COMMUNICATING BY SATELLITE.

Robert Earl Byrd

NAVAL POSTGRADUATE SCHOOL
Monterey, California

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by

Robert Earl Byrd

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This paper covers some of the basic topics encountered by the communications manager faced with the task of familiarizing himself in the rapidly growing field of communications satellites. It is not intended to be an in-depth discussion but rather a brief introduction to the ionosphere, the decibel measurement system and some very basic rocket and space mechanics. Commerical ventures by INTELSAT have been most successful in this field and, for that reason, a section on INTELSAT and its progress has been

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included. Finally, a glossary of useful satellite terminology is included to supplement other available sources of information.

COMMUNICATING BY SATELLITE

BY

ROBERT EARL BYRD
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ABSTRACT

THIS PAPER COVERS SOME OF THE BASIC TOPICS ENCOUNTERED BY THE COMMUNICATIONS MANAGER FACED WITH THE TASK OF FAMILIARIZING HIMSELF IN THE RAPIDLY GROWING FIELD OF COMMUNICATIONS SATELLITES. IT IS NOT INTENDED TO BE AN IN-DEPTH DISCUSSION BUT RATHER A BRIEF INTRODUCTION TO THE IONOSPHERE, THE DECIBEL MEASUREMENT SYSTEM AND SOME VERY BASIC ROCKET AND SPACE MECHANICS. COMMERCIAL VENTURES BY INTELSAT HAVE BEEN MOST SUCCESSFUL IN THIS FIELD AND, FOR THAT REASON, A SECTION ON INTELSAT AND ITS PROGRESS HAS BEEN INCLUDED. FINALLY, A GLOSSARY OF USEFUL SATELLITE TERMINOLOGY IS INCLUDED TO SUPPLEMENT OTHER AVAILABLE SOURCES OF INFORMATION.

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I. THE HISTORY OF THE COMMUNICATIONS SATELLITE

INTRODUCTION

THE WORLD IN WHICH WE LIVE TODAY IS AN INCREASINGLY TECHNICAL ONE, WITH ADVANCEMENTS IN TECHNOLOGY OFTEN OUTDISTANCING OUR ABILITY TO MANAGE THEM. THE LANDS ACROSS THE OCEANS WHICH ONCE SEEMED TOO FAR DISTANT TO IMAGINE SUDDENLY APPEAR CLOSER AS ADVANCEMENTS IN MOBILITY CONTINUE TO "SHRINK" THE WORLD. THE PACE OF WORLD-LIFE HAS QUICKENED AND THE SINGLE COMMUNITY OF EARTH IS NOW A MORE EASILY-IMAGINED REALITY.

A MAJOR REASON FOR THIS APPARENT CHANGE IN THE WORLD HAS BEEN THE DEVELOPMENTS IN COMMUNICATIONS TECHNOLOGY AND, IN PARTICULAR, THE DEVELOPMENT AND USE OF COMMUNICATIONS SATELLITES. FOR THE AVERAGE AMERICAN TELEVISION VIEWER MUNICH AND PEKING WERE, ONLY TWO DECADES AGO, CITIES OF ANOTHER WORLD, PAGES IN A GEOGRAPHY BOOK OR A BYLINE ON A NEWSPAPER STORY. NOW, WHEN HISTORICAL OR NEWSWORTHY EVENTS OCCUR, THEY ARE AS NEAR AS THE ON-OFF SWITCH OF THE FAMILY TV. THE WORDS "VIA SATELLITE" FLASHED ACROSS THE SCREEN ARE NOW TOO COMMONPLACE TO AWE THE CASUAL VIEWER. OUR CHILDREN ARE GROWING UP WITH A DIFFERENT SENSE OF NEARNESS TO OTHER NATIONS OF THE WORLD THAN WE EXPERIENCED IN OUR CHILDHOOD. COMMUNICATIONS SATELLITES HAVE HAD AND WILL CONTINUE TO HAVE A PROFOUND EFFECT UPON OUR WORLD.

IT WOULD THEREFORE APPEAR LOGICAL THAT TO MORE FULLY UNDERSTAND OUR PRESENT COMMUNICATIONS STATUS, BOTH MILITARY AND CIVILIAN, IN THE ART OF SATELLITE COMMUNICATIONS WE

SHOULD BEGIN WITH AN APPRECIATION OF THE HISTORY OF SATELLITE COMMUNICATIONS PRIOR TO WHAT COULD BE CALLED THE OPERATIONAL STAGE WHICH BEGAN WITH THE LAUNCHING OF THE EARLY BIRD (INTELSAT I) GEOSTATIONARY, SYNCHRONOUS ORBIT COMMUNICATIONS SATELLITE.

A. COMMUNICATIONS SATELLITE TEST/EVALUATION STAGE

THE MOON IS OUR NATURAL SATELLITE AND PRESENTS A TARGET AND REFLECTOR FOR MICROWAVE TRANSMISSIONS BEAMED AT IT FROM THE EARTH. IN 1954, THE NAVAL RESEARCH LABORATORY (NRL), IN AN EFFORT TO TEST THE FEASIBILITY OF SATELLITE COMMUNICATIONS, TRANSMITTED A SIGNAL TO THE MOON AND RECEIVED ITS ECHO, ESTABLISHING THE FIRST EARTH-MOON-EARTH RADIO LINK. FURTHER INVESTIGATION LED TO THE FIRST TRANSCONTINENTAL TRANSMISSION IN 1955. LATER, IN 1959, A TWO-WAY (DUPLEX) LINK BETWEEN WASHINGTON, D.C. AND HAWAII BECAME OPERATIONAL ON FREQUENCIES OF 400 AND 450 MHZ. THE HUMANS WERE "HOWLING AT THE MOON" IN A BIG WAY.

1. PASSIVE VS ACTIVE SATELLITES

IN THE PREVIOUS EXAMPLE THE MOON WAS ACTING AS A PURELY PASSIVE SATELLITE, THAT IS , IT MERELY REFLECTED THE SIGNAL BEAMED TO IT. SUBSEQUENT RESEARCH WAS TO TEST THE FEASIBILITY OF MAN-MADE PASSIVE SATELLITES AGAINST ACTIVE SATELLITES OF TWO DIFFERENT TYPES. AN ACTIVE SATELLITE IS ONE WHICH, INSTEAD OF MERELY REFLECTING THE SIGNAL, RECEIVES IT, AMPLIFIES IT AND RETRANSMITS IT BACK TO EARTH. ACTIVE SATELLITES UNDER CONSIDERATION WERE DIVIDED INTO TWO CLASSES: THE DELAYED-REPEATER AND THE ACTIVE-REPEATER. THE DELAYED-REPEATER WAS THE FIRST TO BE TESTED IN THE ACTIVE SERIES AND IT CONSISTED OF AN ORBITING SATELLITE WHICH COULD RECEIVE INFORMATION, STORE IT AND LATER, UPON COMMAND, RETRANSMIT IT BACK TO EARTH. THE ACTIVE-REPEATER, ON THE

OTHER HAND, CAN RECEIVE, AMPLIFY AND TRANSMIT SIMULTANEOUSLY FOR REAL-TIME INFORMATION PASSAGE.

2. PROJECT SCORE

THE ALMOST TOP SECRET PREPARATIONS FOR THE LAUNCH OF PROJECT SCORE HAD TWO MAIN OBJECTIVES. THE FIRST WAS TO TEST THE FEASIBILITY OF USING MAN-MADE SATELLITES AS COMMUNICATION RELAY STATIONS IN EARTH ORBIT AND THE SECOND WAS TO TEST THE ATLAS ICBM AS A LAUNCH VEHICLE.

ON 18 DECEMBER 1958 AN ATLAS WAS LAUNCHED FROM CAPE CANAVERAL CARRYING 150 POUNDS OF COMMUNICATIONS EQUIPMENT CONSISTING OF DUPLICATE PACKAGES OF TAPE RECORDERS, RADIO RECEIVERS AND TRANSMITTERS, CONTROL UNITS AND MINITRACK BEACON TRANSMITTERS. THE ATLAS ICBM WAS A 1 1/2 STAGE VEHICLE, THE HALF STAGE BEING TWO BOOSTERS STRAPPED TO IT. THESE BOOSTERS WERE EJECTED AFTER SERVING THEIR PURPOSE AND THE ENTIRE REMAINDER OF THE VEHICLE WAS PLACED INTO EARTH ORBIT. PRESIDENT DWIGHT D. EISENHOWER HAD PRE-RECORDED A CHRISTMAS MESSAGE TO THE WORLD AND ON ITS THIRTEENTH ORBIT SCORE BROADCAST THIS HISTORIC MESSAGE TO EARTH. SCORE CONTINUED TO RECEIVE, RECORD AND RELAY MESSAGES FROM EARTH FOR THIRTEEN DAYS BEFORE ITS ORBIT DECAYED AND IT RE-ENTERED THE EARTH'S ATMOSPHERE ON 21 JANUARY 1959. SCORE HAD PROVEN THE FEASIBILITY OF STORE AND FORWARD (DELAYED REPEATER) COMMUNICATIONS SATELLITES.

3. ECHO

ECHO WAS AN ATTEMPT TO DUPLICATE THE REFLECTIVE QUALITIES OF A SPHERE SUCH AS THE MOON ORBITING MUCH CLOSER TO THE EARTH. IT WAS A TRUE PASSIVE COMMUNICATIONS SATELLITE BEING SIMPLY A 100-FOOT DIAMETER BALLOON COATED WITH ALUMINUM AND CARRYING ONLY TWO ELEVEN OUNCE BEACONS FOR

LOCATING AND TRACKING PURPOSES.

HAVING SUCCESSFULLY LAUNCHED AND OPERATED SCORE, A DELAYED-REPEATER ACTIVE COMMUNICATIONS SATELLITE, MANY SCIENTISTS WERE OF THE OPINION THAT A PURELY PASSIVE SATELLITE WAS A MORE FEASIBLE IDEA GIVEN THAT A REFLECTOR WOULD HAVE MULTIPLE ACCESS CAPABILITY AND INCREASED RELIABILITY DUE TO THE LACK OF ELECTRONIC EQUIPMENT ONBOARD. ANOTHER MAIN CONSIDERATION WAS THAT PASSIVE SATELLITES WERE CONSIDERABLY CHEAPER THAN ACTIVE SATELLITES.

THE FIRST ATTEMPT AT LAUNCHING ECHO WAS UNSUCCESSFUL DUE TO A FAILURE IN THE THOR DELTA LAUNCH VEHICLE ON 13 MAY 1960. THREE MONTHS LATER, ON AUGUST 12TH, ECHO I WAS SUCCESSFULLY LAUNCHED AND INFLATED. AGAIN PRESIDENT EISENHOWER HAD PRE-TAPED A MESSAGE AND IT WAS RELAYED FROM CALIFORNIA TO NEW JERSEY TO PROVIDE SOME 150 TRANSMISSIONS OF TELETYPE, VOICE AND FACSIMILE BETWEEN THE EAST AND WEST COASTS OF THE UNITED STATES AND BETWEEN THE UNITED STATES AND GREAT BRITAIN DURING THE LIFE OF ECHO I. ECHO I RE-ENTERED THE EARTH'S ATMOSPHERE ON 24 MAY 1968.

ECHO 2 WAS PLACED IN A NEAR-POLAR ORBIT OF 600 TO 800 MILES AND USED A THOR AGENA B ROCKET AS LAUNCH VEHICLE. ECHO 2 CONTINUED THE COMMUNICATIONS TESTS OF ECHO 1 USING TELETYPE, VOICE AND FACSIMILE AND IN ADDITION WAS USED FOR THE FIRST JOINT US/USSR COMMUNICATIONS EXPERIMENTS. ECHO 2'S ORBIT DECAYED ON 7 JUNE 1969.

4. COURIER

COURIER WAS A DELAYED-REPEATER ACTIVE SATELLITE DESIGNED FOR FEASIBILITY TESTS BY THE SIGNAL CORPS OF THE US ARMY. IT WEIGHED 500 POUNDS WITH 300 POUNDS OF COMMUNICATIONS EQUIPMENT ONBOARD INCLUDING FIVE TAPE RECORDERS (FOUR DIGITAL AND ONE ANALOG), A TELEMETRY

GENERATOR, VHF DIPLEXER, COMMAND DECODER AND SPARES. COURIER WAS SPHERICAL WITH A 51 INCH DIAMETER AND COVERED WITH 19,200 SOLAR CELLS PROVIDING SIXTY-TWO WATTS OF POWER.

THE FIRST ATTEMPT (18 AUGUST 1960) TO LAUNCH COURIER 1A WAS UNSUCCESSFUL DUE TO FAILURE OF THE LAUNCH VEHICLE, A THOR ABLE STAR. TWO MONTHS LATER ON 4 OCTOBER 1960, COURIER 1B WAS PLACED INTO ORBIT FROM CAPE CANAVERAL. INITIAL TESTS WERE MADE OF COURIER'S STORE AND FORWARD CAPABILITIES BUT THE SATELLITE CEASED OPERATING SEVENTEEN DAYS INTO THE MISSION. IT HAD BEEN DESIGNED TO LAST FOR ONE YEAR.

5. TELSTAR

THE TELSTAR SATELLITES WERE DESIGNED AND BUILT BY BELL TELEPHONE LABORATORIES AND PLACED INTO ORBIT BY NASA USING A 3-STAGE THOR DELTA. TELSTAR WAS AN ACTIVE REPEATER TYPE WITH EMPHASIS ON VOICE CHANNELS. TELSTAR WAS CAPABLE OF 600 ONE-WAY VOICE CHANNELS OR ONE TELEVISION CHANNEL. ITS UPLINK FREQUENCY WAS 6.39 GHZ AND ITS DOWNLINK FREQUENCY WAS 4.179 GHZ OUTPUTTING 2.25 WATTS VIA A TRAVELING WAVE TUBE (TWT). THE SATELLITES THEMSELVES WERE SPHERICAL, WEIGHING 175 POUNDS AND COVERED WITH 3600 SOLAR CELLS.

TELSTAR 1 WAS SUCCESSFULLY ORBITED ON 10 JULY 1962. TELEPHONE, FACSIMILE AND HIGH AND LOW SPEED DATA TRANSMISSION EXPERIMENTS WERE ALL CARRIED OUT SUCCESSFULLY INCLUDING A FIRST: ON THE EITHTEENTH ORBIT AN EIGHT MINUTE TV PROGRAM WAS BROADCAST FROM FRANCE AND CARRIED BY US NETWORKS. TELSTAR 1 ENCOUNTERED DAMAGING RADIATION MUCH HIGHER THAN EXPECTED IN THE VAN ALLEN RADIATION BELT AND STOPPED TRANSMITTING ON 2 FEBRUARY 1963.

ON 7 MAY 1963 TELSTAR 2 WAS PLACED INTO ORBIT WITH IMPROVEMENTS TO PROTECT AGAINST THE DETRIMENTAL EFFECTS OF

HIGH RADIATION EXPERIENCED BY TELSTAR 1 AND WITH A HIGHER ORBITAL APOGEE TO PROVIDE LONGER MUTUAL VISIBILITY BETWEEN THE US AND EUROPE. TELSTAR 2 CEASED OPERATIONS IN MAY OF 1965.

6. RELAY

NASA THEN DESIGNED AND BUILT ITS OWN ACTIVE-REPEATER COMMUNICATIONS SATELLITE AND NAMED IT RELAY. USING THE NEWLY IMPROVED THOR DELTA ROCKET RELAY 1 WAS ORBITED FROM CAPE CANAVERAL ON 13 DECEMBER 1962. WEIGHING 172 POUNDS, RELAY WAS OCTAGONALLY SHAPED AND TAPERED AT ONE END TO FIT WITHIN THE DELTA PAYLOAD FAIRING. ALL EIGHT SIDES WERE COVERED WITH A TOTAL OF 8215 SOLAR CELLS PROVIDING 45 WATTS OF AVERAGE POWER. AFTER SOME TECHNICAL DIFFICULTIES RELAY 1 CARRIED OUT SUCCESSFUL COMMUNICATIONS TESTS BETWEEN THE US, GREAT BRITAIN, FRANCE AND ITALY UNTIL FEBRUARY OF 1965.

SIMILAR EXPERIMENTS WERE CARRIED OUT WITH RELAY 2 PLACED INTO ORBIT ON 21 JANUARY 1964. ONE SUCH EXPERIMENT WAS THE FIRST SATELLITE RELAY BETWEEN JAPAN AND THE US.

7. SYNCOM

EXPERIMENTS WITH PASSIVE, DELAYED-REPEATER AND LOW-ALTITUDE NON-SYNCHRONOUS ACTIVE-REPEATER SATELLITES HAD SHOWN THE RELATIVE STRENGTHS AND WEAKNESSES OF EACH. THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION NOW TURNED TO THE POSSIBILITY OF LAUNCHING AN ACTIVE-REPEATER INTO A SYNCHRONOUS ORBIT AND NAMED THE SERIES SYNCOM.

THE LAUNCHINGS OF SYNCOM 1,2 AND 3 ALSO SERVED TO TEST AND PERFECT THE LENGTHY AND COMPLICATED TECHNIQUES OF INSERTING A SATELLITE INTO A SYNCHRONOUS ORBIT.

EACH SATELLITE WAS 28 INCHES IN DIAMETER AND WEIGHED, IN ORBIT, ONLY 86 POUNDS. THE COMMUNICATIONS SUIT WAS REDUNDANT, EMPLOYING FREQUENCY TRANSLATION AND CAPABLE OF

ONE TWO-WAY TELEPHONE AND SIXTEEN TELETYPE OR ONE TV CHANNEL. THE DUAL UPLINK FREQUENCIES WERE NEAR 7.36 GHZ AND THE SINGLE DOWNLINK FREQUENCY WAS 1.815 GHZ.

THE LAUNCH OF SYNCOM 1 ON 14 FEBRUARY 1963 WAS SUCCESSFUL AND THE BIRD WAS INSERTED INTO A NEAR SYNCHRONOUS ORBIT BEFORE ALL CONTACT WAS LOST. THE SUGGESTED REASON FOR ITS FAILURE WAS A RUPTURED NITROGEN BOTTLE.

SYNCOM 2 WAS LAUNCHED ON 26 JULY 1963 AND AFTER MUCH MANEUVERING WAS PLACED INTO A SYNCHRONOUS-BUT NOT STATIONARY-ORBIT OVER BRAZIL. THIS SATELLITE WAS USED TO RELAY A TELEPHONE CALL ON 9 AUGUST 1963 FROM CALIFORNIA TO AFRICA, A DISTANCE OF 7,700 MILES AND THE LONGEST LINE-OF-SIGHT COMMUNICATION MADE TO THAT DATE.

SYNCOM 3 WAS ORBITED ON 19 AUGUST 1964 AND BECAME THE FIRST SATELLITE TO BE PLACED INTO A GEOSTATIONARY, SYNCHRONOUS ORBIT WHEN FINALLY POSITIONED OVER THE PACIFIC OCEAN.

SYNCOM 3 WAS ENTIRELY SUCCESSFUL AND WAS USED TO RELAY COVERAGE OF THE OLYMPIC GAMES FROM TOKYO TO CALIFORNIA.

8. END OF THE TEST/EVALUATION STAGE

SYNCOM 3 WAS THE LAST AMERICAN COMMUNICATIONS SATELLITE ORBITED BEFORE THE LAUNCH OF EARLY BIRD (INTELSAT I) ON 6 APRIL 1965 BY THE NEWLY FORMED COMMUNICATIONS SATELLITE CORPORATION (COMSAT) AND THE INTERNATIONAL TELECOMMUNICATIONS SATELLITE CONSORTIUM (INTELSAT) AND THUS SERVES AS A CONVENIENT AND APPROPRIATE DIVIDING LINE BETWEEN THE TEST AND EVALUATION STAGE OF COMMUNICATIONS SATELLITE RESEARCH AND THE OPERATIONAL STAGE. IT WAS NOW TIME FOR THE COMMUNICATIONS SATELLITE TO BEGIN PAYING FOR ITSELF AND MAKING ITS MARK UPON WORLD COMMUNICATIONS.

B. THE ADVENT OF GLOBAL COMMUNICATIONS: COMSAT/INTELSAT

"THE CONGRESS HEREBY DECLARES THAT IT IS THE POLICY OF THE UNITED STATES TO ESTABLISH, IN CONJUNCTION AND IN COOPERATION WITH OTHER COUNTRIES, AS EXPEDITIOUSLY AS PRACTICABLE A COMMERCIAL COMMUNICATIONS SATELLITE SYSTEM, AS PART OF AN IMPROVED GLOBAL COMMUNICATION NETWORK, WHICH WILL SERVE THE COMMUNICATION NEEDS OF THE UNITED STATES AND OTHER COUNTRIES, AND WHICH WILL CONTRIBUTE TO WORLD PEACE AND UNDERSTANDING." (COMMUNICATIONS SATELLITE ACT OF 1962, P.L. 87-624, SEC 102(A))

1. COMMUNICATIONS SATELLITE CORPORATION (COMSAT)

UNDER THE PROVISIONS OF P.L. 87-624 COMSAT WAS INCORPORATED IN EARLY 1963 AS A UNIQUE, PRIVATELY-OWNED U.S. COMMUNICATIONS CARRIER COMPANY OPERATING UNDER A MANDATE FROM THE CONGRESS OF THE UNITED STATES.

PRESSURES HAD BEEN BUILDING FOR SEVERAL YEARS FOR SUCH A POSITIVE STEP FORWARD. AS EARLY AS 1955 A DOCTOR PIERCE OF BELL TELEPHONE LABORATORIES HAD POINTED OUT THE POTENTIAL AND USEFULNESS OF COMMUNICATIONS SATELLITES. (16,152) SHORTLY AFTER WORLD WAR II, WRITING IN WIRELESS WORLD, A BRITISH ENGINEER (AND LATER, A SCIENCE-FICTION WRITER) NAMED ARTHUR C. CLARKE DESCRIBED THE MAIN OUTLINES OF THE SYSTEM ACTUALLY NOW IN USE. (5,118) BELL CONTINUED RESEARCH IN 1959 AND 1960 ON THE DESIGN OF AN ACTIVE REPEATER SATELLITE AND IN 1960 EXPERIMENTED WITH NASA'S PASSIVE SATELLITE ECHO I. INTENSIVE DEVELOPMENT OF AT&T'S OWN DESIGN KNOWN AS TELSTAR BEGAN THE FOLLOWING YEAR.

ALONG WITH AT&T OTHER COMMON CARRIERS AND AEROSPACE FIRMS BEGAN TO DISPLAY AN ACTIVE INTEREST IN VARIOUS ASPECTS OF A COMMERCIAL SATELLITE SYSTEM DEVOTED TO COMMUNICATIONS. IT WAS CLEAR THAT CONCISE, CLEAR PROCEDURES FOR THE

DEVELOPMENT OF SUCH A SYSTEM WERE IN ORDER. THE FEDERAL COMMUNICATIONS COMMISSION, ACTING AS THE PUBLIC'S "WATCHDOG OF THE AIRWAVES", OPENED HEARINGS ON THE ISSUE IN MAY OF 1961. REPORTING OUT THAT SAME MONTH THE FCC STATED THAT THE CONSENSUS OF ITS INQUIRY WAS THAT A JOINT PRIVATE ENDEAVOR WAS PREFERRED TO A PUBLIC, GOVERNMENT SPONSORED SYSTEM. ACCORDINGLY, THE FCC CREATED A COMMITTEE MADE UP OF REPRESENTATIVES FROM THE VARIOUS COMMON CARRIERS TO ESTABLISH A PLAN FOR THE ESTABLISHMENT OF A COMMERCIAL COMMUNICATIONS SATELLITE SYSTEM.

ALSO IN MAY OF 1961 CONGRESS BEGAN TO HOLD HEARINGS ON THE SUBJECT IN VARIOUS COMMITTEES. AS MIGHT HAVE BEEN EXPECTED, THE RESULT WAS THAT SOME INTERESTS FAVORED PRIVATE OWNERSHIP AND SOME PUBLIC. SEVERAL BILLS WERE INTRODUCED REFLECTING THESE TWO PHILOSOPHIES OF OWNERSHIP EARLY IN 1962. AFTER MUCH DEBATE ON THIS QUESTION, THE ACT AS FINALLY PASSED CALLED FOR A PRIVATELY-OWNED CORPORATION WITH RATHER SPECIFIC RELATIONSHIPS ESTABLISHED BETWEEN THE CORPORATION, THE PRESIDENT OF THE UNITED STATES, THE FCC AND NASA. FURTHER IT STIPULATED THAT ONE-HALF OF THE OUTSTANDING STOCK WOULD BE OWNED BY THE "AUTHORIZED COMMON CARRIERS" AND ONE-HALF BY THE PUBLIC.

CONGRESS ALSO INTENDED TO HAVE A SAY IN THE FUTURE MANAGEMENT OF THE CORPORATION BY WRITING INTO P.L. 87-624 THE PROVISION THAT THE 15-MEMBER BOARD OF DIRECTORS WOULD BE SEATED AS FOLLOWS: SIX MEMBERS ELECTED BY THE "AUTHORIZED COMMON CARRIERS", SIX MEMBERS BY THE PUBLIC STOCK HOLDERS AND THREE MEMBERS APPOINTED BY THE PRESIDENT WITH THE ADVISE AND CONSENT OF THE SENATE. BY REQUIRING SENATE CONFIRMATION OF THREE MEMBERS CONGRESS INSURED THAT IT WOULD HAVE SOME

SAY IN THE FUTURE MANAGEMENT OF COMSAT.

THE PRESIDENT FURTHER INSERTED HIS OFFICE INTO THE ESTABLISHMENT AND MANAGEMENT OF COMSAT BY ISSUING EXECUTIVE ORDER 11556 OF SEPTEMBER 4, 1970 WHICH ASSIGNED FUNCTIONS TO THE OFFICE OF TELECOMMUNICATIONS POLICY (OTP) THAT HAD BEEN CREATED IN THE EXECUTIVE OFFICE OF THE PRESIDENT EARLIER THAT YEAR. OTP, THROUGH ITS DIRECTOR, WAS TO:

> "(1) AID IN THE PLANNING AND DEVELOPMENT, AND AID IN FOSTERING THE EXECUTION, OF A NATIONAL PROGRAM FOR THE ESTABLISHMENT AND OPERATION, AS EXPEDITIOUSLY AS POSSIBLE, OF A COMMERCIAL COMMUNICATIONS SATELLITE SYSTEM (SEC 2(B)(1)).
>
> (2) CONDUCT A CONTINUOUS REVIEW OF ALL PHASES OF THE DEVELOPMENT AND OPERATION OF SUCH A SYSTEM, INCLUDING THE ACTIVITIES OF THE CORPORATION (SEC 2(B)(2)).
>
> (3) COORDINATE THE ACTIVITIES OF GOVERNMENTAL AGENCIES WITH RESPONSIBILITIES IN THE FIELD OF TELECOMMUNICATION, SO AS TO INSURE THAT THERE IS FULL AND EFFECTIVE COMPLIANCE AT ALL TIMES WITH THE POLICIES SET FORTH IN THE ACT (SEC 2(B)(3)).
>
> (4) MAKE RECOMMENDATIONS TO THE PRESIDENT AND OTHERS AS APPROPRIATE, WITH RESPECT TO ALL STEPS NECESSARY TO INSURE THE AVAILABILITY AND APPROPRIATE UTILIZATION OF THE COMMUNICATIONS SATELLITE SYSTEM FOR GENERAL GOVERNMENT PURPOSES IN CONSONANCE WITH SECTION 201(A)(6) OF THE ACT (SEC 2(B)(4)).
>
> (5) HELP ATTAIN COORDINATED AND EFFICIENT USE OF THE ELECTROMAGNETIC SPECTRUM AND THE TECHNICAL COMPATIBILITY OF THE COMMUNICATIONS SATELLITE SYSTEM WITH EXISTING COMMUNICATIONS FACILITIES BOTH IN THE UNITED STATES AND ABROAD (SEC 2(B)(5)).
>
> (6) PREPARE, FOR CONSIDERATION BY THE PRESIDENT, SUCH PRESIDENTIAL ACTION DOCUMENTS AS MAY BE APPROPRIATE UNDER SECTION 201(A) OF THE ACT, MAKE NECESSARY RECOMMENDATIONS TO THE PRESIDENT IN CONNECTION THEREWITH, AND KEEP THE PRESIDENT CURRENTLY INFORMED WITH RESPECT TO THE CARRYING OUT OF THE ACT (SEC 2(B)(6)).

(7) SERVE AS THE CHIEF POINT OF LIAISON BETWEEN THE PRESIDENT AND THE CORPORATION (SEC 2(B)(7))." (27,10-11)

TO GET COMSAT STARTED, THE PRESIDENT WAS ALSO REQUIRED TO APPOINT (AGAIN, WITH THE ADVISE AND CONSENT OF CONGRESS), A GROUP OF INCORPORATORS WHO WERE TO SERVE AS AN INTERIM BOARD OF DIRECTORS. FOURTEEN WERE SO APPOINTED AND ON FEBRUARY 1, 1963 COMSAT CAME OFFICIALLY INTO BEING.

THE INTERIM BOARD HAD BEFORE IT A SUBSTANTIAL EFFORT. TO GET COMSAT OFF THE GROUND IT HAD TO:

"(1) RECRUIT A COMPETENT TECHNICAL, ADMINISTRATIVE AND LEGAL STAFF.

(2) ARRANGE FOR INTERIM FINANCING.

(3) PREPARE FOR A STOCK ISSUE.

(4) DECIDE ON TECHNIQUES FOR A SYSTEM, AND PROCEED WITH ITS DEVELOPMENT AND DEPLOYMENT.

(5) ARRANGE FOR FOREIGN PARTICIPATION IN THE SYSTEM." (16,154)

2. INTERNATIONAL TELECOMMUNICATIONS SATELLITE CONSORTIUM

THE COMMUNICATIONS SATELLITE ACT OF 1962 REQUIRED THAT IT BE THE POLICY OF THE UNITED STATES "TO ESTABLISH IN CONJUNCTION AND COOPERATION WITH OTHER COUNTRIES A COMMUNICATIONS SATELLITE SYSTEM." SOON AFTER THE ENACTMENT OF THE ACT A EUROPEAN CONFERENCE WAS HELD. THIS CONFERENCE

"CAME TO A MOST IMPORTANT CONCLUSION: THAT SATELLITE COMMUNICATIONS SHOULD BE ORGANIZED ON AN INTERNATIONAL BASIS IN SUCH A WAY AS TO ENABLE ALL

COUNTRIES TO PARTICIPATE IN THE DESIGN OF THE SYSTEM, TO SHARE IN ITS OWNERSHIP AND TO PLAY A FULL PART IN ITS MANAGEMENT". (5,127)

AS A RESULT OF THE AFOREMENTIONED INTENT OF THE ACT TO DEVELOP AN INTERNATIONAL CONSORTIUM AND THE EUROPEAN CONFERENCE, TWO INTERNATIONAL AGREEMENTS WERE DRAWN UP AND OPENED FOR SIGNATURE IN WASHINGTON ON AUGUST 20, 1964. SOURCES DIFFER ON THE EXACT NUMBER OF ORIGINAL SIGNATORIES. THE DIFFERENCE MAY BE IN THE INTERPRETATION OF THE WORD "ORIGINAL". ONE SOURCE (5,127) REPORTS THAT "ELEVEN NATIONS SIGNED THE AGREEMENTS ON THAT DATE (AUGUST 20,1964) AND THEREBY FORMED INTELSAT". BY THE END OF 1964 NINETEEN NATIONS HAD BECOME MEMBERS OF THE CONSORTIUM AND WERE ASSIGNED VARIOUS INVESTMENT QUOTAS. THE UNITED STATES, WITH ITS VIRTUAL MONOPLY IN THE FREE WORLD OF SATELLITE EXPEFTISE, FACILITIES AND LAUNCH VEHICLES, WAS ACCORDED THE LION'S SHARE. DEFINITIVE AGREEMENTS WERE RATIFIED BY THE REQUIRED 54 MEMBER COUNTRIES AND THE INTERNATIONAL TELECOMMUNICATIONS SATELLITE CONSORTIUM OFFICIALLY CAME INTO EXISTENCE ON FEBRUARY 12, 1973 CONSISTING OF "MORE THAN 80 MEMBER NATIONS REPRESENTING APPROXIMATELY 95 PER-CENT OF THE TELECOMMUNICATIONS TRAFFIC OF THE WORLD." (15,3) AS OF AUGUST, 1975, INTELSAT WAS COMPOSED OF 91 MEMBER NATIONS. (28)

IN THE ELEVEN YEARS SINCE ITS INAUGURATION INTELSAT HAS COME A LONG WAY IN ITS STATED OBJECTIVE OF ACHIEVING A TRJLY GLOBAL TELECOMMUNICATIONS SYSTEM. THE INTELSAT SERIES OF SATELLITES EXHIBIT THE RAPID PROGRESS THAT TECHNOLOGY IN THIS FIELD HAD MADE.

A. INTELSAT I

"EARLY BIRD", AS IT WAS ORIGINALLY KNOWN, WAS LAUNCHED FROM CAPE KENNEDY ATOP A THRUST-AUGMENTED DELTA ROCKET ON APRIL 6, 1965. THE SATELLITE WAS EXPERIMENTAL AND OPERATIONAL. EXPERIMENTAL IN THAT IT WAS TO PROVIDE DATA ON, AMONG OTHER THINGS, THE APPLICABILITY OF SATELLITE USAGE FOR TELEPHONE CIRCUITS, THE EFFECT OF RAIN ON GROUND STATION RECEPTION AND THE REACTION OF TELEPHONE USERS TO THE TIME DELAY OF A SYNCHRONOUS SATELLITE. IT WAS OPERATIONAL IN THAT, ASSUMING THE ANSWERS TO THE QUESTIONS ABOVE AND OTHERS WERE SATISFACTORY, IT COULD PROVIDE COMMERCIAL SERVICE BETWEEN THE ANDOVER, MAINE U.S. STATION AND PLEUMEUR BODOU, FRANCE; RAISTING, GERMANY; FUCINO, ITALY AND GOONHILLY, GREAT BRITAIN.

AMONG THE DATA GAINED FROM INTELSAT I WAS THE FACT THAT EARTH STATIONS WITHOUT RADOMES (ANTENNA COVERS) EXPERIENCED A 2 TO 3 DB DEGRADATION IN CARRIER TO NOISE DUE TO RAIN AND WIND WHILE THOSE WITH INFLATED RADOMES EXPERIENCED DEGRADATIONS OF UP TO 6 TO 9 DB DUE TO RAIN. (1,70)

INTELSAT I HAD A 240 CIRCUIT OR ONE TV CHANNEL CAPACITY. IT PERMITTED ONLY POINT-TO-POINT COMMUNICATIONS IN THE HEAVY TRAFFIC PATH BETWEEN NORTH AMERICA AND EUROPE. IT POSSESSED NO MULTIPLE ACCESS CAPABILITY AND, IN ORBIT, WEIGHED 85 POUNDS. AS OF JULY 1975 THIS SATELLITE IS STILL IN ORBIT (THOUGH NO LONGER SYNCHRONOUS DUE TO THE EXPENDITURE OF ALL THE PROPELLANT USED TO MAINTAIN A GEOSYNCHRONOUS ORBIT) AND IS STILL FUNCTIONING.

B. INTELSAT II

THIS SATELLITE WAS LAUNCHED INTO SYNCHRONOUS ORBIT IN OCTOBER, 1966 OVER THE PACIFIC OCEAN IN RESPONSE TO A NEED BY NASA IN ITS SPACE PROJECTS FOR A MULTICHANNEL COMMUNICATION CAPABILITY BETWEEN THEIR STATIONS IN THE PACIFIC AND THE MANNED SPACE FLIGHT HEADQUARTERS IN HOUSTON, TEXAS. BECAUSE INTELSAT I'S ANTENNA PERMITTED COVERAGE OVER ONLY ONE HEMISPHERE AND ITS RECEIVER LIMITERS PREVENTED MULTICARRIER USAGE IT WAS NOT SATISFACTORY FOR NASA'S NEEDS. INTELSAT II HAD A CAPACITY OF 240 CIRCUITS OR ONE TV CHANNEL. IT'S ANTENNA CONFIGURATION ALLOWED FOR COVERAGE OF BOTH THE NORTHERN AND SOUTHERN HEMISPHERES OF THE EARTH AND IT INTRODUCED A MULTIPOINT CAPABILITY BETWEEN EARTH STATIONS IN THE AREA OF COVERAGE. IN ORBIT IT WEIGHED 190 POUNDS. BOTH INTELSAT I AND II WERE BUILT BY HUGHES AIRCRAFT COMPANY.

C. INTELSAT III

THE FIRST INTELSAT III SATELLITE WAS LAUNCHED IN SEPTEMBER, 1968 BUT HAD TO BE DESTROYED A FEW SECONDS LATER DUE TO A ROCKET FAILURE. AFTER THIS RATHER UNFORTUNATE BEGINNING, THESE SATELLITES WERE SUCCESSFULLY PLACED IN ORBIT OVER THE ATLANTIC, PACIFIC AND INDIAN OCEANS ACHIEVING INTELSAT'S GOAL OF GLOBAL COVERAGE. THEY EACH HAD A CAPACITY OF 1500 CIRCUITS OR 4 TV CHANNELS OR COMBINATIONS OF TELEPHONE, DATA AND TV SERVICE. INTELSAT III WEIGHED 334 POUNDS IN ORBIT POINTING OUT THE CONTINUAL IMPROVEMENTS MADE TO THE DELTA LAUNCH VEHICLE.

D. INTELSAT IV

THE SECOND SERIES OF INTELSAT'S GLOBAL COVERAGE SATELLITES, INTELSAT IV, IS A GREATLY IMPROVED VEHICLE WITH EXPANDED CAPABILITIES. IT HAS AN AVERAGE CAPACITY OF 4,000 TELEPHONE CIRCUITS OR 12 TV CHANNELS OR MIXTURES THEREOF. IT

HAS TWELVE TRANSPONDERS, EACH WITH A 36-MHZ BANDWIDTH. IT IS DESIGNED FOR MULTIPLE ACCESS AND SIMULTANEOUS TRANSMISSION CAPABILITIES WITH TWO GLOBAL TRANSMIT ANTENNAS, TWO GLOBAL RECEIVE ANTENNAS AND TWO STEERABLE SPOT BEAM TRANSMIT ANTENNAS. IN ORBIT THE INTELSAT IV WEIGHS 1,610 POUNDS. THE MUCH GREATER WEIGHT OF THE IV SERIES REQUIRES A NEW LAUNCH VEHICLE. ORIGINALLY THE TITAN-AGENA VEHICLE WAS CONSIDERED BUT LATER DROPPED IN FAVOR OF THE ATLAS-CENTAUR MANUFACTURED BY THE CONVAIR AEROSPACE DIVISION OF GENERAL DYNAMICS. THE CENTAUR UPPER STAGE (THE FIRST LAUNCH VEHICLE TO USE LIQUID HYDROGEN AS A FUEL) SITS ATOP THE ATLAS BOOSTER. THE AIR FORCE DEVELOPED THE ATLAS AS A WEAPONS SYSTEM BUT IT HAS PROVEN TO BE AN EXCELLENT LAUNCH VEHICLE.

HUGHES AIRCRAFT COMPANY RECEIVED THE CONTRACT FOR THE FOUR ORIGINAL INTELSAT IV SATELLITES. TWO PROPOSED DESIGNS FOR INTELSAT IV WERE CONSIDERED. THEY DIFFERED PRIMARILY IN THE STABILIZATION METHOD, ONE BEING BODY STABILIZED, THE OTHER WITH SPIN-STABILIZATION AND A DESPUN ANTENNA SECTION. PRIOR SATISFACTORY EXPERIENCE IN SPIN STABILIZATION WITH INTELSAT'S I, II, AND III LED TO THIS CHOICE FOR INTELSAT IV. (23,VIII)

SIXTY PER-CENT (450 KG) OF THE SATELLITE'S WEIGHT SPINS AT A NOMINAL 51 RPM. THIS INCLUDES THE TWO CYLINDRICAL SOLAR PANEL ARRAYS, THE ELECTRICAL POWER, DESPIN CONTROL, AND POSITIONING AND ORIENTATION SUBSYSTEMS. FOR ELECTRICAL POWER THE SATELLITE IS PROVIDED 365 WATTS OF USEFUL DC POWER BY THE SOLAR PANELS AND, DURING THE 90 ANNUAL ECLIPSES, BY TWO 25-CELL NICKEL-CADMIUM BATTERIES DISTRIBUTED ABOUT THE SPINNING PORTION. THE DESPIN CONTROL SUBSYSTEM PROVIDES A DRIVE SIGNAL WHICH, IN NORMAL OPERATION, KEEPS THE ANTENNAS

POINTED TOWARD THE EARTH.

3. SUMMARY

THE COMMUNICATIONS SATELLITE ACT OF 1962 HERALDED IN THE AGE OF GLOBAL COMMUNICATIONS BY SATELLITE. THE ORGANIZATION OF COMSAT AND LATER, INTELSAT, BROUGHT INTERNATIONAL COOPERATION TO PLAY IN A UNITED FRONT TOWARD THE ACHIEVEMENT OF A SIGNIFICANT GOAL. OCEAN CABLES AND LANDLINES HAVE CONNECTED THE MAJOR CONTINENTS TO ONE ANOTHER FOR YEARS BUT SUCH CABLES ARE SUBJECT TO BREAKAGE AND LONG, EXPENSIVE REPAIR TIMES--CUTTING OFF NECESSARY COMMUNICATIONS IN THE MEANTIME. CABLES HAVE BECOME SATURATED AS THE VOLUME OF TRAFFIC HAS INCREASED EACH YEAR. WITH THE ADVENT OF THE SOPHISTICATED INTELSAT IV SATELLITE, COUNTRIES NOT LOCATED WITH A COASTLINE AND NOT POSSESSING AN OCEAN CABLE TERMINATION NOW ARE INSTANTLY IN TOUCH WITH THE REST OF THE FREE WORLD. THE SATELLITES HAVE REDUCED THE COSTS OF COMMUNICATION LINKS AND THE NECESSITY OF RELYING ON A NEIGHBORING COUNTRY'S LAND LINES TO REACH AN OCEAN CABLE TERMINATION.

FUTURE DEVELOPMENTS IN COMMERCIAL SATELLITE COMMUNICATIONS WILL BRING SUPERIOR EDUCATIONAL FACILITIES TO UNDERDEVELOPED COUNTRIES VIA TV BROADCAST (ALREADY BEING DONE IN INDIA), LESS EXPENSIVE LONG-HAUL TELEPHONE CIRCUITS ACROSS CONTINENTS AND FASTER DATA COMMUNICATION CAPABILITIES UTILIZING DIGITAL TRANSMISSION TECHNIQUES AND LOW COST TERMINALS.

II. A LOOK AT A COMSAT EARTH STATION

THE COMMUNICATIONS SATELLITE CORPORATION'S (COMSAT) EARTH STATION AT JAMESBURG, CALIFORNIA IS A MAJOR LINK IN THE INTERNATIONAL TELECOMMUNICATIONS SATELLITE CONSORTIUM'S (INTELSAT) WORLD-WIDE SYSTEM. WITH ITS 97-FOOT DISH ANTENNA TRACKING ONE OF THE TWO INTELSAT IV SPACECRAFT IN SYSCHRONOUS ORBIT OVER THE PACIFIC, JAMESBURG IS IN CONSTANT COMMUNICATIONS WITH FOURTEEN SIMILAR EARTH STATIONS SCATTERED ABOUT THE PACIFIC AREA.

JAMESBURG IS JOINTLY OWNED (AS DECIDED BY THE FCC) BY COMSAT (50%), AT&T (28.5%), RCA GLOBAL COMMUNICATIONS (10.5%), ITT WORLD COMMUNICATIONS (7%) AND WESTERN UNION INTERNATIONAL (4%) (14,5) BUT COMSAT HAS THE SOLE RESPONSIBILITY FOR ITS MANAGEMENT. COMSAT ITSELF IS A PRIVATELY OWNED CORPORATION WHICH IS REGULATED BY THE U.S. GOVERNMENT AS A PUBLIC UTILITY. GOVERNMENTAL PARTICIPATION IN COMSAT IS EXTENSIVE. THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION PROVIDES TECHNICAL SUPPORT AND LAUNCHES THE SATELLITES ON A COST REIMBURSABLE BASIS; THE DEPARTMENT OF STATE HANDLES INTERNATIONAL NEGOTIATIONS AND THE FEDERAL COMMUNICATIONS COMMISSION IS THE REGULATORY AUTHORITY. IN ADDITION TO MANAGING THE U.S. GROUND STATIONS, COMSAT IS CHARGED BY INTELSAT WITH THE DEVELOPMENT, MANAGEMENT AND OPERATION OF THE SPACECRAFT THEMSELVES. THERE ARE PRESENTLY THREE INTELSAT IVS OVER THE ATLANTIC, TWO INTELSAT IVS OVER THE PACIFIC AND TWO INTELSAT IVS OVER THE INDIAN OCEAN. ADDITIONALLY, TWO INTELSAT IIIS ARE STILL AVAILABLE AS

STANDBYS. ONE IS OVER THE INDIAN OCEAN AND ONE IS OVER THE PACIFIC. ALTHOUGH THE VOTING PROPORTION OF COMSAT WITHIN THE INTELSAT CONSORTIUM HAS DECREASED FROM A HIGH OF JUST OVER 50% TO A PRESENT FLUCTUATING 38-40%, COMSAT CONTINUES TO EXERT A SIGNIFICANT FORCE WITHIN THE CONSORTIUM. USAGE OF THE GLOBAL SYSTEM DETERMINES VOTING PROPORTIONS AND WHILE AMERICAN USAGE HAS BEEN STEADILY INCREASING, WORLD-WIDE USAGE HAS BEEN INCREASING AT A FASTER PACE THEREBY LOWERING COMSAT'S OVERALL PERCENTAGE.

A. LOCATION

THE JAMESBURG STATION IS LOCATED ON A 170-ACRE TRACT IN THE CACHAGA VALLEY, ABOUT 30 MILES SOUTH-EAST FROM MONTEREY, CALIFORNIA. THIS SITE WAS CHOSEN FOR THE EARTH STATION DUE TO ITS LOCATION IN A RELATIVELY RADIO QUIET VALLEY. IN A NOISIER ENVIRONMENT, THE SENSITIVE ANTENNA WOULD PICK UP UNWANTED SIGNALS AND MAKE RECEPTION OF THE EXTREMELY WEAK SIGNALS FROM THE SATELLITE VERY DIFFICULT. THE NAME OF THE STATION COMES FROM A POST OFFICE ESTABLISHED NEAR THERE IN 1886. IT WAS IN A CONVERTED STORAGE ROOM IN THE RANCH HOUSE OF THE JAMES FAMILY, HENCE THE NAME, "JAMESBURG".

JAMESBURG BECAME OPERATIONAL 1 DECEMBER 1968 AND HAS SINCE PARTICIPATED IN NOTEWORTHY NEWS EVENTS SUCH AS APOLLO SPLASHDOWNS, A ROYAL CORONATION, PRESIDENT NIXON'S TRIP TO CHINA AND PERHAPS THE MOST SPECTACULAR OF ALL: ASTRONAUT NEIL ARMSTRONG'S FIRST STEP ON THE MOON. THIS EVENT DEMONSTRATED THE RELIABILITY AND FLEXIBILITY OF THE INTELSAT SYSTEM. SIGNALS FROM THE LUNAR MODULE WERE RECEIVED IN AUSTRALIA, SENT VIA SATELLITE TO JAMESBURG, THEN BY LANDLINE TO HOUSTON, TEXAS. FROM HOUSTON THEY WENT ON TO NEW YORK WHERE THE SIGNALS MADE ENTRY INTO COMMERCIAL TV NETWORKS AND

THEN BACK TO JAMESBURG WHICH SENT IT TO THE PACIFIC SATELLITE AND IN A TWO-HOP FASHION VIA THE INDIAN OCEAN SATELLITE ON TO EUROPE.

B. EARTH STATION ORGANIZATION

THE OVERALL RESPONSIBILITY FOR THE OPERATION AND PERFORMANCE OF JAMESBURG RESTS WITH THE STATION MANAGER. HE HAS THREE "DEPARTMENTS" WORKING FOR HIM IN THE THREE BROAD AREAS OF ADMINISTRATION, OPERATIONS AND MAINTENANCE.

THE ADMINISTRATION SECTION IS HEADED BY THE STATION ADMINISTRATOR AND HE HAS TWO ASSISTANTS; ONE A MATERIAL AND SUPPLY EXPERT AND THE OTHER A SECRETARY AND PERSONNEL RECORDS SPECIALIST.

THE OPERATIONS PERSONNEL ARE DIVIDED INTO FOUR TEAMS, EACH HEADED BY AN OPERATIONS CONTROLLER ASSISTED BY AT LEAST TWO ELECTRONICS TECHNICIANS. THESE FOUR TEAMS MAN THE STATION 24 HOURS A DAY, SEVEN DAYS A WEEK IN EIGHT-HOUR SHIFTS CONDUCTING THE DAY-TO-DAY OPERATIONS AND PERFORMING SOME ROUTINE MAINTENANCE.

THE STATION ENGINEER, A POSITION OF IMPORTANCE IN THE ORGANIZATIONAL STRUCTURE SECOND TO THE STATION MANAGER, HEADS THE MAINTENANCE SECTION WHICH IS DIVIDED INTO THE ELECTRONIC DEPARTMENT AND THE FACILITIES DEPARTMENT. THE ELECTRONIC DEPARTMENT IS STAFFED BY THE ELECTRONICS MAINTENANCE SUPERVISOR AND ONE ELECTRONICS MAINTENANCE TECHNICIAN. THEIR RESPONSIBILITIES ARE IN PLANNING AND DOCUMENTING PREVENTIVE MAINTENANCE BEYOND THE SCOPE OF THE OPERATIONS TEAM WATCHSTANDERS. THE FACILITIES DEPARTMENT IS COMPRISED OF A FACILITIES ENGINEER, TWO MECHANICS AND A UTILITYMAN. THE FACILITIES ENGINEER AND HIS TWO MECHANICS TAKE CARE OF THE AIR CONDITIONING AND AUXILLARY POWER PLANTS

WHILE THE UTILITYMAN ACTS ESSENTIALLY AS A JANITOR.

BENSON AND PERSELL (4) POINTED OUT THE SIMILARITIES OF THIS ORGANIZATION TO THAT OF A NAVY SHIP. THE ADMINISTRATIVE SECTION IS ANALOGOUS TO A COMBINED SUPPLY DEPARTMENT AND SHIP'S OFFICE; THE OPERATIONS SECTION IS ANALOGOUS TO COMMUNICATIONS WATCH STANDERS; THE POSITION OF STATION ENGINEER IS ANALOGOUS TO THE SHIP'S CHIEF ENGINEER AND EXECUTIVE OFFICER COMBINED SINCE THE STATION ENGINEER FUNCTIONS AS THE STATION MANAGER IN HIS ABSENCE; FINALLY, THE FACILITIES DEPARTMENT OF THE MAINTENANCE SECTION IS COMPARED TO THE A-GANG OF A SHIP'S ENGINEERING DEPARTMENT.

THE CURRENT (AUGUST,1975) MANPOWER AUTHORIZATION FOR JAMESBURG IS 23. (28) THAT THE STATION OPERATES SO EFFICIENTLY AND SMOOTHLY WITH SUCH A SMALL NUMBER IS A TRIBUTE TO THE SELECTION AND TRAINING OF THE PERSONNEL, THE MANAGEMENT OF THE STATION AND THE HIGH STANDARDS OF EXCELLENCE EXHIBITED BY THE EMPLOYEES.

AS MIGHT BE EXPECTED WITHIN SUCH A SMALL ORGANIZATION, THE MAJOR MODE OF INTERNAL COMMUNICATION IS STRICTLY INFORMAL BY WORD-OF-MOUTH. MORE IMPORTANT INFORMATION IS ROUTED VIA A ROUTE SLIP REQUIRING INITIALS OF SUPERVISORY PERSONNEL.

GUIDANCE FROM COMSAT COMES IN THE FORM OF COMSAT SYSTEM PRACTICES (CSP'S), WHICH ARE DIRECTIVES THAT PERTAIN TO THE OPERATION, MANAGEMENT AND MAINTENANCE OF A COMSAT EARTH STATION. THE CSP'S BECOME THE "BIBLE" FOR JAMESBURG AND OTHER COMSAT EARTH STATIONS. DIRECTIVES FROM OTHER ORGANIZATIONS SUCH AS THE BELL SYSTEM PRACTICES (BSP'S), FCC REGULATIONS, AND OCCUPATIONAL STANDARDS FOR HEALTH AND SAFETY ARE ALSO KEPT ON FILE FOR READY REFERENCE. FOR MATTERS THAT PERTAIN ONLY TO JAMESBURG, THE STATION IS

REQUIRED TO SUBMIT TO COMSAT A COPY OF ITS STANDARD STATION PRACTICES (SSP) WHICH IS MUCH LIKE A NAVY SHIP'S ORGANIZATION AND REGULATION MANUAL.

C. COMMUNICATIONS SYSTEM

THE 97-FOOT ALUMINUM DISH ANTENNA POSSESSES AN AUTO TRACK GUIDANCE SYSTEM TO KEEP IT POINTED AT THE INTELSAT IV SATELLITE IN USE OVER THE PACIFIC OCEAN TO WITHIN HUNDREDTHS OF A DEGREE. IN AN EMERGENCY, THERE IS A PROVISION FOR MANUAL TRACKING.

AN INTERESTING FEATURE OF THE ANTENNA IS ITS USE OF CIRCULAR POLARIZATION: LEFT-HAND CIRCULAR POLARIZATION FOR TRANSMISSION FROM THE EARTH STATION AND RIGHT-HAND CIRCULAR POLARIZATION FOR RECEPTION BY THE EARTH STATION. RECALLING THAT COMMERCIAL AM RADIO STATIONS HAVE VERTICAL POLARIZATION AND REQUIRE A VERTICAL ANTENNA FOR MOST EFFECTIVE RECEPTION WHILE COMMERCIAL FM RADIO STATIONS USE HORIZONTAL POLARIZATION AND REQUIRE HORIZONTAL ANTENNAS FOR MOST EFFICIENT RECEPTION, ONE CAN VISUALIZE THE DIFFICULTIES WHICH COULD BE ENCOUNTERED IN PROPER RECEPTION OF THE EXTREMELY WEAK SIGNAL FROM THE SATELLITE WHEN THE FEED OF THE ANTENNA MUST BE ROTATED TO COINCIDE WITH THE POLARIZATION OF THE SATELLITE'S SIGNAL. DIURNAL VARIATIONS ASSOCIATED WITH FARADAY ROTATION AND SIMULATION PERIODS CAUSE ANGULAR VARIATIONS IN VERTICAL AND HORIZONTAL POLARIZATIONS WHICH WOULD ONLY ADD TO THE DIFFICULTIES IF VERTICAL OR HORIZONTAL POLARIZATION WERE USED. CIRCULAR POLARIZATION ELIMINATES THIS MAJOR PROBLEM.

TO DECREASE THE THERMAL NOISE INHERENT IN AMPLIFIERS, THE LOW NOISE AMPLIFIERS (LNA) USED ON THE RECEIVE SIDE ARE CRYOGENICALLY COOLED.

FROM THE LNA, THE SIGNAL PASSES THROUGH THE INTERFACILITY LINK (IFL) TO THE GROUND COMMUNICATIONS EQUIPMENT. THE IFL IS COMPOSED OF WAVEGUIDES.FROM THE GROUND COMMUNICATIONS EQUIPMENT (BASICALLY A MICROWAVE INSTALLATION WITH SOME VARIATIONS) THE SIGNAL PASSES THROUGH FILTERS FOR SEPARATION AND THRESHOLD EXTENSION DEMODULATORS BEFORE ENTERING A MULTIPLEXER AND THE AT&T INTERFACE AND ON TO THE SUBSCRIBERS.

THE REVERSE PROCEDURE (TRANSMIT) IS ESSENTIALLY THE SAME WITH THE EXCEPTION THAT A HIGH POWERED AMPLIFIER (HPA) IS USED IN PLACE OF THE RECEIVING LNA.

D. POWER SUPPLY

NORMAL POWER (300-350KW) IS SUPPLIED TO JAMESBURG VIA AN ABOVE-GROUND PG&E LINE FROM NEARBY CARMEL VALLEY VILLAGE. UPON CROSSING THE STATION BOUNDARY THE LINE GOES UNDERGROUND TO THE STATION. WHILE NORMALLY ADEQUATE, THIS SOURCE IS SUBJECT TO POWER LOSS. AN IN HOUSE 800 KW DEISEL GENERATOR IS READY FOR AUTOMATIC SERVICE SHOULD THE PG&E SOURCE FAIL AND SHOULD BOTH THE NORMAL AND ALTERNATE POWER SOURCES FAIL A SMALL 150 KW MOBILE GENERATOR IS LOCATED OUTSIDE THE MAIN BUILDING IN A VAN. THIS GENERATOR MUST BE MANUALLY STARTED AND CAN ONLY PROVIDE FOR THE ESSENTIAL OR "TECHNICAL" LOAD (140 KW) OF THE STATION. THE STATION HAS A BANK OF BATTERIES TO SUPPLY POWER DURING THE SHORT PERIOD OF TIME (A FEW SECONDS) BETWEEN LOSS OF POWER AND DIESEL GENERATOR ASSUMPTION OF THE LOAD. AN UNINTERRUPTABLE POWER SUPPLY SYSTEM IS IN OPERATION TO SMOOTH OUT POWER FLUCTUATIONS, ACT AS AN AC-DC CONVERTER AND, MOST IMPORTANTLY, TO PROVIDE A CONSTANT SOURCE OF POWER TO THE STATION WHILE SWITCHING TO ALTERNATE POWER SOURCES. PLANS HAVE BEEN MADE TO EVENTUALLY REPLACE THE 800 KW DIESEL GENERATOR WITH A GAS-TURBINE

GENERATOR.

III. THE DEPARTMENT OF DEFENSE COMMUNICATIONS SATELLITE PROGRAM

IN 1962 THE SECRETARY OF DEFENSE ESTABLISHED THE DEFENSE COMMUNICATIONS SATELLITE PROGRAM (DCSP) TO "DEVELOP A SATELLITE COMMUNICATION SYSTEM THAT WOULD PROVIDE LONG-HAUL LINKS BETWEEN FIXED, TRANSPORTABLE OR SHIPBOARD TERMINALS". (30,C-1) THE PROGRAM WAS TO BE DIVIDED INTO PHASES IMPLEMENTING IMPROVEMENTS IN EACH SUCCESSIVE PHASE. OVERALL RESPONSIBILITY FOR DCSP WAS ASSIGNED TO THE DEFENSE COMMUNICATIONS AGENCY.

A. INITIAL DEFENSE COMMUNICATIONS SATELLITE PROGRAM

THE FIRST PHASE OF THIS PROGRAM WAS CALLED THE INITIAL DEFENSE COMMUNICATIONS SATELLITE PROGRAM (IDCSP) AND WAS OTHERWISE KNOWN AS DSCS PHASE I. SIMPLICITY WAS STRESSED IN THIS FIRST PHASE WITH NO IN-ORBIT CONTROL BEING ALLOTTED TO THE 26 SATELLITES COMPRISING IDCSP. THE FIRST OBJECTIVE WAS TO ALLOW FOR SYSTEM RESEARCH, INCLUDING INVESTIGATION INTO THE COMPATIBILITY OF THE PRESENT DCS NETWORK WITH A SATELLITE SYSTEM. ADDITIONALLY, IT WAS PLANNED TO CONVERT THIS RESEARCH TOOL INTO AN OPERATIONAL SYSTEM FOR CERTAIN USERS OF THE NATIONAL COMMUNICATIONS SYSTEM (NCS) WHILE MAINTAINING AN EMERGENCY CAPABILITY FOR THE NATIONAL MILITARY COMMAND AND CONTROL SYSTEM. A LITTLE MORE THAN A YEAR AFTER THE INITIAL LAUNCH (16 JUNE 1966), THE ENTIRE PACIFIC NETWORK WAS PLACED INTO OPERATIONAL STATUS DUE TO THE REQUIREMENTS OF THE VIETNAM CONFLICT. THIS FOLLOWED THE SUCCESSFUL ESTABLISHMENT OF EMERGENCY LINKS IN DECEMBER,

1966 BETWEEN HAWAII AND VIETNAM AND BETWEEN THE PHILLIPINES AND VIETNAM.

1. LAUNCH

THE TITAN IIIC WAS USED AS THE LAUNCH VEHICLE, CONFIGURED TO PLACE SEVERAL SATELLITES IN ORBIT PER LAUNCH. THE 26 IDCSP SATELLITES WERE PLACED INTO A NEAR-SYNCHRONOUS, NEAR-EQUATORIAL ORBIT ON A RANDOM BASIS IN ORDER TO ACHIEVE A DISPERSAL OF THE SATELLITES WHICH WOULD PROVIDE MORE COMPLETE SATELLITE VISIBILITY TO THE EARTH STATIONS. THERE WERE FOUR SUCCESSFUL LAUNCHES BEGINNING ON 16 JUNE 1966 WITH JUST ONE FAILURE (26 AUGUST 1966).

2. THE PHASE I SATELLITE

THESE ACTIVE-REPEATERS WERE GIVEN AN AUTOMATIC RADIATION SHUT-OFF DEVICE TO DEACTIVATE THEM AFTER SIX YEARS. THIS MECHANISM HAS NOT PERFORMED ADEQUATELY WITH THE RESULT THAT SEVERAL (6) OF THE SATELLITES ARE STILL OPERATIONAL.

THE SATELLITES WERE NOT EQUIPPED WITH BATTERIES AND RELIED ENTIRELY UPON SOLAR CELLS FOR POWER.

THE TRANSPONDER CARRIED IS CAPABLE OF ONLY ONE DUPLEX LINK RECEIVING AT 8.0 GHZ AND TRANSMITTING AT 7.3 GHZ.

B. PHASE II

THE PHASE II SATELLITE IS A GREATLY IMPROVED VEHICLE OVER THE PHASE I BIRD. IN ADDITION TO POSSESSING A HIGHER EIRP (SEE GLOSSARY) AND A GREATER CAPACITY, THESE SATELLITES ARE IN SYNCHRONOUS ORBIT GIVING A MUCH BETTER SATELLITE AVAILABILITY. THE PROBLEMS OF SATELLITE TRACKING, HANDOFF AND THE DOPPLER SHIFT INHERENT IN PHASE I (CAUSED BY THE APPARENT "RISING" OF THE SATELLITE IN RELATION TO THE EARTH TERMINAL) HAVE BEEN EITHER ELIMINATED OR MADE LESS SEVERE BY PLACING THE SATELLITES INTO A SYNCHRONOUS ORBIT AT 22,300

STATUTE MILES (35,900 KM).

1. LAUNCH SCHEDULE

IN NOVEMBER, 1971 THE FIRST TWO DSCS PHASE II SATELLITES WERE LAUNCHED AND PLACED INTO ORBIT WHERE THEY SOON FAILED. THE NEXT LAUNCH WAS IN DECEMBER OF 1973 WHEN ONE PHASE II WAS PLACED INTO SYNCHRONOUS ORBIT OVER THE PACIFIC AND ONE OVER THE ATLANTIC. THESE TWO SATELLITES ARE STILL IN OPERATION. IN MAY OF 1975 ANOTHER LAUNCH OF TWO PHASE II SATELLITES WAS ATTEMPTED BUT FAILED DUE TO PROBLEMS IN THE LAUNCH VEHICLE. THE NEXT LAUNCH IS PLANNED FOR MAY OF 1976.

2. THE PHASE II SATELLITE

THE SATELLITES CARRY A TRANSPONDER WITH MULTICHANNEL CAPABILITY. EACH CHANNEL HAS A USABLE BANDWIDTH OF 410 MHZ. THE PHASE II CARRIES FOUR ANTENNAS: ONE EARTH COVERAGE RECEIVE ANTENNA, ONE EARTH COVERAGE TRANSMIT ANTENNA AND TWO STEERABLE NARROW BEAM ANTENNAS CAPABLE OF TRANSMITTING AND RECEIVING SIMULTANEOUSLY. THE EARTH COVERAGE ANTENNA IS CAPABLE OF ILLUMINATING ONE-THIRD OF THE EARTH WITH AN EIRP OF 28 DBW. THE NARROW BEAM ANTENNAS ARE STEERABLE BY GROUND COMMAND AND COVER, AT THE HALF POWER POINT, AN AREA OF ABOUT 750 MILES IN DIAMETER DIRECTLY BELOW THE SATELLITE WITH AN EIRP OF 43 DBW. ALL TRANSMITTING ANTENNAS ARE LEFT-HAND CIRCULARLY POLARIZED WHILE THE RECEIVE ANTENNA IS RIGHT-HAND CIRCULARLY POLARIZED. THE GROUND STATION'S TRANSMIT AND RECEIVE ANTENNA IS POLARIZED TO COINCIDE WITH THE SATELLITE'S RECEIVE AND TRANSMIT ANTENNAS RESPECTIVELY. THIS RESULTS IN THE SATELLITE'S RECEIVE PORTION REJECTING ANY LEFT-HAND POLARIZED SIGNALS.

REDUNDANCY IS PREVALENT IN THE DSCS II AS ALL ACTIVE

COMPONENTS HAVE A BACK-UP.

THE CAPABILITIES OF DSCS II REPRESENT A SIGNIFICANT INCREASE OVER THOSE OF DSCS I. PHASE II PROVIDES FOR 1300 DUPLEX VOICE CHANNELS OR UP TO 100 MEGABIT DATA RATES USING FREQUENCY DIVISION MULTIPLEX (FDM). WHEN GROUND STATIONS ARE CONVERTED TO AN ALL DIGITAL SYSTEM USING TIME-DIVISION MULTIPLE ACCESS (TDMA) A QUANTUM EXPANSION OF THESE NUMBERS IS POSSIBLE. (13,21)

IV. SOME BASIC LAUNCH AND ORBITING CONSIDERATIONS

THE LAUNCHING OF A SATELLITE INTO SYNCHRONOUS ORBIT IS NOT SIMPLY A MATTER OF ATTACHING A SATELLITE TO THE TOP OF A LAUNCH VEHICLE AND BLASTING AWAY. THERE ARE MANY IMPORTANT AND COMPLEX CONSIDERATIONS TO BE TAKEN INTO ACCOUNT. IT IS AN OPERATION REPLETE WITH COMPROMISES AND ENORMOUS COSTS WHICH MAKE THE DESIGNER'S JOB QUITE A TASK. THE SCOPE OF THIS WORK DOES NOT ALLOW FOR A THOROUGH EXAMINATION OF THE COMPLEXITIES OF SUCH A LAUNCH BUT AN ATTEMPT WILL BE MADE TO ILLUSTRATE TO THE AVERAGE COMMUNICATOR THE DIFFICULTY OF ACHIEVING THE OBJECTIVES IN A COMMUNICATIONS SATELLITE SYSTEM.

A. BASIC ROCKET MECHANICS

THE KEY FACTORS INVOLVED IN LAUNCH VEHICLE CONSIDERATIONS ARE ROCKET VELOCITY AND TOTAL MASS OF THE VEHICLE AND ITS PAYLOAD. THE BASIC ROCKET EQUATION:

$$VR = VG \; LN \; (MT/MT-MF)$$

WHERE: VR = ROCKET VELOCITY
VG = EXHAUST VELOCITY
LN = NATURAL LOG (LOG TO BASE E)
MT = TOTAL MASS
MF = MASS OF FUEL

CAN BE USED TO ILLUSTRATE THE COMPROMISES NECESSARY TO ORBIT EVEN SUCH A SMALL MASS AS A SATELLITE.

NOTE THAT THE FRACTIONAL PORTION OF THE EQUATION IS A NATURAL LOGARITHMIC FUNCTION. RECALLING THAT THE NATURAL LOG OF ONE IS ZERO AND THAT THE FUNCTION SLOWLY INCREASES IT CAN BE SEEN THAT THE DENOMINATOR MUST BE AS NEAR TO ZERO AS POSSIBLE FOR AN EFFECTIVE CONTRIBUTION TO THE ROCKET VELOCITY. IN OTHER WORDS, THE MASS OF THE VEHICLE FRAME AND THE PAYLOAD (THE SATELLITE) IS CRITICAL AND MUST BE KEPT LOW. BUT WHY NOT SIMPLY DESIGN A ROCKET ENGINE WHOSE EXHAUST VELOCITY IS HIGH ENOUGH TO LAUNCH THE PAYLOAD OF DESIRED MASS? UNFORTUNATELY, PRESENT AND IMMEDIATE-FUTURE TECHNOLOGY IN MATERIALS DICTATES THAT THE MAXIMUM EXHAUST VELOCITY AVAILABLE IS APPROXIMATELY 9000 FEET PER SECOND. THIS FACT PLACES AN ADDITIONAL CONSTRAINT UPON VEHICLE LAUNCH.

IN ORDER TO ESCAPE THE GRAVITATIONAL PULL OF THE EARTH, THE VELOCITY OF THE ROCKET MUST BE EQUAL TO OR GREATER THAN 37,000 FPS. SUBSTITUTING THIS VALUE FOR ROCKET VELOCITY AND THE MAXIMUM AVAILABLE EXHAUST VELOCITY INTO THE ROCKET EQUATION WE HAVE:

$$37 \times 10^{3} \text{ FPS} = 9 \times 10^{3} \text{ FPS LN } (MT/MT-MF)$$

THE SOLUTION OF WHICH IS APPROXIMATELY:

$$MT = 1.017 \text{ MF (USING } E^{4.1} \cong 60)$$

FURTHERMORE, RECALLING THAT:

MT = MFR(FRAME) + MF(FUEL) + MPL(PAYLOAD)

AND EQUATING THIS TO OUR ROCKET EQUATION SOLUTION:

MT = 1.017MF = MFR + MF + MPL

WE FIND THAT:

MPL + MFR = .017MF

IN OTHER WORDS, 1.7% OF THE MASS OF THE FUEL USED IS ALL THAT IS AVAILABLE FOR THE MASS OF THE ROCKET FRAME AND THE PAYLOAD.

FURTHER MATHEMATICAL ANALYSIS REVEALS THE GENERAL RULE THAT STATES:

EACH EXTRA 1.7 POUNDS IN THE PAYLOAD MASS REQUIRES AN APPROXIMATE INCREASE OF 100 POUNDS IN THE MASS OF THE ROCKET FUEL.

B. BASIC SPACE MECHANICS

IN THIS SECTION WE SHALL BRIEFLY EXAMINE THE FORCES ACTING UPON AN ARTIFICIAL SATELLITE IN A CIRCULAR EARTH ORBIT. AS ILLUSTRATED BELOW, THERE ARE THREE FORCES AT WORK UPON A SATELLITE IN CIRCULAR ORBIT AT AT ALL TIMES.

ACCORDING TO NEWTON'S LAW OF GRAVITATION:

$$FN = G\ ((ME \times MS)/R)$$

WHERE: G = GRAVITATIONAL CONSTANT
ME = MASS OF EARTH
MS = MASS OF SATELLITE
R = RADIUS FROM EARTH

THE CENTRIFUGAL FORCE EQUATION IS:

$$FC = (MS \times VT^2)/R$$

WHERE: VT = TANGENTIAL VELOCITY

IN CIRCULAR ORBIT MECHANICS THE TWO FORCES MUST BE EQUAL SO THAT:

VT = SQUARE ROOT OF ((G X ME)/R)

THE IMPORTANT POINT TO GAIN FROM THIS EXERCISE IS THAT, ONCE IN A CIRCULAR ORBIT, THE MASS OF THE SATELLITE IS NO LONGER A FACTOR OF IMPORTANCE. IT MAY BE INCREASED OR DECREASED WITHOUT AFFECTING THE SATELLITE'S ORBIT. IT ALSO SHOULD BE NOTED THAT AS THE RADIUS IS INCREASED, THE TANGENTIAL VELOCITY IS DECREASED. THIS IS IMPORTANT IN DECIDING UPON THE ALTITUDE FOR A GEOSTATIONARY (ALSO REFERRED TO AS A GEOSYNCHRONOUS) SATELLITE. IT HAS BEEN FOUND THAT AN ALTITUDE OF 22,300 STATUTE MILES MOST CLOSELY APPROXIMATES THE PERIOD OF THE EARTH'S ROTATION. SO THAT AS THE EARTH ROTATES ABOUT ITS AXIS ONCE IN EVERY 24 HOURS (ACTUALLY, 23 HOURS, 56 MINUTES, 4.091 SECONDS), THE SATELLITE COMPLETES ONE ORBIT IN THE SAME AMMOUNT OF TIME. ONCE POSITIONED THIS WOULD MAKE THE SATELLITE APPEAR TO BE STATIONARY ABOVE A FIXED POINT ON THE EARTH'S EQUATOR.

C. FLIGHT SEQUENCE OF THE INTELSAT IV

THE FALL, 1972 ISSUE OF THE COMSAT TECHNICAL REVIEW (VOL. 2, NR. 2, P. 394-395) PROVIDES A STEP BY STEP CHRONOLOGY OF THE INTELSAT IV'S FLIGHT SEQUENCE. IT IS REPRODUCED HERE IN A DIFFERENT FORM AS AN ILLUSTRATION OF THE COMPLEXITIES IN LAUNCHING A COMMUNICATIONS SATELLITE. "T" IS SUFFIXED BY THE NUMBER OF SECONDS AFTER LIFTOFF.

T ± 0 LIFTOFF.

T + 2 LAUNCH VEHICLE BEGINS ROLL TO FLIGHT AZIMUTH OF 101 DEGREES.

T + 15 VEHICLE BEGINS A PROGRAMMED PITCHOVER MANEUVER DESIGNED TO KEEP THE ANGLE OF ATTACK NEAR ZERO DURING ATMOSPHERIC FLIGHT.

T + 152 BOOSTER SHUT DOWN

T + 155 BOOSTER JETTISONED. SUSTAINER ENGINE BURNING.

T + 196 INSULATION PANELS SURROUNDING THE CENTAUR'S LIQUID HYDROGEN TANKS JETTISONED.

T + 241 SUSTAINER AND VERNIER ENGINES SHUT DOWN.

T + 243 ATLAS SEPARATES FROM CENTAUR. RETROROCKETS ON ATLAS INCREASE DISTANCE BETWEEN STAGES.

T + 253 CENTAUR'S MAIN ENGINES START.

T + 265 NOSE FAIRING JETTISONED.

T + 626 (APPROX) FIRST MAIN ENGINE BURN STOPPED. CENTAUR AND INTELSAT IV PLACED INTO AN ELLIPTICAL PARKING ORBIT. A 15-MINUTE COAST PERIOD IS REQUIRED TO INSURE THAT INJECTION WILL TAKE PLACE NEAR THE EQUATOR.

T + 1,519 MAIN ENGINES REIGNITED.

T + 1,594 MAIN ENGINES SHUT DOWN. TRANSFER ORBIT ACHIEVED. DURING THE NEXT 135 SECONDS THE CENTAUR IS YAWED 90-DEGREES TO ALLIGN THE SPACECRAFT FOR SEPARATION.

T + 1,729 SPACECRAFT SEPARATION.

V. LIVING WITH THE IONOSPHERE

COMMUNICATORS HAVE LONG BEEN SUBJECT TO THE VAGARITIES OF THE EARTH'S ELECTRICAL CANOPY. WITH THE ADVENT OF COMMUNICATIONS SATELLITES A NEW PROBLEM HAS ARISEN DUE TO THE FLUCTUATING ION CONTENT OF THE IONOSPHERE. SCINTILLATION IS DEFINED IN DICTIONARIES AS A TWINKLING OR SPARKLING, AS OF A STAR. IN THE SENSE THAT WE ARE CONCERNED WITH HERE, SCINTILLATION MEANS A FLUCTUATION IN SIGNAL STRENGTH DUE TO THE ABSORPTION OR REFRACTION OF THE SIGNAL AS IT PASSES THROUGH THE IONOSPHERE. ALTHOUGH A FOCUSSING EFFECT IS POSSIBLE WITH ACCOMPANYING INCREASES IN SIGNAL STRENGTH, OUR MAIN CONCERN AS COMMUNICATORS IS WITH THE FADING IN SATELLITE DOWNLINKS THAT MOST OFTEN OCCURS.

A. IONOSPHERIC STRUCTURE (18,23-29)

SOLAR RADIATION IS OF SUFFICIENT INTENSITY TO CAUSE IONIZATION OF THE EARTH'S UPPER ATMOSPHERE GIVING BIRTH TO A PARTIALLY IONIZED REGION KNOWN AS THE IONOSPHERE. THE CONCENTRATION OR DENSITY OF GASES IS LOW ENOUGH SO THAT EVEN DURING THE NIGHT WHEN SOLAR RADIATION IS ABSENT, SUFFICIENT IONS REMAIN UNCOMBINED TO CAUSE SCINTILLATION. THE IONOSPHERE IS GENERALLY RECOGNIZED TO HAVE SEVERAL DISTINCT LAYERS OR REGIONS: D, E, F1 AND F2. THE F1 AND F2 LAYERS COMBINE AT NIGHT AND ARE THEN REFERRED TO AS SIMPLY THE F LAYER.

1. THE D LAYER

THE ALTITUDE GENERALLY ASCRIBED TO THE D LAYER IS FROM 60 TO ABOUT 85 KILOMETERS (1 KILOMETER = 0.64 MILE). IT IS

BELIEVED THAT THE SUBSTANCE IONIZED BY SOLAR RADIATION IS NITRIC OXIDE, WHICH IS A MINOR INGREDIENT OF THE EARTH'S ATMOSPHERE. MEASUREMENTS HAVE SHOWN THE ION CONCENTRATION TO BE NEAR 1000 PER CUBIC CENTIMETER AT AN ALTITUDE OF ABOUT 80 KM. THESE ELECTRONS SEEM TO LARGELY DISAPPEAR AT NIGHT, APPARENTLY THROUGH RECOMBINATION. GAS DENSITIES IN THIS REGION ARE HIGH ENOUGH TO CAUSE CONSIDERABLE ABSORPTION OF ELECTROMAGNETIC ENERGY. BUT AT NIGHT, WHEN ELECTRON CONCENTRATIONS ARE LOWEST THIS ABSORPTION, OR ATTENUATION, OF COMMUNICATION SIGNALS IS DECREASED. SOLAR FLARES GIVING OFF X-RAYS CAUSE SUDDEN IONOSPHERIC DISTURBANCES (SID'S) IN THE LOWER PORTION OF THE D LAYER. SID'S ARE RESPONSIBLE FOR STRONG RADIO INTERFERENCE AND BLACKOUTS AND USUALLY LAST FOR HALF AN HOUR AND OCCUR DURING THE DAYTIME. A PHENOMENON OCCURRING DURING THE NIGHT IS DUE PRIMARILY TO ACTIVE AURORAS AND MAGNETIC DISTURBANCES. THIS, TOO, RESULTS IN RADIO SIGNAL ABSORPTION. A THIRD TYPE OF ABSORPTIVE PHENOMENON OCCURS OVER THE POLAR CAPS FOLLOWING SOLAR FLARES EMITTING LOW-ENERGY COSMIC RADIATION. THIS ACTIVITY, CALLED POLAR-CAP BLACKOUTS, IS CAUSED BY THE PENETRATION OF ENERGETIC PARTICLES INTO THE D REGION AND BELOW. FREQUENTLY THE ABOVE ABSORPTION EFFECTS ARE REFERRED TO AS TYPES I, II, AND III ABSORPTIONS, RESPECTIVELY, AND A STRONG POSITIVE CORRELATION BETWEEN THEM AND THE 11-YEAR SUNSPOT CYCLE EXISTS.

2. THE E LAYER

THE E REGION IS GENERALLY RECOGNIZED TO EXIST FROM 85 TO 140 KM WITH AN ELECTRON CONCENTRATION ON THE ORDER OF FROM 100,000 TO 10,000,000 PER CUBIC CENTIMETER DEPENDING ON SUNSPOT ACTIVITY. THIS CONCENTRATION IS HIGHEST NEAR NOON LOCAL TIME AND DROPS OFF SYMMETRICALLY ON BOTH SIDES

DIURNALLY. A COMMON PHENOMENON OCCURRING IN THE E REGION IS THE APPEARANCE OF A THIN LAYER OF HIGH ELECTRON CONCENTRATION ONLY A FEW KILOMETERS THICK. THIS CONDITION IS KNOWN AS SPORADIC E AND IS RESPONSIBLE FOR THE UNPREDICTABLE REFLECTIVE PROPERTIES OF THE LAYER. SPORADIC E USUALLY OCCURS AT NIGHT IN THE HIGH LATITUDES AND IN THE DAY NEAR THE MAGNETIC EQUATOR. MORE SPORADIC E OCCURS DURING THE SUMMER THAN THE WINTER IN THE TEMPERATE LATITUDES.

3. THE F1 LAYER

THE F1 LAYER IS A REGION ROUGHLY FROM 140-200 KM WHICH ONLY OCCURS DURING THE DAYTIME. IN ITS ABSENCE AT NIGHT A LARGE GAP OR "VALLEY" OF ELECTRON CONCENTRATION DEVELOPS ABOVE THE E LAYER. THE ELECTRON CONCENTRATION OF THE F1 LAYER DEPENDS UPON SUNSPOT ACTIVITY AND RANGES FROM 2.5 TO 4 MILLION ELECTRONS PER CUBIC CENTIMETER.

4. THE F2 LAYER

THE ALTITUDE OF THE F2 LAYER VARIES CONSIDERABLY WITH LATITUDE, DURING SUNSPOT ACTIVITY AND DIURNALLY BUT IN GENERAL IT EXISTS BETWEEN 200 TO 1000 OR 2000 KM. THE REASON FOR A SECOND F LAYER IS THAT AT HIGHER ALTITUDES THE RATE OF RECOMBINATION FALLS OFF MORE RAPIDLY THAN THE RATE OF IONIZATION AND, AS A RESULT, ANOTHER IONIZATION PEAK FORMS.

THE INTERESTING PHENOMENON ASSOCIATED WITH THE F2 LAYER IS THE FORMATION OF ELECTRON "CLOUDS" HAVING DENSER CONCENTRATIONS OF IONS. MEASUREMENTS HAVE SHOWN AN AXIAL RATIO OF 60 TO 1 IN THESE CLOUDS WITH THE LONGER AXIS PARALLEL TO THE EARTH'S MAGNETIC FIELD. (26,4) THIS CONDITION OCCURS MAINLY AT NIGHT AND IS CALLED "SPREAD F". THE DIELECTRIC CONSTANT OF THE IONOSPHERE VARIES WITH THE ION CONCENTRATION AND IT IS BELIEVED THAT THESE ION CLOUDS

CAUSE THE SCINTILLATION OF RADIO SIGNALS FROM COMMUNICATION SATELLITES. DURING PERIODS OF LOW SUNSPOT ACTIVITY, THIS PHENOMENA OCCURS MOST OFTEN AT LOW LATITUDES (NEAR THE EQUATOR).

B. SCINTILLATION

THE CONCLUSIONS ARRIVED AT BY HOPKINS AND PAULSON (26,1) GIVE AN ACCURATE SUMMARIZATION OF WHAT IS KNOWN ABOUT SCINTILLATION. THESE CONCLUSIONS ARE QUOTED BELOW:

1. THE UHF SCINTILLATION NEAR 250 MHZ WAS VERY INTENSE, EXCEEDING 25 DB PEAK-TO-PEAK, AND FADED QUITE REGULARLY INTO THE SYSTEM NOISE. THIS SCINTILLATION WAS PREDOMINANTLY A NIGHTTIME PHENOMENON.

2. SAMPLES OF SCINTILLATION DATA FOR THREE SUCCESSIVE YEARS (1970,71,72) SUGGEST THAT THE EXTENT OF OCCURRENCE OF SCINTILLATION VARIES WITH SOLAR ACTIVITY.

3. INVESTIGATION OF LATITUDE DEPENDENCE OF SCINTILLATION SHOWED THE INTENSITY OF THE SCINTILLATION TO BE COMPARABLE AT ALL THREE SITES WHEN IT OCCURRED. THE OCCURRENCE OF SCINTILLATION, HOWEVER, WAS COMPARABLE AT THE MAGNETIC EQUATOR AND 7-1/2 DEGREES NORTH, BUT WAS MUCH LESS AT THE SITE 17-1/2 DEGREES NORTH OF THE MAGNETIC EQUATOR.

4. INVESTIGATION OF ELEVATION-ANGLE DEPENDENCE SHOWED THE INTENSITY OF THE SCINTILLATION TO BE COMPARABLE AT ALL THREE ELEVATION ANGLES (30, 56 AND 72-DEGREES).

5. LIMITED TESTS OF FREQUENCY DIVERSITY AND SPACE DIVERSITY SUGGEST THAT FREQUENCY DIFFERENCES GREATER THAN 100 MHZ WOULD BE NECESSARY FOR FREQUENCY DIVERSITY TO

OVERCOME THE EFFECTS OF SCINTILLATION AND THAT, FOR SPACE DIVERSITY TO BE EFFECTIVE, SEPARATION DISTANCES GREATER THAN THE DIMENSIONS OF A SHIP WOULD PROBABLY BE REQUIRED.

6. STATISTICAL EVALUATION OF THE SCINTILLATION RECORDS INDICATES THAT ANY SYSTEM DESIGNED TO OVERCOME THE EFFECTS OF SCINTILLATION MUST BE ABLE TO HANDLE SIGNAL FADEOUTS WITH DURATIONS ON THE ORDER OF SECONDS.

7. NO SCINTILLATION EFFECTS WERE OBSERVED AT 7.3 GHZ, BUT DURING SOME LIMITED MEASUREMENTS PEAK-TO-PEAK SCINTILLATIONS OF 2 TO 5 DB WERE OBSERVED AT 2.3 GHZ. THE INTENSITY OF THIS SCINTILLATION WAS MUCH LESS THAN THAT OBSERVED AT 250 MHZ DURING THE SAME TIME PERIOD.

VI. UNDERSTANDING THE DECIBEL

OCCASIONALLY GAINS AND LOSSES OF A SYSTEM WILL BE REFERRED TO AS A GAIN OF X DB OR A LOSS OF Y DB. DB STANDS FOR DECIBEL AND IS AN ABBREVIATION USED IN THE DECIBEL MEASUREMENT SYSTEM, A SYSTEM DEVISED TO ACCURATELY MEASURE SIGNAL GAINS, LOSSES OR COMPARE LEVELS OF TRANSMITTED ENERGY.(31)

IN THE DECIBEL SYSTEM, THE STANDARD UNIT OF MEASUREMENT IS THE BEL IN HONOR OF ALEXANDER GRAHAM BELL WHO PIONEERED STUDIES IN ACCOUSTICS. A BEL EXPRESSES A RATIO BETWEEN TWO LEVELS. FOR EXAMPLE, IF AN AMPLIFIER INCREASED AN INPUT OF ONE WATT TO AN OUTPUT OF TEN WATTS THE RATIO OF POWER OUT (P2) TO POWER IN (P1) WOULD BE 10:1 OR ONE BEL. ONE CAN SEE FROM THIS EXAMPLE THAT A BEL REPRESENTS A RATIO OF 10:1 BETWEEN OUTPUT AND INPUT. AS A FURTHER EXAMPLE SUPPOSE THE TEN WATT OUTPUT FROM THE FIRST AMPLIFIER TO BE THE INPUT TO A SECOND, IDENTICAL AMPLIFIER. THE OUTPUT POWER OF THE SECOND AMP WOULD THEN BE 100 WATTS, REPRESENTING A GAIN OF ONE BEL IN THE SECOND AMPLIFIER BUT TWO BELS IN BOTH AMPLIFIERS. NOW IT CAN BE SEEN THAT THE TERM 2 BELS REPRESENTS A RATIO OF 100:1 BETWEEN OUTPUT AND INPUT.

JUST AS IT IS OFTEN MORE CONVENIENT TO USE MICROVOLTS OR MILLIAMPS INSTEAD OF THE STANDARD VOLT OR AMP, IT WAS FOUND TO BE MORE USEFUL TO MAKE THE DECIBEL THE COMMON UNIT IN THIS MEASUREMENT SYSTEM. ORIGINALLY, THE BEL WAS USED IN ACCOUSTICS RESEARCH WHERE IT WAS FOUND THAT THE SMALLEST CHANGE DISCERNABLE TO THE HUMAN EAR WAS APPROXIMATELY A 25%

CHANGE. USING THE BEL WOULD HAVE INVOLVED THE USE OF FRACTIONS WHICH COULD BECOME TEDIOUS.

THE DECIBEL IS ONE-TENTH OF A BEL. FOR EXAMPLE, A POWER INCREASE FROM:

0 TO 10 = 1 BEL = 10 DECIBELS
0 TO 100 = 2 BELS = 20 DECIBELS
0 TO 1000 = 3 BELS = 30 DB
0 TO 10,000 = 4 BELS = 40 DB

AND SO FORTH.

THE IMPORTANT RULE IS: <u>FOR AN INCREASE OF 10 DB THE POWER IS INCREASED BY A FACTOR OF 10.</u> FOR EXAMPLE, IF THE INPUT TO A 20 DB AMPLIFIER IS 1 WATT THEN THE OUTPUT POWER WOULD BE INCREASED BY TWO FACTORS OF 10 TO 100 WATTS: 1 WATT X 10 X 10 = 100 WATTS.

FROM THIS IT SHOULD BE SURMISED THAT A LOGARITHMIC RATIO TO THE BASE 10 (LOG) IS IN USE. AS A FURTHER EXPLANATION, NOTE THAT THE GAIN IN BELS IS THE NUMBER OF TIMES THAT 10 IS TAKEN AS A FACTOR TO EQUAL THE RATIO OF OUTPUT POWER TO INPUT POWER. FOR EXAMPLE, IF THE POWER OUT (P2) IS 100 TIMES THE POWER IN (P1), THE RATIO IS 100:1, OR 10 X 10 TO 1. THE GAIN IS THEREFORE 2 BELS OR 20 DECIBELS (DB).

FROM THE ABOVE, FORMULAS FOR THE BEL AND THE DECIBEL CAN BE OBTAINED:

BEL = LOG (P2/P1)

DECIBEL (DB) = 10 LOG (P2/P1)

THE DECIBEL FORMULA CAN NOW BE USED TO COMPUTE GAIN WHEN BOTH THE INPUT AND OUTPUT POWER IS KNOWN.

EX: A CERTAIN AMPLIFIER PRODUCES AN OUTPUT POWER OF 1000 WATTS WITH A POWER INPUT OF 10 WATTS. WHAT IS THE GAIN IN DECIBELS?

P2 = 1000 WATTS	DB = 10 LOG (P2/P1)
P1 = 10 WATTS	DB = 10 LOG 100
	DB = 10 X 2
	DB = 20

LESS SIMPLE PROBLEMS MAY BE SOLVED BY USING A CALCULATOR OR A LOGARITHMIC TABLE.

EX: IF THE ABOVE AMPLIFIER HAD AN OUTPUT POWER OF 25 WATTS WITH A POWER INPUT OF .3 WATTS, THE P2/P1 RATIO WOULD BE 25/.3 = 83.3 AND THE DECIBEL EQUATION WOULD BE:

DB = 10 LOG 83.3.

REFERRING TO A LOGARITHMIC TABLE, THE LOG OF 83.3 IS FOUND TO BE 1.9208. SUBSTITUTING,

$$DB = 10\ (1.9208)$$
$$DB = 19.2$$

THE DECIBEL FORMULA HOLDS TRUE FOR CHANGES IN VOLTAGE OR CURRENT LEVELS AS WELL WITH ONE SMALL MODIFICATION. INSTEAD OF MULTIPLYING THE LOG OF THE RATIO BY 10, IT IS MULTIPLIED BY 20 FOR BOTH CURRENT AND VOLTAGE LEVEL CHANGES. COMPARE THE FOLLOWING FORMULAS:

<u>POWER</u>

$$DB = 10\ LOG\ (P2/P1)$$

<u>CURRENT</u>

$$DB = 20\ LOG\ (I2/I1)$$

<u>VOLTAGE</u>

$$DB = 20\ LOG\ (E2/E1)$$

THERE IS AN ADDITIONAL CONSIDERATION WHEN DEALING WITH VOLTAGE OR CURRENT: IMPEDANCE. SINCE $P = E^2/R$, THE DB

EQUATION BECOMES:

$$DB = 10 \ LOG \ (E2^2/R2)/E1^2/R1)$$

IF R2 = R1, THEY WILL CANCEL LEAVING:

$$DB = 10 \ LOG \ (E2^2/E1^2)$$

WHICH MAY BE REWRITTEN AS:

$$DB = 20 \ LOG \ (E2/E1)$$

$$\text{OR} \quad DB = 20 \ LOG \ (I2/I1)$$

A. DB LOSSES

UP TO NOW WE HAVE BEEN CONCERNED ONLY WITH DB GAINS BUT DB LOSSES ARE JUST AS SIMPLE TO CALCULATE IF A SPECIAL METHOD OF SOLUTION IS USED:

SIMPLY_INVERT_THE_RATIO,__SOLVE_AS_USUAL_AND__ALWAYS_PRECEDE THE_ANSWER_WITH_A_MINUS_SIGN_(-).

EX: THE POWER INPUT TO A TRANSMISSION LINE IS 1000 WATTS. AT THE END OF THE LINE THE POWER OUT IS FOUND TO BE 10 WATTS. WHAT IS THE POWER LOSS EXPRESSED IN DB'S?

DB = 10 LOG (10/1000)

INVERT THE RATIO,

DB = 10 LOG (1000/10)

DB = 10 LOG 100

DB = 20

PRECEDE THE ANSWER BY A MINUS SIGN TO INDICATE A LOSS:

DB = -20

REMEMBER: FOR DB LOSSES, INVERT THE RATIO, SOLVE IN THE NORMAL MANNER AND ADD A MINUS SIGN TO THE ANSWER.

BEFORE CONCLUDING THIS DISCUSSION OF DECIBELS IT IS IMPORTANT TO NOTE THAT STATING A DECIBEL GAIN IS MEANINGLESS UNLESS THE REFERENCE POWER (P1) IS KNOWN. IF AN AMPLIFIER IS SAID TO HAVE A GAIN OF 30 DB THE FIRST QUESTION SHOULD BE:

"30 DB ABOVE WHAT?" IF IT IS THEN FOUND THAT THE REFERENCE (P1) IS .1 WATT THEN THE OUTPUT POWER CAN BE CALCULATED AT 100 WATTS FOR A 30 DB GAIN.

B. HOW BIG IS BIG?

THE FOLLOWING EXAMPLE MAY HELP TO ILLUSTRATE THE RELATIVE SIZE OF DB GAINS AND LOSSES.

P2 = 10 WATTS	DB = 10 LOG (10/5)
P1 = 5 WATTS	DB = 10 LOG 2
	DB = 10 (0.3010)
	DB = 3.0

IN OTHER WORDS, A 3 DB GAIN IS EQUIVALENT TO TWICE THE POWER INPUT. CONVERSELY, A 3 DB LOSS IS EQUIVALENT TO ONE-HALF THE POWER INPUT.

C. SUMMARY

1. THE DECIBEL MEASUREMENT WAS DEVISED TO EASILY RELATE POWER GAINS, LOSSES OR COMPARE LEVELS OF TRANSMITTED ENERGY.

2. THE STANDARD UNIT IN THIS SYSTEM IS THE BEL, BUT FOR CONVENIENCE, THE DECIBEL IS MOST OFTEN USED.

3. A BEL REPRESENTS A LOGARITHMIC RATIO BETWEEN TWO LEVELS OF POWER, CURRENT OR VOLTAGE. THE NUMERATOR IS P2 (OUTPUT POWER) AND THE DENOMINATOR IS THE REFERENCE POWER (P1). A RATIO OF 10:1 IS EQUAL TO ONE BEL.

4. SINCE A DECIBEL IS ONE-TENTH OF A BEL, ITS FORMULA IS:

DB = 10 LOG (P2/P1) (POWER)

OR DB = 20 LOG (E2/E1) (VOLTAGE, WHEN R1 = R2)

OR DB = 20 LOG (I2/I1) (CURRENT, WHEN R1 = R2)

5. TO FIND DB LOSSES SIMPLY INVERT THE P2/P1 RATIO, SOLVE AS USUAL AND ALWAYS PRECEDE THE ANSWER WITH A MINUS SIGN.

6. STATING A DB GAIN OR LOSS IS MEANINGLESS WITHOUT ALSO STATING THE REFERENCE (P1) LEVEL. COMMON REFERENCES ARE DBW (DB ABOVE ONE WATT) AND DBMW (ABOVE ONE MILLIWATT).

7. A GAIN OF 3 DB IS EQUAL TO A DOUBLING OF POWER; A LOSS OF 3 DB IS EQUAL TO A HALVING OF THE REFERENCE POWER.

VII. GLOSSARY OF SATELLITE TERMINOLOGY

ACTIVE REPEATER A SATELLITE WHICH CARRIES ONE OR MORE TRANSPONDERS (RECEIVER-AMPLIFIER- TRANSMITTER) TO PROVIDE A STRONGER SIGNAL AT EARTH TERMINALS AND TO PROVIDE FOR REAL-TIME COMMUNICATIONS.

AFSCF AIR FORCE SATELLITE CONTROL FACILITY. THE FACILITY EXERCISING ACTUAL CONTROL OVER THE DSCS PHASE II SATELLITES. THE AFSCF IS CONNECTED VIA AN ORDERWIRE TO DCAOC WHERE DECISIONS ABOUT THE SATELLITE ARE MADE.

AKM APOGEE KICK MOTOR. USED TO CIRCULARLIZE THE ORBIT OF AN EARTH SATELLITE.

ALGORITHM ANY SPECIAL METHOD FOR SOLVING A PARTICULAR PROBLEM.

AMSAT AMERICAN SATELLITE CORPORATION.

ANALOG SIGNAL A SIGNAL IN THE FORM OF CONTINUOUSLY VARIABLE PHYSICAL QUANTITIES. (SEE DIGITAL SIGNAL.)

AN/FSC-9 GROUND TERMINAL MODIFIED IN 1971 TO BE USED WITH DSCS PHASE I SATELLITES. THE ANTENNA IS A 60-FOOT DIAMETER PARABOLOID REFLECTOR WITH AN AUTOMATIC TRACKING FEED SYSTEM. TWO OF THESE TERMINALS EXIST: ONE AT FORT DIX, NEW JERSEY, THE OTHER AT CAMP ROBERTS, CALIFORNIA.

AN/MSC-46 A MOBILIZED SATELLITE COMMUNICATIONS TERMINAL UTILIZING A 40-FOOT DIAMETER CASSEGRAIN TYPE ANTENNA DESIGNED FOR SYNCHRONOUS OR NEAR-SYNCHRONOUS COMMUNICATIONS SATELLITES. THE TOTAL SYSTEM (114,000 POUNDS) CAN BE TRANSPORTED IN ONE CARGO PLANE AND REQUIRES AN EIGHT-MAN CREW TO SET IT UP.

AN/MSC-57 ONE OF SEVERAL TACSAT GROUND SYSTEMS, IT IS A VEHICULAR TERMINAL WHICH USES A 3-FOOT DIAMETER ANTENNA AND A TRAVELLING WAVE TUBE AMPLIFIER.

AN/MSC-60 (HT) A HEAVY TRANSPORTABLE GROUND TERMINAL DESIGNED AS A SEMIFIXED INSTALLATION AND AS A NODAL TERMINAL IN THE DSCS PHASE II SYSTEM BY PHILCO-FORD. THE SYSTEM, WITH ITS 60-FOOT DIAMETER ANTENNA, REQUIRES ABOUT 45 DAYS TO INSTALL.

AN/MSC-61 (MT) A MEDIUM-WEIGHT COUNTERPART TO THE AN/MSC-60 (HT) WITH AN 18-FOOT CLOVERLEAF ALUMINUM ANTENNA LIKE THAT USED WITH THE AN/TSC-54. TOTAL SYSTEM WEIGHT IS

APPROXIMATELY 100,000 POUNDS-OR ABOUT 1/4 THAT OF THE AN/MSC-60 (HT).

AN/SSR-1 A SATELLITE SIGNAL RECEIVING SYSTEM NOW BEING INSTALLED ON NAVY SHIPS TO ENABLE THEM TO RECEIVE FLEET BROADCASTS 24-HOURS A DAY WHEN THE GAPFILLER AND LATER, FLTSATCOM SATELLITES ARE OPERATIONAL. THE SHIPBOARD SYSTEM CONSISTS OF FOUR ANTENNAS, EACH PLACED IN A DIFFERENT QUADRANT OF THE SHIP SO AS TO COMPENSATE FOR SHIP HEADING AND MOTION, FOUR AMPLIFIER CONVERTERS, A COMBINER-DEMODULATOR AND A TELETYPE DEMULTIPLEXER.

ANTENNA GAIN THE GAIN OF AN ANTENNA IS THE RATIO OF ITS MAXIMUM RADIATION INTENSITY TO THE MAXIMUM RADIATION INTENSITY FROM A REFERENCE ANTENNA WITH THE SAME POWER. IF THE REFERENCE IS AN ISOTROPIC POINT SOURCE, THEN THE GAIN IS THE ABSOLUTE GAIN.

AN/TSC-54 A TRANSPORTABLE SATELLITE COMMUNICATION EARTH SYSTEM WEIGHING LESS THAN 27,500 POUNDS. IT IS CONFIGURED TO BE TRANSPORTABLE BY AIR OR OVERLAND. THE TERMINAL USES AN ARRAY OF FOUR 10-FOOT DIAMETER PARABOLIC DISHES AND CAN BE ERECTED OR DISMANTLED BY A SIX MAN CREW IN TWO HOURS. THE TERMINAL IS PLANNED FOR USAGE IN THE DSCS PHASE II SYSTEM.

AN/TSC-80 A TACTICAL SATELLITE COMMUNICATIONS GROUND

TERMINAL DESIGNED FOR OVERLAND OR AIR TRANSPORT. WITH A 4-FOOT ANTENNA, THE SYSTEM CAN BE SET UP BY A TWO-MAN CREW IN UNDER 20 MINUTES.

APOGEE THE POINT FARTHEST FROM THE EARTH IN THE PERIOD OF A NATURAL OR MAN-MADE SATELLITE, AS OPPOSED TO PERIGEE.

ATTITUDE CONTROL USED ON PRACTICALLY ALL SATELLITES, ATTITUDE CONTROL ALLOWS FOR POINTING ACCURACY IN DIRECTIVE SATELLITE ANTENNAS AND FOR POSITIONING OF SOLAR ARRAYS FOR PRIME POWER. IT MAY BE IMPLEMENTED ABOUT ONE, TWO OR ALL THREE AXES.

BANDPASS FILTER THIS TYPE OF FILTER PASSES ONLY A NARROW BAND OF FREQUENCIES. FREQUENCIES ABOVE OR BELOW THE DESIRED BAND ARE ATTENUATED RAPIDLY.

BAUD A UNIT OF SIGNALLING SPEED. THE SPEED IN BAUDS IS THE NUMBER OF DISCRETE CONDITIONS OR SIGNAL EVENTS PER SECOND. IF EACH SIGNAL EVENT REPRESENTS ONLY ONE BIT THEN BAUD IS THE SAME AS BITS PER SECOND (BPS).

BEACON SIGNAL A SIGNAL NORMALLY TRANSMITTED FROM THE SATELLITE TO AID IN ACQUISITION AND TRACKING BY THE EARTH TERMINAL ANTENNA.

BIT A CONTRACTION OF "BINARY DIGIT", THE SMALLEST UNIT OF MEASUREMENT IN A BINARY SYSTEM. A BIT REPRESENTS THE CHOICE BETWEEN A ONE OR A ZERO (MARK OR SPACE) CONDITION.

BROADBAND_JAMMING A TECHNIQUE THAT SPREADS ENERGY OUT OVER A BROAD BAND OF FREQUENCIES RATHER THAN ON A SPOT FREQUENCY. THIS METHOD RESULTS IN A LOWER NOISE DENSITY AT ANY ONE PARTICULAR FREQUENCY.

CARRIER A CONTINUOUS FREQUENCY CAPABLE OF BEING MODULATED, OR IMPRESSED WITH A SECOND INFORMATION CARRYING SIGNAL.

CASSEGRAIN_FEED USED WITH A PARABOLOID REFLECTOR TO DECREASE THE ELECTRICAL LENGTHS OF TRANSMISSION LINES TO FEED HORNS. THE FEED, LOCATED NEAR THE VERTEX OF THE PARABOLOID, ILLUMINATES A HYPERBOLOID REFLECTOR LOCATED ON THE FOCAL AXIS. THE REFLECTED FEED WAVES APPEAR TO REACH THE PARABOLOID FROM ITS FOCAL POINT.

CIACT_COMMITTEE THE CHIEF OF NAVAL OPERATIONS' CIVILIAN INDUSTRIAL ADVISORY COMMITTEE ON TELECOMMUNICATIONS. REPORTING IN MID-1972, THE COMMITTEE NOTED NUMEROUS PROBLEMS IN FLEET COMMUNICATIONS.

CIRCULAR POLARIZATION THE RESULTANT ELECTRIC FIELD WHEN EQUAL AMPLITUDE HORIZONTAL AND VERTICAL POLARIZED WAVES 90-DEGREES OUT OF PHASE ARE COMBINED.

COMSAT COMMUNICATIONS SATELLITE CORPORATION. ESTABLISHED BY THE COMMUNICATIONS SATELLITE ACT OF 1962, COMSAT IS THE US REPRESENTATIVE IN INTELSAT.

CRYOGENIC REFERRING TO VERY LOW TEMPERATURES. CRYOGENICS IS THE SCIENCE THAT DEALS WITH THE PRODUCTION OF VERY LOW TEMPERATURES.

DB SEE DECIBEL

DBM SEE DECIBEL. DBM BECOMES A UNIT OF POWER, WHERE THE M IS THE UNIT, MEANING ABOVE OR BELOW ONE MILLIWATT. SINCE 1 MW IS NEITHER ABOVE OR BELOW 1 MW, 1 MW = 0 DBM.

DBMW DECIBELS ABOVE ONE MILLIWATT.

DCA DEFENSE COMMUNICATIONS AGENCY. ESTABLISHED IN 1960 BY THE SECRETARY OF DEFENSE WITH THE OBJECTIVE OF ACHIEVING A UNIFIED SINGLE SYSTEM APPROACH TO LONG-HAUL COMMUNICATIONS. DCA IS THE SYSTEM ARCHITECT FOR ALL DEFENSE SATELLITE COMMUNICATIONS. THE DIRECTOR, DCA ALSO SERVES AS MANAGER FOR

NCS AND REPORTS TO THE SECDEF IN THAT FUNCTION.

DCAOC DEFENSE COMMUNICATIONS AGENCY OPERATIONS CENTER, LOCATED IN ARLINGTON, VA.

DECIBEL ABBREVIATED DB, THE DECIBEL IS ONE-TENTH OF THE INTERNATIONAL TRANSMISSION UNIT, THE BEL. THE DECIBEL REPRESENTS A RATIO OF SIGNAL INTENSITIES AND IS USED TO MEASURE GAINS OR LOSSES. THE ORIGIN OF THE BEL IS THE COMMON LOGARITHM (BASE 10) OF THE RATIO.

DELAYED-REPEATER_SATELLITE A COMMUNICATIONS SATELLITE WHICH CAN RECEIVE DATA, STORE IT AND LATER, UPON COMMAND, RETRANSMIT IT BACK TO EARTH.

DEMODULATOR A DEVICE TO RECOVER AT THE RECEIVER A SIGNAL THAT HAS BEEN MODULATED ON A CARRIER WAVE. DETECTOR.

DEMODULATOR_THRESHOLD QUALITATIVELY DEFINED AS THAT VALUE OF INPUT S/N BELOW WHICH THE DEMODULATOR PERFORMANCE EXHIBITS PHASE FLIPS AND CYCLE SKIPPING.

DIGITAL_SIGNAL A SIGNAL WHOSE VARIOUS STATES ARE DISCRETE INTERVALS APART.

D-LAYER THE LOWEST LAYER OF THE IONOSPHERE EXISTING ONLY IN THE DAYTIME. IT BEGINS AT AN ALTITUDE OF ABOUT 40 MILES AND MERGES WITH THE E-LAYER.

DSCS_PHASE_I THE FIRST PHASE OF THE DEFENSE SATELLITE COMMUNICATIONS SYSTEM. AT ITS MAXIMUM THIS SYSTEM CONSISTED OF 26 LOW-POWER ACTIVE REPEATER SATELLITES DRIFTING SLOWLY IN NEAR-SYNCHRONOUS, NEAR EQUATORIAL ORBITS, EACH WITH A 6-YEAR AUTOMATIC CUTOFF LIFE. EACH SATELLITE COULD SUPPORT ONLY ONE DUPLEX LINK CAPABLE OF FROM ONE TO FIVE VOICE CHANNELS.

DSCS_PHASE_II THE SECOND PHASE OF THE DEFENSE SATELLITE COMMUNICATIONS SYSTEM CONSISTING OF GEOSTATIONARY-ORBIT SATELLITES WITH BOTH EARTH COVERAGE AND STEERABLE NARROW-BEAM ANTENNAS. THE VARIOUS STAGES WITHIN THIS PHASE WILL LEAD TO AN ALL DIGITAL SYSTEM EMPLOYING TDMA.

DOWNLINK THE RF PATH FROM THE SATELLITE TO THE EARTH TERMINAL, THE FREQUENCY USED ON THIS PATH.

DTS_TERMINAL DIPLOMATIC TELECOMMUNICATIONS SYSTEM TERMINAL INTENDED TO PROVIDE RELATIVELY INEXPENSIVE DEDICATED OR SPECIAL-PURPOSE USER SERVICE. IT IS DESIGNED FOR UNATTENDED OPERATION WITH A RELOCATABLE CONFIGURATION.

E.I.R.P. EFFECTIVE ISOTROPIC RADIATED POWER. A CONVENIENT TERM USED TO DESCRIBE THE POWER RADIATED FROM A TERMINAL. IT IS THE PRODUCT OF TRANSMITTER POWER OUTPUT AND ANTENNA GAIN OR, IF IN DECIBELS, THE SUM.

E-LAYER A LAYER OF THE IONOSPHERE AT AN ALTITUDE OF ABOUT 60 MILES THAT CAN REFLECT RADIO WAVES.

EMI ELECTROMAGNETIC INTERFERENCE.

FDM FREQUENCY DIVISION MULTIPLEX. A SYSTEM IN WHICH THE AVAILABLE FREQUENCY RANGE IS DIVIDED INTO NARROWER BANDS, EACH USED FOR A SEPARATE CHANNEL.

F-LAYER THE HIGHEST REGULAR LAYER OF THE IONOSPHERE, WHERE HIGH FREQUENCY RADIO WAVES ARE REFLECTED. IT IS DIVIDED INTO AN F1 AND AN F2 LAYER.

FLTSATCOM FLEET SATELLITE COMMUNICATIONS SYSTEM. A NAVY UHF SATELLITE SYSTEM TO PROVIDE HIGH PRIORITY UHF COMMUNICATIONS WORLDWIDE BETWEEN SHIPS, SUBMARINES, GROUND STATIONS AND AIRCRAFT. FOUR SATELLITES WILL BE PLACED INTO GEOSYNCHRONOUS EQUATORIAL ORBITS TO PROVIDE WORLDWIDE COVERAGE. A MAJOR

BENEFIT EXPECTED FROM FLTSATCOM IS THE REDUCTION IN RELIANCE ON HF COMMUNICATIONS.

FM FREQUENCY MODULATION. ONE OF THE THREE WAYS TO MODIFY A CARRIER FREQUENCY TO MAKE IT "CARRY" INFORMATION. THE CARRIER HAS ITS FREQUENCY MODIFIED IN ACCORDANCE WITH THE INFORMATION TO BE TRANSMITTED.

FREE_SPACE_LOSS THE LOSS IN SIGNAL LEVEL EXPERIENCED BY AN ELECTROMAGNETIC WAVE OF FREQUENCY F, TRAVELING A DISTANCE D, BETWEEN TWO OMNIDIRECTIONAL ANTENNAS.

FREQUENCY_HOPPING AN ANTIJAMMING TECHNIQUE TO COMBAT SPOT JAMMING. CHANGING TO A NEW FREQUENCY CAUSES THE SPOT JAMMER TO HAVE TO SEARCH FOR THE NEW FREQUENCY DURING WHICH TIME THE FREQUENCY CAN AGAIN BE CHANGED. FREQUENCY HOPPING FORCES THE JAMMER TO SPREAD HIS ENERGY IN BROADBAND JAMMING REDUCING HIS JAMMER NOISE DENSITY ON ANY ONE CHANNEL.

FSB DIGITAL FLEET SATELLITE BROADCAST SUBSYSTEM. ONE OF THREE GROUPS OF SUBSYSTEMS PLANNED FOR FLTSATCOM. FSB IS EXPECTED TO GIVE GREATER COVERAGE, BETTER EFFICIENCY AND RELIABILITY THAN THE PRESENT HF SYSTEM WHILE REDUCING MANPOWER REQUIREMENTS AND ALLOWING A REDUCTION IN THE NUMBER AND SCOPE OF NAVY HF RADIO FACILITIES THROUGHOUT THE WORLD.

GAPFILLER A COMSAT GENERAL MARISAT SPACECRAFT. THE NAVY WILL LEASE CHANNELS IN THIS SATELLITE FOR ITS UHF RELAY CAPABILITY UNTIL FLTSATCOM SATELLITES ARE OPERATIONAL.

GROUP NORMALLY 12 TELEPHONE CHANNELS OCCUPYING ADJACENT FREQUENCY BANDS OF ABOUT 4 KHZ EACH AND TRANSMITTED TOGETHER. A FORM OF FDM.

G/T ANTENNA RECEIVING FIGURE OF MERIT. THE RATIO BETWEEN THE RECEIVER GAIN TO THE RECEIVER SYSTEM NOISE TEMPERATURE EXPRESSED IN DECIBELS. IT IS AN INDICATION OF THE RELATIVE CAPABILITY OF THE RECEIVER SUBSYSTEM TO RECEIVE A SIGNAL. A TERMINAL WITH A G/T OF 36 DB REQUIRES TWICE AS LARGE A RECEIVED SIGNAL LEVEL FOR PROPER RECEPTION AS DOES A TERMINAL WITH A G/T OF 39 DB.

HF HIGH FREQUENCIES (3-30 MHZ).

HORIZONTAL POLARIZATION THE ELECTRIC FIELD LIES IN THE HORIZONTAL PLANE.

HPA HIGH POWER AMPLIFIER.

IDCSP INITIAL DEFENSE COMMUNICATIONS SATELLITE PROGRAM.

IDLE_NOISE SHOT NOISE PLUS THERMAL NOISE.

INTELSAT INTERNATIONAL TELECOMMUNICATIONS SATELLITE CONSORTIUM. PRESENTLY THIS BODY IS MADE UP OF 91 MEMBER NATIONS EACH WITH OWNERSHIP OF ITS OWN GROUND TERMINALS.

INTERMODULATION_NOISE INTERFERENCE CAUSED BY THE INTERACTION OF TWO SIGNALS.

IONOSPHERE THAT PART OF THE EARTH'S ATMOSPHERE BEGINNING AT ABOUT 25 MILES AND EXTENDING TO ABOUT 22,000 MILES.

IXS DIGITAL INFORMATION EXCHANGE SUBSYSTEM. ONE OF THREE GROUPS OF SUBSYSTEMS IN FLTSATCOM. IXS IS DESIGNED WITH HIGH TRANSMISSION RATES TO REDUCE NAVY SHIP/SHORE/SHIP MESSAGE DELIVERY TIME.

JAMMING ACTION TAKEN AGAINST A COMMUNICATIONS SYSTEM TO PREVENT IT FROM ACCOMPLISHING ITS FUNCTION. JAMMING CAN BE ACCOMPLISHED BY SUBJECTING THE SYSTEM TO ELECTROMAGNETIC RADIATION TO CAUSE INTERFERENCE WITH, OR LOSS OF, COMMUNICATIONS.

JOHNSON NOISE SEE THERMAL NOISE

KLYSTRON THE KLYSTRON IS A VELOCITY-MODULATED TUBE IN WHICH THE VELOCITY MODULATION PROCESS PRODUCES A DENSITY-MODULATED STREAM OF ELECTRONS. THE VELOCITY MODULATION IS OBTAINED BY ACCELERATION AND RETARDATION OF ELECTRONS BY AN ALTERNATING VOLTAGE IMPRESSED BETWEEN ELECTRODES THAT HAVE VERY SHORT SPACING OR BY A MOVING ELECTRIC FIELD THAT HAS APPROXIMATELY THE SAME VELOCITY AS THE ELECTRON BEAM. THE KLYSTRON OSCILLATOR CAN BE USED AS A PUMP IN A PARAMETRIC AMPLIFIER.

LINK AVAILABILITY THE PROBABILITY THAT A LINK OF SPECIFIED CAPACITY AND QUALITY CONNECTING SYSTEM USERS IS OPERATING SATISFACTORILY AT ANY TIME.

LNA LOW NOISE AMPLIFIER.

MAGNETRON A DEVICE USED AS A GENERATOR OF MICROWAVE FREQUENCIES IN THE CENTIMETER AND MILLIMETER WAVELENGTH RANGES. MAGNETRONS ARE AVAILABLE AS PULSED OR C-W GENERATORS BUT FIND GREATEST APPLICATION AS RADAR TRANSMITTERS AS THEY ARE CAPABLE OF FURNISHING HIGH PEAK POWER.

MICROWAVES ELECTROMAGNETIC WAVES, OCCUPYING A PORTION OF THE FREQUENCY SPECTRUM BETWEEN 0.20 AND 300 THOUSAND MHZ.

MODEM A CONTRACTION OF "MODULATOR-DEMODULATOR".

MODULATION THE PROCESS BY WHICH INFORMATION IS IMPRESSED ON AN RF CARRIER FREQUENCY FOR TRANSMISSION.

MOLNIYA II A RUSSIAN COMMUNICATIONS SATELLITE USED IN THE WASHINGTON-MOSCOW HOTLINE.

MONOPULSE TRACKING A FOUR-HORN ANTENNA FEED AND COMPARATOR NETWORK ARE USED TO FORM THE NECESSARY ANTENNA BEAM. A SUM AND DIFFERENCE PATTERN IS USED TO GENERATE ERROR VOLTAGES TO KEEP THE ANTENNA POINTED IN THE DIRECTION OF THE TARGET.

MULTIPLEXER A DEVICE WHICH SEPARATES A TRANSMISSION FACILITY INTO TWO OR MORE CHANNELS. IT MAY BE FREQUENCY-DIVISION (FDM) OR TIME-DIVISION (TDM).

NCS NATIONAL COMMUNICATIONS SYSTEM, ESTABLISHED BY PRESIDENT KENNEDY ON 21 AUGUST 1963 TO PROVIDE BETTER COMMUNICATIONS SUPPORT TO CRITICAL FUNCTIONS OF GOVERNMENT. THE SECRETARY OF DEFENSE IS THE EXECUTIVE AGENT FOR THE NCS. THROUGH THIS SYSTEM, THE DAY-TO-DAY BUSINESS OF GOVERNMENT IS CARRIED OUT, OUR DEFENSE POSTURE IS MAINTAINED AND THE CONTINUITY OF GOVERNMENT IS SUPPORTED IN WARTIME.

PARAMETRIC AMPLIFIERS LOW NOISE AMPLIFIERS CAPABLE OF AMPLIFYING MICROWAVE FREQUENCIES. ITS OPERATION DEPENDS UPON THE VARIATION OF ONE OR MORE PARAMETERS WITH TIME.

PASSIVE SATELLITE AN EARTH SATELLITE CARRYING NO ELECTRONIC GEAR EXCEPT FOR PERHAPS A BEACON TRANSMITTER FOR LOCATION AND TRACKING PURPOSES. THE SATELLITE IS A HIGHLY REFLECTIVE OBJECT SUCH AS ECHO I AND II. THE MOON IS A NATURAL PASSIVE SATELLITE.

PERIGEE THE POINT NEAREST TO THE EARTH IN THE PERIOD OF A NATURAL OR MAN-MADE SATELLITE, THE OPPOSITE OF APOGEE.

PROGRAM TRACKING ORBITAL DATA RELATED TO THE SATELLITE PATH ARE STORED IN A DIGITAL COMPUTER WHICH CONTINUOUSLY COMPUTES THE CORRECT ANTENNA POINTING ANGLES AND COMMANDS THE ANTENNA TO POINT AT THESE ANGLES.

PCM PULSE-CODE MODULATION. THE MODULATION OF A PULSE TRAIN IN ACCORDANCE WITH A CODE.

PSK PHASE-SHIFT KEYING. BY SHIFTING THE PHASE 180-DEGREES A ONE OR A ZERO MAY BE REPRESENTED. ALSO CALLED BINARY

ANTIPODAL MODULATION.

SAMSO AIR FORCE SPACE AND MISSLE OFFICE. THE MANAGER OF THE FLTSATCOM PROJECT (ACQUISITION). IN RETURN, FLTSATCOM WILL CARRY SOME TRANSPONDERS TO SUPPORT AIR FORCE REQUIREMENTS.

SATELLITE_AVAILABILITY THE PROBABILITY THAT A PARTICULAR SATELLITE WILL BE AVAILABLE FOR USE AT A GIVEN POINT IN TIME.

SATELLITE_TRANSPONDER A DEVICE TO RECEIVE, AMPLIFY AND RETRANSMIT INPUT SIGNALS.

SCINTILLATION A FLUCTUATION OF SIGNAL STRENGTH DUE TO ABSORPTION AND REFRACTION OF THE SIGNAL DURING ITS PASSAGE THROUGH THE IONOSPHERE. THIS PHENOMENON IS MOST ACTIVE IN THE POLAR AND EQUATORIAL REGIONS.

SCT-21 A TRANSPORTABLE EARTH TERMINAL DESIGNED BY PHILCO-FORD INTENDED FOR NONMILITARY USAGE.

SHANNON'S_EQUATION GIVES THE MAXIMUM RATE, CALLED CHANNEL CAPACITY, WHICH CAN BE TRANSMITTED THEORETICALLY OVER A PARTICULAR CHANNEL.

SHF SUPER HIGH FREQUENCIES, 3-30 GHZ.

SHOT_EFFECT NOISE DUE TO THE RANDOM ARRIVAL OF ELECTRONS (OR HOLES) AT THE COLLECTOR, DRAIN OR PLATE OF AN ACTIVE ELEMENT, SIMILAR TO LEAD SHOT FALLING ON A METALLIC SURFACE.

SKYNET A BRITISH MILITARY COMMUNICATIONS SATELLITE SYSTEM. THE FIRST SKYNET SATELLITES WERE BUILT AND LAUNCHED BY THE U.S.

S/N SIGNAL TO NOISE RATIO. THIS INDICATES THE DEGRADATION OF A SIGNAL BY NOISE.

SOLAR_CELL A DEVICE WHICH, WHEN EXPOSED TO SUNLIGHT, WILL GENERATE AN ELECTROMOTIVE FORCE. SOLAR CELL ARRAYS (SOLAR BATTERIES) ARE USED AS THE PRIME POWER SOURCE IN COMMUNICATIONS SATELLITES. ALSO CALLED PHOTOVOLTAIC CELL.

SPADE A DIGITAL MULTIPLE-ACCESS DEMAND-ASSIGNMENT SYSTEM IN USE BY INTELSAT. MORE EFFICIENT USAGE IS MADE OF THE SATELLITE DUE TO ASSIGNMENTS OF CAPACITY ON A DEMAND BASIS. THIS IS MOST BENEFICIAL FOR SMALL COUNTRIES WITH LIGHT LOADS.

SPIN_STABILIZATION ONE TYPE OF ATTITUDE CONTROL SYSTEM FOR COMMUNICATIONS SATELLITES.

SPOT_JAMMING CONCENTRATING ALL OF THE JAMMING TRANSMITTER'S ENERGY IN A NARROW FREQUENCY BAND TO ACHIEVE A HIGH NOISE DENSITY IN THAT BAND.

STATION__KEEPING REFERS TO THE MAINTENANCE OF A FIXED SATELLITE POSITION RELATIVE TO ANOTHER OBJECT (IN THE CASE OF A SYNCHRONOUS SATELLITE, THE EARTH).

STEP_TRACKING A TECHNIQUE FOR AUTOMATIC EARTH TERMINAL TRACKING OF A SATELLITE. THE KEY ELEMENT IS THE AMPLITUDE OF THE RECEIVED SIGNAL. THE ANTENNA BEAM IS MOVED BY PRESET INCREMENTS IN AZIMUTH AND ELEVATION. IF THE RECEIVED AMPLITUDE INCREASES IN ONE STEP THE BEAM IS STEPPED IN THE SAME DIRECTION NEXT TIME; IF IT DECREASES, THE DIRECTION IS REVERSED IN THE NEXT STEP.

SUPERGROUP FIVE GROUPS (60 TELEPHONE CHANNELS OF 4-KHZ EACH).

SVC DIGITAL SECURE VOICE COMMUNICATIONS SUBSYSTEM. ONE OF THREE GROUPS OF SUBSYSTEMS IN FLTSATCOM. SVC WILL CARRY THE SECURE HIGH COMMAND VOICE NETWORK (HICOM) AND THE SECURE

FLEET COMMON VOICE NETWORK (FLTCOM).

SWEPT-SPOT JAMMING COMBINES THE HIGH NOISE DENSITY OF SPOT JAMMING WITH THE WIDE BANDWIDTH OF BROADBAND JAMMING BY SWEEPING THE SPOT JAMMER AT A VERY HIGH SWEEP RATE ACROSS THE SPECTRUM TO BE JAMMED.

SYNCHRONOUS ORBIT AN ORBIT WITH A PERIOD WHICH APPROXIMATES THE ANGULAR VELOCITY OF THE EARTH. SYNCHRONOUS SATELLITES HAVE AN ORBITAL HEIGHT OF 22,300 STATUTE MILES AND APPEAR TO REMAIN STATIONARY OVER A FIXED POINT ON THE EARTH'S SURFACE.

SYNCOM AN EXPERIMENTAL NASA SATELLITE SERIES (SYNCOM I, II, III) USED TO TEST A SYNCHRONOUS ORBIT COMMUNICATIONS SATELLITE. SYNCOM III WAS PLACED IN SYNCHRONOUS ORBIT IN AUGUST, 1964.

TACSAT A US MILITARY SYNCHRONOUS COMMUNICATIONS SATELLITE DESIGNED TO PROVIDE COMMUNICATIONS BETWEEN MOBILE TACTICAL TERMINALS IN EITHER THE SHF OR UHF RANGE.

TATS TACTICAL TRANSMISSION SYSTEM. A FREQUENCY HOPPING SYSTEM USED AS AN OPERATIONAL MODE FOR TACSAT IN MILITARY COMMUNICATIONS ENVIRONMENTS. FREQUENCY HOPPING IS AN ANTIJAMMING TECHNIQUE.

TDA TUNNEL DIODE AMPLIFIER. A LOW NOISE AMPLIFIER HAVING HIGH GAIN AND WIDE BANDWIDTH.

TDMA TIME-DIVISION MULTIPLE ACCESS. EACH OF SEVERAL EARTH STATIONS IS ALLOTED THE ENTIRE SATELLITE POWER AND BANDWIDTH IN A SEQUENTIAL MANNER WITH EACH STATION TRANSMITTING IN SHORT BURSTS.

THERMAL_NOISE ALSO KNOWN AS JOHNSON OR WHITE NOISE. THIS NOISE IS CAUSED BY THE RANDOM MOVEMENT OF ELECTRONS IN LINEAR, PASSIVE ELEMENTS. AS THE TEMPERATURE RISES, SO DOES THERMAL AGITATION AND THE RESULTANT NOISE.

THRESHOLD_EXTENSION_DEMODULATOR A DEVICE FOR LOWERING THE SIGNAL TO NOISE RATIO POINT AT WHICH THE DEMODULATOR'S PERFORMANCE BECOMES ABNORMAL.

THRESHOLD_REGION THAT VALUE OF INPUT SIGNAL TO NOISE RATIO (S/N) BELOW WHICH THE DEMODULATOR PERFORMANCE IS ABNORMAL.

TTY TELETYPE

TWTA TRAVELING WAVE TUBE AMPLIFIER. USED AS A POWER

AMPLIFIER IN EARTH TERMINALS DUE TO ITS HIGH BANDWIDTH (500 MHZ).

UHF ULTRA HIGH FREQUENCIES (300-3000MHZ).

UPLINK FREQUENCY THE FREQUENCY USED FOR TRANSMISSIONS FROM AN EARTH TERMINAL TO A SATELLITE.

VERTICAL POLARIZATION THE ELECTRIC FIELD IS IN THE VERTICAL DIRECTION

VHF VERY HIGH FREQUENCIES (30-300 MHZ).

WHITE NOISE SEE THERMAL NOISE.

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