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ACCELERATING INNOVATION

Turning
Goals
Into
Reality

huntsville 2000

Background Presentation
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NASA

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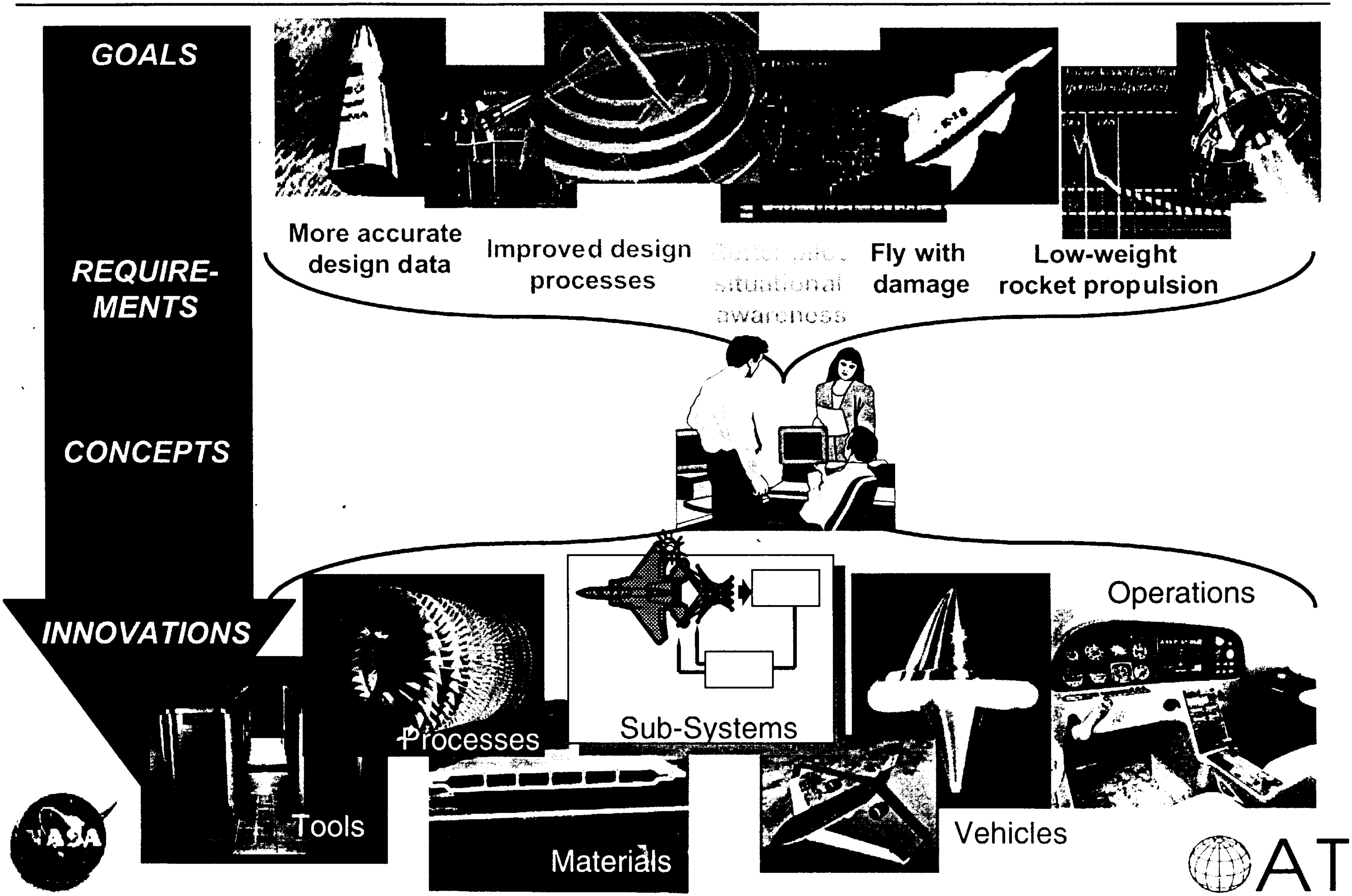
WHAT DRIVES EFFECTIVE INNOVATION?

- A Top-Down Model -



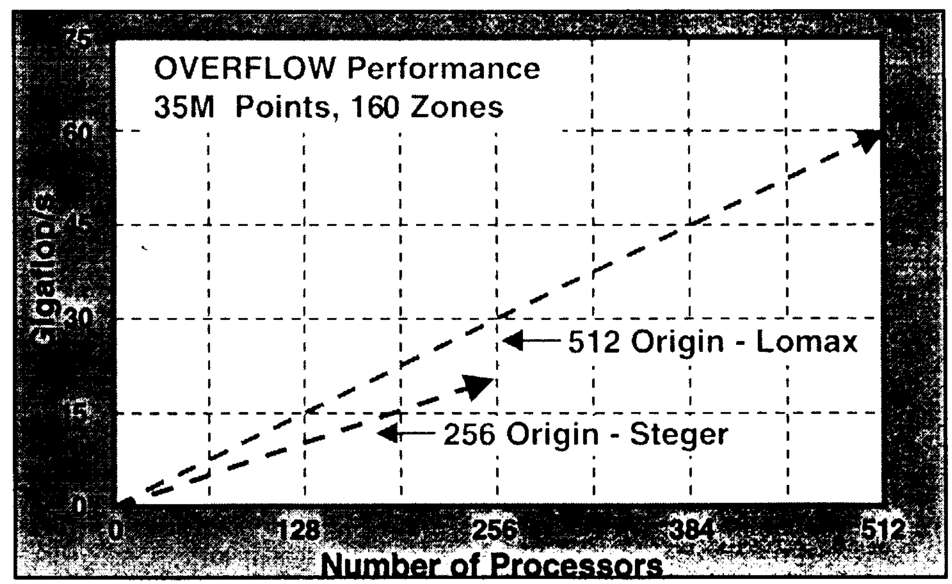
HIGH-PERFORMANCE COMPUTING

World's largest single system image supercomputer, delivers unprecedented performance

Innovation:

- World's largest single system image supercomputer installed:
  - 512-processor SGI 2800
  - Single system image allows easier software program development and system administration
  - Element of NASA/SGI.MOU on joint R&D in high-performance computing
- High-performance obtained on complex analysis codes within one week:
  - Over 50 Gigaflops obtained on complex CFD simulations
  - Less than 1% of code was altered

SGI 512 Origin



512 Origin is 13.0x faster @ 2.6x Cheaper than 16-C90

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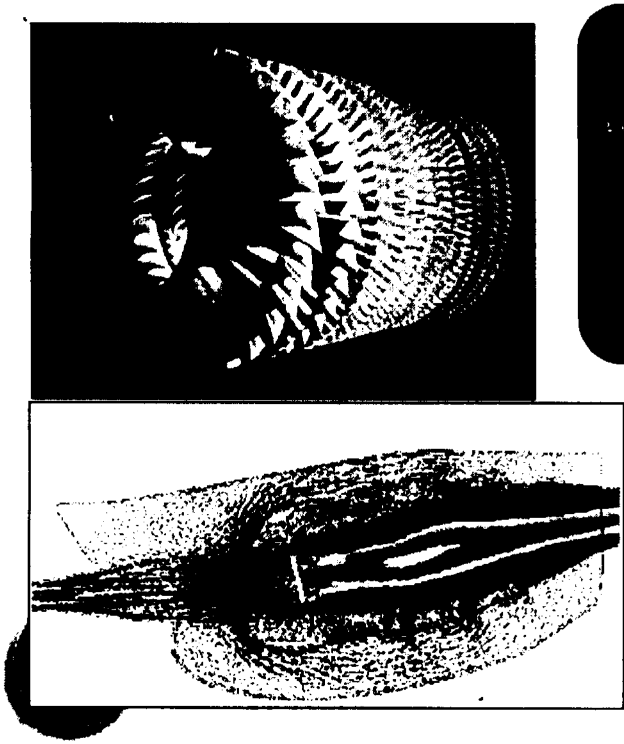
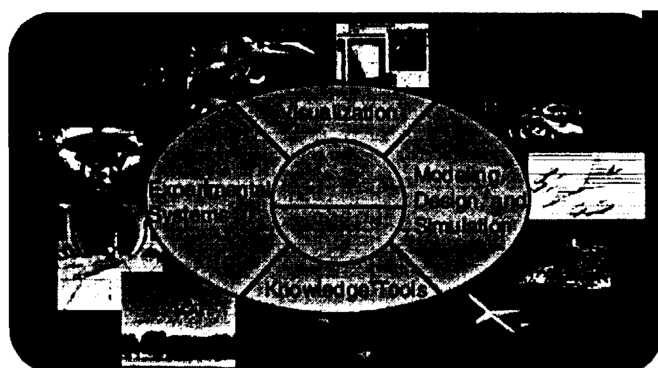
ADVANCED TECHNOLOGIES FOR AEROSPACE SYSTEM DESIGN

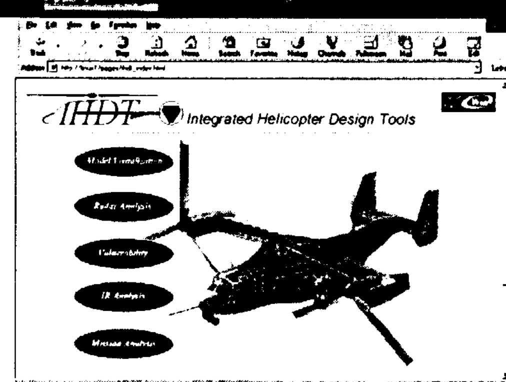
Advanced information and design technologies to enable new design paradigms

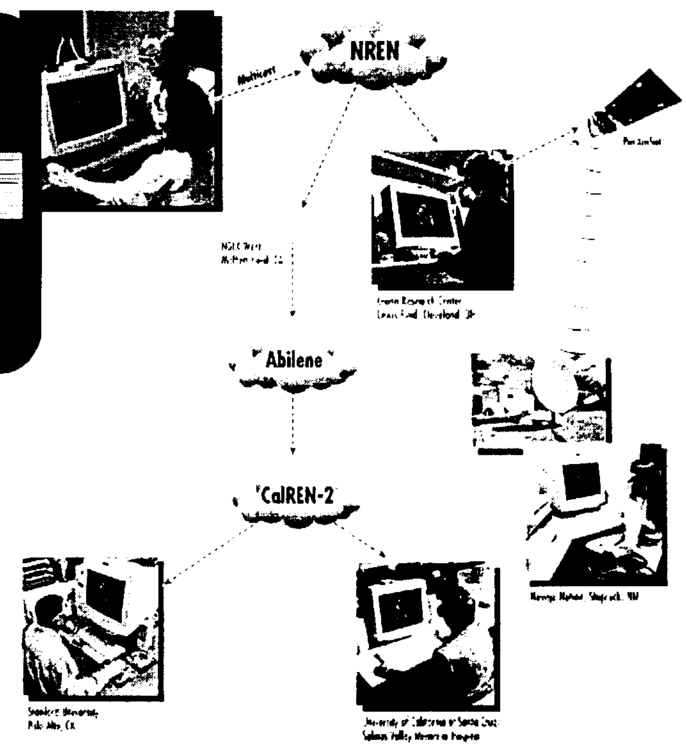
Innovation:

- Identify, develop, integrate, and test advanced information and design technologies for design:
  - Advanced analysis and design methodologies
  - Exploit high-performance computing and communications technologies to enable use of creation and sharing of high-quality data early in the design process
  - Extend web-inspired technologies to aerospace system design
  - Adapt "plug and play" technologies to variable fidelity, distributed design events
- 200X reduction in time to solution for propulsion systems
- 500X improvement in data -exchange rate
- Advanced integrated design systems for fixed-wing, rotorcraft, space transportation, and propulsion systems







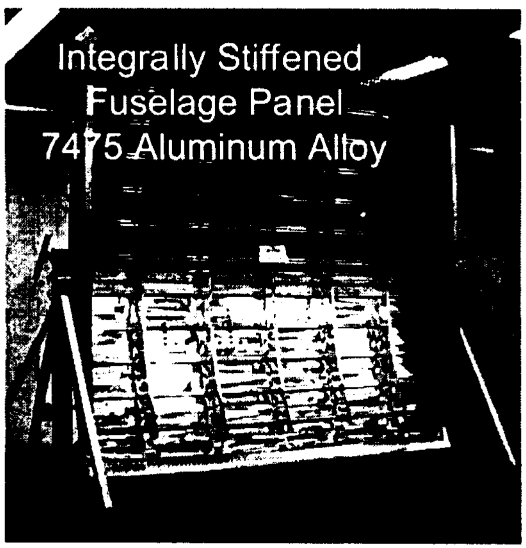


ADVANCED MATERIALS AND MANUFACTURING PROCESSES

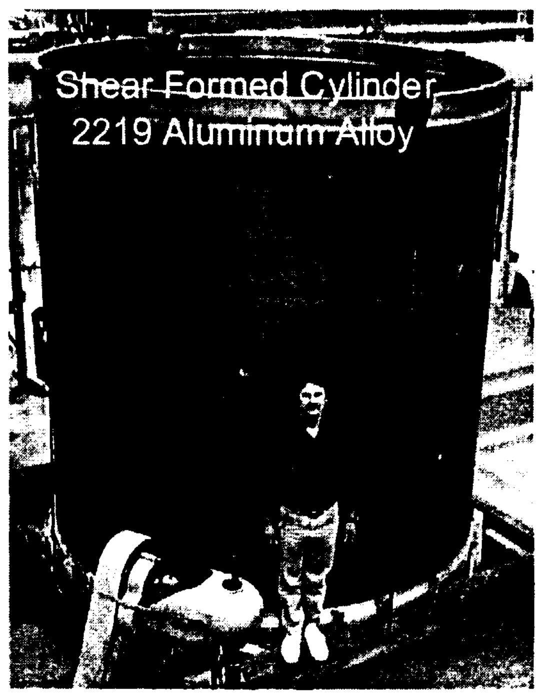
Replacing riveted metallic fuselage structure to reduce cost while maintaining structural performance

Innovations:

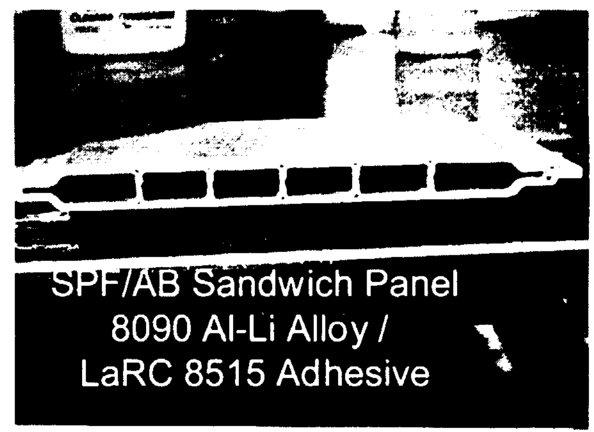
- Curved fuselage panel machined from 7475 aluminum to produce integral stiffeners and frame attachment pads.
  - Structural performance equivalent to riveted construction, produced at a cost savings of 61% and over 90% part count reduction compared to riveted built-up structure.
- 2219 aluminum cylinder is the largest single piece aluminum cylinder produced using shear forming.
  - The use of large shear formed cylinders with welded or bonded stiffeners has the potential to significantly reduce part count.
- The sandwich panel is the first produced by a concurrent four-sheet superplastic forming/adhesive bonding (SPF/AB) process employing 8090 aluminum-lithium and LaRC 8515 polyimide adhesive.
  - The SPF/AB sandwich panel demonstrated the potential for up to 30% weight savings compared with aluminum honeycomb core structure.



Integrally Stiffened Fuselage Panel 7475 Aluminum Alloy



Shear Formed Cylinder 2219 Aluminum Alloy



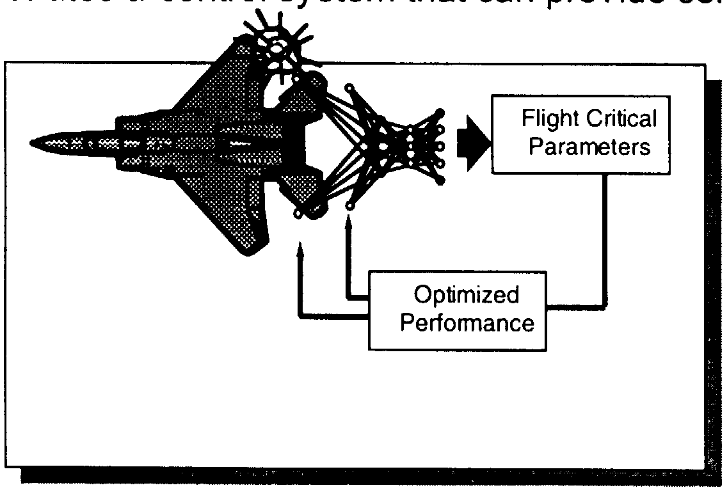
SPF/AB Sandwich Panel 8090 Al-Li Alloy / LaRC 8515 Adhesive

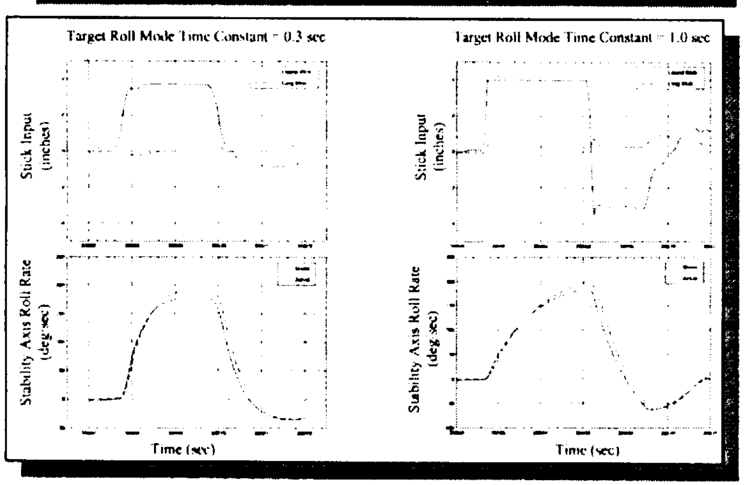
NEURAL-BASED FLIGHT CONTROL

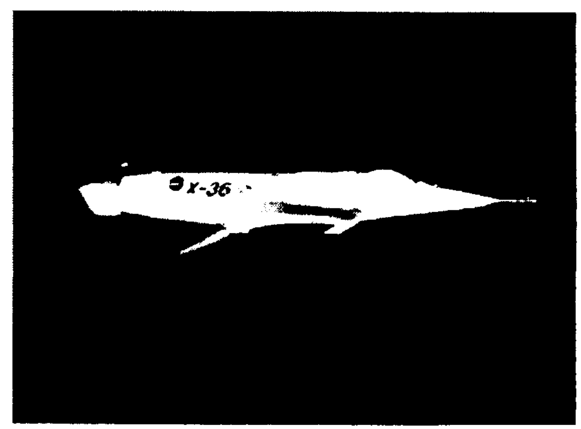
Demonstrate neural-based flight control technology for increased safety, performance, and reduced cost

Innovation:

- Neural-based adaptive flight controller demonstrated in flight on the F-15 ACTIVE aircraft and X-36.
  - Identifies aircraft stability and control characteristics using neural networks.
  - Adaptable to damage, failures or unforeseen flight conditions.
  - Reduces costs associated with flight control law development.
  - Demonstrates a control system that can provide selected handling qualities for any mission mode.







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LINEAR AEROSPIKE ENGINE

Revolutionary propulsion concept to improve access to space

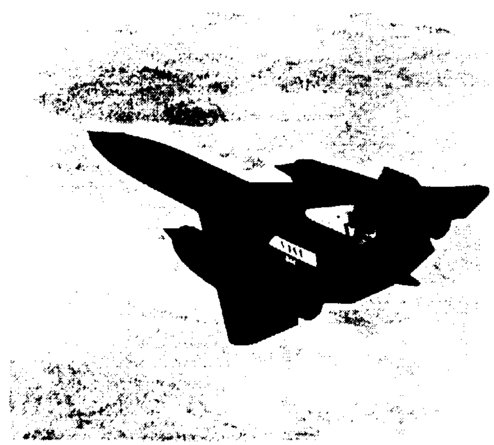
Innovation:

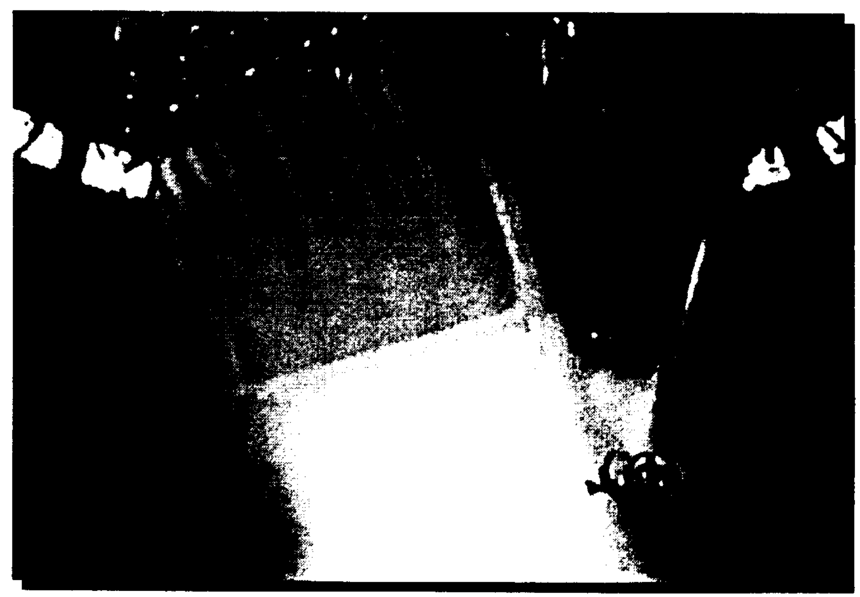
- Prepare revolutionary rocket propulsion technology for production space flight
  - Near optimal performance at all altitudes
  - Improved integration in advanced vehicle configurations (e.g., X-33)
  - Boeing-Rocketdyne partner

- Small-scale flight test completed

- Large-scale engines set under construction

- Large-scale engine test proceeding



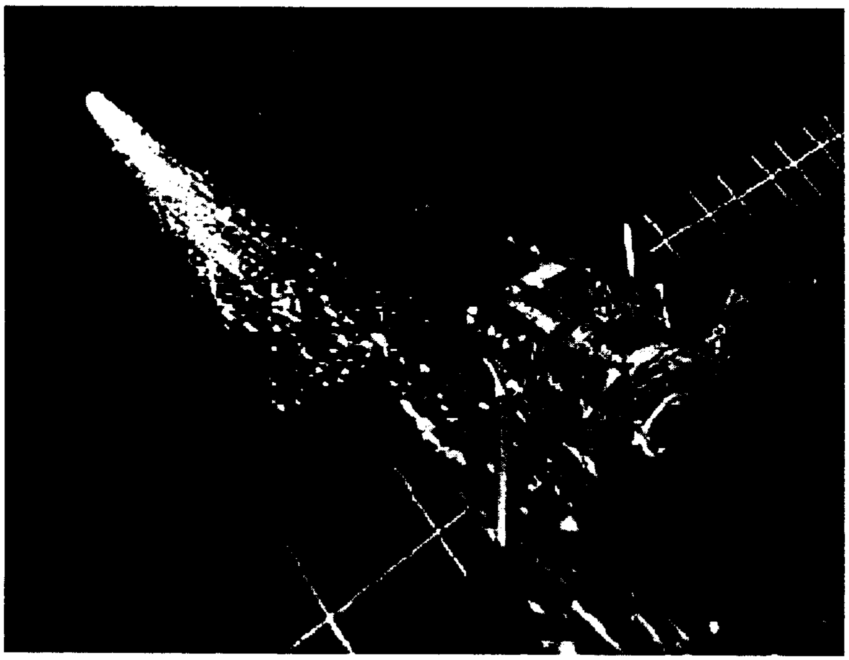


ADVANCED SPACE PROPULSION SYSTEMS

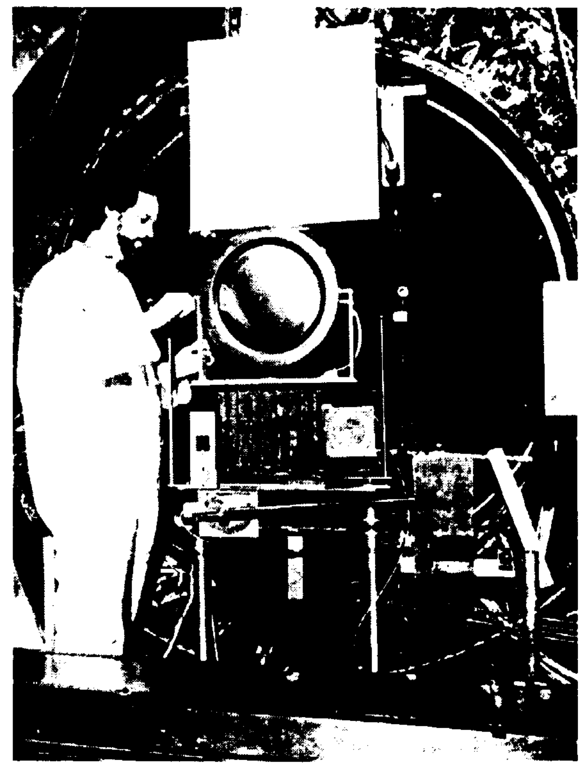
Ion-electric propulsion system powers Deep Space-1 mission - 200 million miles traveled

Innovation:

- First ever use of ion thruster technology as the primary propulsion system for a deep space mission:
  - 10X as efficient as a chemical propulsion system
  - Significant weight saving
  - Successfully propelled vehicle over 200 million miles
- NASA Glenn, NASA JPL, and Hughes Electron Dynamics R&D and manufacturing partnership
  - NASA Glenn: Development of engines and power processors
  - NASA JPL: Xenon feed system, diagnostics, and integration
  - Hughes: Design and manufacture



Deep Space-1 Spacecraft powered by NSTAR ion engine



NSTAR engine installed at JPL for 8,000-hr test

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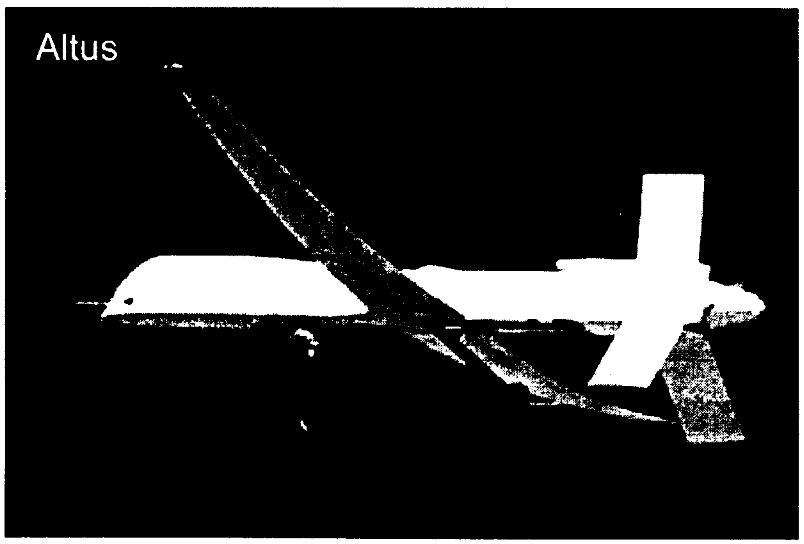
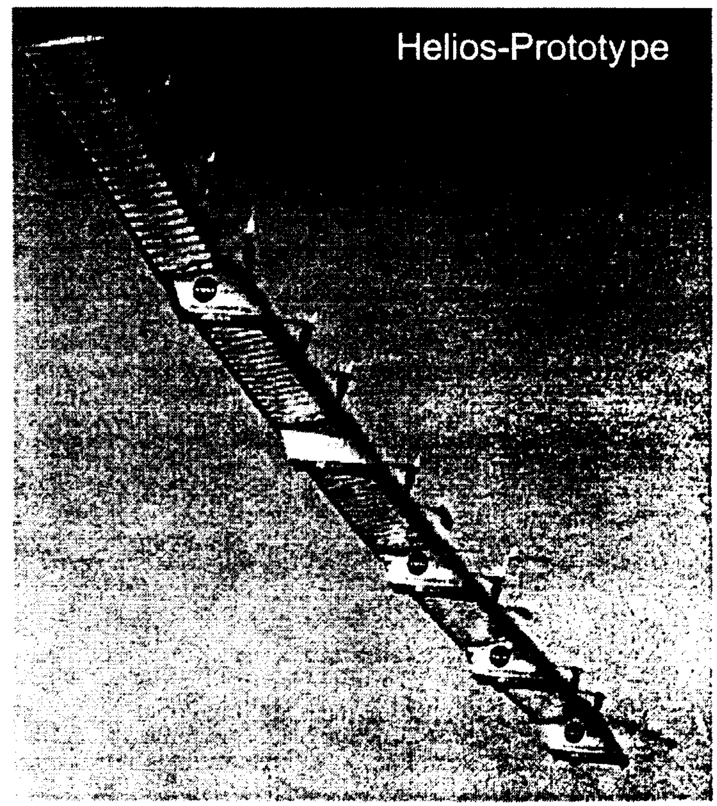
HIGH-ALTITUDE, LONG-DURATION AUTONOMOUS FLIGHT

Effective, flexible earth-observing platforms for the 21st Century

Innovation:

- Identify, develop, integrate, and test technologies to enable high-altitude, long-duration autonomous flight:
  - Improved high-altitude aerodynamics, strongly coupled aero-structures, and overall design methods
  - Innovative fuel, power, and propulsion systems
  - Innovative autonomous and over-the-horizon control
  - See & Avoid technologies
- Remotely-piloted vehicle (Altus) flown to 55,000 ft for 4-hours
- Battery-powered remotely-piloted vehicle (Helios-Prototype) enters flight test phase





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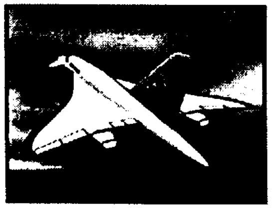
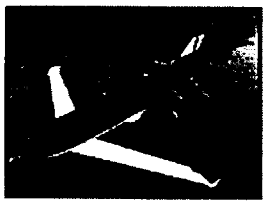
ADVANCED VEHICLE CONCEPTS

Innovative vehicle concepts with the potential to dramatically benefit National aerospace goals



Advanced Supersonic Vehicle Technology (ASVT): Lockheed Martin Skunkworks (Palmdale)

- Cooperative study to identify practical low-boom technologies that will allow overland supersonic flight of an 8-10 passenger, Mach ~1.6 business jet



Box Wing: Lockheed Martin Aeronautical Systems (Marietta)

- 2010 technology-level long range medium/high capacity transport study
  - Challenges: Aerodynamics, propulsion airframe integration, structures
- Large payload/reduced span improves system capacity by fitting plane into existing infrastructure
  - 20% smaller footprint allows 5 Box Wings to occupy gate space of 4 advanced conventionals
- Modest emissions and cost reductions/available seat mile
  - 3-6% compared to equivalent technology advanced conventional transport

Strut-Braced Wing: Lockheed Martin Aeronautical Systems (Marietta)

- 2010 technology-level long range, medium capacity transport study
  - Challenges: Strut design and integration, propulsion/airframe integration
- Significant emissions, weight & cost reductions due to a lighter wing, less drag, & reduced fuel burn
  - 6-12% compared to equivalent technology advanced conventional transport

Intermodal Transport: Boeing Douglas Prod. Div. (Long Beach)

- State-of-the-art technology-level medium capacity, medium range transport study
- Challenges: Pod/aircraft structural interface, low-noise tech for 24 hr/day utilization
- Quick-change pod allows increased utilization due to reduced turnaround time and further improves utilization with quick change between cargo and passengers accommodations
  - 20 hours/day utilization provides capacity benefits and >2X profitability

Low-Emissions Transport: Boeing Commercial Aircraft Group (Seattle)

- State-of-the-art technology-level low capacity, short range (high frequency) transport study
  - Challenges: slotted-wing aerodynamics, propulsion airframe integration
- Significant emissions & trip cost reductions due to a straight, slotted wing, advanced engines
  - 27% lower CO_2 for a high wing transport powered by an advanced ducted prop engine and 9% lower cost/trip (500 mile stage length)

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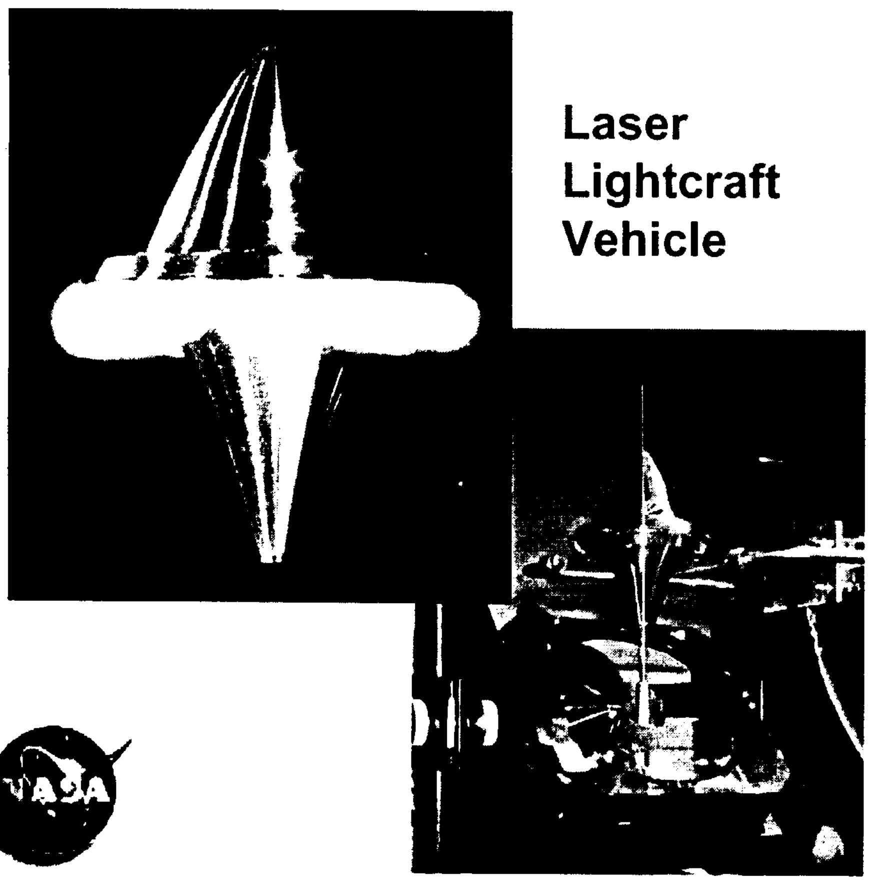
ADVANCED SPACE PROPULSION SYSTEMS

Laser Lightcraft vehicle launched to 125 feet

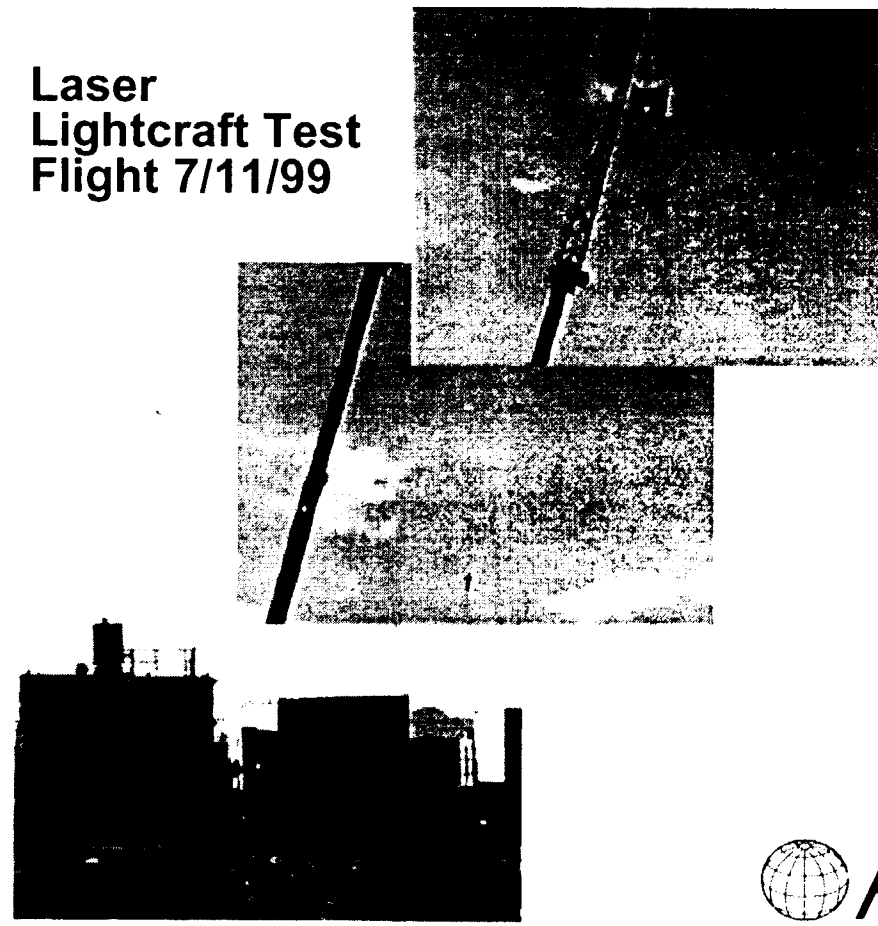
Innovation:

- Revolutionary propulsion system requires no on-board fuel:
  - Ground-based laser system heats air to a plasma, creating a short pulse of high thrust
  - Potential to launch a kilogram size payload into space for a few hundred dollars of electricity and the cost of a simple vehicle
- Joint Air Force/NASA R&D:
  - The Laser Lightcraft launched to 125 feet at White Sands using 10Kw laser
  - Seeking 100-150 Kw laser for further testing



Laser Lightcraft Vehicle

Laser Lightcraft Test Flight 7/11/99

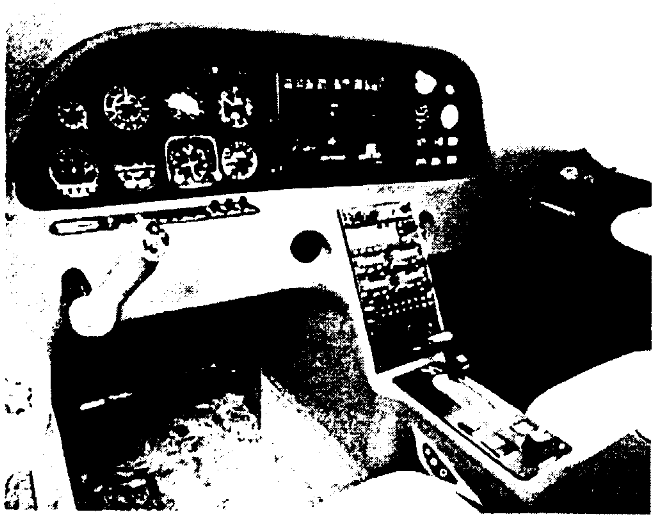


ADVANCED WEATHER INFORMATION

Bring advanced weather information to pilots to improve safety

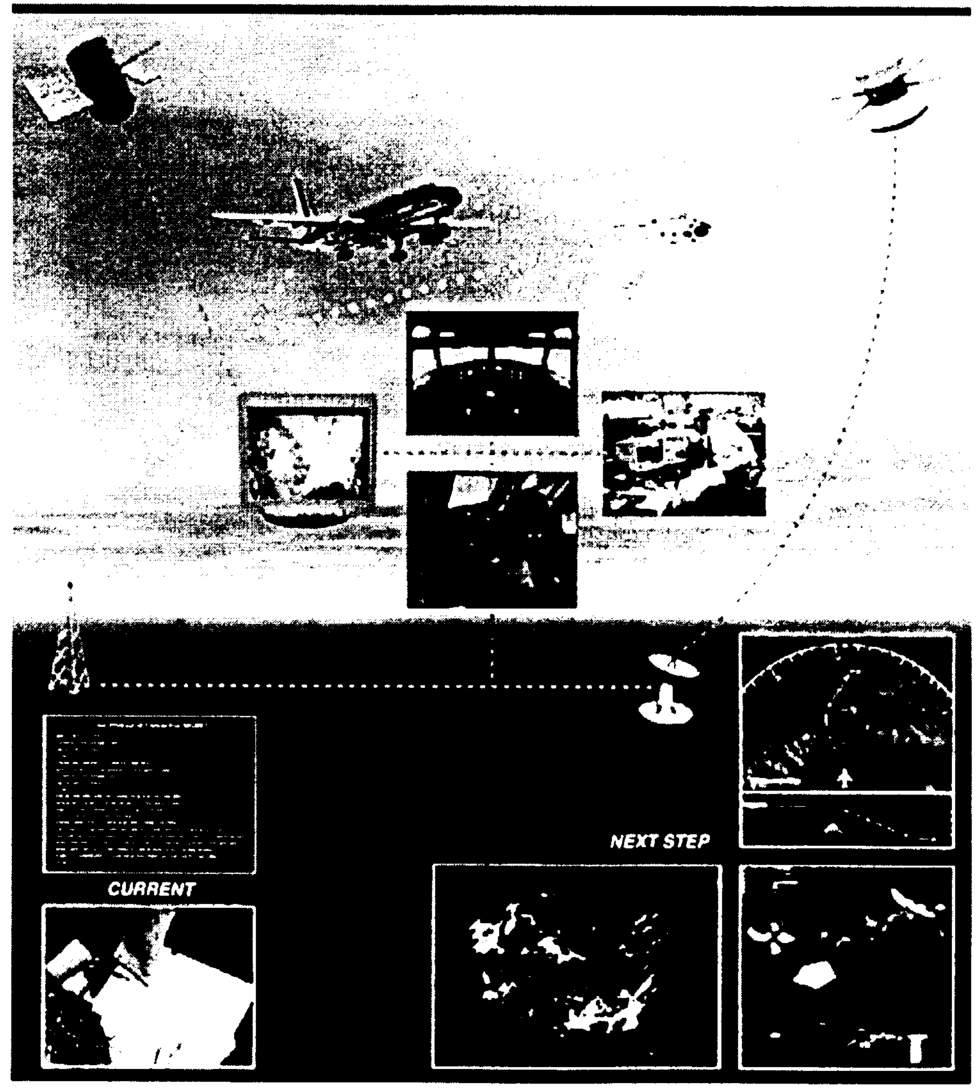
Innovation:

- Provide graphical weather information in the flight deck
  - Delivered to flight deck via ground-based and satcom broadcast, and cellular phone communications
  - Various packaged weather products, delivered including turbulence, weather radar, and convection detection
  - Demonstrated public/private partnership to accomplish common research goals



Multi-Function Display Installation

AVIATION "Weather Channel"



INNOVATION: STATUS AND OPPORTUNITIES FOR IMPROVEMENTS

Level of innovation appears to be at high-water mark:

Why?

- Aggressive and clearly stated goals
- Rapid deployment of new programs, flexibility in existing programs
- Engaging engineers in *what* is needed, not specifying *how* it is to be done
- Open sharing of ideas
  - NASA-Industry sharing of concepts & development of concepts in common
- Broadened approach to meeting goals
  - Addressing tools, processes, and operations more aggressively

Opportunities for improved innovation:

- Stronger NASA partnering
  - Federal agencies
  - Academia
  - Small companies
- Cross-goal, cross-technology synergy
  - Address technology "stove-piping"
- Aggressively exploit information revolution
  - NASA needs to be as near to the bleeding edge as its missions allow