Press Kit

CRRES PRESS KIT

COMBINED RELEASE AND RADIATION EFFECTS SATELLITE (CRRES)

ATLAS I
(ATLAS/CENTAUR-69)
LAUNCH VEHICLE

PRESS KIT

JULY 1990

CONTENTS

RELEASE: 90-94

CRRES LAUNCH SET FOR JULY TO STUDY "EARTHSPACE"

Launch of the Combined Release and Radiation Effects Satellite (CRRES) is currently targeted for no earlier than July 17, 1990, at 3:41 p.m. EDT. Scheduled to be placed into a highly elliptical, geosynchronous transfer orbit of approximately 217 by 22,236 miles, CRRES is to conduct complex scientific research in what is referred to as "Earthspace" -- the space environment just above Earth's atmosphere which, far from being empty, includes the ionosphere and magnetosphere containing a dynamic ocean of invisible magnetic and electrical fields and particles.

Much as a high school physics student spreads iron filings around a magnet to "see" its invisible magnetic field, CRRES will carry 24 canisters of various chemicals into orbit and release the chemicals over a period of time. When released, the chemicals will be ionized by the Sun's ultraviolet light creating large luminous clouds that will elongate along Earth's magnetic field lines, briefly "painting" these invisible structures.

By observing the motion of the clouds, scientists will be able to measure electric fields in space and "see" how they interact with charged particles to form waves and to better understand how the Earth extracts energy from the solar wind. The luminous clouds also will be studied from the ground, from specially equipped aircraft and from CRRES itself. The CRRES releases will be augmented by chemical releases from 10 sounding rockets launched from Puerto Rico and the Marshall Islands.

Under a launch services contract between NASA and General Dynamics, launch of the joint NASA/U.S. Air Force payload is to take place from Complex 36B, Cape Canaveral Air Force Station, Fla., aboard an Atlas I (Atlas/Centaur-69) launch vehicle.

NASA's Marshall Space Flight Center, Huntsville, Ala.; the U.S. Air Force Space Systems Division, Los Angeles; and Ball Aerospace Systems Group, Boulder, Colo. -- prime comtractor of CRRES -- are principal spacecraft participants in the upcoming mission. Atlas I launch services, with technical oversight by NASA's Lewis Research Center, Cleveland, and Kennedy Space Center, Fla., will be provided by General Dynamics Space Systems Division, San Diego, Calif. The Lewis Research Center manages the NASA-General Dynamics launch services contract and is responsible for launch vehicle/spacecraft integration activities.

- end general release; press kit follows -

THE COMBINED RELEASE AND RADIATION EFFECTS SATELLITE

SCIENCE BACKGROUND

The Combined Release and Radiation Effects Satellite (CRRES), a joint NASA/Air Force project, will attempt to learn more about the hostile environment often referred to as "the vacuum of outer space."

Outer space, however, is not empty. It is a dynamic mix of invisible magnetic and electric fields, energetic particle radiation and electrically charged plasmas, collections of negatively charged electrons and positively charged atoms whose interactions are influenced by long-range electric forces, rather than by the atomic collisions that govern the behavior of neutral gases.

Complex interactions involving these fields and particles extract energy from the solar wind, a continual flow of particles from the Sun, and deposit much of this energy into the Earth's upper atmosphere, ionosphere and magnetosphere. The Earth's neutral atmosphere, extending approximately 40 miles above the Earth's surface, is a shell of neutral gases that encompasses the Earth's weather and protects its life. The ionosphere, which extends from above the atmosphere to approximately 620 miles above the Earth, is an electrically charged transition zone between the atmosphere and the magnetosphere.

Beyond the ionosphere lies the magnetosphere, populated with energetic, charged particles. When this magnetosphere is hit by a cloud of energetic particles from a solar flare, a so-called geomagnetic storm can occur that can disrupt power systems and long-distance communications. Today's increasingly complex satellites, carrying sophisticated electronics and sensors such as the Tracking and Data Relay Satellite and other geostationary spacecraft, are susceptible to damage from solar energetic particles that can limit the satellite operational lifespan.

Scientists have been studying the magnetosphere for decades, using a combination of ground-based measurements and satellite observations. Beginning this summer, the CRRES satellite will conduct experiments allowing direct observations of the Earth's magnetic field.

CRRES OBJECTIVES

CRRES will carry 24 canisters containing various chemicals. For each experiment, one or two canisters will be ejected by the spacecraft. Approximately 25 minutes later, after the canister and spacecraft are far enough apart to prevent contamination, the canister will release its chemical vapors. The chemical will be ionized by the Sun's ultraviolet light, creating luminous clouds initially about 60 miles in diameter. The clouds will elongate along Earth's magnetic field lines, briefly "painting" these invisible structures so that they become visible.

By observing the motion of the clouds, scientists will be able measure electric fields in outer space, to "see" how these fields interact with charged particles to form waves and to better understand how the Earth extracts energy from the solar wind. These clouds will be studied by instruments on the ground, in specially equipped aircraft and aboard CRRES itself. The CRRES releases will be augmented by releases from sounding rockets to conduct further experiments.

The CRRES program is the latest in a new generation of space research missions studying earthspace, the space environment just above Earth's atmosphere, through complementary, active experiments and passive observations. CRRES is a joint program of NASA, through its Marshall Space Flight Center, and the Department of Defense's (DOD) Air Force Space Test and Transportation Program. NASA's role in the mission is the release of tracers. The DOD experiments will measure the natural radiation in space and its effects on microelectronics.

The satellite was built by the Ball Aerospace Systems Group, Boulder, Colo. The scientific instruments and investigations are being supplied by scientists from institutions throughout the United Sates, Europe and South America.

CRRES PROGRAM HISTORY

In 1984, the CRRES satellite was designed as a dual-mission spacecraft carrying 48 canisters of chemicals for release. The spacecraft initially was to be deployed from the Space Shuttle in a low-Earth-orbit (LEO) of 215 miles altitude. At LEO it would have performed chemical release experiments for 90 days. Following the LEO mission, a trans-stage motor would have placed CRRES in a geosynchronous transfer orbit (GTO), where additional chemical releases and the primary DOD mission would be carried out.

The loss of Challenger in January 1986 forced a major restructuring of the CRRES Program. In June 1987, NASA decided to launch CRRES directly to GTO on an Atlas-Centaur carrying 24 canisters, complemented by a program of sounding rocket launches to perform some of the experiments deleted from the original 48-cannister CRRES mission.

CRRES OPERATIONS

The 24 canisters on the CRRES/GTO mission will perform 14 experiments. Seven of these will be undertaken at altitudes ranging from 1,200 to 21,000 miles (the original GTO releases). The remainder will be undertaken near perigee at altitudes between 240 and 300 miles.

The mission will be complemented by 10 sounding rockets to perform releases that require precise targeting of location, local time and altitude. Six rockets are to be launched from Puerto Rico and four from Kwajalein, Marshall Islands.

GROUND-BASED, IN SITU AND AIRCRAFT DIAGNOSTICS

The successful execution of the chemical release experiment demands a wide variety of diagnostics. Principal ground-based facilities that will monitor and track the releases include the Arecibo Incoherent Scatter Radar and the Arecibo HF Ionospheric Heater Facility in Puerto Rico, the Jicamarca (Peru) Radar Facility, the ALTAIR Radar Facility at Kwajalein and the Millstone Hill Radar Facility in Massachusetts.

These facilities will be used to diagnose the state of the ionosphere prior to, during and just after each release. They also will examine in detail the structure of the artificial plasma clouds. The radars can measure the state of the ionosphere and artificial plasma clouds simultaneously over a wide altitude range.

The DOD scientific instruments will complement the CRRES chemical-science mission, measuring the effects of the releases at close range. For releases, the instruments will measure the state of particles and waves in the magnetosphere and assess whether a large magnetic storm is imminent. This will help the scientists determine the best time to conduct a release.

No less important will be an array of ground- and aircraft-based optical diagnostics, including wide-field cameras, high-sensitivity television systems, spectrographs and interferometers. Portable VHF coherent scatter radars will diagnose regions not accessible to the fixed radars, and radio receivers on board aircraft will measure disruptions in signals received from satellites resulting from the ionospheric disturbances.

(See DETAILED EXPERIMENTS DESCRIPTION section of this press kit.)

ATLAS I (ATLAS/CENTAUR) LAUNCH VEHICLE

GENERAL DESCRIPTION

The Atlas I is a derivative of the Atlas/Centaur built by General Dynamics Space Systems Division (GDSSD) for NASA. The Atlas/Centaur previously was used by NASA as its standard launch vehicle for intermediate weight payloads. Atlas I is the first of a new family of launch vehicles that can be used to boost payloads into low-Earth orbit, geosynchronous-Earth orbit and on interplanetary trajectories. Eleven-foot and 14-foot diameter payload fairings are available to accommodate a variety of spacecraft.

The Centaur upper stage was the nation's first high-energy, liquid hydrogen/liquid oxygen propelled rocket. Developed and launched under the direction of NASA's Lewis Research Center, Cleveland, it became operational in 1966 with the launch of Surveyor 1, the first U.S. spacecraft to soft-land on the lunar surface.

Since that time, both the Atlas booster and the Centaur upper stage have undergone many improvements. At present, the Atlas I vehicle/14-foot fairing combination can place 13,000 pounds into low-Earth orbit, 4,950 pounds in a synchronous transfer orbit and 2,400 pounds on Earth escape trajectories. Since the first use of Atlas in the space program in the early 1960s, thrust of the Atlas engines has been increased about 50,000 pounds.

The Atlas I vehicle, approximately 143-feet high, consists of an Atlas I booster and a Centaur I upper stage. The Atlas booster develops 438,922 pounds of thrust at liftoff using two 188,750-pound-thrust booster engines, one 60,500-pound-thrust sustainer engine and two vernier engines developing 461 pounds of thrust each. The two RL-10 engines on Centaur produce a total of 33,000 pounds of thrust. Both the Atlas and Centaur are 10 feet in diameter.

Until early 1974, Centaur was used exclusively in combination with the Atlas booster. Subsequently, it was used with a Titan III booster to launch heavier payloads into Earth orbit and interplanetary trajectories. A new wide-body Centaur will be used as an upper stage on Titan IV launch vehicles.

The Centaur I has an integrated electronic system that performs a major role in checking itself and other vehicle systems before launch and also maintains control of major events after liftoff. The new Centaur system handles navigation and guidance tasks, controls, pressurization and venting, propellent management, telemetry forms and transmission and initiates vehicle events. Most operational needs can be met by changing the computer software.

ATLAS/CENTAUR-69 LAUNCH VEHICLE CHARACTERISTICS

The fueled AC-69 weight, including the 3,735-pound CRRES spacecraft, is 365,374 pounds. Liftoff height is approximately 143 feet. Launch Complex 36 (Pad B) is used for the launch operation.

	ATLAS BOOSTER	CENTAUR STAGE
Fueled Weight:	320,821 lbs.	40,818 lbs.
Height:	Approx. 77 feet	Approx. 67 feet with payload fairing
Thrust:	438,922 lbs. at sea level	33,000 lbs. in vacuum
Propellants:	Liquid oxygen and RP-1	Liquid oxygen/ Liquid hydrogen
Propulsion:	MA-5 system two 188,750 lb. thrust booster engines, one 60,500 lb. thrust sustainer engine, two 461 lb. thrust vernier engines	Two 16,500 pound thrust RL-10 engines, 12 small hydrazine thrusters
Velocity:	6,527 mph at booster engine cutoff (BECO) 9,326 mph at sustainer engine cutoff (SECO)	22,262 mph at spacecraft separation
Guidance	Preprogrammed profile through BECO. Switch to inertial guidance for sustainer phase	Inertial guidance

KENNEDY SPACE CENTER VEHICLE PROCESSING, OPERATIONS

ATLAS/CENTAUR-69 PROCESSING

The Atlas/Centaur-69 vehicle arrived aboard a C-5 Air Force transport plane from the General Dynamics plant, San Diego, on April 3. The Atlas stage was erected on Pad 36-B, Cape Canaveral Air Force Station, on April 4 and the Centaur stage was hoisted atop the Atlas on April 5. The vehicle was powered up to begin prelaunch testing on April 16.

On May 30, during a routine wet dress rehearsal test, a high-pressure helium line failed at the beginning of the test causing minor damage to the interstage adapter and delaying the target launch date until July 9. A second test was conducted on June 19, but due to a ground software problem, the test was halted at the T-31 second mark. The decision was made to conduct another retest, delaying the target launch date until July 17. The retest was accomplished on June 26.

On June 14, a simulated flight test was conducted. This check operated the vehicle's electrical and mechanical systems, verifying that they will perform as designed during the ascent to orbit. This was followed by a full countdown demonstration exercise, including the filling of the vehicle with its full complement of liquid hydrogen, liquid oxygen and RP-1 propellants. All countdown events were performed as they are on launch day up to first stage ignition.

A new payload fairing 14 feet in diameter, four feet wider than previous fairings, underwent final assembly in the Payload Hazardous Servicing Facility (PHSF) in the KSC Industrial Area. Fit checks, electrical tests and a mechanical verification to confirm that the fairing would open and separate from the vehicle properly during the ascent were conducted atop the vehicle at the launch pad. It was returned to the PHSF and prepared for encapsulation with the spacecraft.

CRRES PROCESSING

The CRRES spacecraft arrived at the PHSF on March 23. Electrical checks and functional testing of the spacecraft were completed on April 20. During the first week of May, the canisters, designed for releasing the chemicals in orbit, were loaded with their respective elements and were placed aboard the spacecraft. There are eight small and 16 large canisters which collectively contain the elements barium, lithium, strontium and calcium.

On May 14, 3 days of spacecraft end-to-end compatability tests were performed between the CRRES satellite at KSC and the Air Force Consolidated Satellite Test Center (CSTC) in Sunnyvale, Calif. CSTC will be the control center for the spacecraft during the mission. Spacecraft commands, telemetry and data communications were verified.

The spacecraft was fueled with the hydrazine attitude control propellant on May 21 and transported to Launch Complex 36 for mating to the AC-69 vehicle on July 2.

LAUNCH OPERATIONS

Atlas Centaur launch operations will be conducted from the Complex 36 blockhouse by a launch team from General Dynamics, the vehicle's manufacturer. RP-1, a highly refined kerosene fuel burned by the Atlas, will be loaded aboard the stage 3 days prior to launch. The liquid oxygen used by the Atlas and the Centaur will be loaded aboard during the countdown, beginning at T-75 minutes. The loading of liquid hydrogen aboard the Centaur stage at T-43 minutes, running concurrently with the remainder of the liquid oxygen loading.

Since this is a NASA mission, the agency is accountable for mission success and government technical oversight as well as responsibility for supporting CRRES preflight preparations and testing. The NASA Lewis Research Center Project Manager is responsible for the administration and technical oversight of the Atlas I launch services contract.

A NASA launch manager from the Kennedy Space Center represents NASA interests during the launch vehicle checkout and preparations and serves as NASA's liaison with General Dynamics at the launch site. On launch day, he is located in the Mission Director's Center to monitor the countdown and the launch team activity and will provide a NASA final concurrence for launch to the General Dynamics launch director in the blockhouse.

RANGE SUPPORT

The Eastern Test Range, an arm of the Air Force Eastern Space and Missile Center, will provide tracking support for the mission. Radar and communications will be relayed to NASA's Mission Director's Center and central telemetry facility on Cape Canaveral Air Force Station and to the Air Force CSTC control facility at Sunnyvale.

Tracking stations supporting the mission include the U.S. Air Force Tel-4 facility located at KSC, the Jonathan Dickinson Instrumentation Facility Jupiter Inlet in south Florida, the Antigua station in the Bahamas and the NASA radar at Bermuda. Also, two Advanced Range Instrumentation Aircraft (ARIA) will support over the South Atlantic off the coast of Africa to cover the second burn of the Centaur stage and spacecraft separation.

LAUNCH WEATHER

As with the Space Shuttle, weather observations and forecasting for the launch of AC-69 will be provided by the U.S. Air Force from the Cape Canaveral Forecast Facility. The weather criteria for the launch of expendable vehicles and the Space Shuttle are similar in many respects, but in some areas they are tailored to the unique characteristics of the expendable vehicle being launched.

On launch day, a total of nine upper air weather balloon soundings will be made starting at launch minus 6 hours. A weather reconnaisance aircraft will be deployed at launch minus 90 minutes. It will evaluate the weather downrange in the flight path of the vehicle and also assess any weather areas of concern that may be approaching the Cape.

A detailed weather briefing will be provided to the General Dynamics launch director and the NASA launch manager prior to retracting the gantry, again prior to fueling, and then immediately before launch.

FLIGHT EVENTS SEQUENCE: ATLAS I, CRRES SPACECRAFT

EVENT	TIME AFTER LIFTOFF	ALTITUDE (MILES)	DOWNRANGE (MILES)	SPEED (MPH)
Liftoff	T-0			
Atlas Booster Engine Cutoff	2 min 35 sec	37	54	6,527
Jettison Atlas Booster Engine	2 min 38 sec	38	59	6,590
Jettison Centaur Insulation Panels	3 min 0 sec	50	70	6,967
Jettison Nose Fairing	3 min 36 sec	67	154	7,746
Atlas Sustainer/ Vernier Engines Cutoff	4 min 27 sec	85	258	9,326
Atlas/Centaur Separation	4 min 29 sec	86	266	9,330
First Centaur Main Engine Start	4 min 40 sec	89	286	9,306
Centaur Main Engine Cutoff	9 min 53 sec	94	1,298	17,953
Second Centaur Main Engine Start	24 min 53 sec	212	5,366	17,487
Second Centaur Main Engine Cutoff	26 min 29 sec	241	5,836	22,535
Centaur/Payload Separation	28 min 44 sec	334	6,566	22,262

(These numbers may vary depending on exact launch date, launch time and spacecraft weight)

CRRES SPACECRAFT, SCIENCE MANAGEMENT TEAM

NASA HEADQUARTERS

Dr. Lennard A. Fisk	Associate Administrator for Space Science and Applications
Thomas W. Perry	Deputy Director, Space Physics Div.
Richard J. Howard	CRRES Program Manager
Dr. David S. Evans	CRRES Program Scientist

MARSHALL SPACE FLIGHT CENTER

Thomas J. Lee	Director
Sidney P. Saucier	Manager, Space Systems Projects Office
William A. Swords	CRRES Project Manager
Dr. David L. Reasoner	CRRES Project Scientist

UNITED STATES AIR FORCE

Col. John E. Armstrong	Program Director, Space Transportation And Test Program
Maj. Stanley A. Sneegas	Program Manager, Space Test Program

BALL AEROSPACE SYSTEMS GROUP

Ron Brown	CRRES Program Manager
Brian Pieper	Deputy CRRES Program Manager

ATLAS I (ATLAS/CENTAUR-69) LAUNCH MANAGEMENT TEAM

NASA HEADQUARTERS

Dr. William B. Lenoir	Associate Administrator for Space Flight
Joseph B. Mahon	Deputy Associate Administrator for Space Flight (Flight Systems)
Charles R. Gunn	Director, Unmanned Launch Vehicles and Upper Stages
John P. Castellano	Chief, Intermediate and Large Launch Vehicles

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Forrest McCartney	Director
John Conway	Director, Payload Management and Operations
James L. Womack	Director, Expendable Vehicles
Gale Hager	CRRES Launch Site Support Manager
George Looshen	Chief, Launch Operations Division

LEWIS RESEARCH CENTER

Lawrence J. Ross	Director
V.J. Weyers	Director of Space Flight Systems
J.W. Gibb	Manager, Launch Vehicle Program Office
R.E. Orzechowski	CRRES Mission Manager
E. Procasky	Atlas/Centaur-69 Chief Engineer

GENERAL DYNAMICS

B.J. Wier	GDSSD Vice President and Atlas Program Director
B.J. Sherwood	GD/CLS Mission Manager for CRRES
S.K. Baker	GDSSD-CCAFS Engineering Manager, Atlas I/II Launch Operations
J.T. Heffron	GDSSD Atlas Launch Vehicle Program Director

DETAILED EXPERIMENTS DESCRIPTION

NASA EXPERIMENTS

NASA's experiments are divided into four areas:

o Magnetospheric Ion Cloud Injections: This group of experiments will artificially seed the magnetosphere with plasma and, working with DOD particle and electromagnetic wave investigators, use ground-based optical and radar diagnostics to observe large-scale changes in the cloud. In-situ CRRES measurements will examine smaller, local phenomena. The CRRES instruments also will determine the state of the magnetosphere, providing valuable data to allow the determination of optimal conditions for releases. (Experiments G-1 through G-7, G-10.)

o Ionospheric Modifications: This group of experiments introduces disturbances into the ionosphere to study the friction forces arising from the interaction of high-speed injected plasmas and the ionosphere. Scientists also will inject neutral atoms at orbital velocities to understand why unusually efficient ionization occurs when a fast beam of neutral gas passes through a magnetized plasma. Scientists will compare the observed behavior of the injected plasmas with computer models. (Experiments G-8, G-9, G-13, G-14.)

o Electric Fields and Ion Transport: This group of experiments will study the low-latitude electric fields and the movement of ions along magnetic field lines into the ionosphere in response to these electric fields. (Experiments G-11, G-12.)

o Ionospheric Irregularity Simulators: These experiments will produce large-scale releases of chemicals to study irregularities in the ionosphere and the effects of the ionosphere on the propagation of high-frequency-waves. (Experiments AA-1 through AA-7.)

DETAILED PLAN: NASA CRRES SATELLITE EXPERIMENTS

Experiments G-1 through G-4: Diamagnetic Cavity, Unstable Velocity Distributions, Plasma Coupling. Principal Investigators: Robert A. Hoffman, Goddard Space Flight Center, G-1, G-2 and G-3; Steven B. Mende, Lockheed Palo Alto Research Labs,G-4.

Magnetic and solar storms inject plasma into the magnetosphere. The reaction of the natural magnetosphere to these injections is important to understanding energy and particle transport. Injections of barium ions will simulate natural plasma injections in a precisely controlled manner. These four injections will be at different altitudes and magnetic field strengths to understand how different regions of space react to the artificial cloud plasmas.

G-5: Stimulated Electron Precipitation to Produce Auroras. Principal Investigators: Gerhard Haerendal, Max Planck Institut; Paul A. Bernhardt, Naval Research Laboratories.

The late Neil Brice proposed in 1970 that injections of artificial ion clouds in the Van Allen radiation belts would cause the high-energy charged particles to "unstick" from the magnetic field and crash into the atmosphere.

This theory will be tested by injecting an artificial lithium plasma in a region of high-energy, trapped electrons. Observers with optical instruments and radars will closely monitor the footprint of the magnetic field line where it enters the atmosphere in Canada and South America to search for artificial auroras created by these particles.

G-6: Stimulation of Ion-Cyclotron Waves and Artificial Ion Precipitation. Principal Investigator: Steven B. Mende, Lockheed Palo Alto Research Labs.

High-energy protons dominate the pre-midnight sector of the high-altitude magnetosphere. Some of these "leak out" of stable trapped orbits and precipitate into the atmosphere to cause a weak aurora. This experiment will inject an artificial lithium plasma cloud into this proton region and measure any increased proton precipitation.

Essentially this experiment has the same objectives as the previous one, except the particles of interest are protons rather than electrons. The enhanced precipitation will be detected by optical instruments at the base of the magnetic field line, as these protons will produce light in the distinct wavelengths of the hydrogen atom. The instruments on CRRES will monitor the state of the magnetosphere and will aid in determining the best time for the release.

G-7: Ion Tracing and Acceleration. Principal Investigators: William K. Peterson, Lockheed Palo Alto Research Laboratories.

The release of tracer lithium ions will be tracked by instruments aboard the NASA Dynamics Explorer 1, CRRES, SCATHA and the Japanese AKEBONO satellites. The previous two lithium releases also can be used for this experiment, but this release will be made when the relative positions of these satellites are especially favorable for observing the artificial tracer ions.

G-8: Gravitational Instability, Field Equipotentiality, Ambipolar Acceleration. Principal Investigator: Gerhard Haerendel, Max Planck Institut.

Space plasmas often become highly irregular and structured. Electric and magnetic fields are known to be important to this process, but less is known about the effects of gravity. For the light protons in the magnetosphere, it is safe to assume that the effect of gravity is negligible compared to electric and magnetic forces. For the heavier ions, such as oxygen and nitrogen, this assumption is questionable. This release will create a heavy barium plasma along a magnetic field line, and the distortions due to the action of gravity will be studied with optical instruments and the radar at Jicamarca, Peru.

G-9: Velocity Distribution Relaxation and Field Equipotentiality. Principal Investigators: Morris B. Pongratz, Los Alamos National Laboratory; Gene M. Wescott, University of Alaska.

The CRRES satellite releases gas at orbital velocity, and the ion clouds that form are moving very rapidly (8 to 10 kilometers per second) relative to the natural ionosphere. This state is common in nature, occurring when beams of electrons enter the auroral zone or when material is pulled into a star. The beams eventually slow down, but not through physical collisions between particles, as is the case with neutral gases. Instead, the physics of beam-plasma interactions are dominated by the long-range electrical and magnetic forces that act on the charged particles. The exact mechanisms of these interactions are not well understood

In this experiment, barium will be released over an extensive network of ground and aircraft observatories in the Caribbean, while instruments on CRRES will measure the electric and magnetic fields resulting from the interactions.

G-10: Stimulating a Magnetospheric Substorm. Principal Investigator: David J. Simons, Los Alamos National Laboratory.

Sometimes during a magnetospheric substorm a very large number of charged particles reach the atmosphere together, causing a very bright aurora.

This experiment will attempt to create a substorm by injecting an artificial barium plasma at the precise moment which the magnetosphere is unstable, "pushing the magnetosphere over the edge." Since barium ions can be seen glowing in sunlight (the particles normally there cannot), scientists will be able to obtain a clear visual picture of the magnetic substorm creation and its behavior.

G-11, G-12: Mirror Force, Field Equipotentiality, Ambipolar Acceleration. Principal Investigator: Gene M. Wescott, University of Alaska.

As the release of barium ions flows along magnetic field lines, it will be affected by electric fields as well. By tracking the details of the ions' motion, these electric fields can be measured. Such electric fields are important in controlling inter-hemispheric flows of electrons and ions.

The releases over the Caribbean will fill the entire magnetic field line over the equator and down to the other end in South America. Observations from ground and aircraft observatories in the Caribbean and South America will pinpoint the details of the ion motions.

G-13, G-14: Critical Velocity Ionization. Principal Investigator: Gene M. Wescott, University of Alaska.

The objective of these releases is to investigate the critical ionization velocity phenomenon, first proposed by Alfven to explain mass differentiation in planetary formation -- why the inner planets are made of heavy material and the outer planets are mostly hydrogen.

The critical ionization velocity model states that if the relative velocity of electrically neutral chemical species and a magnetized plasma is large enough, ionization of the neutral gas will take place even though the energy available is less than that required for ionization.

Barium, calcium and strontium will be released in these experiments. These materials have a range of critical ionization velocities, allowing study of the effect over a wide range of this parameter.

DETAILED PLAN: NASA CRRES SOUNDING ROCKET EXPERIMENTS

In addition to the releases from the CRRES spacecraft, the CRRES program includes chemical-release experiments from several sounding rockets. Two sounding-rocket campaigns are planned, one from Kwajalein in the Marshall Islands in July and August 1990 and the other from Puerto Rico in June and July 1991:

AA-1: F-Region Irregularity Evolution. Principal Investigators: Herbert C. Carlson, Air Force Geophysics Laboratory; Frank T. Djuth, The Aerospace Corporation.

The reflection of high-frequency (HF) radio waves by a smooth, conducting ionosphere allows reception of AM radio, long-range HF communications and over-the-horizon surveillance radar. When stressed, the ionosphere "fractures" along the direction of the magnetic field and acts like a picket fence to scatter radio waves.

This experiment and a companion, AA-7, will stimulate this plasma fracturing process with large barium releases in the F and E regions of the lower ionosphere over the Arecibo, Puerto Rico, radar site. The radar will diagnose the details of the structuring while airborne instruments monitor fading and disruption of satellite radio signals. Comparing these observations to theoretical predictions will provide an acid test of present understanding of principles of plasma physics with far-reaching implications.

AA-2: HF Ionospheric Modification of Barium Plasma. Principal Investigators: Frank T. Djuth, The Aerospace Corporation; Lewis M. Duncan, Clemson University.

The Arecibo High-Frequency Radio Ionospheric Heater can beam powerful radio waves into the ionosphere. These radio waves, with millions of watts of effective power, can "push the ionosphere around" and create significant perturbations and structures.

In this experiment, a heavy barium plasma will replace the natural light ionosphere plasma (normally hydrogen and oxygen) in the beam of the radio wave heater. The heater beam will be turned on the heavy plasma and scientists can see its response to the perturbations and compare the results to heater experiments with the natural ionosphere.

AA-3: HF-Induced Ionospheric Striations and Differential Ion Expansion. Principal Investigators: Edward P Szczuzcewicz, Science Applications International Corporation; Lewis M. Duncan, Clemson University.

This experiment has two sets of objectives. The first is to release a small tracer amount of barium into an ionospheric region that has been heated and disturbed by the Arecibo transmitter, making the heater-induced perturbations visible. This experiment complements the previous barium plasma heating experiment and enlarges the area under study.

The second objective is a study of multi-ion expansion processes. Since ions are electrically charged, they interact through long-range electrical forces, not just by physical collisions. Many natural processes, such as the population of the magnetosphere with upward flowing ions from the ionosphere and the expansion of the atmospheres of stars, involve ions of more than one type or mass. The presence of one type of ion can have a strong influence on another.

Canisters of lithium (a light ion, mass = 7) and barium (a heavy ion, mass = 137) will be released. As the expanding ion clouds sweep past the rocket, on-board instruments will study the details of the clouds and their complex interactions.

AA-4: Ionospheric Focused Heating. Principal Investigator: Paul A. Bernhardt, Naval Research Laboratory.

The ionosphere bends radio waves just like a lens or prism bends light. A chemical release will create a spherical lens in the ionosphere focusing waves from a high-power ground transmitter into a powerful beam travelling upward. The power density input level is expected to be 10 to 100 times the level it would be without focusing.

The Arecibo radar and instruments will study how the ionosphere is changed by this focused radio beam. This will be important to the understand of how the ionosphere responds to natural energy inputs from magnetic storms and solar flares.

AA-5, AA-6: Equatorial Instability Seeding. Principal Investigator: Michael M. Mendillo, Boston University.

The ionosphere near the Equator, where the magnetic field is horizontal, suffers from natural perturbations known as Spread-F. The normally smooth ionosphere breaks up and radio wave signals are distorted.

These experiments will release sulfur hexafluoride, which will start a "bubble" at the bottom of the ionosphere and trigger artificial Spread-F. This will allow study of the growth and decay of this effect with a controlled experiment. In these experiments, one rocket will deploy the ionospheric depletion chemical, and a second will carry instruments to diagnose the release effects.

AA-7: E-Region Image Formation. Principal Investigator: Herbert C. Carlson, Air Force Geophysics Laboratory.

The ionosphere is divided into layers, designated D, E and F (from lowest to highest). The layers are connected by magnetic field lines, which allow particles to travel between regions.

A large barium release in the F-region will be placed so the connected E-region is directly over the Arecibo radar. The artificial cloud in the F-region will create an image in the E-region that can be mapped by the radar, allowing scientists to study the strength and speed of inter-region ionospheric coupling.

DEPARTMENT OF DEFENSE EXPERIMENTS

More than 50 DOD scientific instruments will be operating aboard CRRES, including a microelectronics package, experimental high-efficiency solar panels and instruments to investigate the effects of solar flares and cosmic rays on the Earth's magnetosphere and radiation belts. Instruments to support the perigee observations include two pulsed plasma probes (a very low frequency wave analyzer with two electric field antennas), a magnetic field loop antenna and a quadrupole ion mass spectrometer.

Some DOD scientific instruments on CRRES will complement the CRRES chemical science mission, measuring the effects of the releases at close range. For some of the releases, the instruments will measure the state of particles and waves in the magnetosphere and assess if a large magnetic storm is imminent. This will help scientists determine the best time to conduct a release. The five main DOD experiments:

- o The High Efficiency Solar Panel (HESP): This experiment will help determine the performance of experimental gallium arsenide solar panels under the effects of natural radiation and under ambient and heated conditions.

- o Spacerad: Consisting of approximately 30 instruments, Spacerad will expose microelectronics to space radiation, measuring the ambient environment (magnetic and electric fields, plasma, particles, waves, etc.). The two pairs of long wire booms that extend up to 50 meters from the spacecraft are part of the Spacerad experiments.

- o Solar Flare Isotopes: This experiment will measure cosmic ray particles and heavy ion composition in the magnetosphere.

- o Energetic Particles and Ion Composition: This experiment will measure the intensity, energy and pitch angles of low-, medium- and high-energy ambient ions.

- o Low Altitude Scientific Studies on Ionospheric Irregularities (LASSI): This experiment will conduct a set of observations near the perigee of selected CRRES orbits during chemical releases. These observations will help scientists study and compare natural and artificial ionospheric disturbances and the effects of these disturbances on communications to and from the satellite.

(Detailed description of USAF experiments is available from USAF public information representatives)

CRRES Program Experiments

Experiment	Release no.	Chemical	Location	Altitude	Release Period
SATELLITE EXPERIMENTS					
Critical Velocity					
Critical Velocity Ionization	G-13	Strontium Barium	Am. Samoa	270-360 mi.	Sept. 1990
	G-14	Calcium Barium	Am. Samoa	270-360 mi.	Sept. 1990
High-Altitude Magnetospheric					
Diagmagnetic Cavity,	G-1	Barium	N. America	1.3 Re*	Jan-Feb 1991
Plasma Coupling	G-2	Barium	N. America	1.8 Re	Jan-Feb 1991
	G-3	Barium	N. America	3.5	Jan-Feb 1991
	G-4	Barium	N. America	5.5	Jan-Feb 1991
Stimulated Electron/ Aurora Production	G-5	Lithium	N. America	>6.0 Re	Jan-Feb 1991
Stimulated Ion-Cyclotron Waves and Ion Precip.	G-6	Lithium	N.America	>6.0 Re	Jan-Feb 1991
Ion Tracing and Acceleration	G-7	Lithium	N. America	>6.0 Re	Jan-Feb 1991
Velocity Distribution Relaxation	G-9	Barium	Caribbean		June-July 1991
Caribbean Perigee					
Grav. Instability Field Equipotentiality	G-8	Barium	Caribbean	270-480 mi.	June-July 1991
Field Line Tracing and Equipotentiality	G-10	Barium	Caribbean	270-480 mi	June-July 1991
	G-11	Barium	Caribbean	270-480 mi	June-July 1991
	G-11A	Barium	Caribbean	270-480 mi	June-July 1991
	G-12	Barium	Caribbean	270-480 mi	June-July 1991
	G-12A	Barium	Caribbean	270-480 mi	June-July 1991

*Re=Earth radii

CRRES PROGRAM EXPERIMENTS

Experiment	Release no.	Chemical	Location	Altitude	Release Period
SOUNDING ROCKET EXPERIMENTS					
Kwajalein					
Equatorial	AA-5	SF6*	Kwajalein	240 mi	Jul.-Aug. 1990
Instability Seeding	AA-6A	SF6	Kwajalein	150 mi	Jul.-Aug. 1990
	AA-6B	SF6	Kwajalein	150 mi	Jul.-Aug. 1990
Puerto Rican Rockets					
F-Region Irregularity Evolution	AA-1	Barium	Puerto Rico	150 mi	June-July 1991
HF Ionospheric Modification of a Barium Plasma	AA-2	Barium	Puerto Rico	150 mi	June-July 1991
E-Region Image Formation	AA-7	Barium	Puerto Rico	150 mi	June-July 1991
HF-Induced Ion	AA-3	Barium	Puerto Rico	90-240 mi	June-July 1991
Striation/Differential		Barium	Puerto Rico	90-240 mi	June-July 1991
Ion Expansion		Barium	Puerto Rico	90-240 mi	June-July 1991
		SF6	Puerto Rico	90-240 mi	June-July 1991
Ionospeheric Focused Heating	AA-4	SF6	Puerto Rico	210-240 mi	June-July 1991

*SF6=Sulfur hexafluoride

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