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Reply to Attn of: CE

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TO: Distribution

FROM: C/Acting Associate Administrator for Advanced Concepts and Technology

SUBJECT: Commercial Development Suborbital Rocket Program

The enclosed report provides information on the sixth flight of the Consort suborbital rocket series. Consort 6 is currently scheduled for launch on February 19, 1993, with lift off at 11:00 a.m., Mountain Time. It will carry seven materials and biotechnology experiments, two accelerometer systems, a controller and battery packs in a module nearly 12 feet tall and weighing approximately 1,004 pounds. Consort 6 will reach an apogee of approximately 200 miles providing about 7 minutes of microgravity time. The entire mission, from launch to touchdown, is expected to last approximately 15 minutes.

The Consort series is part of a unique suborbital rocket launch services program conducted by the Office of Advanced Concepts and Technology (OACT) in conjunction with its Centers for the Commercial Development of Space (CCDS). This service is managed through the Consortium for Materials Development in Space (CMDS), a CCDS based at the University of Alabama in Huntsville (UAH).

This suborbital rocket program provides CCDS investigators with a microgravity environment to achieve commercial development objectives, or to test developmental hardware or techniques in preparation for orbital flights or additional follow-on work. Rocket and launch services for Consort 6, including use of the Starfire 1 launch vehicle, are provided by EER Systems Corporation. Integration of the payload into Starfire 1 will be handled by McDonnell Douglas Space Systems Company.

The enclosed report includes background information on this program, as well as details on the Consort 6 investigations. Inquiries may be directed to OACT, Commercial Innovation and Competitiveness, Commercial Flight Experiments Division.

Gregory M. Reck

Gregory M. Reck

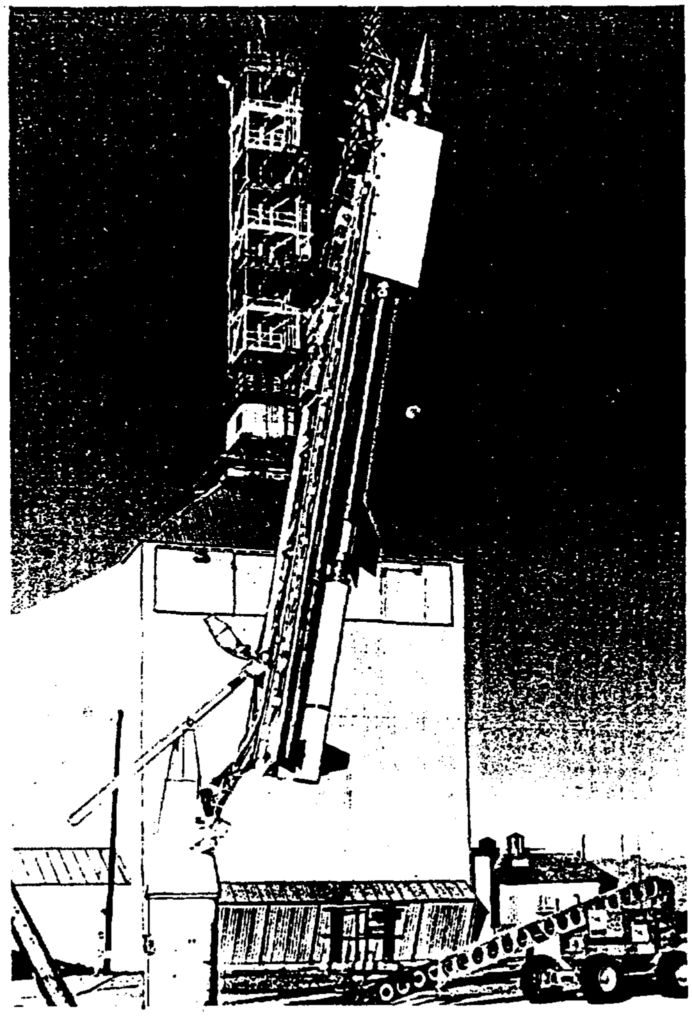
Enclosure

Pre-launch Report

Office of Advanced Concepts and Technology

CONSORT SUBORBITAL ROCKET SERIES*

STARFIRE 1 ON LAUNCH RAIL



*Consort is the name applied to this particular class of launch services, as procured on behalf of the commercial development of space program by the Consortium for Materials Development in Space based at the University of Alabama in Huntsville, a NASA Center for the Commercial Development of Space (CCDS). The Consort series makes use of the Starfire 1 launch vehicle provided by EER Systems Corp., Vienna, Va.

February 1993

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THE OACT SUBORBITAL ROCKET PROGRAM

The Office of Advanced Concepts and Technology (OACT) is sponsoring suborbital rocket launch services through a unique program developed with the Consortium for Materials Development in Space (CMDS) based at the University of Alabama in Huntsville (UAH). This program, initiated in 1988, acquires commercial suborbital launch services through competitive procurements and provides a range of early flight opportunities for various commercial payloads. The key element in this program is that the UAH CMDS seeks commercial launch *services*. First, the UAH CMDS specifies the payload mass and the desired period and level of microgravity. Then, a competitively-selected contractor chooses the launch vehicle and launch licensing and range services. Currently, two rocket services have been initiated, Consort and Joust, each using a vehicle that was selected to achieve the capabilities desired for the individual series.

Five Consort flights were conducted between March 1989 and September 1992. Consort flights 1, 3 and 4 were successfully launched to an altitude of approximately 200 miles and provided 7 to 8 minutes of microgravity. Consort 2, launched in November 1989, was terminated due to a vehicle guidance problem, but the payload was recovered intact and launched on Consort 3. The fifth flight of the Consort series was launched on September 10, 1992, with nine materials science and biotechnology experiments. A premature shutdown of the second stage motor kept the payload from reaching optimum low gravity levels thereby limiting the amount of data researchers received. The sixth flight of the Consort series, scheduled for February 1993, is covered in this pre-launch report. The second series, Joust, launched its first rocket in June 1991. Shortly after launch, Joust 1's thrust vectoring system experienced a structural failure. The rocket had to be destroyed and the payload could not be salvaged, but most of the loss was covered by insurance.

PAYLOAD SUPPORT

Through the UAH CMDS, the OACT suborbital rocket launch services program will provide its experimenters with the following:

- **Power Distribution and Control Unit** -- delivers 28-volt electrical power, discrete on/off control, current limits and power monitoring
- **Experiment Interface Unit** -- allows two-way communications with the payload, provides lift-off and microgravity-onset signals and transmits data during the flight
- **Accelerometer Package** -- determines very low gravity disturbance levels at different experiment locations and provides the best estimation of the microgravity environment
- **Late Access** -- to the payload up to a few hours before launch, depending on an experiment's requirements.
- **Pre-launch Payload Temperature Control** -- provided by a styrofoam enclosure and air conditioning.
- **Recovery** -- of the intact payload
- **Early Retrieval** -- of the experiments within a few hours after launch

CONSORTIUM FOR MATERIALS DEVELOPMENT IN SPACE

The UAH CMDS was established as a NASA-sponsored CCDS in 1985. NASA presently has 17 CCDS's nationwide working on space- and ground-based research for commercial applications of space. The UAH CMDS focuses on investigations in space as a means to develop new materials and processes. These investigations include:

- commercial materials development that benefits from the unique attributes of space;
- commercial applications of the physical chemistry occurring at the surface of a new material, and how materials are transported to the surface; and
- prompt and frequent experiments and operations in space.

Current UAH CMDS corporate partners include:

- AZ Technology
- Boeing Aerospace
- Deere & Company
- Frontier Research
- Interfacial Dynamics, Inc.
- Instrumentation Technology Assoc., Inc.
- Kennametal, Inc.
- Master Builders
- McDonnell Douglas Space Systems Company
- Physical Sciences, Inc.
- RANTEK, Inc.
- Space Hardware Optimization Technology, Inc.
- Teledyne Brown Engineering
- Thiokol Corporation
- Wyle Laboratories

OACT SUBORBITAL ROCKET PROGRAM MANAGEMENT

The principal UAH CMDS points of contact include Dr. Charles Lundquist, director; Dr. Francis Wessling, associate director; Ms. Valerie Seaquist, assistant director; and Dr. Robert Naumann, Consort program manager.

The launch services and vehicle contractor for Consort 6 is EER Systems Corporation of Vienna, Virginia.

An important element in the UAH CMDS suborbital program is teamwork. In addition to the launch services contractors, the UAH CMDS receives support from two firms who are members of the consortium: McDonnell Douglas Space Systems Company (Consort payload integration) and Wyle Laboratories (vibration testing).

The primary NASA partner for the UAH CMDS is Marshall Space Flight Center (MSFC), Huntsville, Alabama, with additional support provided other installations as appropriate.

CONSORT INFORMATION

Consort 1 signified the first commercial launch by a NASA CCDS and was the first commercial launch accomplished under a license by the Department of Transportation's Office of Commercial Space Transportation.

HISTORY TO DATE

On March 29, 1989, Consort 1 was successfully launched from the White Sands Missile Range (WSMR), New Mexico. Consort 1 carried six materials science experiments to an altitude of nearly 188 miles, and it provided the experiments with more than 7 minutes of microgravity. The next flight, Consort 2, was launched on November 15, 1989, and contained a dozen materials science and biotechnology experiments. This flight was terminated due to a malfunction in the rocket's guidance system; however, the 12 experiments were recovered undamaged. Six months later, on May 17, 1990, Consort 3 was successfully launched from the WSMR carrying Consort 2's 12 materials and biotechnology experiments. On November 16, 1992, Consort 4 carried a payload of nine materials science experiments nearly 185 miles into space for a 7 minute microgravity mission. Consort 5 was launched on September 10, 1992, with nine materials science and biotechnology experiments and experienced a malfunction of the second stage motor which kept the payload from reaching low gravity levels thereby preventing the experiments from performing as planned.

Consort 6, currently scheduled for launch in February 1993, will contain seven materials and biotechnology experiments and two accelerometers. Launch services and the launch vehicle (Starfire 1) will be provided by EER Systems Corporation of Vienna, Virginia. Integration of the experiment hardware into Starfire 1 will be handled by McDonnell Douglas Space Systems Company of Huntsville, Alabama. The first three Consort flights were launched by Space Services, Inc. (SSI), Houston, Texas. In 1990, EER Systems acquired SSI and provided the Starfire 1 rocket and launch services for Consort 4. The company recently was awarded a contract for a follow-on series of three flights beginning with Consort 5 in September 1992, with an option for four additional flights.

Starfire 1, used for all previous Consort flights, is a two-stage, solid-fuel vehicle standing approximately 52 feet and weighing about 6,000 pounds. The vehicle can boost up to 1,000 pounds of payload for 7 minutes of microgravity time. Starfire 1 will be launched by a first-stage motor (built by Thiokol Corporation, Huntsville, Alabama), which has been tested more than 270 times with a reliability factor greater than 99%. The second-stage motor (built by Bristol Aerospace of Canada) will house the igniter system, the thrust termination system, the yo-yo despin system, and the payload attachment and separation system.

Starfire 1 has a telemetry system (built by Physical Science Laboratory, Las Cruces, New Mexico) that will transmit information from the payload section to the engineering and science team on the ground. Starfire 1 also has a Rate Control System (RCS) (built by Space Vector Corporation of California) that will control the angular rates of the vehicle around each of its three axes. The RCS will ensure low, stable microgravity levels during the experimental phase of the mission.

Starfire 1's boost phase guidance system is the S19 (built by Saab Space of Sweden). It uses a MIDAS gyro platform, gaseous nitrogen and pneumatically activated canards to provide guided flight during the first few seconds of the mission.

Starfire 1's recovery system, the Ogive Recovery System Assembly (ORSA) (also manufactured by Bristol Aerospace), includes a reentry heat shield to protect the payload and a parachute to reduce the impact of landing. The ORSA will recover the full 1,000-pound payload, including the experiment section which can be reflown on future missions.

MISSION PLAN

Once launched from the WSMR, Starfire 1 will provide just over 7 minutes of microgravity for its experiments. Its trajectory is approximately 200 miles high and 50 miles down range. The entire mission, from launch to touchdown, is expected to last approximately 15 minutes.

Starfire 1's first-stage motor will launch the vehicle to over a mile in altitude within the first few seconds of flight. The second-stage motor will then fire after a brief coast period and carry the vehicle up to 46 miles. Much of the boost period will be guided flight using the S19 system, which will keep the trajectory from being affected by winds.

Approximately one minute into the mission, the payload will separate from the second-stage motor, and then, once acceptable microgravity conditions are determined by the RCS, the payload will be activated. About 3.7 minutes later, Starfire 1 will reach its trajectory apogee of 200 miles. After another 3.4 minutes, Starfire 1's microgravity stage will end and the payload will reenter Earth's atmosphere protected by a reentry heat shield. The RCS will again be activated, placing the payload in a flat spin and allowing it to be slowed by the atmosphere until the proper altitude is reached for parachute deployment. Following reentry and atmospheric braking, a parachute will be deployed and the payload will be retrieved approximately 50 miles down range of the launch site. Two helicopters will be used to reach the payload following its landing. One helicopter will carry the recovery crew to locate the payload, and the other will have a team of experimenters onboard who will prepare the payload for its return to the launch site's vehicle assembly building for post-flight analyses.

CONSORT 6 EXPERIMENT DESCRIPTIONS

Consort 6's payload will contain seven materials and biotechnology experiments, all of which have flown on previous Consort flights. A chart summarizing these experiments is on page 8.

BIOMODULE

Sponsored by the Penn State Center for Cell Research with Photon Technology International, Zetachron, Inc., Whitby Research, Inc., Enzytech, Inc., and TSI, Inc.

The Penn State Biomodule will study the effects of microgravity on mammalian cells, plant tissues and protein crystals, as well as repeat experiments on amphibian tissue. The Biomodule is a computer-controlled minilab which can automatically add, on a variable-time schedule, one or two different fluids to individual biological samples. The experiment will assess the effects of microgravity on the samples as well as the Biomodule's performance and suitability for the studies.

The Biomodule will include seven units containing 56 separate samples. The samples will include amphibian skin tissue, mammalian bone cells, protein solutions for crystallization and two types of cell culture. The 24 bone cell specimens will be carried at 37 degrees Celsius in the temperature controlled section of the Biomodule payload. The remaining 32 samples will fly at ambient temperature (approximately 22 degrees Celsius).

SPACE-FORMED STRUCTURAL BEAM

Sponsored by the UAH CMDS with Thiokol Corporation

This experiment, expected to demonstrate that inflatable structures can be formed in a space environment, will be flown in a vented portion of the payload and will deploy two foam-inflated, resin-impregnated beams. These beams are 2 inches in diameter and 12 inches long. After the beams have been inflated with foam, the resin will be cured by ultraviolet lights. A comparison between this experiment and ground-based experiments will be conducted to determine what kinds of differences exist.

The experiment intends to determine that lightweight, efficiently-stowed, passively-deployed structures can be erected in a space environment. This flight will verify results obtained from Consort 4.

POLYMERIC FOAM FORMATION

Sponsored by the UAH CMDS with Thiokol Corporation

This experiment will prepare a rigid polyurethane foam in a vacuum to provide insight into the future use of foam for space structure applications. The experiment consists of a delivery system, a mixing chamber and a containment vessel. Components from the chambers are mixed and then expelled through the mixing chamber into a containment system. A video camera will tape the foam formation.

Rigid polyurethane foam is an outstanding material for insulation and space structure applications because of its properties in low thermal conductivity, its dimensional stability, and its high strength-to-weight ratio and low density.

ELECTRODEPOSITION PROCESS

Sponsored by the UAH CMDS with McDonnell Douglas Space Systems Company

This experiment will consist of an arrangement of 16 electrodeposition cells designed to produce thin-deposited films under microgravity conditions. The 16 cells are dedicated to nickel and cobalt alloy deposition. The concentration ratios are varied among the cells to produce alloys of different nickel and cobalt compositions. This research will assist in finding metals and alloys with enhanced corrosion resistance, surface hardening and catalytic properties.

CONTROLLED LIQUID PHASE SINTERING

Sponsored by the UAH CMDS with Kennametal, Inc., and Wyle Laboratories

This experiment will examine the influences of microgravity on the liquid phase sintering of selected metallic systems. Liquid phase sintering is a high-temperature process where a liquid metal is used to cement metallic powders with a higher melting point. This treatment is expected to produce metals with a more uniform structure and improved strength.

Potential commercial applications for these products include bearings, magnetic materials, electrical brushes and contact points, advanced cutting tools that cut at higher speeds, irregular-shaped mechanical parts for high-stress environments, and new and improved catalysts for chemical production.

POWDERED MATERIALS PROCESSING EXPERIMENT

Sponsored by the UAH CMDS with Kennametal, Inc.

This experiment will attempt to produce homogeneous ceramic powdered materials. The experiment apparatus has two sample chambers which are pre-charged with two dry ceramic powders. These powders are suspended and mixed by gas jets once acceptable microgravity conditions have been reached. A special hydraulic compaction device and a ram cylinder will capture the ceramic mix during the microgravity period. Throughout recovery, pressure will be kept on the specimen which will then be transported to laboratories at Kennametal, Inc., where the samples will be sintered and analyzed.

This approach is used to produce samples of uniformly dispersed particles of different density and mechanical properties. Kennametal, Inc., markets sintered ceramic composites for use as advanced cutting tools.

ORGANIC SEPARATION BY PHASE PARTITIONING

Sponsored by the UAH CMDS with Space Hardware Optimization Technology, Inc. and Interfacial Dynamics Corp.

This experiment builds on previous efforts and features the first low-gravity testing of a new multi-sample, multi-transfer, bioseparation apparatus. The apparatus is designed to carry out studies and commercial separations involving a liquid-liquid countercurrent separation technique called phase partitioning.

Organic separation deals with the separation of organic materials, such as heavy molecules and cells. The basic phase partitioning process is used on Earth as a purification technique of considerable biotechnological importance, but sedimentation and convection due to gravity on Earth preclude phase partitioning from reaching theoretical potentials.

SUPPORTING HARDWARE

Consort 6's supporting hardware includes an accelerometer package. This hardware is part of a special developmental activity that also supports OACT activities on SPACEHAB.

ACCELEROMETER PACKAGES

Sponsored by the UAH CMDS and Boeing Defense and Space Group

Two accelerometer packages will be flown on this Consort mission. The UAH CMDS package comprises a three dimensional system, using three standard accelerometers aligned in the three orthogonal directions to measure microvibrations such as those generated by other experiment operations, and a single axis Invertible Accelerometer to measure residual absolute microgravity at very low levels and very low frequencies such as those caused by thruster firings, atmospheric drag, rotational motions and venting. The Boeing accelerometer package is a general purpose instrument measuring vibrations, temperature and pressure as a prototype for future Space Station *Freedom* support instrumentation. Acceleration data will be sent to the ground by telemetry link and recorded on the ground for further processing, analysis and correlation, and support to other experiments.

ACRONYMS

CCDS	Center for the Commercial Development of Space
CMDS	Consortium for Materials Development in Space
ITA	Instrumentation Technology Associates, Inc.
LED	(High Output) Light Emitting Diodes
NASA	National Aeronautics and Space Administration
OACT	Office of Advanced Concepts and Technologies
ORSA	Ogive Recovery System Assembly
RCS	Rate Control System
SSI	Space Services, Inc.
UAH	University of Alabama in Huntsville
WSMR	White Sands Missile Range

TABLE 1

OACT-SPONSORED INVESTIGATIONS AND SUPPORTING HARDWARE FLYING ON CONSORT 6

INVESTIGATIONS AND SUPPORTING HARDWARE	INVESTIGATORS	DESCRIPTION
Biomodule*	Penn State with five co-investigators (see text)	Study the effects of microgravity on mammalian cells, plant tissues, protein crystallization, and amphibian tissue.
Space-Formed Structural Beam*	UAH CMDS with Thiokol Corp.	Demonstrate the formation of inflatable structures in microgravity.
Polymeric Foam Formation*	UAH CMDS with Thiokol Corp.	Preparation of a rigid polyurethane foam in a vacuum to provide insight into the future use of foam for space structure applications.
Electrodeposition Process*	UAH CMDS with McDonnell Douglas	Sixteen cells designed to produce thin-deposited films of nickel/cobalt compositions seeking alloys with enhanced corrosion and catalytic properties.
Controlled Liquid Phase Sintering*	UAH CMDS with Kennametal, Inc. and Wyle Laboratories	Examine the influences of microgravity on the liquid phase sintering of selected metallic systems.
Powdered Materials Processing*	UAH CMDS with Kennametal, Inc.	Production of homogeneous ceramic powdered materials.
Organic Separation by Phase Partitioning*	UAH CMDS with Space Hardware Optimization Technology, Inc. and Interfacial Dynamics Corp.	Separating organic materials by a liquid-liquid countercurrent separation technique (phase partitioning).
Accelerometer Packages**	UAH CMDS and Boeing Defense and Space Group	Two systems each developmental and providing mission support. The UAH CMDS systems measure low level microvibrations and absolute microgravity. The Boeing general purpose instrument measures vibrations, pressure and temperature.

*Denotes experiments; all have previously flown on Consort flights.
**Denotes supporting hardware, part of which has flown on Consort flights before.

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