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Suborbital Missions: The Joust

Mr. Bruce Ferguson
Executive Vice President
Orbital Sciences Corporation

JOUST Spaceborne Materials Processing Missions on the Prospector™ Suborbital Vehicle

Second Annual Symposium
on Industrial Involvement and Successes
in Commercial Space

Prepared By
Orbital Sciences Corporation

14 May 1991

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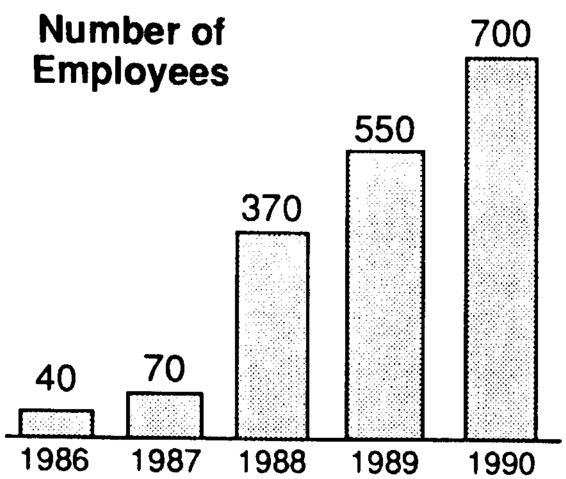
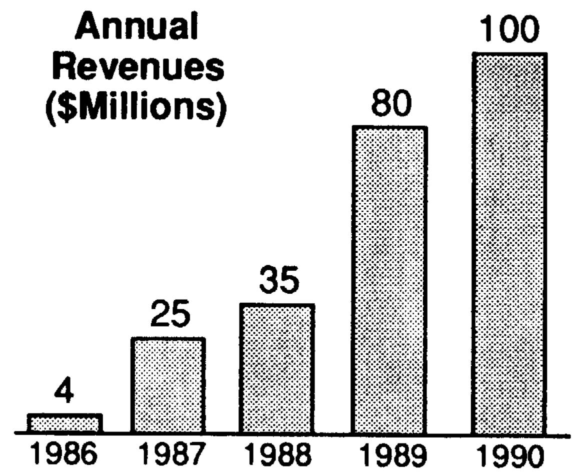
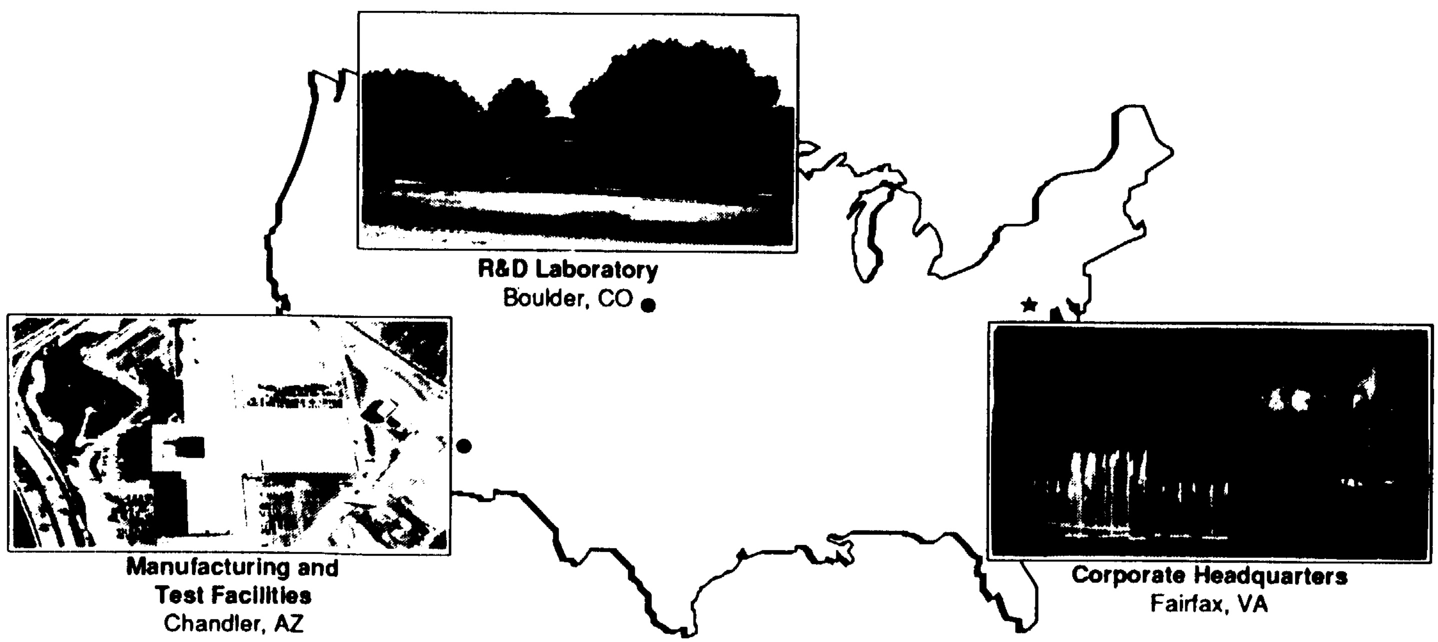
Orbital Sciences Corporation Overview

Orbital Sciences Corporation







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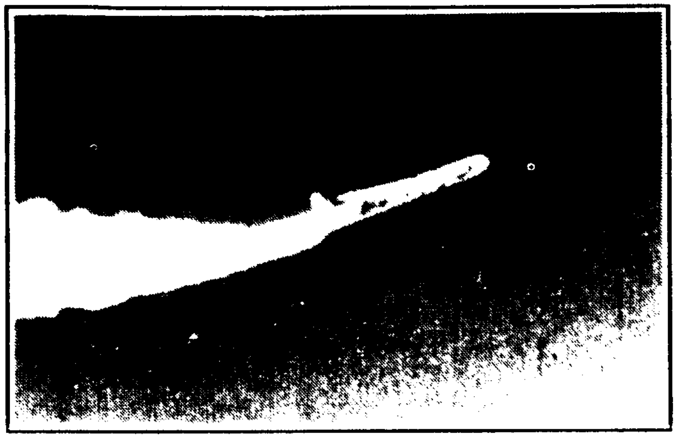
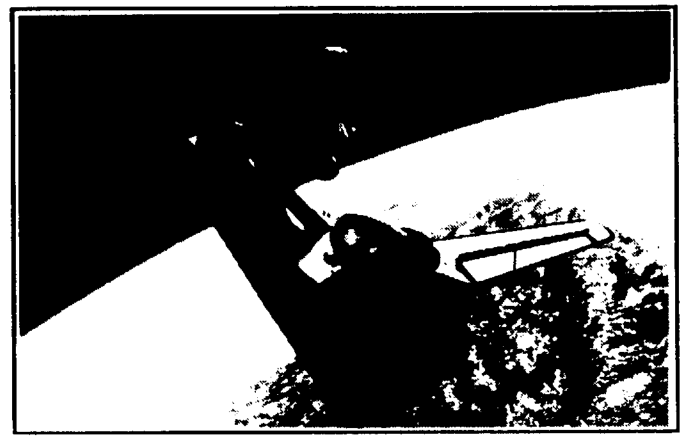
Orbital Is a Leader in Key Market Segments

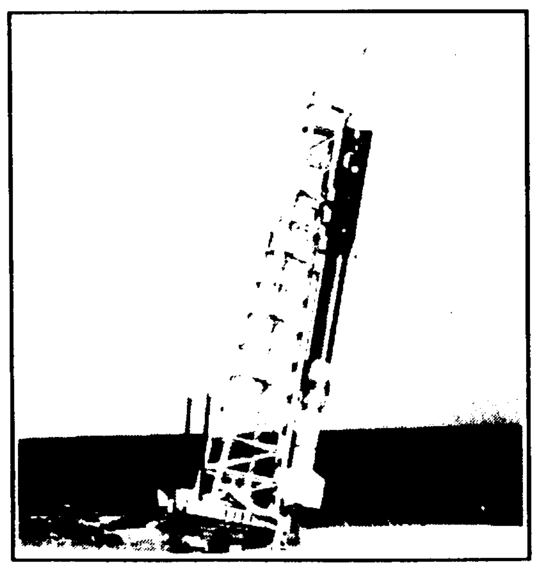
Orbital Sciences Corporation



Space Launch Vehicles



Orbit Transfer Vehicles



Suborbital Launch Vehicles

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And an Innovator of Breakthrough Space-Based Services

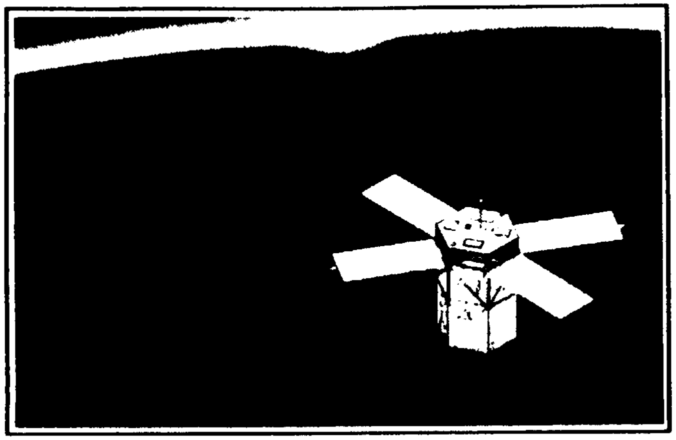
Orbital Sciences Corporation

ORBCOMM Mobile Communications Service

SeaStar™ Environmental Monitoring Service

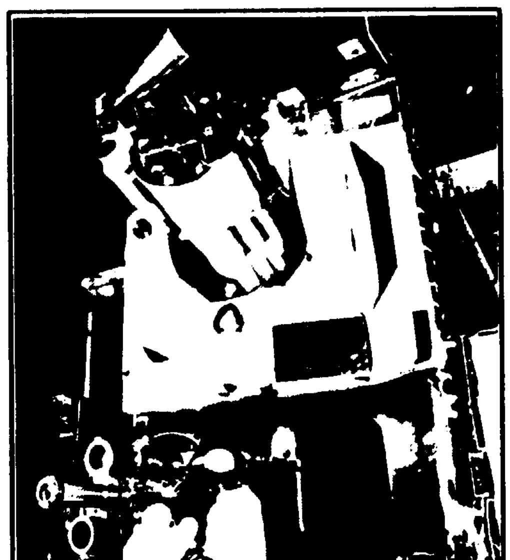
With Broad Capabilities in Other Product Areas

Orbital Sciences Corporation



Spacecraft Systems

Space Support Products



Space Payloads

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JOUST Mission Overview

History

- Series of Suborbital Launches Carrying Experiments by UAH CMDS, One of NASA's 16 Centers for the Commercial Development of Space
- All 16 CCDS are Funded by NASA's Office of Commercial Programs and by Private-Sector Partners
- Orbital Sciences Corporation Selected to Provide Rocket and Launch Services in 1989 with First Mission Within Two Years

Description

- Prospector Vehicle Part of Orbital's Starbird™ Family of Suborbital Vehicles Utilizing State-of-the-Art Technology
- First Mission Scheduled This Month with 10 Microgravity Experiments
- Rocket to be Launched From Launch Complex 20 at Cape Canaveral AFS

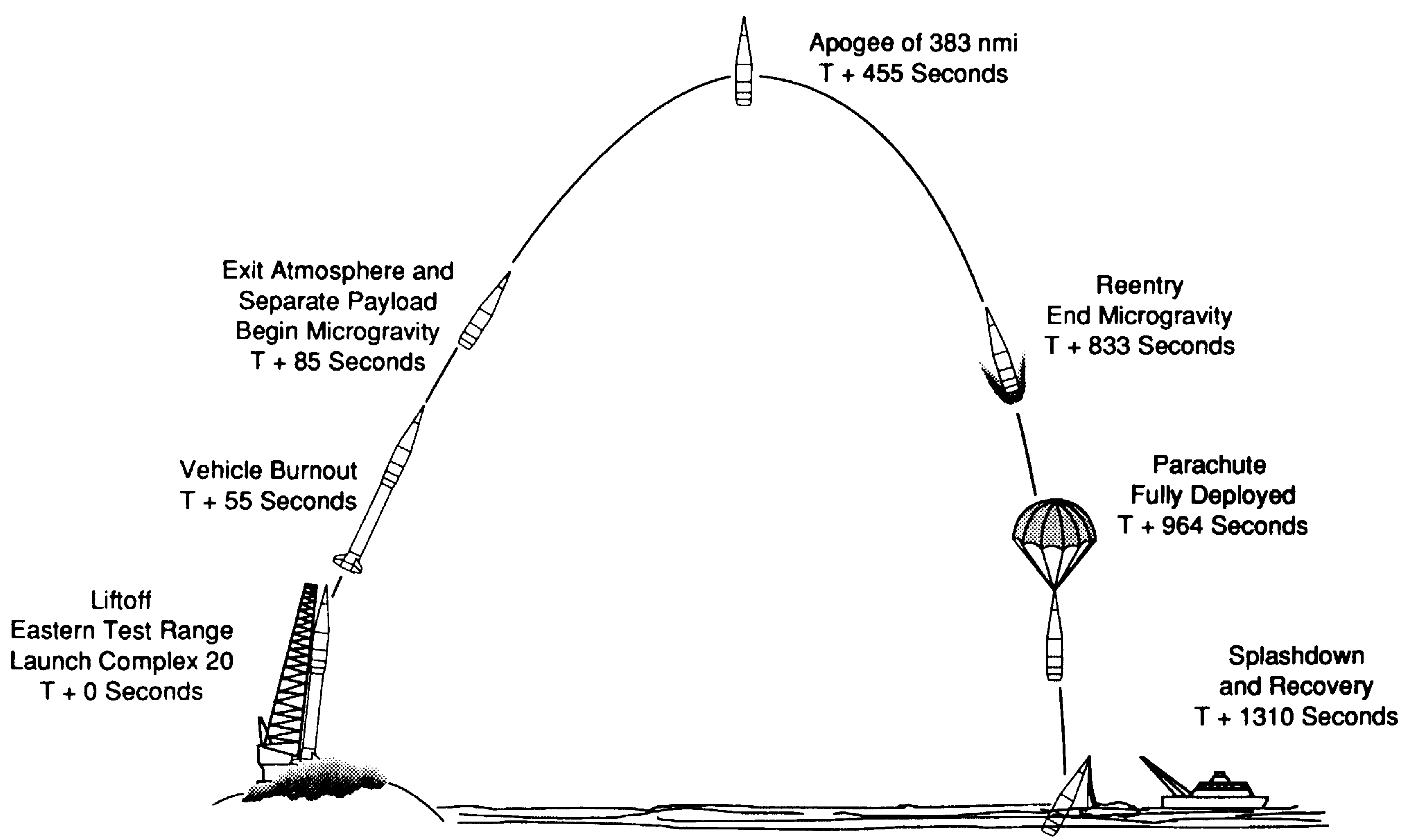
JOUST Mission Plan

Orbital Sciences Corporation

- Prospector Vehicle is a 27,000 Lb, 46 Foot Tall, Single Stage Suborbital Rocket
- Vehicle Powered By a Castor IVA Solid Rocket Motor Built By Thiokol Corporation
- 10 Experiments Will Be Flown in Recoverable Module
- Gross Payload Mass of 1,800 Lbs
- Mission Will Last Approximately 21 Minutes, Providing at Least 13 Minutes of Microgravity Time
- Trajectory is Approximately 380 Miles High and 280 Miles Down Range
- Payload Will Be Located Via Plane and Retrieved Via Ship to Cape Canaveral
- Eastern Space and Missile Center (ESMC) Will Provide Support for the Launch

Joust 1 Mission Scenario

Orbital Sciences Corporation



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Prospector Design

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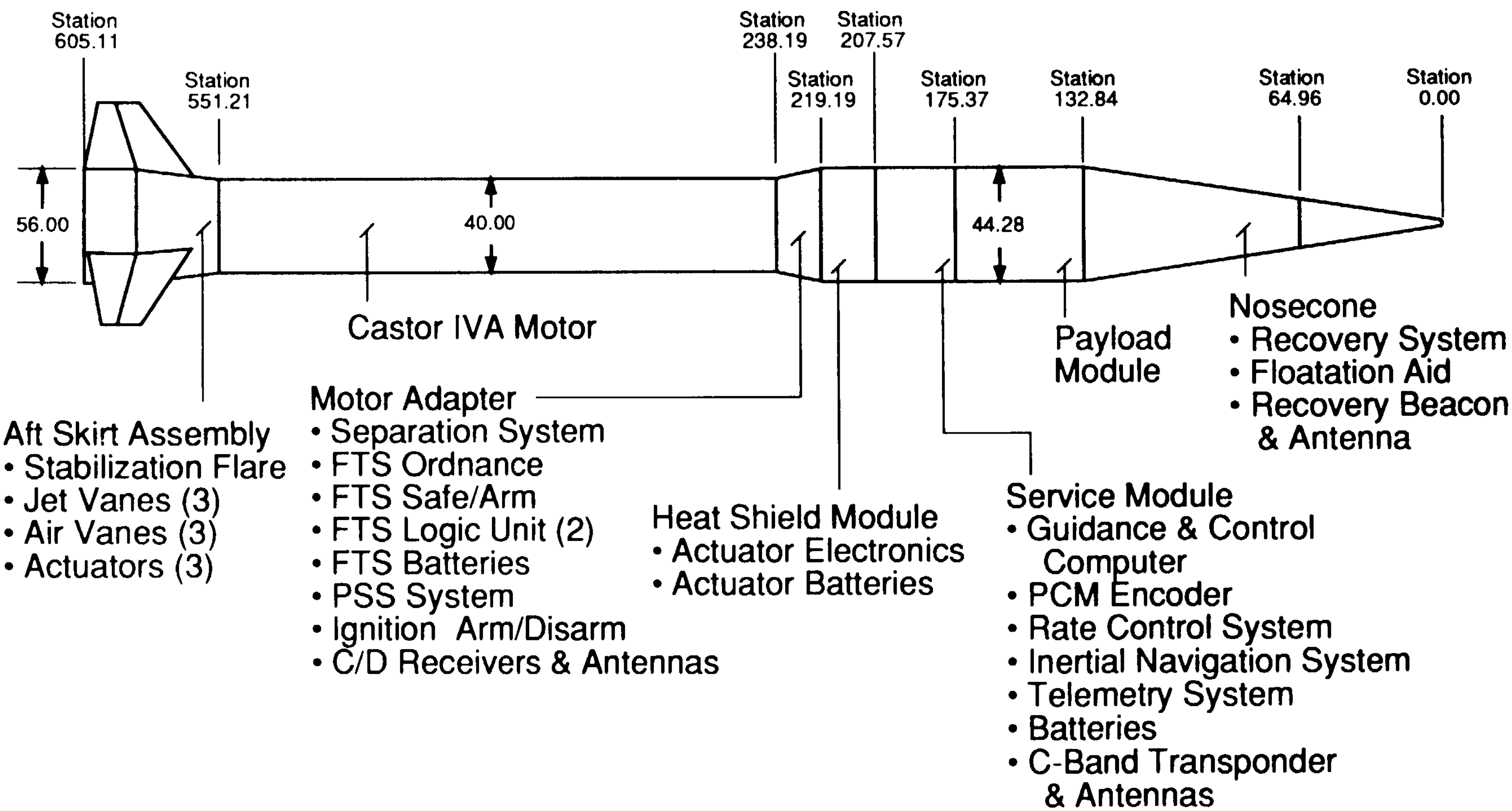

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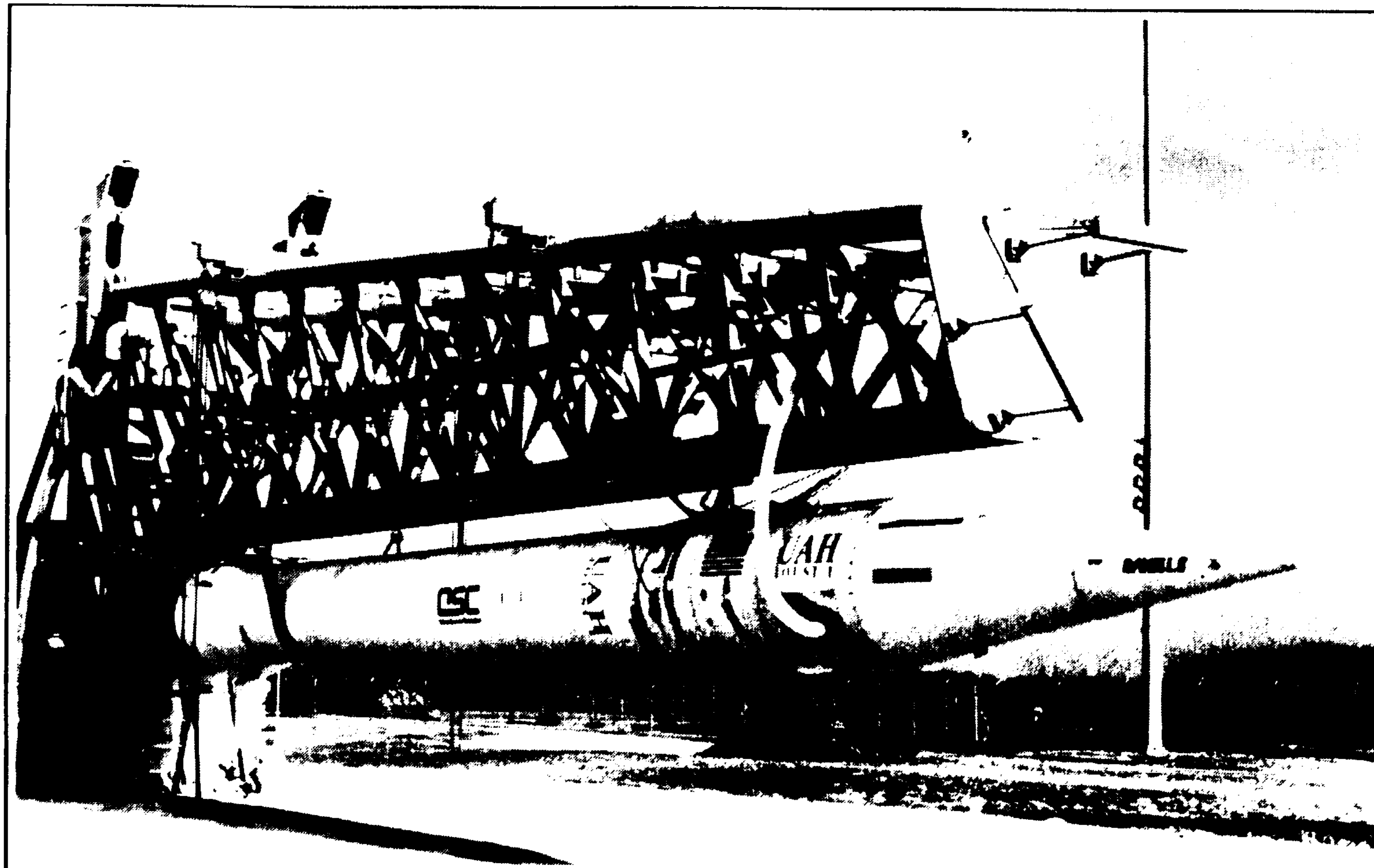
JOUST Rocket

Orbital Sciences Corporation



JOUST Contributions to Commercial Space Development

- Single Prospector Rocket Mission Carries Equivalent of Commercially Allocated Space on Five STS Missions
- Provides CCDS Independent Launch Capability and Stimulates Development of Other Market Applications
- Enables CCDS to Expand Capability and Capacity for Materials Processing in Space
- Provides Low-Cost Proof-of-Concept Testbed for Future Orbital Experiments
- Helps to Keep America First in Space-Based Research in Face of Increasing International Competition

HISTORY

This is the first in a series of Joust launches planned over the next three years by the UAH CMDS. The name Joust was selected for this launch series because it signifies the competition stimulated in the aerospace industry by commercial rocket ventures. The Joust 1 emblem symbolizes that competition through the mounted knight and lance which was popular during the Middle Ages.

Orbital Sciences Corp., Space Data Division was selected to provide the rocket and launch services in 1989. The UAH CMDS has contracts with Space Data to provide up to three launches. Each would be at the Air Force's Eastern Test Range. The cost for the rocket, payload and launch services is approximately $3 million.

NASA's Office of Commercial Programs is responsible for establishing and managing 16 Centers for the Commercial Development of Space. The UAH CMDS has focused on investigations in space as a means to develop new materials and processes.

Current corporate partners are Boeing Aerospace, Deere & Co., Frontier Research, IBM's Almaden Research Center, McDonnell Douglas, Teledyne Brown Engineering, Instrumentation Technology Associates, Thiokol Corp., and Wyle Laboratories. Marshall Space Flight Center, Huntsville, is the consortium's prime NASA partner. Other NASA centers provides substantial support.

Dr. Charles Lundquist is director of the UAH CMDS. Dr. Francis Wessling is associate director and Joust Project Manger and Valerie Seaquist is assistant director.

Space Data, a division of Orbital Sciences Corp., Fairfax, Va., has been developing, building and launching suborbital boosters for over 25 years. Their contracts include the Air Force, Defense Nuclear Agency, U.S. Army, NASA and various non-government customers. Space Data has launched numerous single and multi-stage boosters weighing up to 70,000 pounds to altitudes up to 560 miles carrying payloads up to 6,000 pounds. Space Data is located in Chandler, Ariz.

PROSPECTOR LAUNCH VEHICLE

Space Data is providing its Prospector rocket which is a single-stage, solid-fuel vehicle which stands approximately 46 feet tall and weighs 27,000 pounds. The vehicle will boost a 548 pound payload to an altitude of approximately 400 miles.

The rocket will use a single stage propulsion system provided by a Castor IVA rocket motor. The motor is a derivative of the Castor IV successfully flown over 300 times as a Delta II strap-on booster and as a single stage sounding rocket. The Castor IVA has flown successfully 153 times. The motor is manufactured by Thiokol Inc. The motor will burn approximately 59 seconds after ignition.

The Litton Guidance and Control Systems inertial navigation system will generate the steering commands for the vehicle control system to keep the rocket on course. The system will allow the rocket to be launched under wind conditions up to 40 mph and assist in controlling thrust misalignment.

Attached to the payload will be the nose cone containing the parachute recovery system. Space Data will use a derivative of a nose cone regularly flown on the Aries sounding rocket. A heat shield will be attached to the base of the payload.

JOUST 1 MISSION PLAN

The Prospector is designed to provide about 13 minutes of microgravity time for the UAH payload. Its trajectory is approximately 400 miles high and about 200 miles down range depending on wind conditions from Launch Complex 20 at the Eastern Test Range.

The Eastern Space and Missile Center (ESMC) will provide support for the launch including weather information and other range services. ESMC oversaw the $2.5 million renovation of Complex 20. Complex 20 had been used to launch Titan missiles during the 1960s.

The Castor IVA motor will burn 59 seconds lifting the payload to an altitude of approximately 50 miles. During the boost period, the rocket's guidance system will keep the trajectory from being affected by winds.

At 68 seconds, the payload is separated from the motor and microgravity begins at about 60 miles. The experiments are activated when acceptable microgravity conditions are achieved and continue until the payload begins to re-enter the atmosphere.

The payload will reach its apogee of 395 miles just over eight minutes into the mission. At slightly over 13 minutes, the mission's microgravity stage will end and the payload will reenter the earth's atmosphere. Following reentry, a parachute will be deployed and splashdown into the Atlantic Ocean is expected about 200 miles from Complex 20 at just over 21 minutes after liftoff.

A plane will be used to assist in locating the payload following splashdown. A ship from Harbor xxxx will retrieve the payload and return it to Cape Canaveral. Experiment samples will be removed from the payload and analyzed on board ship during the return to Port Canaveral.

JOUST 1 PAYLOAD

Joust 1 will carry a payload of 10 experiments. The experiments in the payload module will be mated with a service module containing accelerometers, avionics, a low gravity rate control system and battery packs. These two modules will stand over six feet tall and are 44 inches in diameter. They weigh approximately 1,100 pounds.

Payload integration was done jointly by UAH and Teledyne Brown Engineering, Huntsville, Ala. Vibration testing was completed by Wyle Laboratories, Huntsville, Ala., and at Space Data.

EXPERIMENTS

Battelle Advanced Materials Center, Columbus, Ohio
Principal Investigators:
Vince McGinniss
Lisa McCauley
Frank Jelinek

EXPERIMENT: INVESTIGATION INTO POLYMER MEMBRANE PROCESSES

A thin film is formed into a membrane on the ground and is kept saturated with a solvent in a special chamber prior to launch. On reaching the microgravity state, a valve is opened exposing the sample chamber to a vacuum, removing the solvent and allowing the membrane to cure.

Polymer membranes have been used by industry for more than 25 years to assist in desalination, filtering drugs and serums, atmospheric purification and dialysis. Polymer membranes are commercially processed by evaporation casting. It is expected that the resulting pores in the space-processed membrane will be more uniform than those processed on earth.

EXPERIMENT: POLYMER CURING

A heating tape is wrapped around 15 vials containing a polymer resin and a catalyst which cure at elevated temperatures. The heating tape is activated at launch and will reach the desired polymer curing temperature during microgravity.

The experiment will study dispersion under microgravity conditions. Current industrial processing involves the interaction of polymers with other materials such as fibers, metal oxides, glass or carbon fibers. The products of these interactions are non-uniform because gravity causes solids to settle or because materials of different densities disperse unevenly in gravity.

EXPERIMENT: PLASMA PARTICLE GENERATION

This experiment is designed to produce particulate forms of polymeric materials in a microgravity environment. The experiment consists of a particle generation chamber equipped with high voltage electrodes, a gas source for particles, and a laser and sensor system to observe the particle production. A camera in line with the laser beam records the particle diffraction patterns, and the sensor array at 90 degrees measures the laser scatter.

Researchers expect the particles will be suspended in the plasma discharge throughout their growth period permitting the growth of larger particles.

University of Colorado-Boulder
Center for Bioserve Space Technologies
Principal Investigators:
Marvin Luttges
Louis Stodieck

EXPERIMENT: AUTOMATED GENERIC BIOPROCESSING APPARATUS

This experiment consists of six sets of Lexan blocks, each containing 12 to 20 sample wells. A fixed block will contain the process materials. These materials will be mated with a second well in a sliding block initiating the desired experimental process. At the end of the microgravity period, the sliding block will move again to allow a third well to line up with the first to complete the process. In certain cases, the sample wells will have stirring devices to mix the products during the reaction phase.

The experiments will include the study of collagen, a basic building block for all body organs and tissues; microorganism nutrient uptake, which will play an important role in the design of water and oxygen purification systems; and liposomes which have biomedical and biotechnical applications.

Center for Cell Research
Penn State University
Principal Investigator:
Roy Hammerstedt

EXPERIMENT: BIOMODULE

This experiment uses the Penn State Biomodule. It contains 32 solenoids to trigger the release of fluids under computer demand.

The biomodule will test the hypothesis that secretory cells malfunction in microgravity because the internal cell structure is altered. The experiment will use chameleon skin because it is tough enough to withstand the stresses of launch, and its response is easily monitored as a change in color.

Thiokol Corp., Logan, Utah
Principal Investigator:
Charles Zisette

EXPERIMENT: THIN FILMS

Formation of light weight film structures on earth is affected by the density of the various solid particulates which may be added to the base liquid before forming and curing. The denser solid particles added for optical or electrical properties will settle out under gravity forces leaving the solidified membrane non-uniform.

This experiment will examine the creation of a thin film polymer containing iron particulate. The polymer will be examined for uniformity of distribution and optical and electrical properties.

Instrumentation Technology Associates, Exton, Penn.
Principal Investigator:
John Cassanto

EXPERIMENT: MATERIALS DISPERSION APPARATUS (MDA)

Two MDA minilabs will fly on Joust 1. Each consists of upper and lower blocks of inert material which have equal numbers of sample cavities which are held misaligned at launch. When the proper microgravity level has been reached, the blocks are moved into alignment to permit the two fluids in the upper and lower blocks to mix. Before the microgravity conditions are complete, the blocks are moved once more out of alignment.

The MDA will conduct experiments in the biomedical, manufacturing processes and fluid sciences fields.

Consortium for Materials Development in Space
University of Alabama in Huntsville
Principal Investigator:
Samuel McManus
Francis Wessling

EXPERIMENT: FOAM FORMATION

This experiment involves the creation of a polyurethane foam ball containing aluminum particles. Because of their insulating and mechanical properties, polyurethane foams may be prepared in space and used in construction of vehicles like the space station.

The experiment apparatus stores the foam components in separate compartments under pressure. When microgravity begins, the ingredients are released in a special chamber where they are mixed by a stirring motor, then forced through a funnel to cure.

Consortium for Materials Development of Space
University of Alabama in Huntsville
Principal Investigator:
Clyde Riley

McDonnell Douglas Space Systems Co., Huntsville, Ala.
Principal Investigator: George Maybee

EXPERIMENT: ELECTRODEPOSITION PROCESS

This experiment consists of an arrangement of 10 electrodeposition cells containing various electrolyte solutions which will be used to produce thin-deposited films under microgravity conditions. The electrolytes are contained in lucite cells which can be photographed during flight. Some of the cells also have stirring motors which are used to maintain the electrolyte suspensions during the deposition process.

The research will assist in finding better metal catalysts and improved wear resistant co-deposited surfaces.

Consortium for the Materials Development in Space
University of Alabama in Huntsville
Principal Investigator:
James Smith

EXPERIMENT: POWDERED MATERIALS PROCESSING

This experiment will attempt to take advantage of the microgravity environment in space to produce homogeneous ceramic powdered materials. The device will have two sample chambers which will be pre-mixed and stirred during microgravity. A special compaction motor and ram cylinder will capture the ceramic mix during the microgravity period. Pressure will be kept on the specimen through recovery at which time the sample will be fused in a commercial facility.

EXPERIMENT INTEGRATION AND INSTRUMENTATION

Teledyne Brown Engineering Co., Huntsville, Ala.

Teledyne Brown Engineering integrated the Joust 1 experiment hardware into a payload compatible with the Prospector. Major activities included payload assembly, end-to-end mission sequence testing and vibration testing. Mission sequence testing verified payload functions during physical simulations of the launch countdown and flight.