NASA'S

ADVANCED COMMUNICATION TECHNOLOGY SATELLITE (ACTS)

EXPERIMENT OPPORTUNITY GUIDE

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NEW EXPERIMENT OPPORTUNITY WITH ACTS

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CLEVELAND, OHIO, 44135

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I. OPPORTUNITY DESCRIPTION

The National Aeronautics and Space Administration's (NASA) Glenn Research Center (GRC) in Cleveland, Ohio provides the **opportunity to propose additional experiments** using the Advanced Communications Technology Satellite (ACTS).

Experiments are now being sought in these specific areas to be conducted from 1998 through mid-2000:

- Demonstrations of future commercial satellite communication services in support of NASA and other government missions.

- Standards and protocols that test, characterize, validate, and promote the seamless interoperability of satellites with terrestrial networks.

- Characterization of the ACTS system and satellite operations in inclined orbit.

- New Ka-band technology and hardware verification for advanced communication satellite systems.

Proposals are welcomed from U. S. industry, government, and university organizations. Proposals from non-US organizations will be considered if sponsored by a US Satellite Industry partner who actively serves as the Principal Investigator. Company proprietary experiments can be accommodated.

The on-orbit operational life of the ACTS spacecraft and its communications payload will be extended from July 1998 through June 2000 by eliminating north-south stationkeeping maneuvers and operating the spacecraft in an inclined mode (See Appendix B). This operational period extension has created an opportunity to support additional experiments and user investigations starting immediately and continuing until the end of May 2000.

ACTS, an on-orbit, Ka-band test bed launched in September 1993, is testing, characterizing, and validating hopping spot beam technologies using advanced on-board switching and routing to evaluate and demonstrate new and more cost effective user applications as a forerunner to the next generation of commercial communications satellites. To date, over one hundred different industry, government, and university organizations have been involved in the ACTS Experiments Program. Since launch, a multitude of spacecraft and ground system technology experiments have been conducted. A comprehensive set of propagation measurements have also been collected. In addition, numerous user service and network application experiments, investigations, and demonstrations have been accomplished. On-demand voice, video, data, and other multimedia applications at data rates from kilobits per second to hundreds of megabit per second have been supported using ACTS. A more detailed description of the ACTS Program and an overview of the ACTS Communications System is presented in Appendix C.

A number of different types of earth stations have been developed and are being used in the various ACTS investigations (see Appendix D). These earth stations are currently being modified to include tracking for inclined orbit operations. Data rates from 2.4 kilobits per second (kbps) up to 622 megabits per second (Mbps) can be supported using one or another of these earth station types. Arrangements can be made to use these earth stations to conduct new experiments.

Experimenters will fund the conduct of their experiment. Also, an experimenter may be required to reimburse NASA for using the ACTS assets in accordance with the ACTS Usage policy which covers the government's reimbursement policy (see Section III G).

II. EXPERIMENTS PROGRAM

A comprehensive series of technical, user application, and propagation experiments, investigations, user trials and demonstrations have been carried out and completed using the ACTS system. However, there is a current emphasis to examine the use of commercial communication satellite systems and technologies to provide communication services for government missions. In addition, from previous experiments and investigations, additional concerns have been generated regarding the development or modification of network protocols and standards for efficient operation over satellite links. The ACTS on-orbit test bed provides a unique opportunity to address these concerns.

A. EXPERIMENT CATEGORIES

As ACTS enters its final phase of on-orbit operations, experiments are being solicited in a number of specific areas that are discussed below in their order of priority.

1. Demonstrations of future commercial satellite communication services in support of NASA and other Government missions using the ACTS testbed.

Previously NASA and other government agencies have designed, developed, and launched custom communication satellites dedicated to support given missions. A new generation of commercial communication satellites are being planned to provide high data rate, on-demand integrated voice, video, and data services. These systems have the potential to provide cost effective communication services in lieu of custom services. Government agencies including NASA and the DoD are being directed to examine the new commercial satellite systems and technologies to determine if they can be used to support their communications requirements. ACTS provides an excellent testbed with which to investigate the new generation of advanced service offerings and demonstrate the upcoming commercial systems capabilities to support various government missions. ACTS provides satellite manufacturers as well as earth station hardware, user interface, and network interface equipment providers an opportunity to demonstrate their capabilities to serve NASA and other government groups. It allows the government groups to “test drive” these advanced communication satellite services to understand their range of capabilities so as to be better able to tailor their communication system requirements to take advantage of future commercial offerings. In addition, joint trials and demonstrations will allow the commercial communication satellite teams to better understand the requirements of the Government Agencies.

2. Standards and protocols that promote and evaluate the seamless interoperability of satellites with terrestrial networks.

There is a need to assess the ability of satellite networks to connect seamlessly with existing and proposed terrestrial telecommunication networks if a truly global information infrastructure is to be realized. One of the barriers that inhibits the integration of satellites into the National Information Infrastructure (NII)/Global Information Infrastructure (GII) is communication standards and protocols that have been developed without considering the delay introduced by the round trip time to access a geostationary communication satellite. The standards in use and in development for the terrestrial networks are in some cases incompatible with satellite systems or render satellite networks very inefficient. This is the case with many aspects of Asynchronous Transfer Mode (ATM) and Transmission Control Protocol (TCP)/Internet Protocol (IP), the two driving protocols of the NII/GII. The communications industry is addressing these various incompatibility issues and examining a number of approaches to resolve the incompatibility. Potential areas of investigation include:

(1) ATM traffic management and congestion control related to satellite systems.
(2) ATM routing control - how satellite systems can participate in the routing protocols to include handover and signaling aspects.
(3) Modifications to TCP to account for the large bandwidth-delay satellite networks, to include such techniques as spoofing, protocol conversion, caching and TCP extensions.

ACTS provides an excellent test platform to collect data and information, to clearly define and characterize problems of network interoperability and inefficiency, and to test and validate protocol improvements.

3. Characterization of the ACTS satellite and systems operation in inclined orbit.

In the inclined orbit phase of ACTS operations, the opportunity exists to examine aspects of satellite and communication system operations where the spacecraft attitude control is relaxed when compared with its previous stringent pointing requirements. For example, this phase of operation provides an excellent opportunity to examine, test, and characterize various attitude control parameters and ranges of requirements as to their effects on the spot beams and the link parameters associated with them.

4. New Ka-band technology and hardware verification for advanced communications satellite systems.

A number of new communication satellite systems both commercial and government are being designed and developed. ACTS provides an opportunity to test various hardware components, subsystems, and systems (especially those associated with the earth stations) to characterize and/or validate their performance using a geostationary satellite link. In addition, network interface prototype designs or specific hardware implementations can also be tested and evaluated using ACTS.

B. PROPRIETARY EXPERIMENTS

Any experiment considered to have proprietary information either in the proposal or in its results may enter into an agreement with the NASA ACTS Program to keep such information or data protected. The experimenter will still be required to provide NASA with an evaluation of the results of the investigation to be used in the overall evaluation of the ACTS communication system. NASA would like to use the names of the participating organizations, the Principal Investigator, and the general type of investigation being conducted in publicizing the ACTS Program. According to the ACTS Usage Policy, proprietary experiments conducted exclusively for the benefit of an organization will be required to reimburse the government for its costs of conducting the experiment.

C. RESPONSIBILITIES

This section provides a general overview of the responsibilities of both NASA and the experimenter. When an experiment is accepted by NASA, a Space Act Agreement or other appropriate agreement will be prepared by NASA outlining the specific roles and responsibilities of each party.

1. NASA

The ACTS Program will provide to approved experimenters the following:

- ♦ Access to the spacecraft's baseband processor (BBP) or microwave switch matrix (MSM) communication channels and beacons during the experiment period (see Appendix C on the ACTS Communication System).
- ♦ Scheduling of all experiments so as to best meet the needs of all users.

- On-orbit spacecraft operations to ensure spacecraft station keeping and communication system functionality.

- Network operations via 1) the Master Control Station for the BBP mode of operation, 2) the Network Reference Terminal for the MSM Gigabit Network, 3) the GRC Link Evaluation Terminal for USAT, ACTS Mobile Terminal (AMT), and Broadband Aeronautical Terminal (BAT) using the MSM mode of operation.

- Access to engineering measurements from the spacecraft and network operations that are collected and available to the ACTS Operations Group.

- Assistance in coordinating the use of ACTS earth stations owned by NASA or other organizations.

- Access to NASA earth station facilities.

- Maintenance of all NASA owned earth stations.

- Technical assistance regarding the functionality of the various ACTS space or ground systems for developing an experiment proposal as well as technical support during the execution of the experiment.

- Assistance in identifying other organizations who may be interested in teaming on a proposed experiment.

2. EXPERIMENTER

Each experiment shall have a designated Principal Investigator. The Principal Investigator will be the point of contact with NASA. The Principal Investigator will have the overall responsibility for the investigation and the experiment team. The responsibilities of the Principal Investigator include:

- Prepare and submit the experiment proposal.

- Provide for the resources to conduct the experiment to include financial, personnel, facilities, as well as the necessary user application and test hardware.

- Enter into a Space Act Agreement or other appropriate agreement with NASA regarding the conduct of the experiment. The Space Act

Agreement or other appropriate agreement is a formal agreement between NASA and the experimenter that identifies the roles and responsibilities of each party.

- Coordinate with appropriate organizations on the shared use of an ACTS earth station(s) if appropriate. If relocating an earth station, responsible for obtaining the necessary permits and/or approvals required for installation including any site preparation requirements (telephone lines, etc.).

- Ensure that the experiment team is prepared to carry out the planned investigation.

- Provide weekly inputs to NASA regarding schedule requirements.

- Distribute the approved weekly schedules to team members and keep them informed of any schedule changes.

- Notify NASA if daily scheduled times cannot be used.

- Provide NASA with regular status reports on the progress of the experiment.

- Prepare and deliver to NASA a report on the analysis of the experiment within 120 days after the completion of the experiment.

D. EXPERIMENT OPERATIONS

ACTS generally operates 24 hours per day, 7 days per week, year round. Experiment operations however, are not supported during parts of the spring and fall equinox periods when the solar panels are eclipsed. Since ACTS is only experimental, batteries were provided to supply only essential spacecraft bus functions during eclipse periods to save weight and cost. During the 22 days before and after each peak eclipse period, the payload is shutdown so that only essential spacecraft bus functions remain operational. The payload is typically turned off only during the hours of 0530 - 0830 GMT which allows sufficient time on either side of the eclipse period to provide a graceful shutdown and a controlled reactivation of the payload components.

ACTS uses two types of on-board switching to interconnect its multiple spot beams and to route communications traffic to its appropriate destination. The baseband processor (BBP) uses on-board memory and circuit switching to effectively route traffic from small 1.2 meter (m) earth stations. The microwave switch matrix, a crossbar matrix switch (MSM), provides dynamic and static (bent pipe) beam-to-beam routing using a 3x3 configuration and 900 MHz bandwidth channels. When the spacecraft is reconfigured between the BBP and the MSM modes, a short experiment operations outage period occurs. Mode reconfigurations are determined by system operators and scheduled to meet the weekly experiments requirements. One half hour is allocated to these reconfigurations. These reconfigurations are often accomplished in less than the allocated half-hour. Other short reconfiguration periods of nominally 15 minutes are needed for changing the connectivity between different groups of MSM users. Such reconfigurations are coordinated with experimenters ahead of time so as not to disrupt a key phase of their experiment.

Since ACTS is experimental and not an operational system, full CONUS coverage of the spot beams is not provided. The areas covered by the spot beams are outlined in *figure* C-5 (figures are found in Appendix C). A mechanical steerable beam antenna (SBA), whose nominal coverage pattern is also depicted in *figure* C-5, provides the capability to extend ACTS coverage to anywhere within the hemispherical field of view of ACTS from its 100^{0} west longitudinal position. Although the SBA is capable of tracking the space shuttle as well as an aircraft, it generally remains fixed for the conduct of other experiments. It can be readily moved between locations in a matter of minutes, however, it cannot be moved in the millisecond time periods needed to support two different sites in the ACTS BBP or MSM-Gigabit modes of operation. As with any spot location, multiple earth stations within the field of coverage can operate in a given experimenter’s network.

Multiple simultaneous and independent experiments can be supported by the ACTS system both in the BBP, the MSM, or the Mixed BBP/MSM modes of operation. There are, however, some restrictions on mixed mode operations regarding the spot beam locations of the various earth stations operating in the BBP or MSM modes. The capability to operate in a mixed mode has allowed the ACTS system to accommodate multiple experimenters during a given time period. Conflicts are resolved by reverting to either the BBP or MSM mode of operation.

E. EARTH STATION AVAILABILITY

A number of earth stations have been developed for the ACTS Program and are being used to carrier out various experiments, user trials, and demonstrations. *Figure* C-2 provides an overview of the various earth station types available. A descriptive overview of the various ACTS earth stations and their key parameters is presented in Appendix D. Many of these earth stations are available for shared use. Some of the earth stations will have to be used in the location where they are currently installed, others can be transported to and installed at an experimenter’s site. The experimenter may have to fund the costs associated with moving and reinstalling an earth station as well as its return after the completion of the experiment. It should be noted that most of the earth stations currently located at fixed sites have interconnects into the terrestrial telephone and fiber network. In the past, a number of experiments have been conducted via terrestrial interconnections from an experimenter's location(s) both to and from the ACTS earth stations. This satellite/terrestrial network will more closely resemble the future networks of the NII/GII.

The earth stations are grouped according to the ACTS communications mode of operation that they support: baseband processor mode or microwave switch matrix mode.

Experimenters can provide and operate their own earth stations in the ACTS network. The MSM Mode of Operation provides a wide bandwidth, "bent pipe" capability to allow a variety of point-to-point or point-to-multipoint operations. If TDMA, FDMA, or CDMA network operations are required, the experimenter's earth stations and network interface hardware must provide the appropriate network control management.

1. Baseband Processor Mode Earth Stations

T1 Very Small Aperture Terminals(VSAT)
1.2-m diameter antennas, duplex data rates: 64 kbps - 1.79 Mbps.

Currently NASA has T1VSATs available for use. Some of these T1VSATS are, at this writing, located at NASA GRC, Cleveland, OH; Ohio University, Athens, Ohio; National Telecommunication and Information Agency, Boulder CO; Florida Atlantic University, Boca Raton, FL; and COMSAT Corporation, Clarksburg, MD. It is to be noted that these locations are not permanent and the VSATs may be moved. Arrangements can be made with GRC for transporting and installing a VSAT at an experimenter's site.

BBP Traffic Terminal
5.5-m diameter antenna, duplex data rates: 64 kbps - multipleT1(1.54Mbps).

The Master Control Station at the NASA GRC, Cleveland, OH, also serves as a traffic terminal in the BBP mode of operation. An experimenter can make arrangements with GRC to use this station.

2. Microwave Switch Matrix Mode Earth Stations

Ultra Small Aperture Terminal (USAT)

0.3-m, 0.6-m, and 1.2-m diameter antennas, duplex data rates: 4.8 kbps - 1.54 Mbps; up to 45 Mbps receive.

NASA has 10 USATs available for use. Presently they are used in a non-TDMA mode of operation. However, NASA would be willing to partner with an organization to complete the TDMA development for these stations. Arrangements can be made with GRC for moving and installing the USATs to an experimenter's site(s).

Link Evaluation Terminal (LET)
4.7-m diameter antenna, data rates: kbps - 220 Mbps.

The LET is located at NASA GRC, Cleveland, OH. In the past this station has frequently been used in tests and user trials using the MSM mode of operation with experimenters who have their own earth station and need an additional node to complete their satellite link. Terrestrial circuits have been used to return the data from Cleveland to the experimenter's facility. Used in this manner, the experimenter would be required to provide the necessary interface equipment that is compatible with the experimenter station under test. Arrangements can be made with GRC for the shared use of the LET.

High Data Rate Earth Stations (HDR)
3.4-m diameter antenna, duplex data rates: multiple OC-3 (155 Mbps)- OC-12 (622 Mbps).

HDR earth stations located at NASA GRC, Cleveland, OH; Lawrence Livermore National Laboratory, Livermore, CA; and Sprint Corporation, Overland Park, KS, will be available for inclined orbit operations. Since the HDR tracking mechanism is designed for a particular location, it is unlikely that the HDR stations will be moved during inclined orbit operations. All of these HDR stations are accessible via high-speed terrestrial landlines. Arrangements can be made with GRC for their shared use.

ACTS Mobile Terminal (AMT)
0.2-m reflector, data rates: 4.8 kbps - 1.54 Mbps.

Jet Propulsion Laboratory (JPL), Pasadena, CA, has a mobile earth station mounted in a van. Arrangements can be made with JPL (see Appendix F) for use of this mobile facility.

Broadband Aeronautical Terminal (BAT)
0.5-m slotted waveguide array antenna, data rates: 4.8 kbps - 2 Mbps.

JPL has a developed a BAT that has been used on aircraft, a trains, and ships. Arrangements can be made with JPL (see Appendix F) for the use of this station.

3. PROPAGATION

Propagation Receive-Only Terminals
1.2-m diameter antenna.

Seven propagation receive-only terminals, capable of receiving and processing the ACTS beacon signals, will become available at the end of March 1999. These terminals have been collecting ACTS beacon measurements since operations began in 1993. The propagation measurements program will conclude in November 1998. Arrangements can be made with GRC for the use of these terminals.

III.PROPOSAL PROCESS

This section outlines the various steps and provides guidance for preparing and submitting an experiment proposal to NASA. Proposals will be accepted on first-come, first-served basis. Experimenters are requested to inform NASA of their intent to submit a proposal. Proposals should be prepared using the guidelines contained herein. Completed proposals are to be sent to NASA GRC. If a proposal is not yet available for submission, the experimenter is requested to submit a Letter of Intent. The process by which NASA will review the proposals submitted is outlined, and the review and selection criteria are presented. The ACTS Usage Policy, outlining the government's reimbursement policy, is also outlined.

Proposals are welcomed from US industry, government, or university organizations. Teaming with and among organizations is encouraged. Foreign organizations can participate under the sponsor of a US Satellite Industry partner who actively serves as the Principal Investigator.

New proposals will be accepted by NASA immediately and extending through March 31, 2000. NASA plans to continue spacecraft operations in the inclined mode until June 2000. It is NASA's intent to accommodate all selected proposals where a Space Act Agreement or other appropriate agreement can be jointly negotiated with the experimenter.

As the spacecraft is entering this final period of operations, it is suggested that interested organizations submit their proposals as early as possible to ensure the successful development and execution of the proposed experiment within the on-orbit time remaining.

A. INITIAL CONTACT WITH NASA

Interested parties are requested to contact NASA GRC to alert NASA of their interest in participating in this extended ACTS Experiments Program opportunity. The point of contact is Lawrence Wald, ACTS Experiments Manager (see Appendix F). This initial contact should be by telephone or e-mail. The purpose of this contact is to briefly present the experiment or investigation being considered. Mr. Wald will provide feedback regarding the overall relevance of the potential experiment to the focused areas of investigation that NASA is interested in as well as alert the proposer to any technical or operational constraints that may bear on the proposed experiment. From past experience, NASA has found this initial contact valuable to both the experimenter and NASA, saving time by alerting the experimenter to potential programmatic, operational, or technical constraints, obstacles, or restrictions. In addition, NASA may be able to inform the proposer of other experimenters who may be interested in the same line of investigation and would like to cooperate in a joint endeavor.

B. LETTER OF INTENT

Experimenters who are working on developing an experiment and plan to submit an experiment proposal but do not have it completed at this time, are encouraged to send a **Letter of Intent** to NASA outlining their proposed experiment concept as soon as possible. The Letter of Intent should be sent to Lawrence Wald, ACTS Experiments Manager. The Letter of Intent will help NASA in its strategic planning and better manage the Experiments Program. The experimenter benefits by entering into a dialog with NASA and can be alerted to other activities and/or any constraints, scheduling conflicts, or other potential conflicts that could influence experiment planning.

C. PROPOSAL CONTENT

All proposals should have the following information:

1. NAMES & ADDRESSES:

    - The name, organization, address, telephone and facsimile numbers, and E-mail address of requester.
    - The name, organization, address, telephone and facsimile numbers, and E-mail address of the Principal Investigator if different from the requester.

- The names, addresses, and telephone numbers of other organizations sponsoring, funding, or associated with the execution of the proposed experiment. Provide a chart indicating the roles and responsibilities of all affiliated organizations.

2. TITLE OF THE EXPERIMENT:

3. DATE OF SUBMISSION:

4. EXPERIMENT DESCRIPTION:

   - Goals and objectives of the experiment.
   - Technical description of the experiment.
   - Type and location of the earth stations.
   - Data rates to be used.
   - Significance of ACTS to the conduct of the experiment.
   - ACTS mode of operation.

5. EXPERIMENT PLAN:
   - Overall measurement or test plan approach and parameters to be measured.
   - System diagram detailing the various earth stations, user interface and applications equipment, terrestrial interconnections (if appropriate), etc.
   - Plan for checkout and execution of the experiment.

6. RESOURCES BEING SUPPLIED BY EXPERIMENTER:

7. RESOURCES BEING REQUESTED FROM NASA:

8. EXPERIMENT SCHEDULE:

   - Approximate or specific calendar dates of the proposed experiment.
   - Expected length of time needed to complete the experiment (number of days or weeks).
   - Specific increments of time per time period e.g., hours/day/week.
   - Amount of flexibility in the various time period dates and/or weekly and daily time periods.

9. SPECIAL CONSIDERATIONS OR REQUIREMENTS:

- Any other consideration or requirement not covered previously that may bear on the experiment being proposed.
- Proprietary experiment submittals should be marked as such.

It is important for the requesting organization to allow sufficient time between the submission of the proposal and the planned starting date of the proposed experiment. Depending on the complexity of the request and other NASA commitments, the review and planning time to initiate an experiment is typically eight weeks.

D. PROPOSAL SUBMISSION

Proposals and Letters of Intent should be sent to:

Lawrence Wald
ACTS Experiments Manager
Mail Stop 54-6
NASA Lewis Research Center
21000 Brookpark Road
Cleveland, OH, 44135

E. REVIEW & SELECTION PROCESS

Proposals will be accepted on a first come, first served basis. Experiment proposals will be reviewed by personnel in the Space Communications Program at the NASA Glenn Research Center, as organized by the ACTS Project Manager.

Each proposal will be reviewed for both responsiveness to the programmatic guidelines and technical feasibility. Proposals that are programmatically acceptable and technically feasible will be conditionally accepted. Final selection will be contingent upon the negotiation of a Space Act Agreement or other appropriate agreement between the experimenter and NASA.

Phase 1 of the review process will involve programmatic and technical feasibility. In the first step, proposals will be reviewed for programmatic compatibility and acceptability according to the criteria as outlined in Section III E. In the next step, all proposals will be evaluated for technical feasibility with the ACTS spacecraft communications and ground systems. For proposals that are not technically compatible with the ACTS system capabilities, NASA will contact the experimenter to alert them of the incompatibility and provide assistance in an attempt to resolve the problem.   Proposals that are both technically and programmatically acceptable will be **Conditionally Accepted** by NASA. Final acceptance will be contingent on the negotiation of a Space Act Agreement or other appropriate agreement between NASA and the experimenter (Phase 2). Proposals that do not meet the programmatic guidelines or are not technically feasible will be rejected. NASA's goal is to complete Phase 1 activities in 30 days or less and notify the experimenter of its findings.

Phase 2 of the review process for conditionally accepted proposals involves initial resource allocation, the determination of reimbursement, and the preparation of a draft Space Act Agreement or other appropriate agreement. NASA will make an initial allocation of spacecraft schedule, earth station or other NASA resources as required in the proposal. In addition, NASA will determine the level of reimbursement or costs associated with the planned experiment. The experimenter will be notified of these findings and allocations. When NASA and the experimenter are in agreement, NASA will prepare a draft Space Act or other appropriate agreement identifying the roles and responsibilities of both NASA and the experimenter and send it to the experimenter.

The **Final Approval** to proceed with the planned experiment will be a signed Space Act Agreement or other appropriate agreement by both the experimenter and NASA. NASA's goal is to complete Phase 2 activities in 30 days or less.

NASA reserves the right to prioritize all ACTS resource allocations including spacecraft schedule and earth station usage. When conflicts for ACTS system, schedule, and earth station resources arise, priority will be given according to experiment categories as listed in Section II A.

F. EVALUATION CRITERIA

Proposals will be evaluated for both Programmatic and Technical feasibility.

1. PROGRAMMATIC

a) Overall adequacy of the proposal in addressing one or more of the focused experiment categories (see Section II A for more details) as identified in descending order of priority:

   1) Demonstrations of future commercial satellite services in support of NASA or other Government missions using the ACTS testbed.

2) Standards and protocol testing and/or development that promote and validate the seamless interoperability of satellites with terrestrial networks.
3) Characterization of the ACTS satellite and system operations in inclined orbit.
4) New Ka-band technology and hardware verification for advanced communication satellite systems.

b) Capability of the proposing organization(s) to carry out the planned investigation and provide the necessary personnel, technical expertise, equipment, facilities, telephone lines, and financial resources to plan, conduct, complete the experiment, and provide a report of the findings.

c) Spacecraft schedule, earth station, and other NASA resources required.

d) Utilizes some unique aspect of the ACTS system that is unavailable by current commercial systems.

2. **TECHNICAL** Technically feasible and compatible with the ACTS spacecraft, communications payload and ground systems capabilities.

G. ACTS USAGE POLICY

Experimenters are expected to fund the conduct of their experiment. In addition, all experimenters will conform to the ACTS Usage Policy. NASA is required by federal and NASA guidelines to recover costs associated with the operation of ACTS from its users. These costs are identified in the cost estimation portion of the ACTS Usage Policy (see Appendix E). Depending on the type of experiment as identified in Appendix E, costs will be assessed on a zero, partial, or fully reimbursable basis. In addition, costs associated with moving and relocating a NASA earth station to an experimenters site may also be borne by the experimenter.

NASA will determine what category an experimenter meets and the level of reimbursement, if any, required. Reimbursement may involve payment in kind or other form of remuneration or consideration in lieu of a fee.

The full ACTS Usage Policy can be found at the ACTS Web site:

http://acts.grc.nasa.gov

APPENDICES

APPENDIX A

LIST OF ABBREVIATIONS

ACTS	Advanced Communications Technology Satellite
AF	Air Force
AMT	ACTS Mobile Terminal
ATM	Asynchronous Transfer Mode
BAT	Broadband Aeronautical Terminal
BBP	Baseband Processor
BER	Bit Error Rate
CDMA	Code Division Multiple Access
CONUS	Continental United States
DAMA	Demand Assigned Multiple Access
DARPA	Defense Advance Research Projects Agency
dB	Decibel
FDM	Frequency Division Multiplexing
FDMA	Frequency Division Multiple Access
FEC	Forward Error Correction
Gbps	Gigabits Per Second
GII	Global Information Infrastructure
GHz	Gigahertz
GRC	Glenn Research Center
GMT	Greenwich Mean Time
HDR	High Date Rate
HS	High Speed
IF	Intermediate Frequency
IP	Internet Protocol
ISDN	Integrated Services Digital Network
JPL	Jet Propulsion Laboratory
kbps	Kilobits Per Second
LET	Link Evaluation Terminal
m	meter
MBA	Multiple Beam Antenna
Mbps	Megabits Per Second
MGS	Master Ground Station
MHz	Megahertz
MMIC	Monolithic Microwave Integrated Circuit
MSM	Microwave Switch Matrix
NASA	National Aeronautics & Space Administration
NGS	NASA Ground Station
NII	National Information Infrastructure
OC	Optical Carrier
SAA	Space Act Agreement

SBA	Steerable Beam Antenna
SONET	Synchronous Optical Network
SSPA	Solid State Power Amplifier
TCP	Transport Control Protocol
TDM	Time Division Multiplexing
TDMA	Time Division Multiple Access
T1	1.544 Mbps Bell Standard Digital Data Rate
USAT	Ultra Small Aperture Terminal
VSAT	Very Small Aperture Terminal

APPENDIX B

EXTENDED OPERATIONS DESCRIPTION

One of the primary constraints on ACTS mission operations is hydrazine stationkeeping fuel consumption, particularly for inclination control. North-south stationkeeping maneuvers use the bulk of the annual fuel consumption. East-west stationkeeping control requires far less fuel usage. Current stationkeeping fuel estimates indicate that ACTS can be maintained in the current full stationkeeping mode through July 1998. In this mode the spacecraft will remain positioned at 100 ^{0} west longitude and maintained within a +/- 0.05 ^{0} box in latitude and longitude by periodic stationkeeping maneuvers. Starting in August 1998, however, north-south stationkeeping maneuvers will be discontinued to conserve fuel. Orbital inclination will then be allowed to increase at a rate of 0.76^0 per year reaching an inclination of 1.4 ^{0} by June 2000. The ACTS attitude control system provides three-axis control using a momentum wheel for precise pitch control and magnetic torquers for somewhat less precise roll and yaw control. The momentum wheel pivot range of motion limits the maximum controllable inclination to 2 degrees. Using only east-west stationkeeping, ACTS can remain geostationary at 100^0 west longitude +/- 0.05 ^{0}, with orbital eccentricity near zero. **In this inclined orbit operations mode, ACTS operations will be extended until June 2000.** At that time, the ACTS Mission will be terminated. The remaining hydrazine fuel will be used to raise the orbit of the spacecraft by 300 kilometers above the geostationary orbit altitude. All on-board systems and subsystems will be de-energized.

The various ACTS communication payload and satellite bus systems and subsystems have proven to be extremely reliable and have redundancy that has not yet been utilized. Therefore, NASA has high expectations that full operations will be sustained through this extended period.

To provide the necessary three-axis control for precise spot beam pointing in this inclined orbit mode, the ACTS attitude control system software has been upgraded. Weekly uploads are planned to update the ephemeris and other parameters necessary for inclined orbit operations. This inclined orbit operational capability was tested and verified by on-orbit tests in November 1997. From these tests, analysis of ACTS operations in the inclined orbit mode predicts attitude control performance as:

- pitch +/- 0.025 ^{0}
- roll +/- 0.048 ^{0}
- yaw +/- 0.217 ^{0}

APPENDIX C

ACTS PROGRAM & SYSTEM OVERVIEW

FOR ADDITIONAL INFORMATION ABOUT THE ACTS PROGRAM SEE THE *ACTS* WEB PAGE AT:
http://acts.grc.nasa.gov

A. ACTS PROGRAM BACKGROUND

Communication satellites are poised to take on a new and expanded role in the National Information Infrastructure(NII)/Global Information Infrastructure(GII). Satellites will play a key role in implementing a true Global Information Superhighway of seamless and agile satellite and terrestrial networks. ACTS is providing the technology bridge to achieve that vision. The NASA ACTS provides an on-orbit testbed for the hopping spot beams and on-board switching technologies that have the potential to dramatically enhance the capabilities and reduce the user service costs of the satellite communications industry. The ACTS test networks are validating the use of all digital, high bandwidth, on-demand, integrated voice, video, and data and other multimedia services for new and innovative user applications. ACTS operates with a network of over 60 ground stations of various types for fixed and mobile services. Many of these stations are integrated with fiber optic networks to form a hybrid satellite/terrestrial capability to allow user services, protocols and standards to be tested, validated, and characterized to ensure that the full potential of the Information Superhighway is realized.

Key technologies of the ACTS Program include:

- High-gain hopping spot beams: A rapidly reconfigurable pattern of narrow hopping beams. The high gain antenna used to produce the spot beams enables communications with smaller, less costly earth stations.
- On-orbit baseband switching: A high-speed digital processor that resides on the satellite and routes individual circuits to provide single hop, mesh interconnectivity. By contrast, today's conventional VSAT systems typically employ a double hop using a central hub ground station.
- On-orbit microwave switching: A dynamic, reconfigurable, 900 MHz wide bandwidth switch that operates at microwave frequencies within the spacecraft; able to route high-volume, point-to-point, and point-to-multipoint traffic.

- ♦ On-demand services: The ability to dial up satellite circuits with variable bandwidths and to seamless interconnect into the terrestrial communications network.
- ♦ Adaptive rain fade compensation: The ability to automatically and selectively increase the link margins for those transmissions undergoing fades due to rain or other atmospheric effects.

B. ACTS SYSTEM OVERVIEW

An overview of the ACTS system is presented in *figure C*-1. The ACTS system is made up of a flight and ground segment. The flight segment consists of a multibeam communications payload and the spacecraft bus. The key technology components of the communications payload are the multibeam antenna (MBA), the baseband processor (BBP), and the microwave switch matrix (MSM). The spacecraft bus provides the functional support for the communications payload such as attitude control, electric power, thermal control, command reception, telemetry transmissions, and propulsion control for stationkeeping maneuvering.

The ground segment is comprised of the spacecraft and communication network control terminals and the experimenter stations. The Master Ground Station (MGS) is located at the NASA Lewis Research Center in Cleveland, Ohio. This station provides spacecraft and network control, manages experiments and user investigations, and records spacecraft and system data. It processes and sets up all traffic requests, assigning traffic channels on a demand basis by using in-band orderwires via the satellite. Command, ranging, and telemetry information is sent to and received from ACTS via the MGS. A Satellite Operations Center is located at Lockheed Martin Missiles and Space Communications and Power Center in Newton, Pennsylvania. This facility provides 24 hour monitoring of the spacecraft's health and status. Its prime responsibility is generating flight system commands and analyzing, processing, and displaying flight system telemetry data. Orbit maneuver planning and execution are also handled by the satellite operations center. Terrestrial voice and data circuits connect the satellite operation center with the MGS. The Lockheed Martin C-band command, ranging, and telemetry terminal at Carpentersville, New Jersey provided transfer orbit support during launch and serves as an operations backup to the satellite operations center.

The ACTS communication's payload accommodates digital data rates from kilobits per second (kbps) up to hundreds of megabits per second (Mbps) via its various communication modes of operation. A number of fixed and mobile stations operating at data rates within this range have been developed and are operating with ACTS (*figure* C-2). They provide integrated voice, video, data, and multimedia communication services.

The major types of services that have been accommodated include:

- On-demand, integrated voice, video, and date services using T1(1.544 Mbps) links to 1.2 meter customer premises earth stations;
- Very high data rate (622 Mbps) networks;
- Broadband (T1) video and data for aircraft and ships;
- Aeronautical voice and low rate date;
- Low rate mobile voice, video, and data; and
- Interactive, multimedia services (1Mbps outbound and up to 45 Mbps inbound using 0.3 meter and 0.6 meter earth stations.

In addition, a number of receive-only propagation terminals are monitoring the spacecraft beacons for propagation studies and modeling. These user stations are operated by various industry, government and university organizations.

1. SPACECRAFT

The on-orbit configuration of ACTS is shown in *figure* C-3. ACTS is a three-axis stabilized spacecraft weighing 3250 pounds at the beginning of its on-orbit life. ACTS measures 14.5 meters from tip to tip along the solar arrays and 9.2 meters across the main and transmitting antenna reflectors. The solar panels rotate once per day to track the sun. The ACTS multibeam antenna (MBA) comprises separate Ka-band receive and transmit antennas each with horizontal and vertical polarization subreflectors. The 2.2-meter, 30 GHz, receive antenna collects uplinked signals while the 3.3 meter, 20 GHz, transmitting antenna radiates downlink signals. Antenna feed horns produce narrow spot beams with a nominal 120 mile coverage diameter on the surface of the earth. Fast, less than 1- microsecond (µs), switching beam-forming networks consisting of ferrite switches, power dividers and combiners, and conical multiflair feed horns provide sequential hopping from one spot beam location to another. These hopping spot beams interconnect multiple users on a dynamic, traffic demand basis. A separate 1.1-meter, mechanically steerable beam antenna (SBA), receiving and radiating both uplink and downlink signals, is used to extend ACTS' communication coverage to any location within the hemispherical field of view from ACTS' 100 degree west longitude. Beacon signals at 20.2 GHz and 27.5 GHz are transmitted from two small, separate antennas.

2. COMMUNICATION MODES OF OPERATION

The multibeam antenna provides dynamic coverage with the hopping spot beams. Each hopping spot beam can be programmed to cover a sequential set of spots and dwell long enough to communicate with users in each spot. By assigning each user an access time, multiple users may transmit and receive at the same frequency on a time-shared basis allowing efficient frequency reuse. This time division, multiple access (TDMA) technique requires a switching system on board the spacecraft to interconnect the beams and route messages. The ACTS communications payload provides two types of on-board switching to interconnect the multiple spot beams and to route signals to their appropriate destinations: (1) Baseband Processing and (2) Microwave Switch Matrix (*figure* C-4).

The BBP is a high-speed digital processor on the satellite that provides on-demand circuit switching to efficiently route traffic among small user stations in a full mesh network. ACTS has the ability to conduct both time and space switching on board the satellite. Using time slot interchange, the BBP switches traffic between the various uplink and downlink beams. A key feature of the BBP design is its remote programmability for traffic handling and routing. Programmability provides system flexibility for dynamic reconfiguration during rapidly changing traffic loads. The spacecraft baseband switch uses on-board stored, baseband switched TDMA. In the BBP mode of operation, four simultaneous and independent hopping beams (two uplink and two downlink) provide flexible, demand access communications between small (1.2 meter antenna diameter) user stations. Uplink bursts are organized in a frequency division multiplexed (FDM), TDMA format. Downlink bursts are time division multiplexed. The receive signals are demodulated, decoded as required, temporally stored in memory, routed on a 64kbit individual circuit basis, remodulated, encoded if required and transmitted in the proper downlink spot beam. During the one-millisecond TDMA frame time of the BBP mode, the beams hop to many locations dwelling long enough to pickup or deliver the required traffic. In this mode, communication is by demand assigned multiple access (DAMA). The BBP mode provides integrated voice, video, data, and ISDN service applications with information throughputs of 1.79 Mbps (28-64 kbps channels) using 1.2-meter user stations.

The MSM is a dynamic reconfigurable, intermediate frequency (IF) switch capable of routing high volume point-to-point traffic and point-to-multipoint traffic over a very wide bandwidth channel. The MSM provides beam-to-beam routing using a 3 x 3-crossbar switch configuration. The MSM uses satellite switched TDMA using very wide band (900 MHz) channels to dynamically interconnect three uplink and three downlink beams. Fixing the beam interconnections in a static mode allows additional flexibility for a variety of continuous digital or analog communications. The MSM mode accommodates user stations operating in the range from low kilobits per second up to hundreds of megabits per second.

The ACTS system can be configured in the BBP mode, the MSM mode or a mixed mode. In the mixed mode both the baseband processor and the microwave matrix switch can be operated simultaneously with some restrictions. The ACTS system and payload can be quickly reconfigured from one mode of operation to another in a matter of minutes further adding to the system's versatility and flexibility. This flexibility along with the large total information throughput capacity of the ACTS system allows multiple related and unrelated users to be accommodated concurrently.

3. GIGABIT SATELLITE NETWORK

The ACTS gigabit network provides point-to-point and point-to-multipoint full duplex Synchronous Optical Network (SONET) based OC-3 (155.54 Mbps) and OC-12 (622.08Mbps) services. The gigabit network uses the wideband, satellite switched TDMA capability of the MSM along with the scanning beam network. The network allows the use of any combination of three uplink and downlink beams. The gigabit network uses a 32-millisecond TDMA fame synchronized to the MSM frame. By programming the MSM and the MBA spot locations, mesh connections can be made between the earth stations in the network, each acting either as a stand alone station or as a node in a terrestrial network.

The ACTS gigabit network design, from the end users standpoint, replicates the functions of terrestrial SONET-based fiber networks. The user interfaces are compatible with SONET standards, performing the function of conventional SONET multiplexers and, as such, are readily integrated with standard SONET fiber-based terrestrial networks. In addition, asynchronous transfer mode (ATM) communications can be readily run on top of the SONET structure.

The best raw channel BER that can be achieved with ACTS at data rates of 622 Mbps is about 10^{-6}, inadequate for compatibility with fiber based services. However, use of Reed-Solomon block, forward error correction coding provides an extremely robust link with a BER of 10^{-11} or less. With the link margins provided by ACTS, the gigabit network provides a rain fade availability of 99% for transmissions at 696 Mbps.

4. SPOT BEAM COVERAGE

The ground coverage patterns for both the MBA and the SBA are presented in *figure* C-5. Since ACTS is an experimental system, it is not intended to provide full U. S. coverage. One of its prime goals is to demonstrate frequency reuse by the simultaneous use of hopping spot beams in two contiguous sectors using the same frequency. A contiguous coverage area of approximately 20 percent of the U. S. was selected. In order to further enhance the versatility of the ACTS system and provide coverage to users in other parts of the country, isolated beams outside these two contiguous areas were identified and incorporated into the hopping beam coverage network.

Each transmit and receive antenna supports 5 separate antenna ports (See *figure* C-4). These antenna ports consist of three stationary fixed beams focused on Cleveland, OH, Atlanta, GA, and Tampa, FL, plus two hopping spot beam families; east and west. The east and west families are orthogonally polarized in both the uplink and the downlink while using the same Ka frequency band. The east family of beams is comprised of a contiguous sector called the east scan sector plus six additional isolated spot locations outside this sector. The west family comprises a west scan sector plus seven additional isolated spot locations. The mechanical SBA is also interconnected into the west family and functions as part of its hopping beam network. It provides coverage anywhere within the ACTS hemispherical field of view from its position at 100 degrees west longitude.

The east and west hopping spot beam families are intended to be primarily used with the BBP mode of operation. On the other hand, the three fixed beams at Cleveland, Atlanta, and Tampa are intended to be used with the MSM mode of operation. However, the versatility of the ACTS design is such that the hopping spot beams can be fixed at a given location for use with the MSM mode and one of the fixed beams can be used with the BBP mode.

5. <u>BEACONS</u>

The ACTS flight system incorporates three Ka beacons for real time fade measurements. Two of these beacons are in the downlink frequency band while the third is in the uplink band. These beacons provide signal sources from which to make continuous measurements for propagation research. The downlink frequency beacons operate at 20.185 GHz with vertical polarization and at 20.195 GHz with horizontal polarization. These beacons primarily provide the normal spacecraft telemetry and ranging functions while producing a stable downlink signal to allow propagation measurements.

Since these beacons carry spacecraft telemetry, it is necessary that there be a redundant beacon; hence, the reason for the two beacons. During on-orbit operations, only one of the two 20.2 GHz beacons is used at a time. The 20.2 GHz beacons are modulated with telemetry transmissions from the spacecraft to the Cleveland MCS. Telemetry data modulates a 64-kHz subcarrier, which is always present. An unmodulated 32-kHz carrier is used as a placeholder when ranging is not being done and is replaced by ranging tones when ranging is being carried out. The amplitude of the ranging tones is adjusted to produce the same carrier modulation as the 32-kHz subcarrier to maintain the beacon carrier amplitude constant. Fade measurements at these 20.2 GHz downlink frequencies are, for all practical purposes, unaffected by the beacon modulation in the operational telemetry mode or the content of the telemetry data.

The uplink frequency beacon operates at 27.505 GHz. This beacon is vertically polarized and is unmodulated. The 27.5 GHz beacon also has a redundant backup at the same frequency and polarization. The 27.505 GHz frequency was selected to avoid interference with the communications signals.

The three beacon signals are derived from independent local oscillators and, therefore, are not coherent to each other. The beacon antennas provide broad coverage primarily to the continental United States.

The beacon reflectors are situated on the earth-facing panel of the spacecraft. The beacon antenna assembly consists of two elliptical reflectors that use offset, rectangular feeds. The 20.2 GHz reflector is the smaller of the two and measures 11 by 6.5-inches. The 27.5 GHz reflector is approximately 13 by 7.5-inches. The 20.2 GHz beacon pattern is formed from a single radiating horn. The 27.5 GHz beacon pattern is formed by two horns. The reflector that forms the 27.5 GHz beacon pattern transmits the continuous wave beacon and also receives uplink commands at 30 GHz. These transmitted and received signals are cross polarized.

KEY REFERENCES:

(1) Wright and J. Bolombin, “ACTS System Capabilities and Performance,” Proceedings of the 14th AIAA International Communications Satellite System Conference, Washington, DC, March 1992.

(2) Naderi and S. Campanella, “NASA’s Advanced Communication Technology Satellite (ACTS): An Overview of the Satellite, the Network, and the Underlying Technologies,” AIAA 12th International Communications Satellite System Conference, Arlington, Virginia, March 1988.

(3) Grabner and W. Cashman, “ACTS Multibeam Communications Package: Technology for the 1990’s,” Proceedings of the 13th International AIAA Communications Satellite Systems Conference, Los Angeles, California, March 1990.

rd Ka-Band Utilization Conference, Sorrento, Italy,
September 1997.

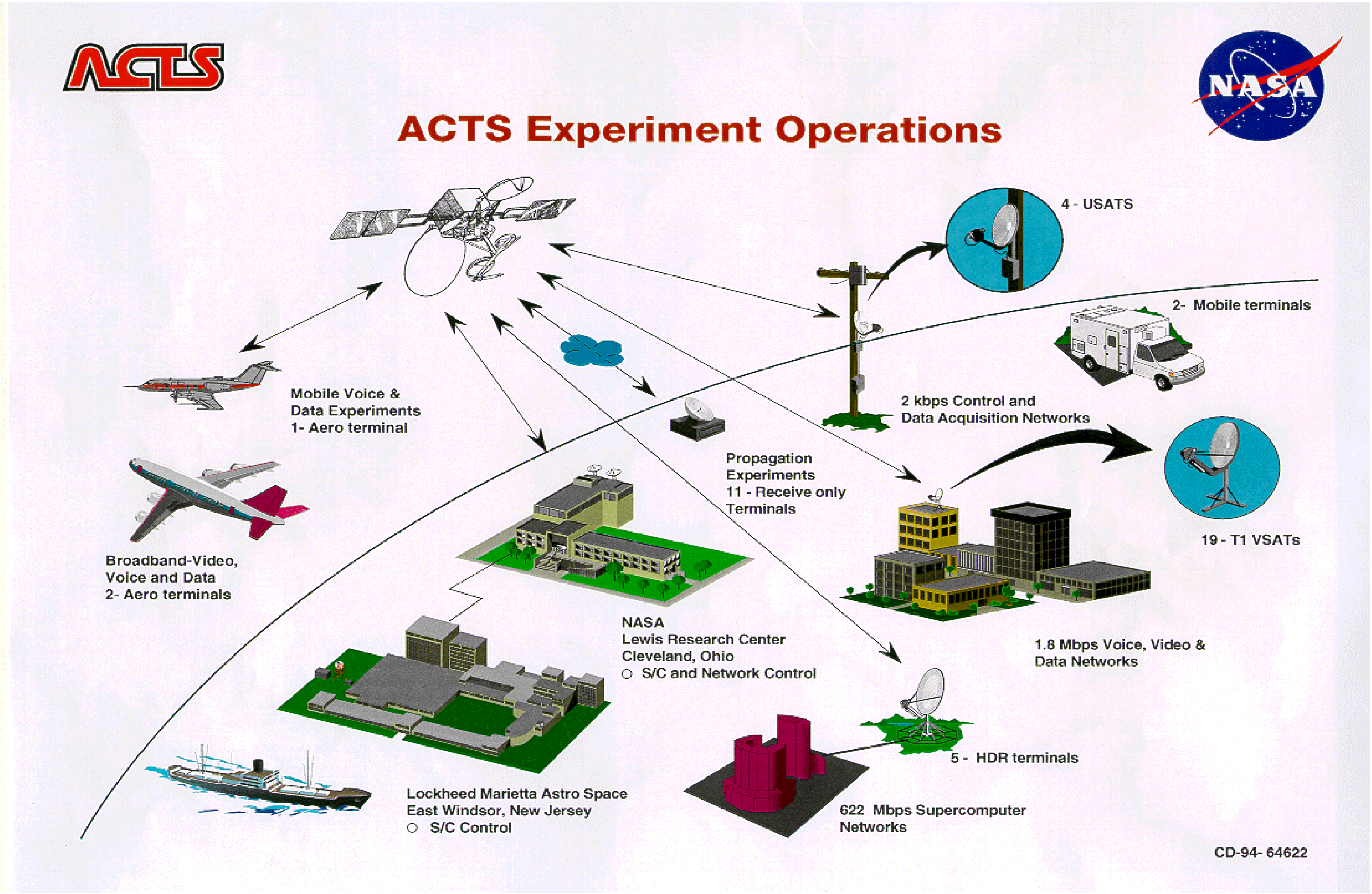
ACTS
NASA
ACTS Experiment Operations
4 - USATS
2- Mobile terminals
Mobile Voice &
Data Experiments
1- Aero terminal
2 kbps Control and
Data Acquisition Networks
Propagation
Experiments
11 - Receive only
Terminals
19 - T1 VSATs
Broadband-Video,
Voice and Data
2- Aero terminals
NASA
Lewis Research Center
Cleveland, Ohio
○ S/C and Network Control
1.8 Mbps Voice, Video &
Data Networks
5 - HDR terminals
Lockheed Marietta Astro Space
East Windsor, New Jersey
○ S/C Control
622 Mbps Supercomputer
Networks
CD-94- 64622

FIGURE C - 1

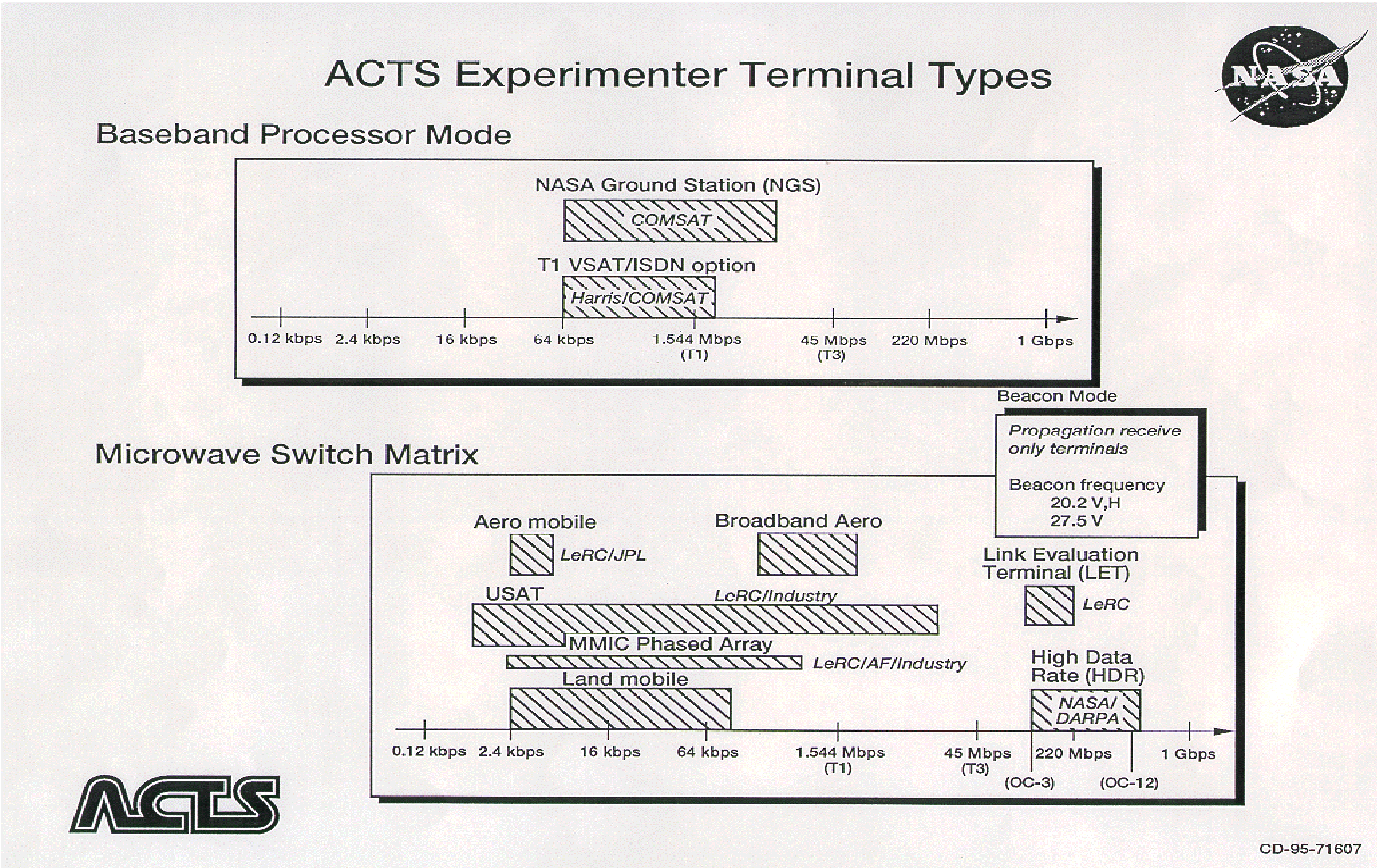
ACTS Experimenter Terminal Types
Baseband Processor Mode
NASA Ground Station (NGS)
COMSAT
T1 VSAT/ISDN option
Harris/COMSAT
0.12 kbps
2.4 kbps
16 kbps
64 kbps
1.544 Mbps (T1)
45 Mbps (T3)
220 Mbps
1 Gbps
Beacon Mode
Propagation receive only terminals
Beacon frequency
20.2 V,H
27.5 V
Microwave Switch Matrix
Aero mobile
LeRC/JPL
Broadband Aero
Link Evaluation Terminal (LET)
LeRC
USAT
LeRC/Industry
MMIC Phased Array
LeRC/AF/Industry
High Data Rate (HDR)
NASA/ DARPA
Land mobile
0.12 kbps
2.4 kbps
16 kbps
64 kbps
1.544 Mbps (T1)
45 Mbps (T3)
220 Mbps
1 Gbps
(OC-3)
(OC-12)
CD-95-71607

FIGURE C - 2

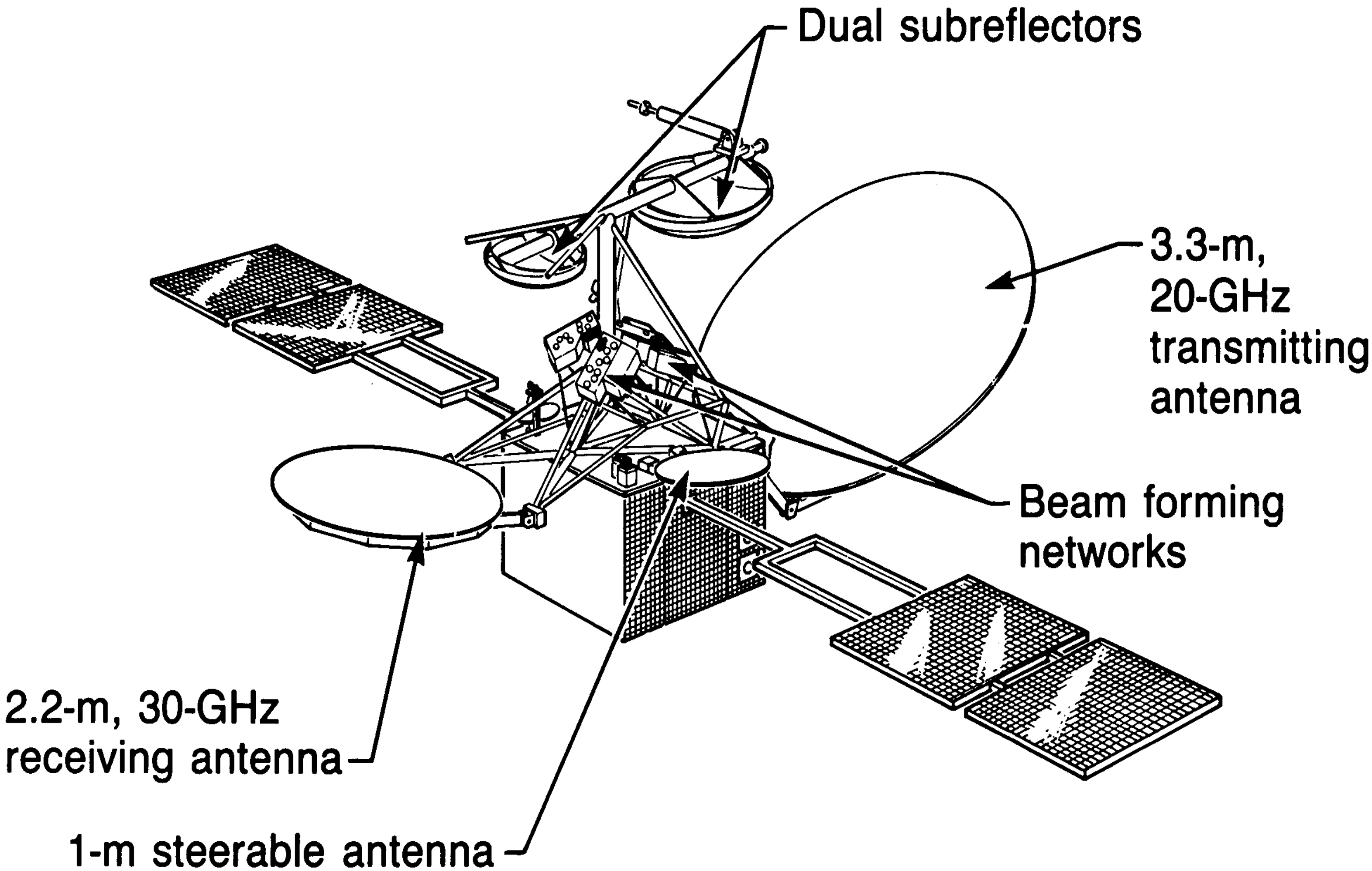
Dual subreflectors
3.3-m,
20-GHz
transmitting
antenna
Beam forming
networks
2.2-m, 30-GHz
receiving antenna
1-m steerable antenna

FIGURE C - 3

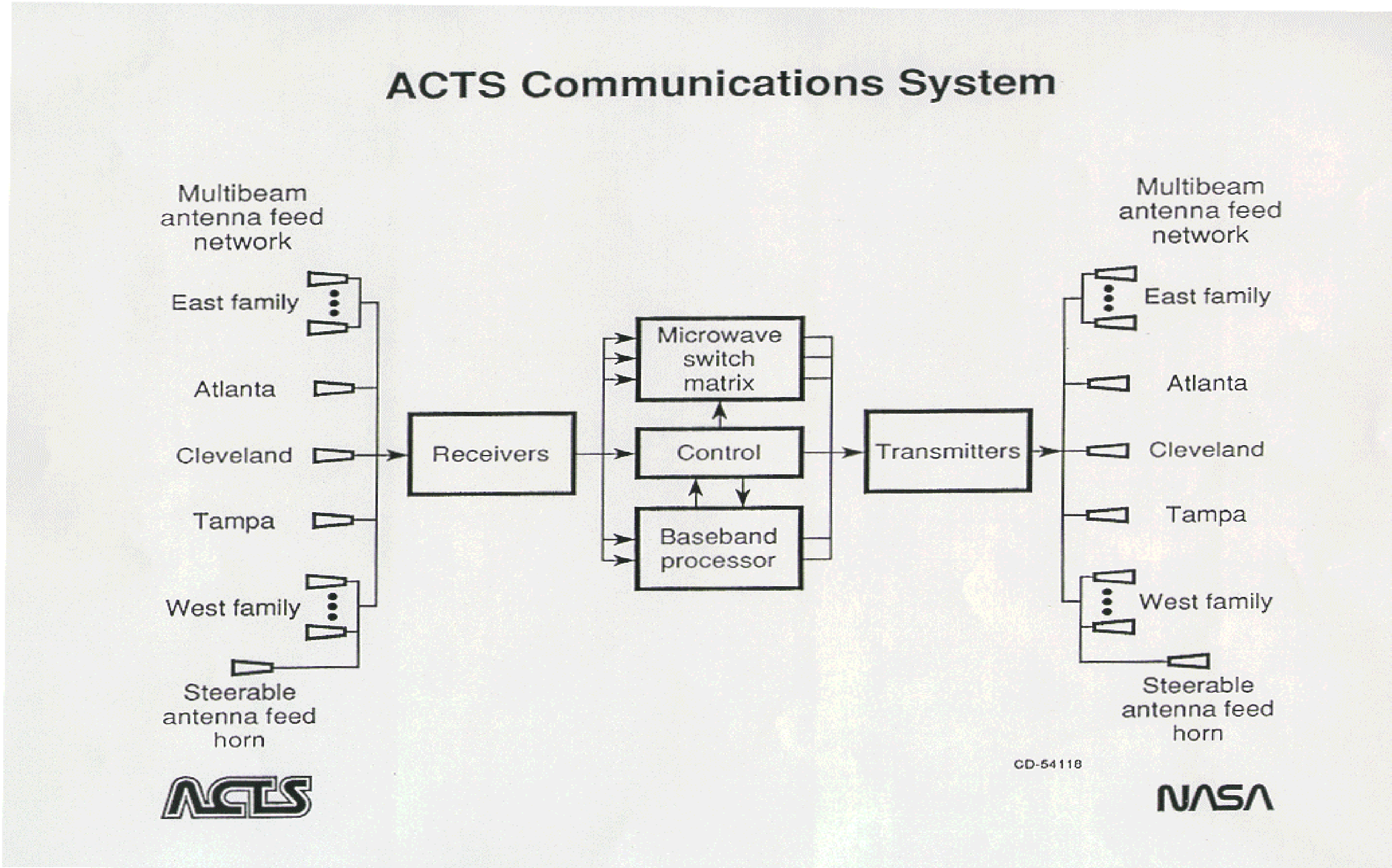
ACTS Communications System
Multibeam
antenna feed
network
East family
Atlanta
Cleveland
Tampa
West family
Steerable
antenna feed
horn
Receivers
Microwave
switch
matrix
Control
Baseband
processor
Transmitters
Multibeam
antenna feed
network
East family
Atlanta
Cleveland
Tampa
West family
Steerable
antenna feed
horn
CD-54118

FIGURE C - 4

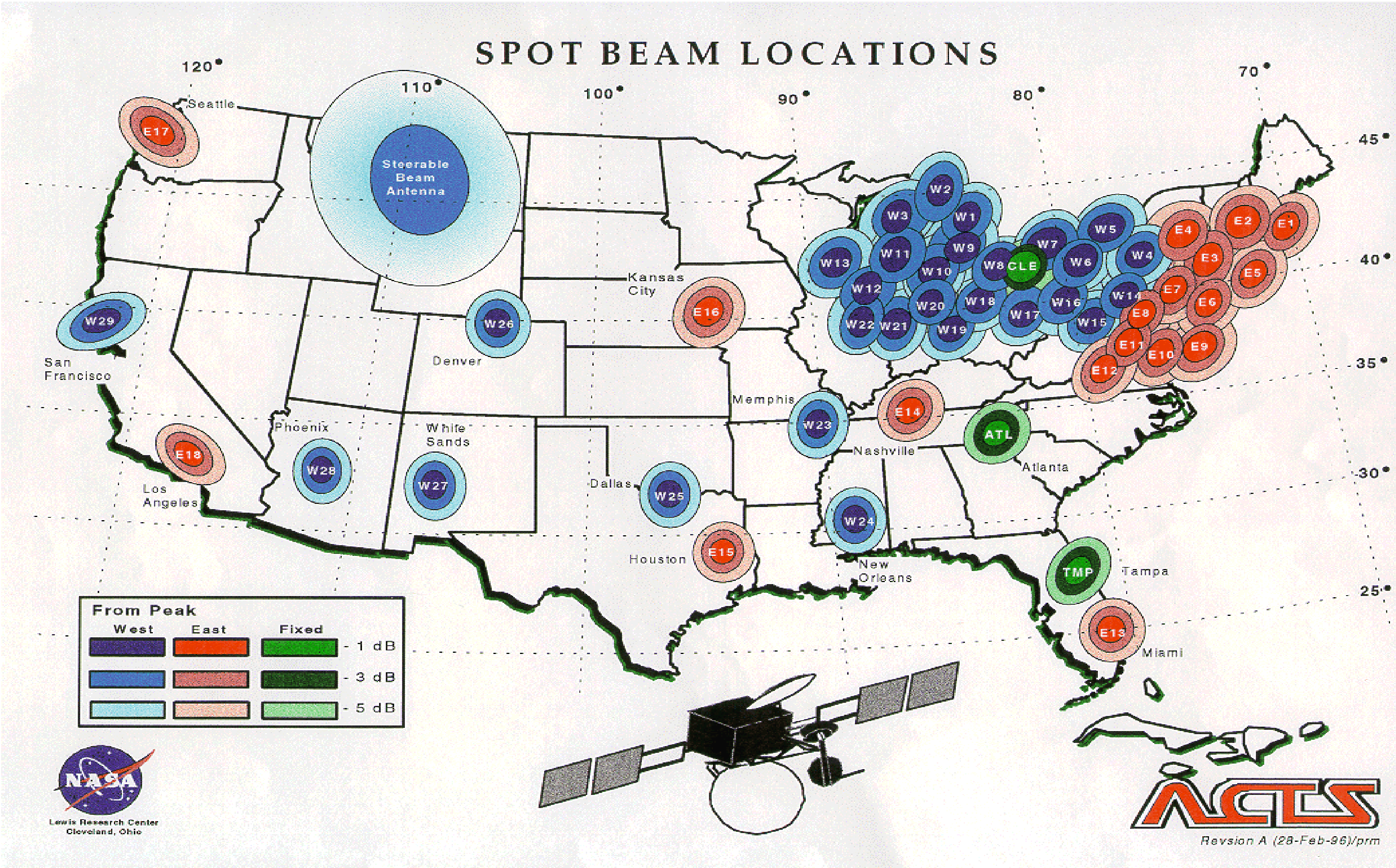
SPOT BEAM LOCATIONS
120°
110°
100°
90°
80°
70°
45°
40°
35°
30°
25°
Seattle
Steerable Beam Antenna
Kansas City
San Francisco
Denver
Memphis
Phoenix
White Sands
Nashville
Atlanta
Los Angeles
Dallas
Houston
New Orleans
Tampa
Miami
E1
E2
E3
E4
E5
E6
E7
E8
E9
E10
E11
E12
E13
E14
E15
E16
E17
E18
W1
W2
W3
W4
W5
W6
W7
W8
W9
W10
W11
W12
W13
W14
W15
W16
W17
W18
W19
W20
W21
W22
W23
W24
W25
W26
W27
W28
W29
CLE
ATL
TMP
From Peak
West
East
Fixed
- 1 dB
- 3 dB
- 5 dB
Lewis Research Center
Cleveland, Ohio
ACTS
Revsion A (28-Feb-96)/prm

FIGURE C - 5

APPENDIX D

EARTH STATION DESCRIPTIONS

Experimenter earth stations are classified into three general types: those that are used with the Baseband Processor (BBP) mode, those that are used with the Microwave Switch Matrix (MSM) mode, and receive-only propagation terminals. Using one or another of these earth stations data rates from 2.4 kbps to 622 Mbps can be accommodated. Figure C-2 delineates these various types of ACTS stations.

I. EARTH STATIONS OPERATING IN THE BBP MODE

The T1VSAT is the primary earth station type for use with the BBP mode of operation. Nineteen T1VSATs have been built and are used in the experiments program. The Master Control Station at NASA GRC in Cleveland also serves as a BBP mode traffic station. To use the BBP mode, the earth station must have the necessary serial minimum shift keying, TDMA equipment for operation in the network.

A. T1VSAT

Antenna Diameter:	1.2-meter, tripod or non-penetrating roof mount
Amplifier:	12 watts
Uplink Burst Rate:	27.5 Mbps-uncoded, 13.75 Mbps-coded
Downlink Burst Rate:	110 Mbps-uncoded, 55 Mbps-coded
Modulation Type:	SMSK
Rain Fade Compensation:	Adaptive FEC
Access to Satellite:	Demand Assigned TDMA
Throughput:	64 kbps - 1.79 Mbps; 28 - 64 kbps circuits
Features:	User interface is a small programmable central office that supports a variety of Bell Standard hardware interfaces such as line circuits, ground and loop start trunks, 2 wire and 4 wire E&M trunks, additive conference cards, AMI and B8ZS full and fractional T1 trunks, and more.

B. Master Control Station Traffic Terminal

Antenna Diameter:	5.5 meters
Amplifier:	54 watts

Uplink Burst Rate:	110 Mbps-uncoded, 55 Mbps-coded
Downlink Burst Rate:	110 Mbps-coded, 55 Mbps-coded
Rain Fade Compensation:	Adaptive FEC
Access to Satellite:	Demand Assigned TDMA
Throughput:	64 kbps-multiple T1(1.54 Mbps), 68.9 Mbps total throughput
Features:	User interface supports all the Bell Standard hardware interfaces identified for the T1VSAT above.

All these BBP mode earth stations provide digital voice, video, data, and multimedia services in a full mesh network that is completely compatible with the terrestrial telephone network. The user interface allows direct connection of telephones, facsimiles, modems, computers, video teleconferencing equipment, etc.

C. EARTH STATIONS OPERATING IN THE MSM MODE

The MSM mode of operation can accommodate a wide variety of stations. Stations using the mode can use any type of modulation format that is compatible with the ACTS transponders. Various forms of channel sharing such as CDMA, FDMA, or TDMA can be accommodated. Operation in a continuous single or multiple carrier per transponder FDMA fashion is possible in the MSM mode by using the spot beams in a static or fixed state (bent pipe). Data rates from 2.4 kbps to 622 Mbps have been transmitted via the MSM mode of operation.

1. High Data Rate (HDR)

Antenna Diameter:	3.4 meters
Amplifier:	100 watts
Uplink Burst Rate:	348 Mbps & 696 Mbps
Modulation Type:	Offset BPSK & Offset QPSK
Rain Fade Compensation:	Reed-Soloman FEC
Access to Satellite:	TDMA, No DAMA access to satellite, must be pre-arranged
Throughput:	OC-3 (155 Mbps) or OC-12 (622 Mbps)
Bit Error Rate:	Uncoded BER 10^{-4}, coded BER 10^{-11}
Features:	The system will multiplex or demultiplex STS-1 or STS-3 SONET frames. Synchronization of the stations is by loopback through ACTS. System can provide a mixture of OC-3 and OC-12 links up to an aggregate data rate of 622 Mbps on each of three ACTS transponders.

2. LINK EVALUATION TERMINAL(LET)

The LET is located at the NASA ACTS ground station in Cleveland, Ohio. The LET is a basic Ka-band RF terminal that can be adapted to support various modulation and digital formats to communicate with ACTS. The LET has supported a number of experiments where the experimenter has equipped the terminal with compatible receiving and/or transmitting electronics so it functions as a second terminal for conducting an experiment.

Antenna Diameter:	4.7 meters
Amplifier:	10 to 60 watts (variable)
Uplink/Downlink Burst Rates:	Variable depending on experimenter's electronics. Can be operated in the continuous-bent pipe-mode.
Throughput:	Up to 622 Mbps depending on experimenter's electronics.

3. Ultra Small Aperture Terminal (USAT)

Antenna Diameter:	0.3, 0.6, or 1.2 meters
Amplifier:	SSPAs -0.25 watts to 4 watts
Data Rates:	duplex data rates of 4.8 kbps to 1.544 Mbps; up to 45 Mbps receive
User Interface:	70 MHz, necessary upconverter and downconverter equipment for proper frequency translation to Ka-band.
Features:	Can support a variety of digital telephony and video services. Can use FDM/TDMA access. Modulation BPSK/QPSK. Three user interface ports. Extremely portable.

4. ACTS MOBILE TERMINAL (AMT)

Antenna:	Elliptical Reflector, Radome- 8 inch diameter, 4 inches high. Tracking capability using pilot tones.
Amplifier:	10 watts
Data Rates:	2.4 kbps to 2 Mbps
Features:	Mounted in a van. Has Data Analysis System which performs continuous measurements and recordings for a wide variety of propagation,

communication link, and terminal parameters.

5. BROADBAND AERONAUTICAL TERMINAL (BAT)

The BAT consists of a slotted waveguide array antenna interfaced with the electronics from the ACTS mobile terminal. This high gain antenna uses two slotted waveguide arrays and is mechanically steered in both elevation and azimuth. The actual dimensions of each array are 4 inches by 8 inches by 0.5 inches thick. A polarizer in front of each array provides for required circular polarization. A radome, 27.6 inches in diameter and 6.7 inches peak height, covers the array. The antenna is capable of tracking a full 360^0 in azimuth and minus 5^0 to zenith in elevation. The antenna tracking mechanism is designed to maintain pointing to within 0.5 dB of beam peak throughout all phases of flight. The overall tracking system accommodates tracking rates up to 60 degrees per second in azimuth, and 30 degrees per second in elevation. Duplex data rates up to 2 Mbps can be accommodated.

APPENDIX E

COST ESTIMATION
(From the ACTS Usage Policy)

This information is provided to users of ACTS subsystems to facilitate a rough order of magnitude estimate of the costs incurred by NASA Glenn Research Center to perform experiments involving the ACTS flight and ground segments.

Appropriate usages of ACTS subsystems are experiments and demonstration having to do with following activities. The following will be used as framework for determination of whether or not a proposal is fully or partially cost reimbursable:

1. ACTS Technology Verification Experiments (Non-reimbursable)
2. Experiments and demonstrations benefiting the United States in general (Partially Cost Reimbursable)
3. Experiments and demonstrations for a specific organization (Fully Cost Reimbursable)

The ACTS Project will make the determination as to which of the above categories a given experiment or demonstration proposal would fall under, and the type of agreement best appropriate for the given proposal.

Basis for computation of NASA Costs (see Note1):

Cost Element	**Cost or Cost Rate (Dollars)**		
Civil Service (CS) Labor Cost:	$47/Hour		
Travel Cost:	Estimated per request		
Direct Material Cost:	Estimated per request		
	1st Shift	2nd Shift	3rd Shift
ACTS Network Support Cost:	$500/Hour	$385/Hour	$320/Hour
Support Contractor (SC) Labor Cost:	$65/Hour		
ACTS Terminal Usage (VSAT):	$150/Day/Terminal		
ACTS Terminal Usage (USAT):	$140/Day/Terminal		
ACTS Terminal Usage (HDR):	$350/Day/Terminal		
Subtotal Cost:	Sum of CS Labor, Travel, Direct Material, ACTS Network Support, SC Labor, & ACTS Terminal Usage Costs		
Indirect Cost:	20% to 50% of subtotal cost		
Total Cost:	Subtotal plus Indirect cost		

Note 1: An actual cost estimate is highly dependent on the specific requirements of the unique experiment or demonstration proposal. An actual cost estimate, including the experiment/demonstration checkout requirements, will be made by NASA and communicated to experimenters upon receipt of a proposal.

The ACTS Usage Policy can be found at the ACTS Web site: http://acts.grc.nasa.gov

APPENDIX F

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