

Office of
Aeronautics and
Space
Technology

NASP TECHNOLOGY TRANSFER

Presentation to

ITP Workshop

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81208-36N

NATIONAL AERO-SPACE PLANE (NASP)

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GOAL: To develop and then demonstrate the technologies for single-stage-to-orbit flight and hypersonic cruise with airbreathing primary propulsion and horizontal takeoff and landing

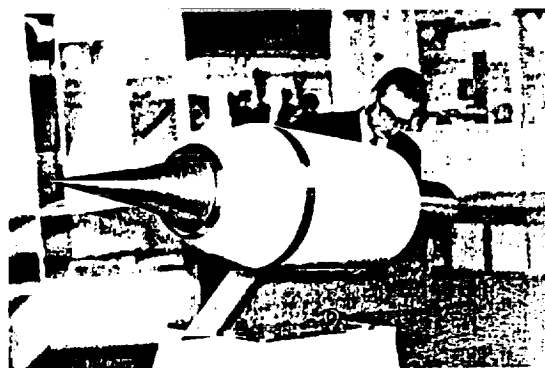
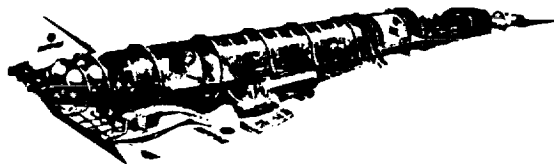
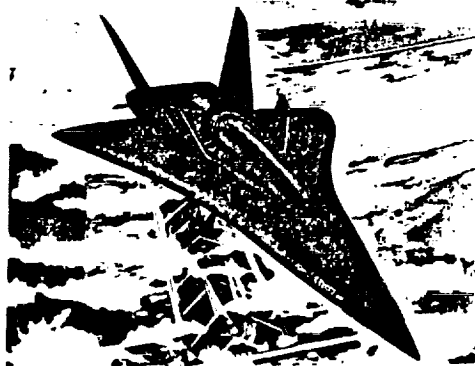
VALUE:

- technology for flexible, efficient access to space
- technology for hypersonic cruise
- advancement of U.S. aerospace-technology base

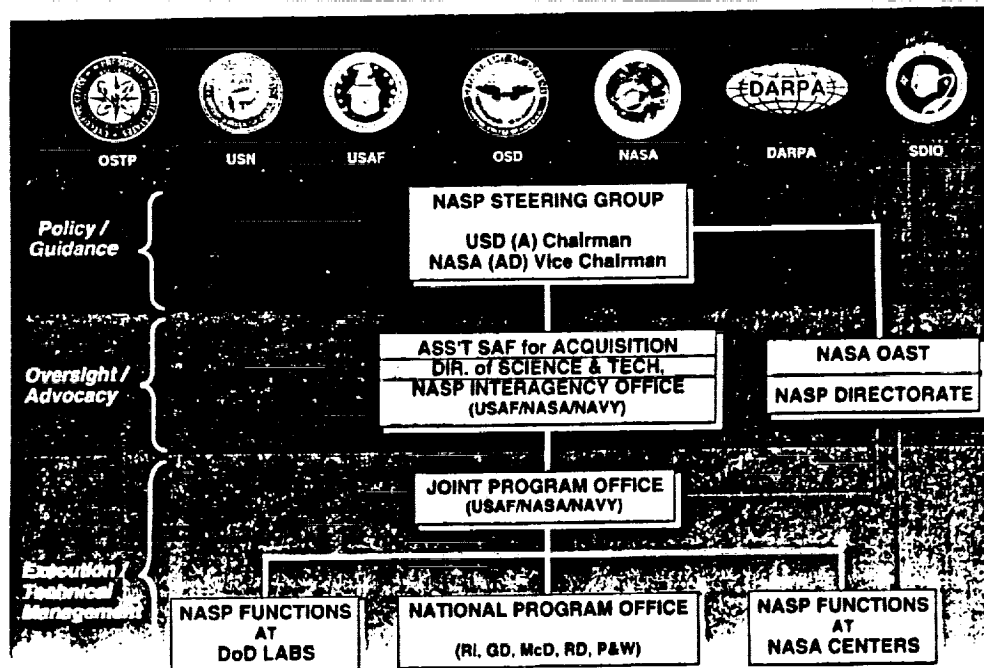


INTERNATIONAL AEROSPACE-PLANE TECHNOLOGY

- Several countries are pursuing aerospace-plane technologies: the German vehicle concept is named Sanger (right); the Japanese are working toward concepts for single-stage-to-orbit (below); the Russian civil aerospace-plane project has flight-tested a subscale scramjet to Mach 5.5 (below right).
- International competitors have already used government / industry teams to gain large segments of the aerospace market (i.e., Airbus and ESA -Ariane).

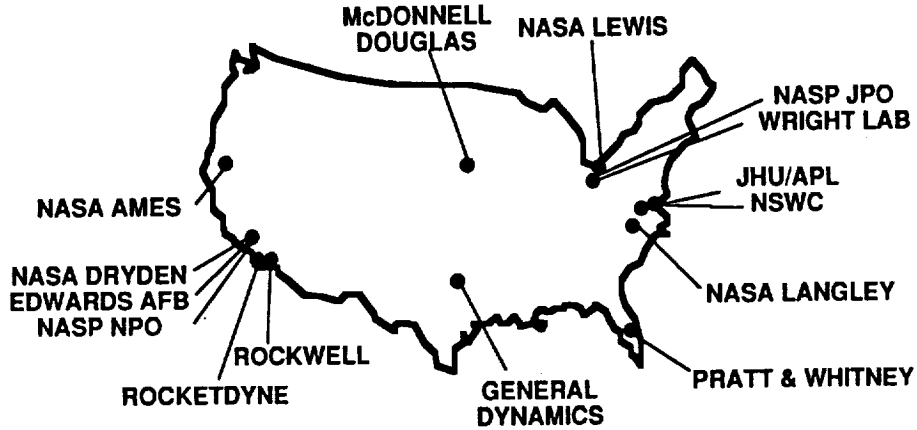


NASP PROGRAM MANAGEMENT ORGANIZATION

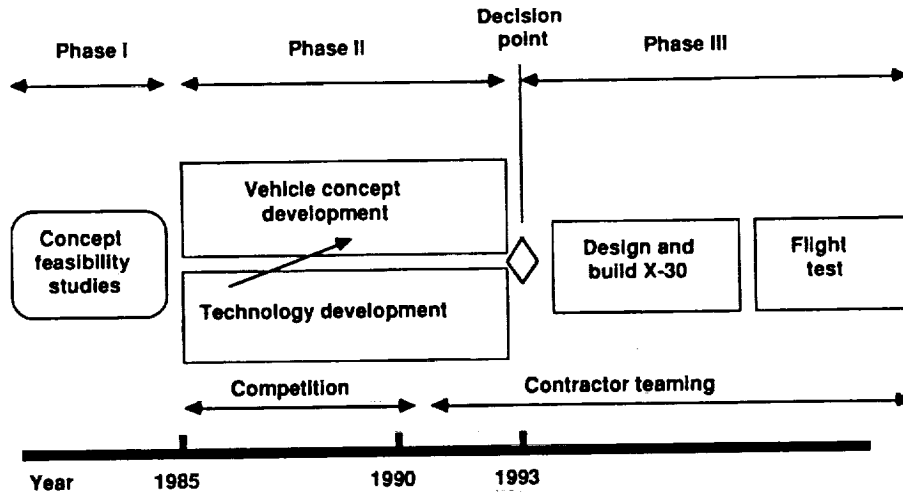


NASP NATIONAL TEAM

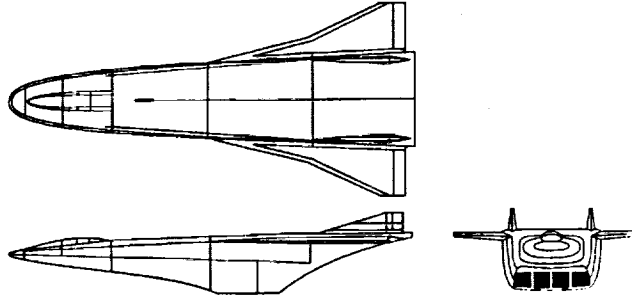
- The NASP prime contractors formed a single team for NASP in 1990. The airframe team members are General Dynamics, McDonnell Douglas, and North American Rockwell. The engine team members are Pratt & Whitney and Rocketdyne. Their joint site, the NASP National Program Office, is located in Palmdale, California. They have 460 subcontractors in 40 states.
- The government laboratories are key members of the industry/government national team. They have 114 subcontractors in 24 states. The key participants include the Air Force Wright Laboratory, NASA Research Centers (Ames, Langley, and Lewis), the Naval Surface Weapons Center, and Johns Hopkins University/Applied Physics Laboratory.



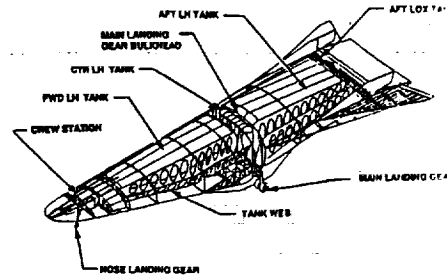
NASP SCHEDULE



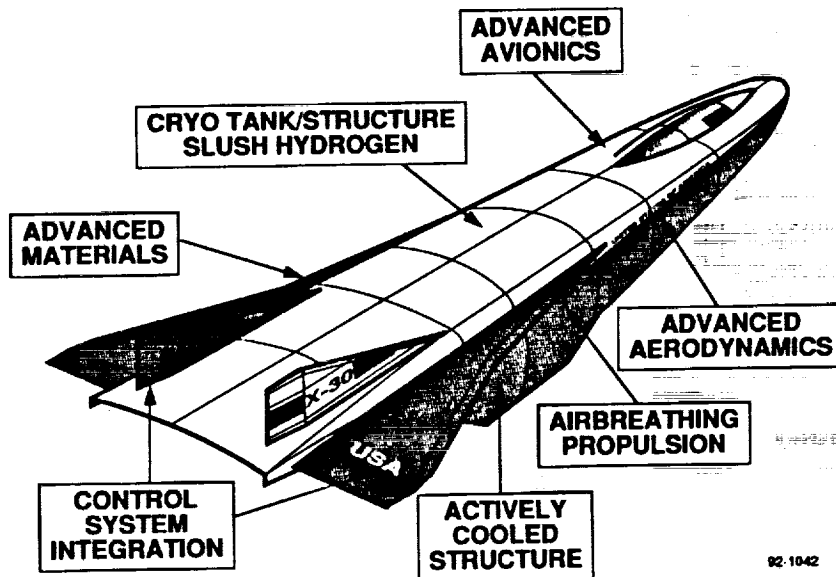
NASP VEHICLE CONCEPT (X-30)



- Payload: instrumentation
- Lifting-body shape with delta wings
- Flattened nose: lower drag and smoother inflow to engine
- Propulsion: low-speed system / ramjet / scramjet / rocket
- Fuel: slush hydrogen
- Cryogenic fuel tank: graphite epoxy
- Fuselage shell: fiber-reinforced titanium
- Thermal protection: carbon-carbon panels, active cooling, and passive cooling (heat pipe)

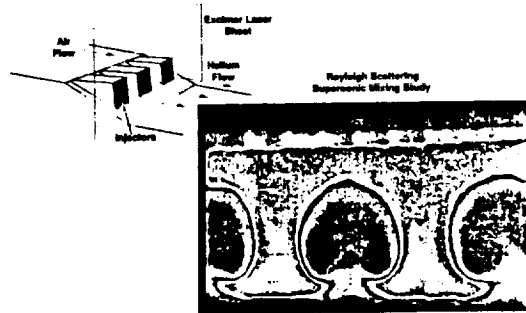
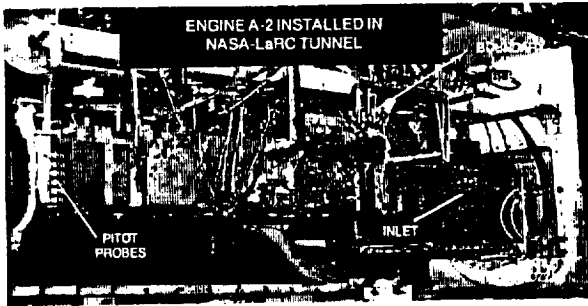


KEY AERO-SPACE PLANE TECHNOLOGIES



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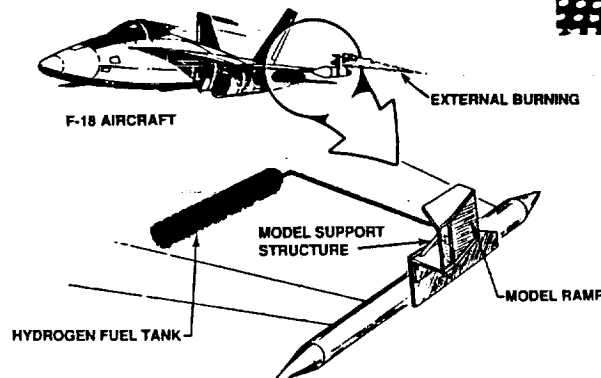
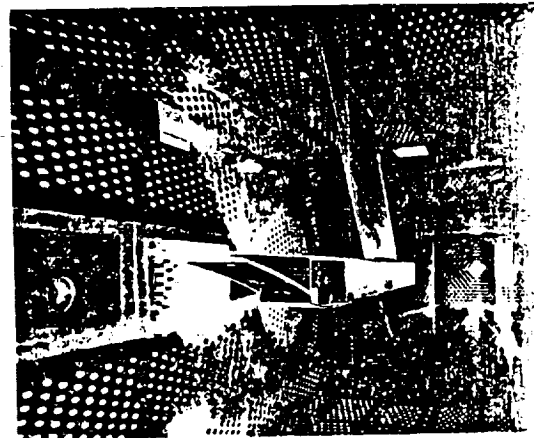
NASP PROPULSION TECHNOLOGY



- The NASP propulsion systems must perform efficiently between Mach 0 and 25.
- 1/4 to 1/6-scale model scramjets (above left) have been tested in conditions simulating flight as fast as Mach 8.
- The NASP data base includes ground-test results on components, such as fuel injectors (above right), for flight conditions up to Mach 17.

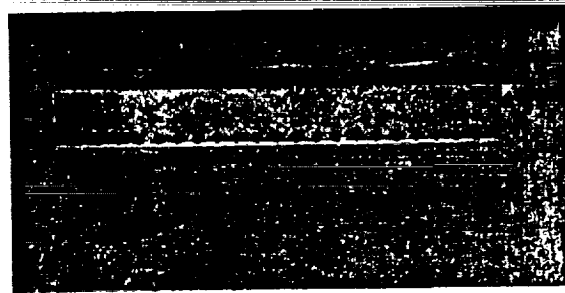
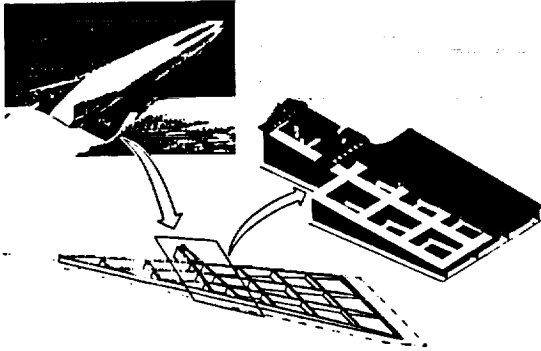
NASP PROPULSION TECHNOLOGY - NOZZLES

- The rear undersurface of the X-30 acts as a nozzle - the pressure of the exhaust provides thrust.
- Wind-tunnel tests (right) explored X-30 performance and allowed validation of computer codes.
- Flight tests with an F-18 aircraft (below) complemented wind-tunnel data on external burning - a way to reduce nozzle drag at transonic speeds.



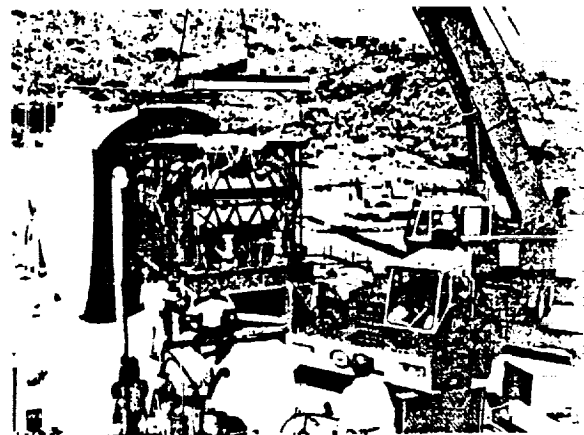
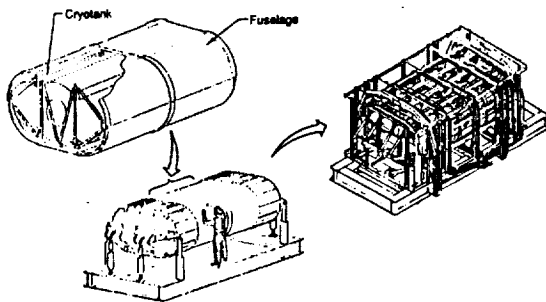
NASP STRUCTURES AND MATERIALS

- Movable panels in extremely hot regions of the engines require edge seals (right). Tests with red-hot fixtures verified sealing properties of "rope" and ceramic wafer seals (below right).
- Structural tests of a simulated wing segment (below) revealed a need to improve computer modeling of some titanium metal-matrix structures.

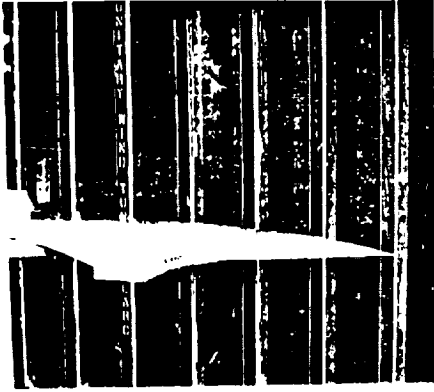


NASP STRUCTURES AND MATERIALS

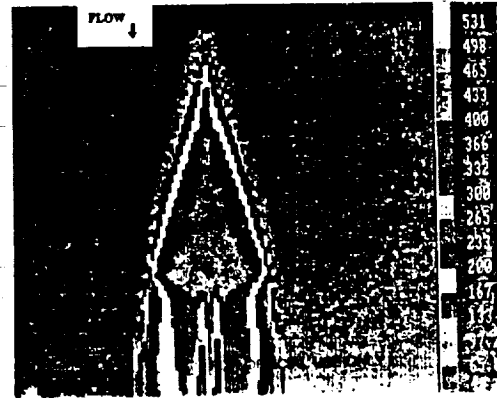
- A 900-gallon graphite-epoxy fuel tank installed in a simulated fuselage shell of titanium metal-matrix composite was tested at Wyle Labs in Norco, California.
- On February 7, 1992, it was filled with liquid hydrogen (at -423°F). The assembly then successfully endured bending and heating (1300°F) loads on the shell that simulated Mach 16, NASP conditions.



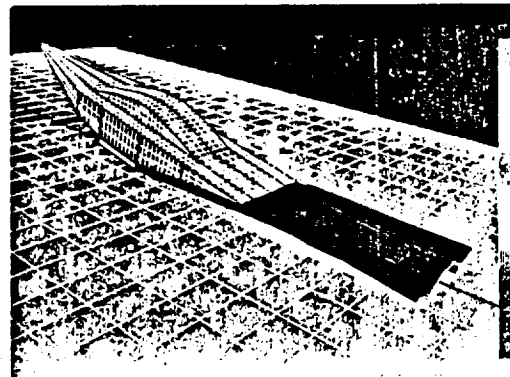
NASP AEROTHERMODYNAMICS



- Much initial aerothermal testing was done with the Test-Techniques Demonstrator (TTD) model, shown here.
- The pictures show models for supersonic tests (above) and subsonic, "free-flight" tests with thrusting engine simulators (above right).
- A digitized, "false-color" image of aerothermal heating on the TTD nose is shown for Mach 10 flow (right).



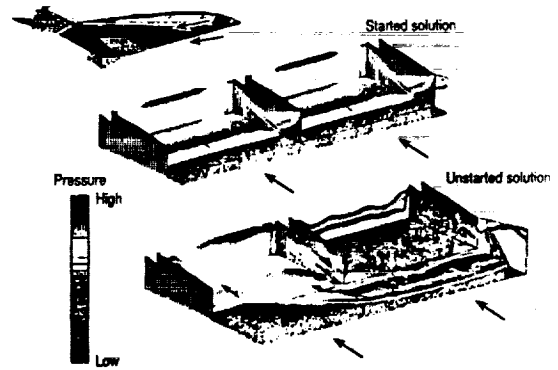
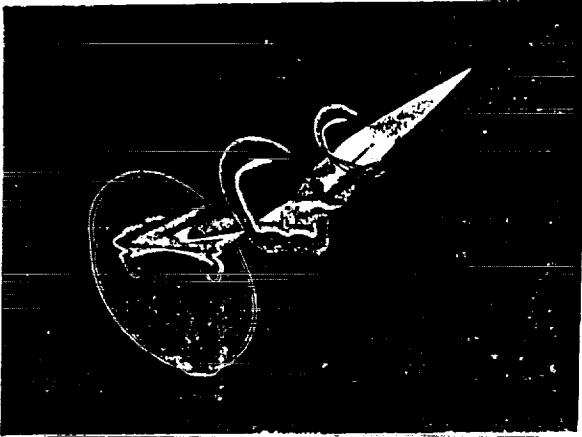
NASP AEROPROPULSION INTEGRATION



- The propulsion system and the aerodynamic systems interact in different ways in different parts of the flight profile.
- Results for a powered TTD-type model in wind-tunnel tests were verified by computer calculations. They show strong interactions between exterior aerodynamics and propulsion on takeoff.

NASP COMPUTATIONAL FLUID DYNAMICS (CFD)

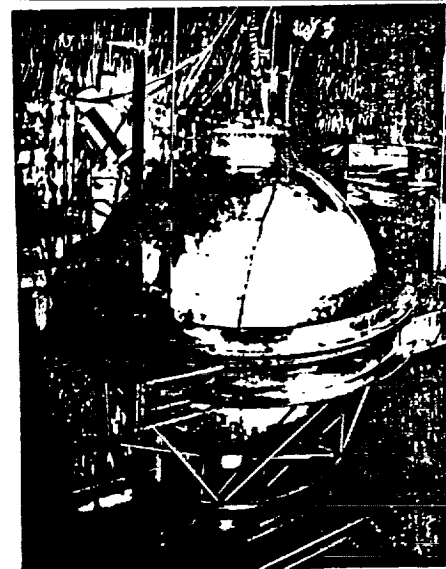
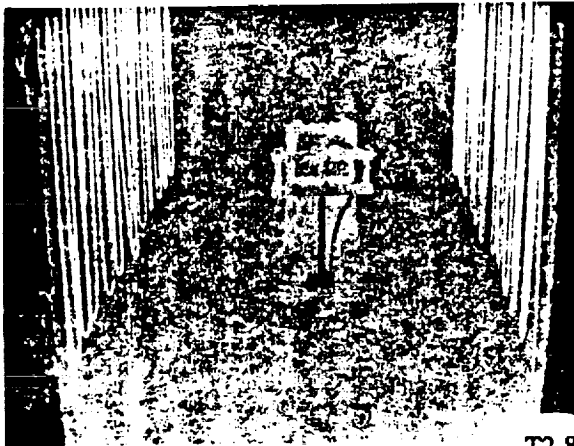
- Powerful supercomputers allow the exploration of propulsion phenomena such as an engine unstart, something like a backfire, at Mach 10 (right).



- CFD calculations for the TTD at Mach 10 predict nozzle performance and exhaust effects on tail control surfaces (left).

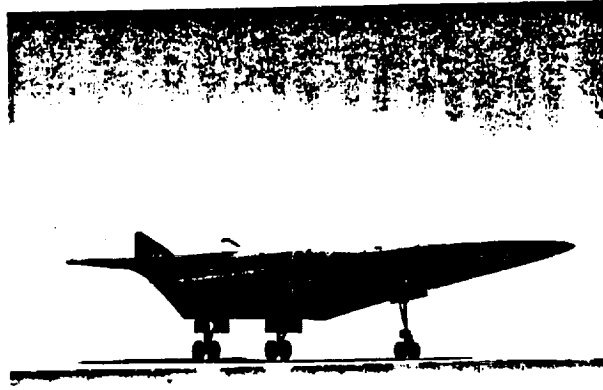
NASP SYSTEMS RESEARCH AND DEVELOPMENT

- Slush hydrogen, a mixture of frozen and liquid hydrogen, has greater density and heat-sink capability than liquid hydrogen. Scaled-up systems have demonstrated production of over 50,000 gallons of slush. A 5-foot diameter tank (right) provided crucial data on slush handling and transfer.
- NASP instrumentation must give good information at extreme conditions. The test, pictured below, shows strain-gages measuring loads at 1775 degrees Fahrenheit.



NATIONAL AERO-SPACE PLANE

- NASP is developing the technologies to satisfy important U.S. civil and military needs
- NASP is making significant technical progress
- NASP remains a technically challenging program
- NASP needs full FY93 funding to ensure continued progress



Only after flight validation can the technologies be applied to the next generation of aerospace vehicles with confidence and safety

NASP TECHNOLOGY TRANSFER MECHANISMS

- NASP JOINT PROGRAM OFFICE:
 - JPO CONTRACTOR SUPPORT (SAIC)
 - USAF RESERVISTS TEAM
 - SDIO TECHNOLOGY APPLICATIONS INFORMATION SYSTEM
- NASA - STANDARD T.U. CONTACTS - "TECH BRIEFS," ETS.
- JOINT ACTIVITIES: FOCUSED WORKSHOPS
(EX: MATERIALS AND INSTRUMENTATION TECHNOLOGY WORKSHOP AT LANGLEY ON MARCH 24 AND 25, 1992)
- NASP CONTRACTORS AND SUBCONTRACTORS

NASP TECHNOLOGY TRANSFER CONTACTS

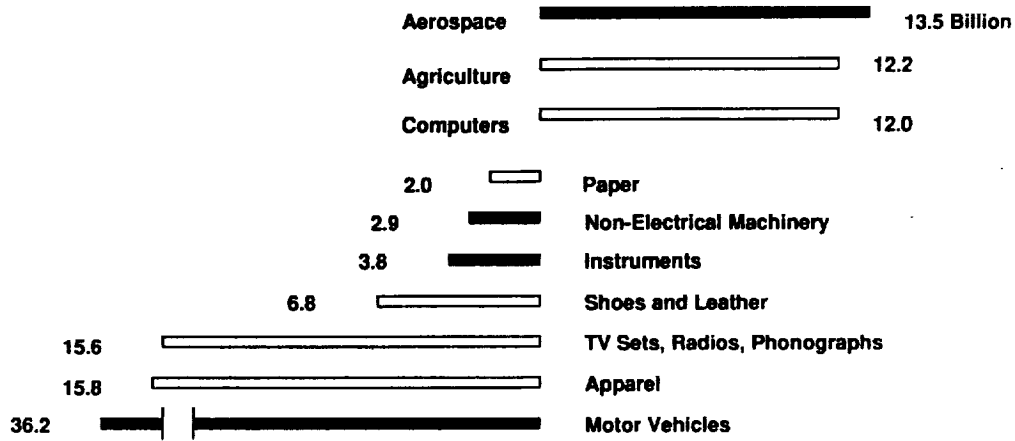
- **NASP JOINT PROGRAM OFFICE:**
 - **APPLICATIONS DIRECTORATE (COL. MATTHEWS, BILL POWELL,.....)**
 - **SPECIAL ASSISTANT FOR TECH. TRANS. (DICK CULPEPPER)**
- **NASA, CODE C- TECHNOLOGY UTILIZATION OFFICE (RAY GILBERT)**
- **NASA, CODE RN - NASP DIRECTORATE (CHARLES MORRIS)**

NASP TECHNOLOGY TRANSFER CHALLENGES

- **IDENTIFICATION OF TECHNOLOGY APPLICATIONS (RE.: "CONNECTIONS" BY BURKE)**
- **PROGRAM PROTECTION - SOME OF NASP PROGRAM IS CLASSIFIED AND SOME IS PROTECTED BY ITAR**
- **CONTRACTOR RETICENCE TO IDENTIFY APPLICATION BEFORE "CONTROL" OF MARKET**
- **TRANSFER TO U.S. VERSUS OTHERS: PATENTS, SDIO SYSTEM, ETC.**
- **PRESSURE ON TECHNICAL COMMUNITY MEMBERS TO "PUBLISH OR PERISH" .-> UNCONTROLLED DISSEMINATION**
- **FOREIGN COUNTRIES HAVE ORGANIZATIONS TO ENHANCE TECHNOLOGY TRANSFER FROM U.S.**



1991 U.S. Balance of Trade Estimates*



● Potential Impact of NASP Technology is Significant (■)

* Source: Univ. of Md INFORUM Model



Computational Fluid Dynamics (CFD)



NASP Impact on CFD

- New Algorithms for Faster Computations
- Better Modeling of Physics
 - Turbulence
 - Combustion
- Validation of Codes Via Comparison with Experiments

Technology Description

- High Speed Computing Tool
 - Predicts Aerodynamics of Aircraft, Missiles, Auto
 - Models Internal Flows of Aircraft, Auto Engines

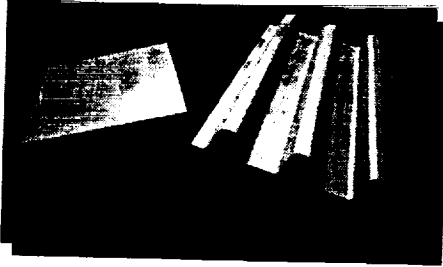
Applications of NASP CFD Technology

- More than 50 Users Include:
 - MD-11 CFD Analysis by Douglas Aircraft (Long Beach, CA)
 - High Speed Civil Transport CFD Analysis by Boeing (Seattle, WA)
 - Standard Design Tool for Inlet/Exhaust Systems at GE Aircraft Engines (Evendale, OH)

UNCLASSIFIED



Metal Matrix Composites



Technology Description

- Advanced Metal Matrices
- High Strength Fibers
- Lay-up Providing Tailored Strength Properties

NASP Impact

- Compatible Fibers and Matrices
- XD™ Process
 - Clean, Well Bonded Interfaces
 - Tensile Strength Increase of 50%
- Fabricability Demonstrated

Applications of NASP Technology

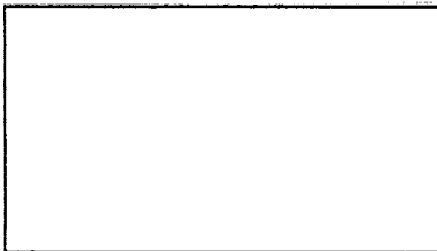
- Texas Instruments (MA)
 - Copper Niobium Rings
 - Circuit Board Components
- Howmet Corp. (Greenwich, CT)
 - XD-Process Ti Al Missile Fins
- Martin Marietta Corp (Bethesda, MD)
 - XD-Ti Impeller

UNCLASSIFIED

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Advanced Titanium Alloys



Technology Description

- High Strength, Light Weight Materials
- High Temperature Capability

Primary Materials for NASP Hot Structure Air Frame

NASP Impact

- Alloys with 100x Improvement in Corrosion Resistance
- Higher Temperature Capable Alloys [1500°F to 1800°F]
- Fabricability Comparable to Current Alloys

Applications of NASP Technology

- Timet (Henderson, NV)
 - Matrix Material for Fiber Reinforced Composites
 - Sour Gas Well Piping
 - Orthopedic Implants
- Boeing (Seattle, WA)
 - 777 Tail Cone

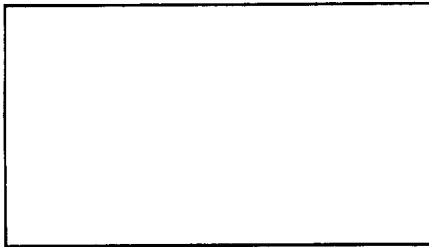
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Beryllium Alloys



Technology Description

- Lightweight Material with High Elastic Modulus
- Material with Good Thermal Conductivity

NASP Impact

- Fabrication Methods that Raise Temperature Capability
- Rapid Solidification Rotary Atomization Powder Process
- Manufacturing Sciences Corp (Oak Ridge, TN)
 - Product Line in Place:
 - Mirror for Space-Based Solar Power
 - Tubing for High-Energy Physics
 - Foil for X-Ray Windows

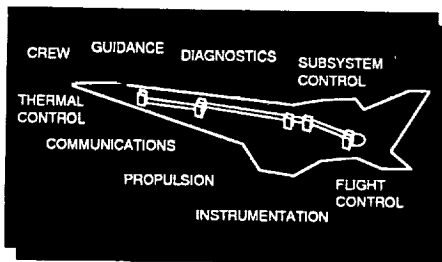
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Neural Network for Fault Monitoring/Diagnosis



Technology Description

- "Neuron-like" Computer Chips
- Interconnections of Chips Analogous to Operation of Human Brain
- Trainable Computer System

NASP Impact

- Novel Design and Hardware Implementation
- Use of Neural Network for Fault Monitoring Function
 - NASP Thermal Management System

Application of NASP Technology

- NASP Neural Network Concept Adapted for System Diagnosis of Cray Supercomputer (Minneapolis, MN)
- NASP Small Business Phase II Award
 - Accurate Automation Corp (Chattanooga, TN)

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NASP TECHNOLOGY TRANSFER SUMMARY

- NASP IS PROACTIVE DESPITE CLASSIFICATION AND ITAR RESTRICTIONS ON SOME INFORMATION
- BOTH NASA AND DOD ARE INVOLVED
- THE EFFORT IS NEW AND STILL EVOLVING