

Space News Roundup

Vol. 26 No. 3

February 6, 1987

National Aeronautics and Space Administration

News Briefs

Ben Guerir approved

NASA and the Royal Moroccan Air Force have concluded an agreement under which Morocco will permit the use of Ben Guerir airport, near Casablanca, as an emergency landing site for the Space Shuttle. The agreement, under discussion since last summer, provides for a landing site and recovery operations in the event of a trans-Atlantic abort on missions launching out of the Kennedy Space Center. The agreement was signed by NASA Administrator Dr. James C. Fletcher and Moroccan General Kabbaj, the Inspector of the Royal Moroccan Air Force. Activities are currently underway to make the facility ready to support Shuttle launch activity next year. The new landing site was necessary due to weather and safety concerns associated with TAL aborts to Dakar, Senegal.

JPL gets new lab

A groundbreaking ceremony was held Jan. 21 at the Jet Propulsion Laboratory for a new Microelectronics Laboratory. On the same day, an agreement was signed between NASA and the California Institute of Technology for the establishment of a Center for Space Microelectronics Technology, to be housed in the new facility. The Center will provide long range supporting research and development in advanced microelectronics for a wide range of U.S. space-related efforts. JPL Director Dr. Lew Allen said the new facility will make JPL a national center for excellence in selected parts of space microelectronics. During 1986, JPL's microelectronics program highlights included fabrication of a superconducting tunnel junction detector for sub-millimeter wave astronomy. JPL is a division of Caltech, operated for NASA.

Block II designs in

Five companies have submitted designs for second generation Shuttle solid rocket boosters. The Block II designs were submitted to NASA in December. The designs are now under consideration and recommendations are expected in the spring. Marshall Space Flight Center Director J. R. Thompson told the Senate Science, Technology and Space Subcommittee Jan. 22. NASA awarded \$500,000 contracts in September to Aerojet Strategic Propulsion Co., Atlantic Research Corp., United Technologies, Hercules Aerospace and Morton Thiokol.

Rocket launch successful

The Goddard Space Flight Center's Wallops Flight Facility successfully launched a sounding rocket carrying a University of Pittsburgh experiment for studying the atmosphere from the White Sands Missile Range at 1:15 p.m. CST Jan. 28. The two-stage Terrier-Black Brant rocket lofted the scientific payload weighing 1,044 pounds to an altitude of 159 statute miles. The payload consisted of a multipurpose platform containing 11 instruments designed to study airglow and ionospheric processes in the Earth's atmosphere. The objective of the launch was to study how the Sun affects the Earth's environment. This experiment package was flown successfully a year ago, recovered, and refurbished for the Jan. 28 flight.

ATAC chairman picked

Robert A. Nunamaker, Director of Space at Langley, has been appointed as Chairman of the Advanced Technology Advisory Committee (ATAC) by NASA Administrator James C. Fletcher. Nunamaker succeeds JSC Director Aaron Cohen as chairman of ATAC, which was established in conjunction with the Space Station program to identify specific systems that advance automation and robotics technologies.

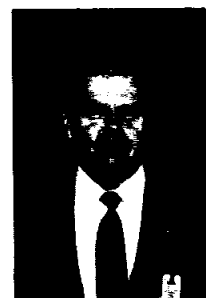


A Great Blue Heron enjoys the spring-like weather of late January from a rocky outcropping along the banks of one of JSC's ponds. JSC employee Jack Jacob captured the bird on film as it balanced in a characteristic one-legged stance.

New posts go to MOD veterans

Three veterans of the manned spaceflight program, representing a combined 70 years of NASA experience, have been given new assignments, Eugene Kranz, Director of Mission Operations, said.

Effective immediately, John W. O'Neill becomes Acting Deputy Director of the Mission Operations Directorate. Charles R. Lewis becomes Assistant to the Director, MOD, for Space Station Operations. Donald R. Puddy, Assistant Director for Systems, MOD, is on temporary assignment to NASA Headquarters.



John W. O'Neill

O'Neill has held several key positions in MOD. His most recent assignment has been as Assistant Director for Operations. He was Chief of the MOD Operations Division Chief, 1981-85; Chief of the Payload Operations Division, Operations Directorate, 1980-81; Assistant Division Chief for Operations, Flight Control Division, 1974-80, and Chief of the Flight Planning Branch, Crew Procedures Division, 1967-74.



Charles R. Lewis

He also served as head of the Thermo-Mechanical (Continued on page 2)

Space Station support RFPs out

NASA has issued a request for proposals to U.S. industry for a Program Support Contractor (PSC) to assist the Space Station Program Office in Washington, D.C., with systems engineering, analysis and integration activities and also to support field offices to be established at five NASA centers. Proposals are due April 3.

The PSC will assist the Space Station program office in assuring that top-level system design considerations are preserved, that the program goals of productivity and versatility to achieve user needs are achieved and that NASA's goals

of flight safety and cost effective performance are met.

The program office is responsible for overall development of the Space Station, including engineering analysis, program planning and control, resources, configuration management and integration of all elements into an operating system.

A major portion of the systems integration will be performed at NASA centers through Space Station field offices to be established at Goddard Space Flight Center, JSC, Kennedy Space Center, Lewis Research Center and Marshall Space Flight Center.

The PSC is the third major request for proposals to be issued in support of future Space Station development activities. The technical and management information system and software support environment RFPs currently are under evaluation. Contracts are expected to be awarded in April and May, respectively. The program support contract is expected to be awarded in July.

NASA also is expected to issue, in the near future, RFPs for the detailed design and development of Space Station hardware and systems.

Debris becomes orbiting hazard

Editor's note: Since 1976, JSC scientists have been studying orbital debris to learn more about the nature of man-made objects and fragments circling the Earth, the means by which they proliferate and ways to control and protect against the problem. This is the first of two articles.

By Kelly Humphries

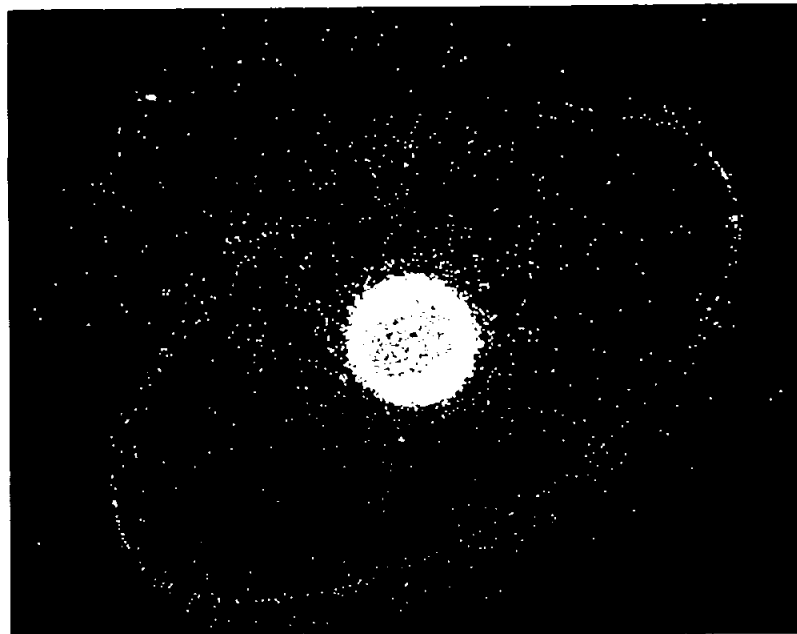
Rings are forming around the Earth.

"We already have them," said Joe Loftus, JSC's Assistant Director for Plans, "they are just awfully thin."

Rings are not unusual in the Solar System. But Earth's rings are being formed out of man-made orbital debris instead of the natural rocks, dust and ice that encircle other planets. As humans increase their activity in space, they are taking with them one of their most insidious problems — pollution.

There are an estimated 4 million pounds of man-made material in Earth orbit today. Approximately 95 percent of that mass is debris. The current launch rate of Earth's spacefaring nations puts an additional 1.8 million pounds into orbit each year, and is expected to increase to nearly 2.7 million pounds a year by the year 2000.

By that time, if current models and forecasts hold true, there will be 9.5 million pounds of man-made material circling the planet. And those forecasts factor in the material that reenters the atmosphere.



Just as pollution creates immediate and long-term hazards on Earth, debris poses immediate hazards in orbit and has broad implications for the future of space exploration. JSC scientists, among the world's foremost experts on the subject, warn that orbital debris is a growing hazard to space vehicles and that it could have far-reaching effects on launch vehicles, payload design, the Space Station, orbit selection and international relations.

"I don't think you can have a long-term presence of man in orbit without these studies," said Don Kessler, the project scientist for

orbital debris studies who has been investigating the problem of both natural and man-made particles in space off and on since 1962. "Today, we're at the threshold of (a heightened) level of concern because it's making a design difference."

"Understanding orbital debris really is the most important part of trying to maintain a manned space presence," said Burton Cour-Palais, a senior JSC scientist working on the project. "I am personally concerned that we have created a situation that is going to have to be stopped or limited."

Before designs and operations practices can be changed, however,

the makeup of debris must be understood, Loftus said. Scientists have had an excellent working knowledge of natural meteoroids for years, but are only beginning to understand man-made orbital debris.

Efforts to characterize the orbital debris environment involve optical, radar and infrared measurements, inspections of satellite and spacecraft parts that have been returned to Earth, laboratory experiments with launchers that boost particles to hypervelocity (which begins at about 3 kilometers per second) and computer modeling, Kessler said.

"What kind of stuff is in orbit?" Loftus asked. "Only five percent of it is payloads that are still operating; 21 percent is payloads that no longer are operating; 25 percent is spent stages, miscellaneous pieces of gear; 49 percent of the objects are breakup debris."

A late 1985 "box score" put out by NORAD (North American Aerospace Defense Command) and the Goddard Space Flight Center listed 6,194 radar-trackable objects—baseball-sized and larger—in space. Of those, 1,582 are payloads, 68 are interplanetary probes, 4,488 are pieces of orbital debris, and 56 are interplanetary probe debris.

In addition to trackable objects, Kessler said, there are about 30,000 marble- to baseball-sized objects, trillions of tiny paint flakes, and tens of hundreds of trillions of still smaller aluminum oxide dust-size (Continued on page 3)

Bulletin Board

Sixth Annual JAIPCC Minisymposium set for March

The Sixth Annual Joint Applications in Instrumentation, Process and Computer Control Minisymposium will be held from 9 a.m. to 4 p.m. March 12 at the University of Houston-Clear Lake. The minisymposium offers engineers the chance to bring their work to the attention of their peers and to exchange ideas. Abstracts of not more than 250 words are being invited in the following areas: aerospace and aeronautics, artificial intelligence, computer simulation, control systems, electro-optics and fiber optics, energy systems, metrology, petroleum and petrochemicals, process management systems and robotics and expert systems. The deadline for submission of abstracts is Feb. 17. The sessions are being sponsored by the local sections of the Institute of Electrical and Electronic Engineers and the Instrument Society of America in cooperation with the University of Houston-Clear Lake. For more information, call Wade Webster at x30147.

JSC Fitness Program evaluation results due

Results of a three-year evaluation of the JSC Physical Fitness Program will be presented by Coordinator Larry Wier and Mary Pinkerton at 10 a.m. Feb. 18 in the Bldg. 30 Auditorium. Pinkerton will explain the basics of fitness programming. Wier will present an analysis of data from the physical fitness tests and medical examinations recorded before and after long-term participation in the program. All of the people included in the study are JSC employees.

Credit Union elections are March 5

Members of the JSC Federal Credit Union are reminded that elections for three directors to the board will be held March 5. Members may vote for the directors in the lobby of the Credit Union during normal business hours, or during the annual meeting at 7 p.m. that evening. For more information, call Molly Springer at 488-7070.

EAA sponsoring Valentine's dinner/dance

The Employee Activities Association will sponsor a Valentine's Day dinner and dance beginning at 7 p.m. Feb. 14 at the Gilruth Recreation Center. The evening begins with a social hour at 7 p.m., followed by a chicken cordon bleu dinner at 8 p.m. and dancing from 9 p.m. to 1 a.m. The cost is \$10 per person, and tickets are on sale through Feb. 11 at the Bldg. 11 Exchange Store. For more information, call Larry Davis at x38055.

IEEE Video conference is Feb. 26

Optical disc issues will be the topic at the next video conference Feb. 26, sponsored by the Clear Lake Council of Technical Societies, the Institute of Electrical and Electronic Engineers and the Instrument Society of America. The one-day video conference will be held from 9:30 a.m. to 3:30 p.m. at the Gilruth Recreation Center. The program is intended to acquaint the viewer with the basics of optical disc technology and its impact in the market place. Issues such as interactive video disc, compact disc, CD-ROM, CD-Interactive and InfoWindow will be discussed. Advanced registration is required. For more information, call Ray Baker at x30078 or Bill Densmore at x30069.

AIAA creates Management Technical Committee

The Houston Section of the American Institute of Aeronautics and Astronautics has created a new Management Technical Committee to focus primarily on project management. The membership of the new committee has plans for several Lunch and Learn sessions in the coming year and hopes to host a national conference on project management during Spaceweek 1988. For more information on the group, call Carlos Campos at x31136 or Chris Cummins at x30354.

Gem and Mineral Show set for Feb. 21 & 22

The Clear Lake Gem and Mineral Society will hold its 12th Annual Gem, Mineral and Jewelry Show Feb. 21 and 22 at the Pasadena Convention Center. The show will feature demonstrations of lapidary, faceting and diamond sawing of rocks, and children will be able to participate in other hands-on projects. Door prizes, as well as a grand prizes of a rutilated quartz pendant set in 14K gold, will be given. Show hours are 9 a.m. to 8 p.m. Feb. 21 and 10 a.m. to 5 p.m. Feb. 22. The Convention Center is located at 7902 Fairmont Parkway in Pasadena. For more information, call Mack Robinson at x30803.

EAA sponsors NASA days at Rodeo

Several of the performances scheduled for the upcoming Houston Livestock Show and Rodeo will be available at reduced prices to NASA employees, thanks to the Employee Activities Association. The regular \$8.50 tickets are now on sale at the Bldg. 11 Exchange Store for \$7, limit 6 tickets per employee. Shows included in the deal are Julio Iglesias on Feb. 26, Larry Gatlin & the Gatlin Bros. Feb. 27; Reba McEntire and Dan Seals March 1; Chicaco March 3; Conway Twitty on March 7 and Crystal Gayle and Gary Morris on March 8.

PSI to hold next meeting Feb. 11

The next meeting of the Clear Lake/NASA Area Chapter of Professional Secretaries International will be at 5:30 p.m. Feb. 11 at the Holiday Inn on NASA Road 1. The social and dinner will include a business meeting at 7 p.m. The featured speaker will be Patrick Dunne, Massey Business College whose topic will be "A Writing Technique." All clerks and secretaries, GS-3 and above, are encouraged to attend. Meetings are held the second Wednesday of each month. For more information, call Jesse Gilmore at x32739 or Beverly Anderson at x32042.

Gilruth Center News

Call x30304 for more information

Physical fitness — The next 12-week course of the JSC Physical Fitness Program will be offered April 6-June 26 from 11 a.m. to noon or 4-5 p.m. All NASA and contractor employees and dependents are eligible upon completion of an acceptable physical exam and a maximal treadmill stress test. Call x30302 for more information.

Defensive driving — Learn to drive safely and qualify for a 10-percent reduction in auto insurance for the next three years. This all-day Saturday class, taught by a representative of the Safety Council of Greater Houston, meets 8 a.m. to 5 p.m. March 21 and April 25.

Beginning weight safety — This is a required course for JSC employees interested in using the Rec Center weight room. The class will be offered Feb. 25 and March 11 from 8-9:30 p.m. Cost is \$4.

St. Patrick's Day 5K — Five-kilometer run will begin at 9 a.m. Saturday, March 14. Preregistration by March 11 costs \$6. Late registration costs \$8. T-shirts and awards will be given.



Cynthia Kohrs



Patricia Ford



Rosie Hernandez

Secretaries receive recognition

Three JSC employees recently earned the Marilyn J. Bocking Secretarial Excellence Award for outstanding overall performance of their duties. Cynthia K. Kohrs, Patricia K. Ford and Rosie S. Hernandez each received a plaque and \$500 in recognition of their service.

Kohrs serves as private secretary to the Tracking and Communications Division chief, and directs the support services of junior secretaries. She was specifically cited for organizing schedules and action items for all division activities associated with the 51-L accident, serving as the

Division contact to the Directorate, and for becoming her Division's central point of contact for regulatory policies and procedures.

Hernandez serves as secretary to the Manager, Customer Integration Office, dealing with many JSC employees and outside contacts, and guiding other secretaries in administrative procedures. She developed and administers office procedures for status reporting and analysis of action items and travel documents, serves as a "goodwill ambassador" for the Space Station users community, and assists the

branch manager's work in serving as co-chair of the Washington-based Space Station Operations Task Force.

Ford provides secretarial, clerical and administrative support to the Thermal Branch of the Structures and Mechanics Division. She has developed standard word processing formats for almost every existing form used by the branch, and was instrumental in providing timely, accurate documentation of extensive 51-L thermal analyses performed by the branch in support of the Failure Scenario Team.

Families send open letter to America

On the anniversary of the *Challenger* 51-L accident, the families of the astronauts who died released an open letter to express their feelings about their loved ones, their gratitude for the support of the American people, and their plans to continue the mission through the *Challenger* Center. Here is the text of that message:

"One year ago, we shared a terrible loss with you. The *Challenger* crew were our husbands, wife, brothers, sisters, mother, fathers, daughters, and sons—the fundamental, irreplaceable people in the fabric of our lives. At the same time, they were an intrinsic part of national life too, part of that great extended family known as 'Americans.' They were pioneers. Together we mourned them and the shortness of their lives. But, in their short time, they contributed mightily.

"They were not people who cherished the soft and easy life, but people who worked hard to extend the reach of humanity no matter what the sacrifice. They risked their lives not for the sake of aimless adventure, but for the nation that gave them opportunity, and for the space frontier which was an

extension of its spirit. They were scientists and teachers guiding us to space. *Challenger's* mission—to give ordinary Americans access to space, to push scientific discovery forward—was a culmination of their work, a fulfillment of their hopes, and an expression of their being.

"Since their loss, we have been troubled by the incompleteness of their mission. Lessons were left untaught, scientific and engineering problems were left unsolved. Perhaps saddest of all is the idea that children must once again put their dreams and their excitement about the future 'on hold.' This is too great a loss, one we cannot accept.

"We wish to carry on *Challenger's* mission by creating a network of space learning centers all over the United States called, cumulatively, the *Challenger* Center. We envision places where children, teachers, and citizens can touch the future. We see them spending a day or a week in a large space-like station, consisting of flight simulators, observatories, laboratories, crew quarters and galleys. We see them using equipment, conducting scientific experiments, solving problems, working together in space-

like surroundings and growing accustomed to space technology. As a team, they can practice the precise gestures and the rigorous procedures that will be required of them on the space frontier. They can embrace the vision and grasp the potential of space too. Though it will take time and money to build, the *Challenger* Center is our idea of a fitting tribute, a celebration of our loved ones' lives, a triumph over their loss. We hope that by making space-like experiences accessible to all people, especially children, we can help prepare them for the day when they will take their own place among the stars.

"If they were alive and could speak to all Americans, we believe the *Challenger* crew would say this: 'Do not fear risk. All exploration, all growth is a calculated risk. Without challenge, people cannot reach their highest selves. Only if we can accept our problems as challenges can today's dreams become tomorrow's realities. Only if we are willing to walk over the edge can we become winners.'"

Letters and contributions may be sent to the *Challenger* Center, Box 90077, Washington, D.C., 20090.

Mission veterans get new assignments

(Continued from page 1)

Section, Flight Crew Support Division, 1963-66.

In his new assignment, Lewis will be responsible for coordinating and integrating all MOD Space Station interfaces. He has held several positions in MOD, including lead Flight Director for several Apollo, Apollo-Soyuz, Orbital Flight Test and STS missions. Lewis, who joined NASA in 1958 as an electrical engineering cop at the White Sands Missile Range, has been Chief of the Space Station Operations Integration Office, MOD, since 1985. He was Chief of the Flight Operations Integration Office, 1984; Flight Director for Space Shuttle Missions, 1978-83; Chief, Flight Training Branch, 1976-78; Chief, Communications and Data Systems Branch, 1974-76; Assistant Chief for Opera-

tions, Flight Operations and Recovery Branch, 1973-74; Assistant Flight Control Operations Branch Chief, 1969-73; Aerospace Technologist, Flight Operations Division, 1963-68, and Remote Site Capsule Communicator for NASA Space Task Group, 1962.

Puddy, who joined JSC in 1964 as a Flight Controller, was a Flight Director for several STS, Apollo, Skylab and Apollo-Soyuz missions.

Most recently he was Chief of the Mission Operations Systems Division, 1982-85; Chief of the Systems Division, 1981-82; Chief of the Mission Operations Branch, 1974-75; Assistant Chief of the Space Science and Technology Branch, 1972-74; Assistant Chief, Lunar Module Systems Branch, 1969-72, and Head of Lunar Module Systems Section, Lunar Module Systems Branch, 1966-69.



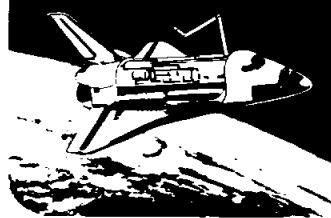
Donald R. Puddy

NASA
Lyndon B. Johnson Space Center

Space News Roundup

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Editor Brian Welch
Assistant Editor Kelly Humphries



ORBITAL DEBRIS

JSC scientists grapple with hazards of space-age pollution

(Continued from page 1)
particles. During hypervelocity impact events, particles as small as the largest paint flakes can be damaging or lethal.

The few trackable objects pose a relatively small hazard to spacecraft because they can be tracked using radar and telescopes, and then avoided. The vast numbers of smaller breakup debris particles present a hazard disproportionate to their size because they are "hidden" by the even greater vastness of space.

The first real proof that breakup debris was striking spacecraft was the S-149 particle collection experiment aboard Skylab, Kessler said. The purpose of the experiment was to look for meteoroid impacts, but researchers also found aluminum-lined pits characteristic of man-made debris hypervelocity impacts.

An examination of the Skylab IV command module windows in orbit in 1973-74 also turned up aluminum-lined pits probably caused by collisions with aluminum oxide particles from solid rocket motor exhaust.

Results of the Explorer 46 meteoroid bumper experiment conducted from 1972 to 1975 weren't published until 1983, but they gave researchers two important clues. The experiment showed that the direction of the particles hitting the bumpers was characteristic of an Earth-orbiting population and that the times of the impacts correlated with solid rocket motor firings in space.

A major milestone occurred in 1984, when ground telescope observations that allowed scientists to see marble-sized pieces of debris turned up eight times as many pieces as had been predicted using the NORAD catalogue alone, Kessler said. At about the same time, the first operational loss of a spacecraft part directly attributable to breakup debris occurred, Kessler said. The crew of STS-7 reported an impact crater on one of *Challenger's* windows, and the damage

was significant enough that the window had to be replaced after landing.

Within weeks of the STS-7 incident, the Soviet's Salyut 7 reported a similar window impact. The crew of that craft reported actually hearing the impact, Kessler said.

In April 1984, astronauts repaired the Solar Maximum Mission satellite in orbit during STS 41-C and returned to Earth with 15 square feet of the satellite's insulation blanket and 10 square feet of aluminum louvers that had been exposed to space for 50 months. JSC scientists found many more pits and holes than expected—thousands of pits, and 32 holes per square foot in the insulation and 6 holes per square foot in the louvers. Chemical analysis of the pits showed most were caused by collisions with paint flakes.

Launch operations, explosion of propellants remaining aboard spent rocket stages, collision with other pieces or some combination of factors are the most common creators of breakup. Collisions, however, are of particular interest to debris investigators because of the extremely high relative speeds of objects in orbit.

"In a collision, where you have a 10-pound mass hit a 1,000-pound stage, you multiply 10 times 25,000 feet per second squared and there's an enormous amount of energy," Loftus said. "Such an event creates 4 million particles and 10,000 bigger pieces. That's why the collision event is so significant."

"We have been developing techniques to determine if breakups are caused by explosion or collision," Kessler said. "That's important for two reasons. One, if it was

caused by an explosion there are fewer small fragments generally and it's fixable by the person that launched it (in terms of preventing future events). Two, if it was caused by a collision it produces more small fragments and increases the hazard and means the space community soon must set policies not to allow this to happen."

One significant contributor to orbital debris was a series of seven Delta rocket second stage breakups. Investigators determined that the cause of the breakups, some of which occurred as much as three years after launch, was exploding unspent hypergolic fuels. Changes in Delta launch procedures, suggested by JSC scientists, were instituted in 1981 and appear to have solved the problem.

One of the most recent breakups in orbit was in November 1986, when a 9-month-old Ariane third stage booster broke up. About 460 fragments of the spent stage are being tracked so far, Kessler said. Most appear to be less than a square meter in size, but the size range has not yet been determined. The debris is in a roughly polar sun-synchronous orbit at 98.70 degrees. The force of the breakup threw debris into orbits as low as 400 kilometers and as high as 1400 kilometers. JSC scientists have been working with European scientists involved in the Ariane program to help determine the cause of the November 13, 1986, breakup. Space Sciences Branch Chief Drew Potter, and scientists Karl Henize, Faith Vilas and John Stanley have been using the opportunity to take optical and infrared measurements of the fresh debris.

Astronomical observers of debris have three main objectives, Villas said. First, they are trying to learn more about the size, altitude and distribution of particles in low Earth orbit. Next, they are trying to determine the visual and infrared reflectivity and other observable characteristics of debris to verify or modify existing models. And,

she said, they are just beginning to develop a collision warning system for the Space Station.

Whatever the cause, breakups significantly increase the amount of mass and the number of pieces circling the globe, which is one of the reasons collisions are expected to become more frequent. And that makes the location of debris in orbit another important part of the information JSC's scientists have been working on, Loftus said.

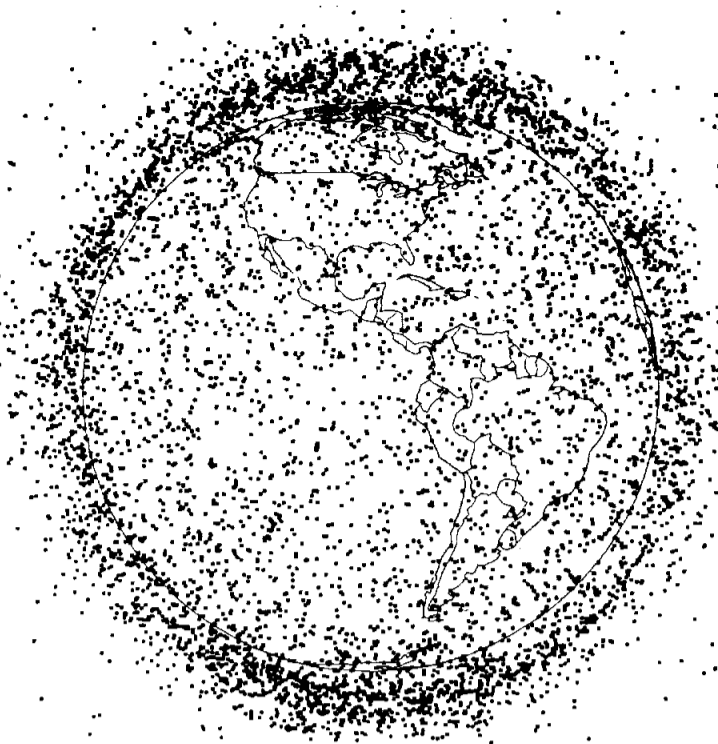
"Not only are things not evenly distributed in inclination, they are not uniformly distributed in altitude," he explained. Below about 500 kilometers, atmospheric drag causes most objects to reenter. "Eight hundred kilometers is Sun-synchronous altitude so you see a big peak there, and then it rapidly falls off to 2,500 kilometers and then there is a big peak at geosynchronous altitudes. In between, very little."

"We understand 60 to 70 percent of what's going on," said Cour-Palais. "With the onset of new materials and new orbital debris models that may change."

JSC scientists are using the knowledge they gain about debris to make computer models that can predict the probability of debris-spacecraft collisions. These probabilities are in turn being used to investigate possible protective measures.

"What we've been doing for the last 10 years for all intents and purposes is trying to understand what the real environment is by making more radar measurements, by making optical measurements, by examining things that we get back from space like the thermal panel from the Solar Max, and gradually we are getting more knowledge about what is there," Loftus said. "We are embarking on a series of studies to find out what various protective and preventive measures cost. We don't know the answer to that yet."

NEXT ISSUE:
Impact at hypervelocity



This computer-generated image shows the locations of the thousands of satellites, spent rocket stages and breakup debris in low Earth orbit. The same computer produced the image on page 1, which also shows the objects in geosynchronous orbit. Teledyne-Brown Engineering, one of the many contractors assisting JSC scientists in orbital debris studies, produced the images.



Burt Cour-Palais poses with a hypervelocity impact test result.

Don Kessler's many years on debris trail pan out

By Kelly Humphries

For years, Don Kessler has been telling his colleagues that man-made orbital debris—space junk—is becoming a serious threat to spaceflight.

Kessler's interest in orbital debris began in 1970 when he was finishing up studies of meteoroid flux for the Apollo program. Using the same modeling techniques he had used to study the probabilities of meteoroid collisions with Apollo spacecraft, he started asking himself: "Under what conditions and how long would it take for two trackable objects in orbit to collide?"

The surprising answer, he said, was that even then, in 1970, a spacecraft ran a bigger risk of running into another man-made object than of running into a 1-gram meteoroid.

He then started thinking about the natural processes that formed moons and rings around planets in the Solar System, and wondered how long it would take satellites and orbital debris to form a ring around Earth.

"Rings are nature's way of saying it doesn't like things in non-circular orbit out of Earth's equatorial plane. Nature wants to tear man-made objects apart to do the same thing," Kessler said.

"The bottom line is, it is just a question of when. The collision process of ring formation will start 10 or 20 years from now."

Kessler later worked for several years as a Skylab flight controller for corollary experiments, and then began studying the environmental impact of Space Shuttle launches and orbital solar power stations while working with people like Burt

Cour-Palais in the Environmental Effects Project Office. Kessler finally was able to delve back into his pet project. He justified spending 10 percent of his solar power station research time on orbital debris because "something that big is going to get hit."

In 1978, Kessler was back at a console, working for the Mission Planning and Analysis Division. While there, he learned how to use radar data and how to put them into his orbital debris models. He wrote a paper on orbital debris that became widely circulated and received so much attention that he was no longer able to spend just 10 percent of his time on the problem. He asked to be assigned to orbital debris studies full-time, and the request went clear to the top at JSC.

"Chris Kraft said we'd be crazy not to follow this," he said, and

soon Kessler was transferred to the Space Sciences Branch to work with many of his former colleagues from the Meteoroid Sciences Branch and Environmental Effects Project Office.

"It's become more and more evident as we gather data that the models Kessler has put together are correct," said Drew Potter, chief of the Space Sciences Branch, and one of those colleagues.

"I consider those 20 years as valuable training experience," said the man who started at JSC as a co-op in 1962. "The full experience of this center has been valuable. I wouldn't have done it any other way."

Kessler spends his personal time taking care of his home in Kirkwood South, scuba diving, and enjoying the shenanigans of his pet monkey, Abe, and ferret, Ferret.



Don Kessler

Roundup Swap Shop

All Swap Shop ads must be submitted on a JSC Form 1452. The forms may be obtained from the Forms Office. Deadline for submitting ads is 5 p.m. the first Wednesday after the date of publication. Send ads to Roundup, AP3, or deliver them to the Newsroom, Bldg. 2 Annex, Room 147. No phone in ads will be taken.

Property & Rentals

Sale/lease: Nassau Bay 2,200 sq. ft. townhouse, new carpet/paint, large garage, deck, atrium, 20 ft. FPL, \$890/mo. or \$119,900. Jerry, x38922 or 474-4310.

Lease: Eldorado Trace condo, 2-2, W/D, DW, FPL, drapes, pool, tennis, security sys., spa, \$400/mo. Rob, x35483 or 480-2997.

Lease: Glen Cove 4-2-2, tri-level, den, FPL, appliances, discount rent, \$600/mo. + \$500 deposit. 538-1816 or 332-3989.

Lease: Friendswood/Forest Bend 3-2, fenced, new paint, clean, good area, close to school, \$450/mo. 482-6609.

Sale/trade: Friendswood/Heritage Park 3-2-2, new section, custom drapes, clean, formal dining, large kitchen, fenced, FPL, will trade for house in CLC area. 482-6609.

Sale: Forest Bend townhouse, 2BR, quiet area, private ctyd., miniblinds, ex. cond., owner finance, \$500 down. Glen, x36541 or 486-0462.

Sale: Kemah/Bayview brick 3-2-2, large lot, built-ins, fans, CC schools, 1,400 sq. ft., owner finance, \$500 down. Glen, x36541 or 486-0462.

Sale: Camino South 3-2-2, DR, den w/FPL, cath. ceiling, rec room w/ bay window, ceramic tile & walk-in pantry, wet bar, fans, front and back patio, many other extras, asking \$76,320, neg. Tom, x38162 or 280-0689.

Sale: League City Countryside South 3-2-2, no down, non-qualify loan, VA assume, nice, \$760/mo. Mike, x33284 or 474-5228.

Sale: Seafarer Townhouse, 2-2-5-1, large loft, on golf course, FPL, custom blinds, immaculate, \$76,400. 488-5185.

Lease: Egret Bay 2-2-2 condo, all appliances, FPL, \$400/mo. + \$200 deposit. 486-8551.

Lease: Forest Bend townhouse, 2-1.5, \$400/mo. Marge, 338-2074.

Sale/lease: Sycamore Valley 3-2-2, new carpet, parquet, custom drapes, FPL, large backyd, w/activity gym, \$625/mo. or \$63,000. 481-9095.

Sale: CLC townhouse, 2-1.75, patio, on golf course, extra storage, 2-car covered parking, \$62,500, by owner. 488-6024.

Sale: 1/2 acre waterfront lot on Clear Creek, big trees, boat dock, septic, water, 5 min. to JSC. 335-1665.

Sale: '84 model mobile home, 14' x 58', 2-1, assume payments of \$225/mo., move to your location. Mutina, x36562 or 944-6730.

Rent: Heavenly Valley ski condo, Lake Tahoe, March 14-21, 2-1, sleeps 6, FPL, hot tub, 3 min. to lifts, 10 min. to casinos, 7 nights, \$900 + refundable \$300 deposit. Quin Shepperd, 486-7770.

Lease: West Galveston Island beach house, 3-2, furnished, by day/week/month. Ed Shumilak, x37686 or 482-7723.

Lease: Baywind I condo, 1-1, all appliances, pool, gameroom, tennis, \$350/mo. + 1 mo. deposit. Walt, x36353 or 532-4766.

Sale: Pipers Meadow 3-2-2A, open floor plan, w/2kitchen bars, FPL, gas util., widow seat in kitchen, brick veneer exterior, small patio in backyard, only 5 yrs. old, asking \$64,900. Michael, x35479 or 482-8496.

Lease: 3-2-2A house, FPL, references, no pets, deposit. 488-1301.

Sale: Pipers Meadow 3-2-2, covered deck, fenced, ex. cond., gas/elec., assumable FHA fixed, \$5K down, \$60s, 346 Wedgerock. 480-8280.

Cars & Trucks

'77 Mercedes 450SL dark brown convertible, must sell, \$1,200 under loan value, runs great, looks great, a steal. Mike, x33284 or 474-5228.

'78 Camaro Type LT, 350 4 bbl., 4-spd., dual exhaust, positraction, radials, gas shocks, new clutch, Z-28 suspension, 85K mi., \$3,200 OBO. Adams, x32567 or 488-3314.

'81 Chevy Chevette, AM/FM stereo, standard, low miles, ex. cond., red, \$1,295 OBO. Mills, x31544 or 481-1837.

'58 Chevy Impala convertible, white, black top, 348 cu. in., 4 spd., std. trans., one owner, low miles, \$4,400 OBO. Mills, x31544 or 481-1837.

'61 Chevy pickup, new motor, registered and inspected, \$800 OBO. 538-1816 or 332-3989.

'83 Ranger XLT pickup, 2.2L diesel, 4 spd., campertop, extras, 34K mi., \$5,200 OBO. Ken, x39845 or 944-0133.

'78 Buick LeSabre, low miles, AC, power, stereo, other options, outstanding. \$1,775. Charles, x37678 or 661-4789.

'84 Chevy Cavalier hatchback, 2 dr., 5 spd., cobalt blue, velour, AM/FM/cassette, cruise, AC, ex. cond., \$4,000. Cindy, 240-1674.

'84 GMC S-15 Jimmy, red/silver, chrome wheels, tinted windows, lots of

extras, sharp truck, \$7,400. Kelly, x34632 or (409) 925-1379.

'77 Chevy Monte Carlo, 350, auto, PS, PB, AC, AM/FM, swivel seats, \$1,000 OBO. Kyle, x33653 or 328-1883.

'71 VW Beetle, good work-car, \$800. L. Park, x58622 or 481-4372.

'78 Plymouth Arrow GT, 2 dr. hatchback, 5 spd., AC, stereo, ex. student or work car, \$1,000. Everett, x36224 or 488-6026.

'80 Mercury Capri, 6 cyl. std. trans., Sony stereo, new tires & brakes, gray/red int., ex. cond., \$1,700 OBO. Millie, x38502 or 486-9191.

'82 Audi 4000S, must sell, PS, AM/FM/cassette, AC, 80K mi., ex. cond., sacrifice at \$2,500. Jennifer, 326-5217.

'77 Champion Titan motor home, 33K mi., very clean, \$10,500. 559-2331.

'79 Ford Granada, 2 dr., AC, PS, PB, AM/FM/cassette, auto, low miles, \$1,695. Jim, 282-3183 or 482-2941.

'78 Chevy Camaro. Charlotte, x37470.

'79 Ford Custom van, 62K mi., 460 V-8, H/D trans/susp., AC, cassette stereo, PS,PAB, 2 captain's chairs, bay windows, carpet, sofabed, more, no rust, good cond. 532-3010.

'83 Ford Escort GL, 5 spd., AC, ex. cond., 41K mi., \$3,250 OBO. Dolores, x32864 or 335-1695.

'78 Chevy Malibu Classic station wagon, AC, PS, PB, radio, good family car, \$1,500 OBO. Walt, x36353 or 480-9280.

'74 Fiat X19, red with black removable targa top, runs well, must sell, \$500. 996-0981.

'77 Chevette, 4-spd., AC, AM/FM, steel belt radials, yes, it runs, \$750. Paul, 470-1466.

'76 Ford E150 van, auto, PS, PB, mag wheels, CB, carpet, \$1,800. 482-9172.

'76 Chevy Malibu, 4 dr., auto, 350 cu. in., new starter/muffler/tag/tires/shocks, recent trans. overhaul, runs very well, looks good, \$800. 333-2444.

Boats & Planes

Sunrunner 23' cabin, sleeps 4, head, galley w/stove & refrig., 228 HP Mercruiser IO, trim tabs, depth finder, 2 yr. old. Frances, x39199 or 332-4081.

'86 Ski Nautique and trailer, only 150 hrs., was promo boat, you get new warranty, immaculate, fresh water only, \$16,000. Rich, x38519 or 996-7630.

31' "Wood" Belize slip, 10'2" beam, 5' dr. full keel, diesel, loaded, truly by the wind sailor. Bailey, 337-1368.

New '86 Matzeler Bronoco S 10' inflatable dinghy, 4'10" beam, 882 lbs. cap., \$675; new '85 Johnson 6 HP std. shaft, \$695. Bailey, 337-1368.

'74 Catalina 27' sailboat, atomic 4 engine, mainsail w/3 head sails, galley, marine head, auto pilot, knot/depth instruments, WSI, recent bottom job, \$14,000. Dorothy, x33200.

Audiovisual & Computers

Sansui recvr., 70 w/chan., .05 THD, loaded w/jacks; TEAC cassette w/Dolby & preamp; Garrard Zero 100 turntable, Shure V-15 Type IV cartridge, \$375. 532-3010.

Heathkit H-8 computer w/H-19 terminal, 2 floppy drives, 64K memory, manuals, users group magazines, sacrifice, \$200 OBO. Dean, x31456 or 554-5933.

Okidata 93A IBM printer, w/parallel and serial ports, \$375; NEC spinwriter daisy wheel printer w/sheet guide and 6 print wheels and ribbons, \$750. Al, 480-2067, 8 a.m.-4 p.m.

Sony AV560 aud/vid receiver, 65 W/C, AM/FM, remote, \$225; Sony HF400 super Beta Hi-Fi stereo VCR, \$300; both less than 1 yr. old. Walker, 486-5313.

Kenwood 45 W/C receiver/amp, \$100 OBO; Advent spkrs., \$150/pr., both ex. cond. Walker, 486-5313.

Commodore 64 software, games, educational, productivity, Steve, x37625. Daisy wheel printer, TRS210 new in box, was \$600, now \$300 OBO; assorted software for TRS80 mod. 4. Mains, 486-5880.

Atari 800 computer, NEC char. generator, Atari 810 disk drive, printer, Atari 850 interface module, AC adaptors, manuals, software, games, floppies, all ex. cond., \$500. Wetherbee, x32747 or 333-1709.

TI 99/4A computer, expansion box, speech synthesizer, command modules, games, make reasonable offer. Bob, x30825 or 921-1715.

Heathkit 19" color TV, GR500, clock display, all manuals and test equip., some problems recently, \$50 OBO. Don, x37647 or 488-1024.

Bell & Howell oscilloscope, Heathkit 5" triggered sweep 5mhz bandwidth, \$50 OBO. Don, x37647 or 488-1024.

Hayes 1200B internal modem, w/ Smartcom II software, for IBM PC and compatibles, used infrequently, perfect

cond., \$225. Philips, 335-8527 or 480-4548.

Cycles

'75 Yamaha 125 Enduro, helmet, \$250. 482-9172.

'81 Honda CB750 custom, ex. cond., 7K mi., new battery, recent tuneup, \$1,500 OBO. Jana, x31653, or Brian, 480-5527.

'87 Honda TRX 250R four wheeler, less than 2 hrs. riding time, sacrifice, \$2,000. Jacques, x38111.

'83 Honda Nighthawk CB550, ex. cond., less than 2,000 mi., crash bar, 1 owner, \$1,500 OBO. Dean, x31456 or 554-5933.

Boys 20" BMX bicycle, \$50 OBO; girl's 16" bike, \$25 OBO. Joan, 532-2674.

Schwinn BMX bike, all chrome moly, 2 yrs. old, ex. cond., \$100. Bland, x488-5051.

Two 16" Strawberry Shortcake bikes, \$25 ea.; one 12" Hedstrom red tricycle, \$10; all in good cond. 554-2665.

Recreational

1980 Coleman light pop up camper, sleeps 6, propane stove, icebox, ex. cond., \$1,500. Joan, 532-2674.

Household

5 piece sectional sofa, tan, \$300. 482-9172.

White wicker bedroom set, double mattress/box spring, headboard, 3 drwr. chest, wall hangings, 5 shelf etagere, ex. cond., \$450. Jana, x31653 or 480-5527.

Magic Chef 4-burner gas stove, less than 1 yr. old, \$275 OBO. Shirley, x34270 or 337-2682.

Plaid sofa, 7' long, matching armchair, both good cond. 333-1709.

TV stand, \$30; modem, \$15. Lorraine, 480-3377, x64.

Montgomery Ward 14.5 cu. ft. white refrigerator w/ice maker, 3yr. old, \$260. Lillian, 333-6039 or 470-9533.

Kenmore cannister vacuum, all attachments except beater bar, \$20. Kelley, x32631.

Samsonite 4-pc. Concord luggage set, hanging bag, train case, 28" Pullman w/wheels, overnight case, maroon, \$75. Kelley, x32631.

L-shaped 7' hide-a-bed, herculon beige, 1yr. old, ex. cond., \$450 OBO; Heavy duty Kenmore washer & dryer, white, 2 yr. old, ex. cond., \$450 OBO. Janet, x38650 or 554-5968.

Brown velour recliner chair, \$25. 488-2652.

Queen size sleeper sofa and matching loveseat, covered in navy, cotton print, like new, \$600 for both. 480-2439.

15 gal. hot water heater; 15' formica bar top; 24" x 30" x 2" maple cutting board; new birch chairs; 4-ton AC, used 1 season. 554-2908.

Maple stained solid pine desk and chair, \$100. Todd, x32202 or 944-1082.

Rear bagger vacuum cleaner, self propelled, very gd. cond., \$90. Luis, x33141.

Speed Queen heavy duty washer, large capacity, runs but needs some work, \$75 OBO. 554-2908.

Matching pillow sofa & loveseat, earth tones, \$100; men's nearly new ski boots, size 9 1/2, \$90; Polaroid camera outfit, \$40. Bob Allgeier, 488-0397.

Rattan sectional couch, pillows need recovering, \$200. 538-1878.

Wanted

Roommate to share 2-2 condo, W/D, 1/2 util. + \$75 deposit, \$250/mo. Rick, x36156 or 480-1218.

Roommate to share 5BR house in Friendswood, hot tub, cable, W/D, microwave, FPL, rent includes util., \$225/mo. Rowena, x31670 or 996-9249.

Male or female roommate to share 3 BR League City house. Frances, x39199 or 332-4081.

Want drafting table, 40x60" top or larger. Chick, 538-3273.

Want Bell & Howell slide cube projector and library, working or not, for parts. Bruce, x37021 or Doris, x37545.

Want any NASA memorabilia, very serious collector. Gene, 476-9080.

Want barbell/dumbbell set, w/metal bar and plates (not vinyl coated concrete) of 150 lbs. or more. Brad, x31678 or 338-1252.

Want bookshelf, 5' to 6' tall, light or med. oak color. Brad, x31678 or 338-1252.

Male roommate to share 3 BR League city house, \$300/mo. + 1/2 util. Matt, 554-7735.

Want metal dog cage for 70 lb. dog. Sharon, x33395 or 486-4156.

Pets & Livestock

30-gal. aquarium, pump, lamp and accessories, \$25. Everett, x36224 or 488-6024.

Pit bull puppies, "PR" bred, UKC, males and females, \$150. 534-3487.

55-gal. aquarium, clean, ready to go, \$180 OBO. Ray, x30823 or 554-5434.

Gelding, 3 yr. old, green broke, Arabian/Quarterhorse, stabled at League City, \$500 OBO. Shirley, x34270 or 337-2682.

Boa constrictor, 6.5', easy to care for, great conversation piece, friendly, cage, gravel and hot rock included, \$150. Rich, x38519 or 996-7630.

Musical Instruments

5-piece drum set w/cymbal, \$425 OBO. Rusty, 485-3273 or Mark, 481-5498.

Olds silver chrome finish trumpet, good cond., \$175 OBO; H. Couf Royalist Cornet, silver chrome finish, w/case, \$200 OBO. Rick, 282-2714 or 559-2735.

Stelling banjo, Sunflower model, the world's finest banjo, \$1,300 OBO. Jim, x30639 or 334-3299.

Miscellaneous

HO train track, on 4x10 table, tunnels, bridges, many trains, parts and buildings, \$125. 335-1665.

Infant car seat for newborn, \$20. Everett, x36224.

New 36" Ninja sword, w/sheath and nylon cover, \$85. (409) 935-4675, lv. mssge.

Duraliner for Toyota LWB pickup, \$100 OBO. Shirley, x34270 or 337-2682.

Indian jewelry, silver & turquoise, several items. Chuck, 538-3273.

4-wheel utility trailer, can be rebuilt for many purposes, \$50. Bruce, x37201 or Doris, x37545.

Sears best treadmill, \$50 OBO; wooden wagon wheels, authentic, never used, \$250 ea. OBO. Mains, 486-5880.

Utility trailer, in usable cond., but needs work. Bob, x30825 or 921-1715.

4 new aircraft aluminum mag wheels, 8 spokes, 1.75 x 14, \$200. 488-2652.

Cargo trailer, 1,000 lb. capacity, 8" wheels w/spare, Sears 18 cu. ft. cargo carrier mounted on trailer deck, like new, \$150. 487-3799.

Yashica TL Electro X 35mm SLR, 50 mm 1.7 lens, Vivitar auto flash, 90-230 zoom lens, set of close up lenses, 2X converter, hard plastic case for all, \$235; Minolta SLR, 110, zoom, auto flash, \$75. 334-1934.

Four drawer metal file cabinet, \$40; Sears super 8 Easi Load movie camera w/pistol grip and 3 to 1 zoom lens, \$25. Steve, x56725.

Week of February 9 — 13, 1987

Monday — Beef & Barley Soup; Beef Chop Suey, Breaded Veal Cutlet w/Cream Gravy, Grilled Ham Steak, Wieners w/Baked Beans (Special); Buttered Rice, Brussels Sprouts, Whipped Potatoes. Standard Daily Items: Roast Beef, Baked Ham, Fried Chicken, Fried Fish, Chopped Sirloin. Selection of Salads, Sandwiches and Pies.

Tuesday — Celery Soup; Fried Shrimp, Pork Chop w/Applesauce, Turkey a la King, Pepper Steak (Special); Au Gratin Potatoes, Breaded Squash, Buttered Spinach.

Wednesday — Seafood Gumbo; Fried Catfish w/Hush Puppies, Braised Beef Ribs, Mexican Dinner (Special); Spanish Rice, Ranch Beans, Buttered Peas.

Thursday — Green Split Pea Soup; Corned Beef w/Cabbage & New Potatoes, Chicken & Dumplings, Tamales w/Chili, Hamburger Steak w/Onion Gravy (Special); Navy Beans, Buttered Cabbage, Green Beans.

Friday — Seafood Gumbo; Deviled Crabs, Broiled Halibut, Liver & Onions, BBQ Link (Special); Buttered Corn, Green Beans, New Potatoes.

Week of February 16 — 20, 1987

Monday — George Washington's Birthday Holiday.

Tuesday — Split Pea Soup; Meatballs & Spaghetti, Liver & Onions, Baked Ham w/Sauce, Corned Beef Hash (Special); Buttered Cabbage, Cream Style Corn, Whipped Potatoes.

Wednesday — Seafood Gumbo; Cheese Enchiladas, Roast Pork w/Dressing, BBQ Link (Special); Pinto Beans, Spanish Rice, Turnip Greens.

Thursday — Beef & Barley Soup; Roast Beef w/Dressing, Fried Perch, Chopped Sirloin, Chicken Fried Steak (Special); Whipped Potatoes, Peas & Carrots, Buttered Squash.

Friday — Seafood Gumbo; Fried Shrimp, Baked Fish, Beef Stroganoff, Fried Chicken (Special); Okra & Tomatoes, Buttered Broccoli, Carrots in Cream Sauce.

Week of February 23 — 27, 1987

Monday — Cream of Potato Soup; Franks & Sauerkraut, Pork Chop, Potato Baked Chicken, Meat Sauce & Spaghetti (Special); French Beans, Buttered Squash, Buttered Beans. Standard Daily Items: Roast Beef, Baked Ham, Fried Chicken, Fried Fish, Chopped Sirloin. Selection of Salads, Sandwiches and Pies.

Tuesday — Navy Bean Soup; Beef Stew, Liver & Onions, Shrimp Creole, Smothered Steak w/Dressing (Special); Corn, Rice, Cabbage, Peas.

Wednesday — Seafood Gumbo; Roast Beef, Baked Perch, Chicken Pan Pie, Salmon Croquette (Special); Mustard Greens, Italian Green Beans, Sliced Beets.

Thursday — Beef & Barley Soup; Beef Tacos, Diced Ham w/Lima Beans, Stuffed Cabbage (Special); Ranch Style Beans, Brussels Sprouts, Cream Style Corn.

Friday — Seafood Gumbo; Fried Shrimp, Deviled Crabs, Ham Steak, Salisbury Steak (Special); Buttered Carrots, Green Beans, June Peas.