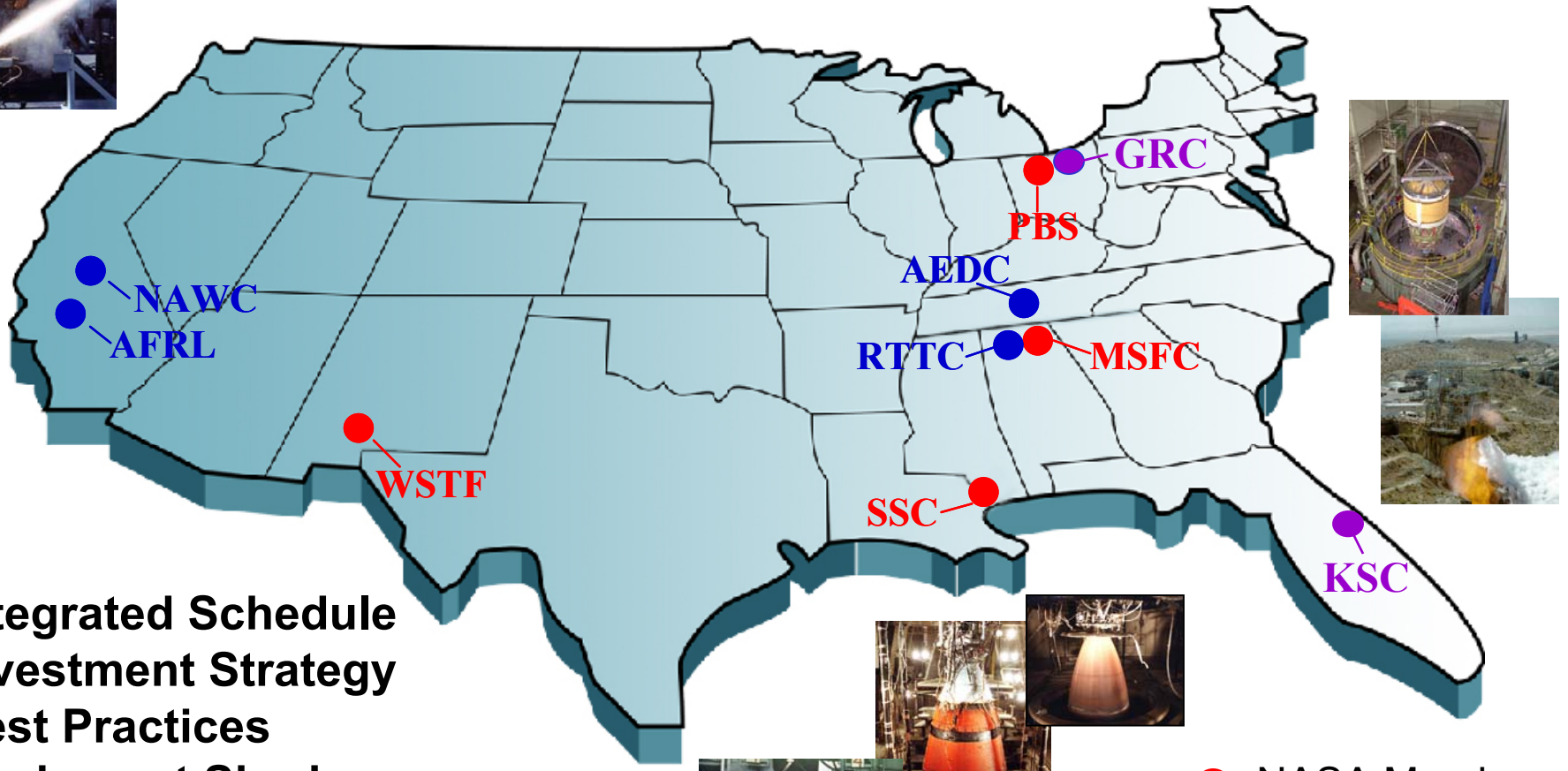
# National Rocket Propulsion Test Alliance (NRPTA)

*Stennis Space Center*

*Mission Statement: To foster a relationship between the National Aeronautics and Space Administration (NASA) and the Department of Defense (DoD), which will shape the government's rocket propulsion test capability to efficiently meet national test needs through intra- and inter- agency cooperation. To pursue initiatives and cooperation to further define and develop advance propulsion test needs.*

# RPTMB/NRPTA Site Locations

*Stennis Space Center*





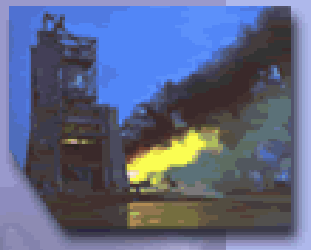



- Integrated Schedule
- Investment Strategy
- Best Practices
- Equipment Sharing
- Facility Utilization
- Facility Capability
- Industry Involvement

- NASA Members
- NASA Associate Members
- DoD

# NASA Sites - Baseline Test Roles

*Stennis Space Center*



**Marshall Space Flight Center**

Primary NASA site for:
- MSFC designed/developed component level test articles
- Technology development test articles with substantial MSFC engineering involvement
- Propulsion component research and technology (low TRL)
- Cryo structural test articles (tanks, ducts, etc.)

Alternate NASA site for:
- Non-hypergolic, ambient testing

**White Sands Test Facility**

Primary NASA site for:
- Altitude testing of small/medium test articles up to 15k lb thrust, excluding LOX/LH2
- All hypergolic testing

**Plum Brook Station**

Primary NASA site for:
- Altitude testing of medium/large test articles in the 1k to 400k lb thrust range, excluding hypergolics; includes all LOX/LH2 testing

Alternate NASA site for:
- Cryo structural test articles (tanks, ducts, etc.)

**Stennis Space Center**

Primary NASA site for:
- Non-hypergolic, ambient/low-altitude testing
- Excludes other centers' baseline test assignment

# DOD Sites - Baseline Test Roles

*Stennis Space Center*

## U. S. Army Redstone Technical Test Center (RTTC)

- Static test stands for solids, hypergolic liquids, gels & hybrid rocket systems
- Cold gas flow test facility

## Arnold Engineering Development Center (AEDC), Arnold Air Force Base

- Aerodynamic and propulsion wind tunnels
- Turbine engine test cells
- Space environmental chambers
- Arc heaters
- Cryogenically cooled test cells for short duration small engine testing at altitudes above 200,000 ft
- Large altitude liquid and solid propellant rocket engine test stand

## Air Force Research Laboratory (AFRL), Edwards Air Force Base

- Small scale liquid rocket engine test cells as small as .01 lbf thrust
- Large liquid/solid test stands up to 10 million lbf thrust

## Naval Air Warfare Center (NAWC)

- Ambient solid and liquid rocket test stands with maximum thrust ranging from 80k lbf to 1500k lbf
- Altitude solid rocket test stands with maximum thrust of 80k lbf

# SSC Technology Development Responsibilities



- Research and development activities leading to new technologies
- assessment, certification, and acquisition of technologies from the commercial, academic, and government sectors
  - to improve safety, efficiency, and effectiveness in the fulfillment of NASA's mission
  - while improving productivity and increasing national competitiveness
- transferring and commercializing technologies to benefit the private sector, academia, and other government entities.

# Technology Development Approach



- All Efforts are directly traceable to the NASA Strategic Plan and the SSC Implementation Plan.

- Technology Requirements/Needs developed by direct liaison with the SSC Mission Area.
  - Focus groups, interviews, direct liaison
  - Technology Roadmaps build on the Requirements/Needs

- Technology Portfolio developed using various tools
  - In-House Technology Development, Collaborative Agreements, Dual Use, SBIR/STTR, CDDF

- Resources are leveraged from several appropriate sources in order to initiate and sustain innovative technology collaboration and development

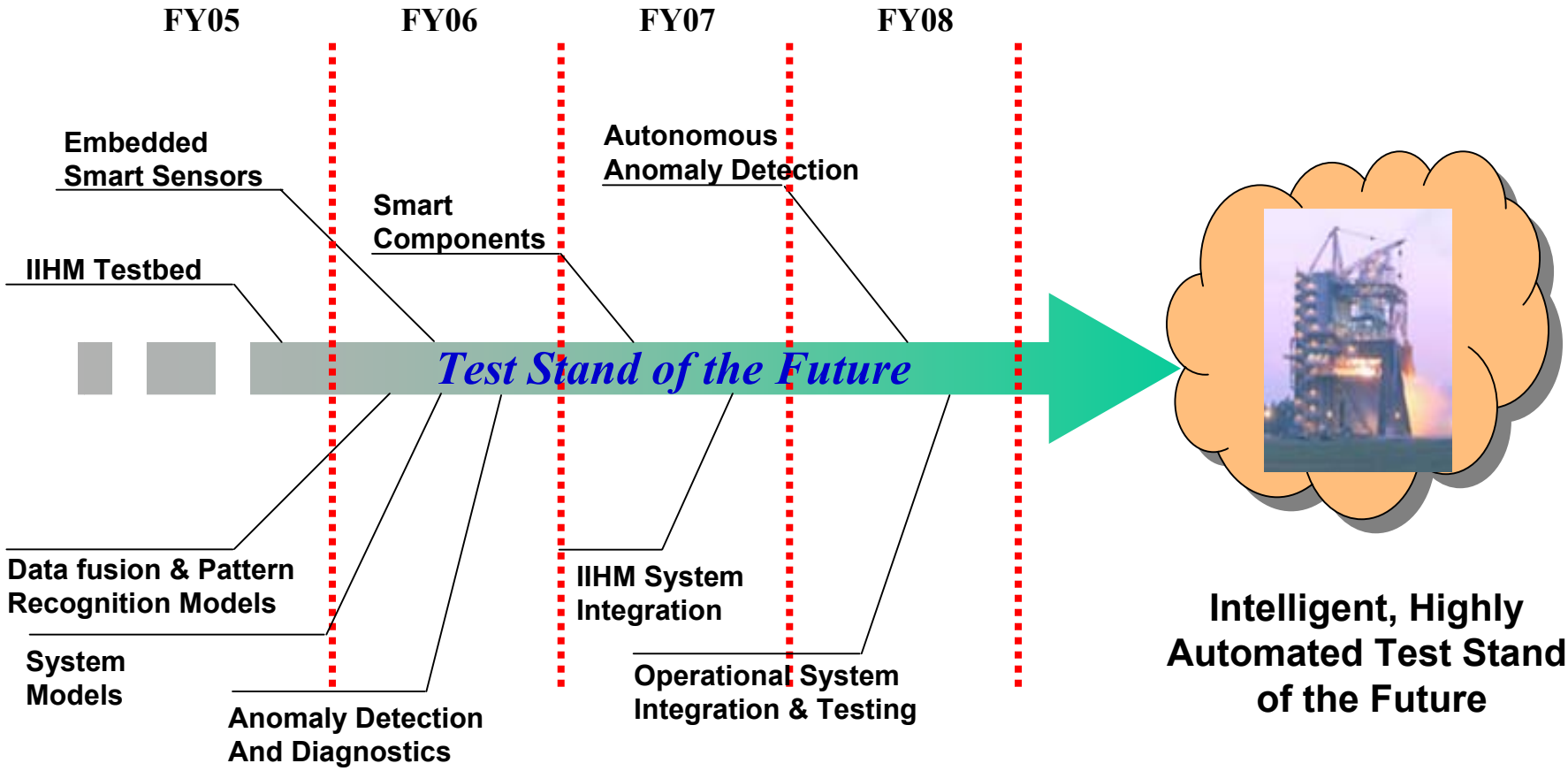
# Test Technology Initiatives at Stennis Space Center



- Sensors for Test Facilities/Articles
  - Wireless Vacuum Monitoring System: Temperature & Vacuum Sensing
  - Strain-Based Level Sensing (mass) for Run Tanks (Fiber Optic & Foil Strain Gages)
- Components and Mechanical Systems
  - UHP Gas/Liquid Mixer Controls System – Modeling and Validation
  - Flow Measurement Techniques: Cavitating Venturi Modeling and Validation
- Plume Effects Monitoring and Prediction
  - Plume Signature Measurement Capabilities
  - SSME Plume Diagnostics (1 to 2 SSME tests per month)
  - Unified Test Stand Design & Environmental Impact Model
- High Performance Data Acquisition and Control System (DACS)
  - Ultra-Wideband Wireless DACS – new SBIR Phase II
  - Intelligent System Health Monitoring - SOMD IR&D, ESMD ESR&T Projects

# Future Test Stand Technology Roadmap






IIHM = Intelligent Integrated Health Management

[Note: Chart developed by Dr. Fernando Figueroa, NASA SSC, and ISHM Team]

# SSC Technology Development Activity

*Stennis Space Center*

- FY2001:
  - –Cavitating Venturi (collaborative project with Purdue University)
  - –Flow Induced Vibrations
  - –Acoustic Data Collection
  - –SSME Plume Diagnostics
- FY2002:
  - –Wireless Sensor Suite Development; deployment of Wireless Temperature Sensors
  - –Integrated Health Management
  - –Fiber optic Sensors
  - –Plume Effects & Monitoring/Plume Environments
    - •Continued SSME Plume Diagnostics support
- FY2003:
  - –Advanced Sensors
    - •Continued Wireless Sensor Suite Development (deployment for Vacuum-Sensing applications)
  - –Advanced Components/Mechanical Systems
  - –Plume Effects & Monitoring, including SSME Plume Diagnostic continuation

# Collaborative Multi-Center Test Technology Activities

*Stennis Space Center*

- FY2002:
  - –MSFC: $150K (for purchase & Development of 2 Alpha Systems)
  - –JSC/WSTF: $50K (for HazMat Protective Suit Development)
- FY2003:
  - –Collaboration between NASA SSC and NASA KSC initiated in mid-CY2002
    - Each Center researched technology needs with emphasis on areas of common requirement & unique capabilities
    - Developed a list of the top five (5) potential projects
      - –High Pressure/High Shock LOX Mass/Level Sensor - Selected
      - –Microsphere Thermal Insulation Systems - Selected
      - –Rocket-Induced Vibroacoustic Response
      - –Liquid Oxygen Temperature Probe
      - –Signal Conditioning Amplifier Recorder
    - $200K transferred from NASA SSC to NASA KSC
      - –Project Plans formally developed
      - –Formal Protocol established for project review, control, and reporting

# Propulsion Technology Development & Investment Team (PTDIT)

*Stennis Space Center*

- Background:
  - In 09/02, RPTMB stated a need for a "team to survey propulsion technologies and identify those of direct value" in order "to collaborate and integrate technology by leveraging expertise and resources….."
  - PTDIT formed & charter approved – 10/02
    - Members: SSC, MSFC, JSC/WSTF, GRC/PBS
    - Associate Members: KSC, GRC
- Tasks
  - Evaluate & compile current inventory of technical capabilities (RPTMB centers)
  - Compile a list of technical challenges with developing propulsion technologies
  - Compare technologies with technical needs within RPTMB, and then with the propulsion community as a whole
  - Primary product: prioritized propulsion technologies for the RPTMB to consider for development, advancement, and application

# Dual Use Program Development of Test Technology



- Goal: to develop a technology to meet a need at NASA as well as developing a commercially viable product.

- Mechanism: Cooperative Agreement Notice
  - Requires concurrence by the Mission Area, before signing
  - NASA and the Participating Partner contribute matching resources
  - Partner contributions may be cash, non-cash, or both
  - CAN released annually, or as needed

- Example: Improved Linear Actuator by BAFCO
    - Designed for operation in gas/liquid/cryogenic systems
    - Increased accuracy, precision, and operating speeds
    - Application in the aerospace or petro-chemical industries
    - NASA SSC purchased 30 actuators at a savings of more than $250,000
      - Cost per unit reduced almost 50%
      - Delivery time reduced from 14 wks to between 4-6 weeks

# Dual Use Projects FY1999 to Date

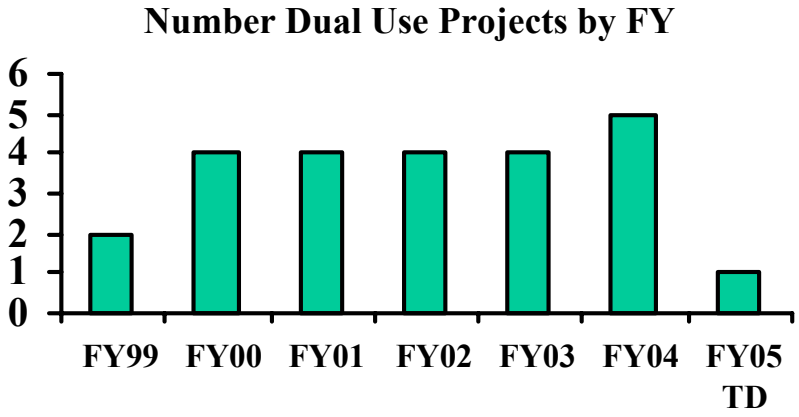


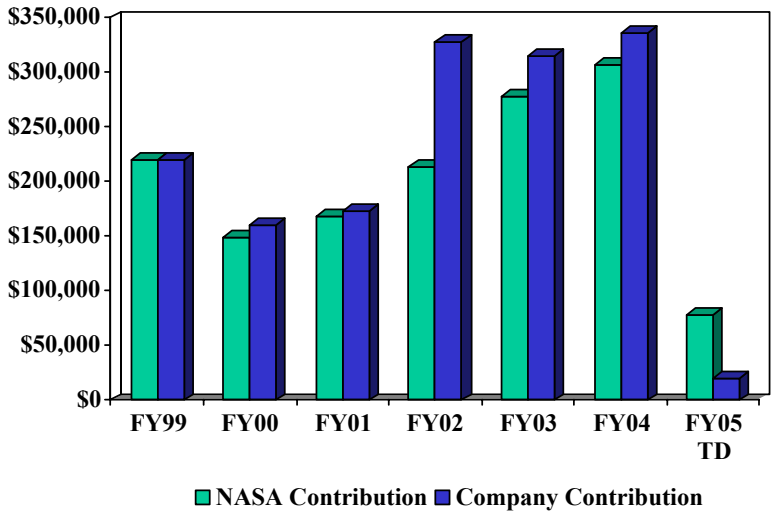
## Total projects to date (FY99-FY05): 24

**NASA Funding:** **$1.414 M**

**Industry Contribution:** **$1.559 M**

**Dual Use Projects value:** **$2.973 M**



# Dual Use Technology Development Projects - Successes

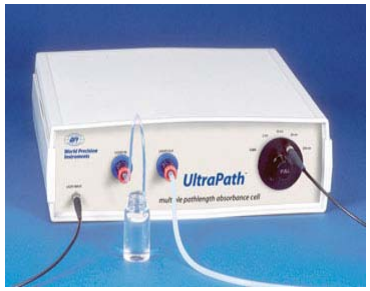
*Stennis Space Center*

## BAFCO Cooperative Agreement

BAFCO Dual Use project produced a new family of Actuators. SSC has purchased 30 at a cost savings of $250K (per unit reduction of almost 50%), with production times reduced from 14 weeks to between 4 - 6 weeks

## ISC/Omni Cooperative Agreement

ISC Dual Use project produced Direct-to-Disk High Speed Data Recording: System implemented for SSME High Speed Data in the SSC SSME Test Area, reducing data errors, providing data extraction 8 times faster than the tape system.




## WPI Cooperative Agreement

WPI Dual Use project produced an innovative instrument to accurately measure Colored Dissolved Organic Matter (CDOM) that provides NASA with a new research tool which is now used by ESA scientists and is commercially available.

# Center Director's Discretionary Fund (CDDF)

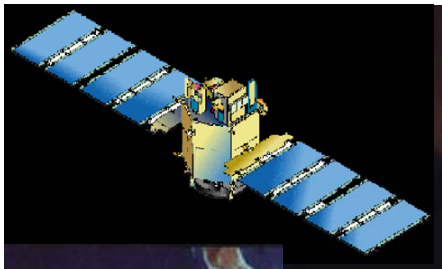


- Traditionally employed to fund "….high risk, high-potential research and development activities that further the goals of the SSC vision statement, which , in turn further support those of NASA…"
- "…used exclusively in support of innovative ideas in research and technology…"
- Must support an established SSC line of business
- Usually rather small projects, $3OK to $75K, single year
- Dramatically impacted with the advent of full cost accounting
  - Ability to produce results with such a small amount of funding in this new environment
  - Funding source is Center G & A; Program zeroed in FY2004, some funding was made available in FY2005; Program not to be funded in FY2006.

# Summary



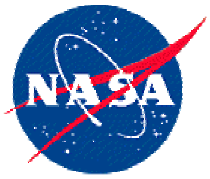
- Substantial efforts have been underway to collaborate and appropriately leverage resources within NASA
  - Multi-center, Multi-Organization Partnerships, with Mutual Benefit
  - Spans across government, commercial industry, and academia
- Stage is set for expanded collaboration with DoD, DOE, Other Government Organizations at all levels, Commercial Industry, as well as Academia
- Test Technology collaboration benefits and lessons learned have high payoff in improvements to safety, efficiency, and effectiveness
- Some advantages of collaboration in technology development are:
  - Technologies are developed that benefit each Organization
  - Costs are minimized for each Organization
  - Combining resources and requirements maximizes the results





**Stennis…The Nation's "partner of choice" for propulsion test. A globally recognized leader in Earth Science Applications. A national leader in education and technology development and transfer.**

**Stennis…A national model for teamwork**







# Propulsion Test Technology:

## *Collaboration is Not a New Concept*

# BACK-UP CHARTS

# Collaborative Technology Development

*Stennis Space Center*

Technologies can also be developed through a collaborative effect with other Centers and Agencies to meet the NASA technology need at SSC. The advantages of this type of agreement are:

- Technologies are developed that benefit each Center or Agency
- Costs are minimized for each Center or Agency
- Combining resources and requirements maximize the results of the technology development effort
- There is more efficient utilization of the resources of "One NASA."

MARSHALL SPACE FLIGHT CENTER
HUNTSVILLE, AL

Johnson Space Center
houston, texas

KENNEDY SPACE CENTER
LAUNCHING A VISION

# Steps to Collaborative Development Projects



Steps for establishing a Collaborative Agreement:

1. Identify the technologies and technology development effort that are of mutual interest and benefit to both SSC and another Center or Agency
2. Determine what similar technology development efforts are in progress at each Center or Agency
3. Determine where the technology can be developed in the most efficient manner, in terms of cost and time
4. Negotiate the cost and schedule for development of the technology at the most efficient facility

MARSHALL SPACE FLIGHT CENTER
HUNTSVILLE, AL

Johnson Space Center
houston, texas

KENNEDY SPACE CENTER
LAUNCHING A VISION