CHURGIN, A. B.

Survey of capabilities and costs of existing, under development or planned communications spacecraft programs.

(2)

SURVEY OF CAPABILITIES AND COSTS OF EXISTING, UNDER DEVELOPMENT OR PLANNED COMMUNICATIONS SPACECRAFT PROGRAMS

PREPARED by: (1) A.B. Churgin
July 1974
ABC

HITECH CANADA LIMITED

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*See Classified Addendum

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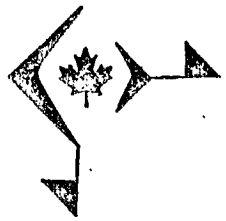

SECTION 1 - INTRODUCTION

SECTION 1:

INTRODUCTION:

On the 27th of June 1974, HiTech Canada Limited was asked to assist the "UHF Communication System Feasibility Study" group in two tasks:

- Examination of existing capabilities of existing spacecraft and those currently under development.
- Examination of costs of existing and presently planned spacecraft, ground control systems and launches.

Dr. S. Ahmed of the Communciations Research Centre and Mr. Allan B. Churgin of HiTech launched a survey to accomplish the objectives of the tasks mentioned above. This report documents the results of the survey. Spacecraft programs considered are listed in Table I. Section 2 of this report presents the detailed data gathered for each program listed in Table I. Section 3 presents a summary of the data in matrix form for ease of comparison.

Two of the programs surveyed (FLTSATCOM and RCA-DND) are classified. Data for these two programs are presented in a classified addendum to this report.

TABLE I

SPACECRAFT PROGRAMS SURVEYED

PROGRAM	PURPOSE	STATUS
MARISAT	Maritime Commercial Communications	Development
ANIK	Domestic Commercial Communications	Operational
SATCOM	Domestic Commercial Communications	Development
EMBS	Experimental Japanese Broadcast Commercial Communications	Development
EMCS	Experimental Japanese Commercial Communications	Development
LES-6	Experimental Military Communications	Operational
TACSATCOM	Military Communications	Operational
AEROSAT	Aeronatuical Traffic Control	Planned
INTELSAT 4	International Commercial Communications	Operational
FLTSATCOM(1)	Military Communications	Development
RCA HYBRID	Government and Commercial Communications	Study
RCA-DND(1)	Military Communications	Study
~~MAROTS~~-OTS	~~Maritime~~ and Domestic European Experimental Communications	Study
CTS	Experimental Domestic Communications	Development

(1) Classified programs presented in a classified addendum to this report.

SECTION 2 - PRESENTATION OF DETAILED DATA

2.0 PRESENTATION OF DETAILED DATA

2.1 MARISAT

SYSTEM OWNER: COMSAT - See Note (1)

SYSTEM CONTRACT: Hughes Aircraft - Spacecraft, COMSAT - System

FREQUENCIES-UP: 300 MHz, 6.0 GHz, 1.65 GHz

FREQUENCIES-DOWN: 250 MHz, 4.0 GHz, 1.55 GHz

NUMBER OF CHANNELS: 5 See Note (3)

BW PER CHANNEL: 25 KHz, 500 kHz, 4 MHz - See Note (4)

EIRP PER CHANNEL: 28 dBW, 23 dBW, 26 dBW, 29.5 dBW - See Note (5)

ANTENNA TYPE: Tri-Helix, Quad Helix, Conical Horn, Despun - See Note (

ANTENNA SIZE: Tri-Helix-6', Quad Helix-3'

STABILIZING METHOD: Spin

POINTING ACCURACY: $\pm$0.65°, Both Axes

BEAMWIDTHS: UHF-30° to 35°, SHF-19°

ATTITUDE SENSING TECHNIQUES: Earth and Sun

Launch Vehicle Type: Delta 2914

LIFT-OFF WEIGHT OF S.C.: 1445 pounds - See Note (7)

IN-ORBIT WEIGHT OF S.C.: Approximately 700 pounds

TOTAL DC POWER: 300 W EOL

ECLIPSE PERFORMANCE: 100% - See Note (8)

STATION KEEPING METHOD: EW only hydrazene thrusters - see Note (9)

STATION KEEPING ACCURACY: $\pm$ 0.5° EW

DESIGN LIFE: 5 Years

ACTUAL OPERATIONAL LIFE REALIZED: N/A

ACTUAL OBSERVED DEFICIENCIES: N/A

S.C. DEVELOPMENT COSTS: Approximately $13M

COST PER ADDITIONAL COPY OF S/C: 7.0 M - See Note (10)

GROUND CONTROL SYSTEM COSTS: 1 M (shared with others)

COMM. CONTROL SYSTEM COST: Included in Ground Control System Costs

COMM. TERMINAL COSTS: Not Available

ORIGINAL OR DERIVED DESIGN: Derived from ANIK

COST CONTRACTING TECHNIQUES (INCENTIVES, ETC.): Fixed Price Incentive

DEVELOPMENT PHASE: 12 Months - See Note (11)

FLIGHT HARDWARE PHASE: 6 Months - See Note (12)

FIRST LAUNCH DATE: February 1975

SOURCES OF INFORMATION: COMSAT Briefing - E. Martin, 12 July 1974

BIBLIOGRAPHY: None

MARISAT NOTES

(1) COMSAT now owns the system, however the eventual owners will be a consortium consisting of:

RCA GLOBECOM	(12.5%)
W.U.I.	(4.0%)
IT&T	(3.3%)
COMSAT	(80.2%)

(2) The UHF 250 - 300 MHz band will be utilized by the U.S. Navy; Commercial Maritime traffic will utilize the 1.55 - 1.65 GHz band, and shore based stations will utilize the 4 - 6 GHz band.

(3) 3 channels, 250 - 300 MHz
1 channel, 1.55 - 1.65 GHz
1 channel, 4 - 6 GHz

(4) 2 channels 25 kHz, (250 - 300 MHz band)
1 channel 500 kHz, (250 - 300 MHz band)
2 channels 4 MHz (1.55 - 1.65 & 4 - 6 GHz)

(5) 500 kHz channel EIRP is 28 dBW
25 kHz channels EIRP are 23 dBW
4 MHz channels EIRP are 26 (C-Band) and 29.5 (L-Band)

(6) UHF-Tri-Helix
L Band-Quad Helix
SHF - Conical Horn

(7) Hydrazene carried aboard to supplement apogee motor.

(8) 100% performance expected with 50% of batteries operating.

(9) Out of plane (inclination) perturbations will be tolerated. There will be a 2° inclination bias. There may be some NS stationkeeping if Hydrazene fuel availability permits.

(10) Not including orbital incentives, approximately $1M, or spares, possibly $1M

(11) Hughes made some design changes prior to receiving contract; it is estimated that their development effort (rotary joint and tubes) took one year.

(12) Hughes began making flight hardware before completion of development effort which is the reason for this relatively short manufacturing phase.

2.2 ANIK

SYSTEM OWNER: Telesat Canada

SYSTEM CONTRACTOR: Hughes Aircraft Corporation - Space Segment

FREQUENCIES-UP: 6.0 GHz band

FREQUENCIES-DOWN: 4.0 GHz band

NUMBER OF CHANNELS: 12 - See Note (1)

BW PER CHANNEL: 36 MHz

EIRP PER CHANNEL: 34 dBW

ANTENNA TYPE: 3-horn fed parabolic disk - despun

ANTENNA SIZE: 5'

STABILIZING METHOD: Spin

POINTING ACCURACY: 0.1° EW; 0.35° NS

BEAMWIDTHS: 8° x 3°

ATTITUDE SENSING TECHNIQUES: Earth and Sun

LAUNCH VEHICLE TYPE: Delta 2914

LIFT-OFF WEIGHT OF S.C.: 1242 pounds

IN-ORBIT WEIGHT OF S.C.: 655 pounds

TOTAL DC POWER: 250 W EOL

ECLIPSE PERFORMANCE: 100% - See Note (2)

STATION KEEPING METHOD: EW and NS, hydrazene thrusters.

STATION KEEPING ACCURACY 0.05° EW & NS

DESIGN LIFE: 7 years

ACTUAL OPERATIONAL LIFE REALIZED: N/A - See Note (3)

ACTUAL OBSERVED DEFICIENCIES: Batteries - See Note (4)

S.C. DEVELOPMENT COSTS: ~~Approximately~~ estimated 40M

COST PER ADDITIONAL COPY OF S/C: 7.6M

GROUND CONTROL SYSTEM COSTS: Not available

COMM. CONTROL SYSTEM COST: Not available

COMM. TERMINAL COSTS: Not available

ORIGINAL OR DERIVED DESIGN: Derived - Intelsat 4 - See Note (5)

COST CONTRACTING TECHNIQUES (INCENTIVES, ETC.) Fixed Price Incentive - See Note (6)

DEVELOPMENT PHASE: 18 Months

FLIGHT HARDWARE PHASE: 18 Months

FIRST LAUNCH DATA: November 1972 (2nd launch April 1973)

SOURCES OF INFORMATION: Telesat Canada briefing

BIBLIOGRAPHY: None.

ANIK NOTES

(1) 12 channels are available - 10 of which are operationally committed.

(2) 10 channels available during eclipse - in the event of 1 battery failure, 5 channels would be available during eclipse.

(3) Spacecraft was launched in November 1972, still operating satisfactorily.

(4) 1 cell in NiCd battery leaking - requires periodic charging during solstice seasons. Life of battery may be affected.

Spike noted periodically in received signal, not affecting users satisfaction.

(5) Items designed for this spacecraft included rotary joint for antenna , light-weight antenna, 5 watt TWT, drive TWT, despin system.

(6) Payment made by milestone, with in-orbit incentives on communications performance and life-achieved. Eclipse performance not included.

2.3 SATCOM - See Note (1)

SYSTEM OWNER: RCA GLOBECOM

SYSTEM CONTRACTOR: RCA Astroelectronics (U.S.) - Space Segment
RCA Limited (Canada) - See Note (2)

FREQUENCIES-UP: 6.0 GHz band

FREQUENCIES-DOWN: 4.0 GHz band

NUMBER OF CHANNELS: 24

BW PER CHANNEL: 36 MHz

EIRP PER CHANNEL: 26 dBW Wide Beam; 34 dBW Spot Beam

ANTENNA TYPE: Fixed Parabolic Dish

ANTENNA SIZE: Approximately 7'

STABILIZING METHOD: 3 Axis Stabilized - See Note (3)

POINTING ACCURACY: ± 0.15° EW, ± 0.21 NS

BEAMWIDTHS: Widebeam 8° x 4°, Spot Beam 2.6° x 1°

ATTITUDE SENSING TECHNIQUES: Earth, Sun, Rate Gyro

LAUNCH VEHICLE TYPE: Delta 3914

LIFT-OFF WEIGHT OF S.C.: 2000 pounds

IN-ORBIT WEIGHT OF S.C.: 1092 - See Note (4)

TOTAL DC POWER: Approximately 650 EOL - See Note (5)

ECLIPSE PERFORMANCE: 100%

STATION KEEPING METHOD: EW, NS, hydrazene thrusters

STATION KEEPING ACCURACY: ± 0.05° EW & NS

DESIGN LIFE: 8 years

ACTUAL OPERATIONAL LIFE REALIZED: N/A - See Note (6)

ACTUAL OBSERVED DEFICIENCIES: N/A - See Note (6)

S.C. DEVELOPMENT COSTS: ~~10M~~ 13M - See Note (7)

COST PER ADDITIONAL COPY OF S/C: 10M - See Note (9)

GROUND CONTROL SYSTEM COSTS: 1 - 1.5M - See Note (8)

COMM. CONTROL SYSTEM COST: Less than 1M

COMM. TERMINAL COSTS: ~~25K~~ See Note (10)

ORIGINAL OR DERIVED DESIGN: Derived - See Note (11)

COST CONTRACTING TECHNIQUES (INCENTIVES, ETC.): FPI

DEVELOPMENT PHASE: 15 - 18 Months - See Note (12)

FLIGHT HARDWARE PHASE: 12 Months

FIRST LAUNCH DATE: November 1975 (SHF SATCOM)

SOURCES OF INFORMATION: RCA Ltd. Briefing

BIBLIOGRAPHY: "RCA Satcom Satellite Technical Description"
RCA Astroelectronics Div., Princeton, N.J.
Dec. '73.

Total $33m — R&D + 3 Flight S/C

RCA SATCOM NOTES

(1) The manufacturer claims that spacecraft is designed as a "bus" and may carry other payloads with a minimum of changes.

(2) RCA Astroelectronics has prime contract, RCA Limited has approximately $8M out of the $25M contract, thus representing a large Canadian content.

(3) Active Nutation Damping, Mementum wheels Damping accomplished through magnetic torquing.

(4) Apogee motor off-load capability of 10%.

(5) BOL Power can range from 750 W to 1000 W by adding solar panels (rigid accordian). After 8 years EOL is 490 W for a 750 W BOL. Number shown (650 W) EOL is estimated by the writer for comparison purposes.

(6) S/C is presently in design phase

(7) $10M refers to the dollars estimated to redesign Antenna and Transponder for UHF range, including military features, (i.e. Anti-jam)

(8) Includes Earth Station for TT&C, and control software.

(9) Does not include orbit incentives of approximately $1M.

(10) Estimated production price in quantity.

(11) Derived from TIROS M.

(12) For redesign and requalification of UHF version.

2.4 EMBS

SYSTEM OWNER: Government of Japan

SYSTEM CONTRACTOR: TOSHIBA - G.E. - System

FREQUENCIES-UP: 14 GHz band

FREQUENCIES-DOWN: 12 GHz band

NUMBER OF CHANNELS: 2

BW PER CHANNEL: 50 MHz, 80 MHz

EIRP PER CHANNEL: 37 dBW - See Note (1)

ANTENNA TYPE: Parabolic Dish

ANTENNA SIZE: Not available

STABILIZING METHOD: 3 Axis - Momentum Wheels

POINTING ACCURACY: $\pm$ 0.1° EW, NS

BEAMWIDTHS: Not available

ATTITUDE SENSING TECHNIQUES: Presumed Earth, Sun

LAUNCH VEHICLE TYPE: Delta 2914

LIFT-OFF WEIGHT OF S.C.: 1480 pounds

IN-ORBIT WEIGHT OF S.C.: 728 pounds

TOTAL DC POWER: 767 W EOL

ECLIPSE PERFORMANCE: Not available

STATION KEEPING METHOD: Not available

STATION KEEPING ACCURACY: Not available

DESIGN LIFE: 3 years.

ACTUAL OPERATIONAL LIFE REALIZED: N/A

ACTUAL OBSERVED DEFICIENCIES: N/A

S.C. DEVELOPMENT COSTS: Not available

GROUND CONTROL SYSTEM COSTS: Not available

COST PER ADDITIONAL COPY OF S/C: Not available

COMM. CONTROL SYSTEM COST: Not available

COMM. TERMINAL COSTS: Not available

ORIGINAL OR DERIVED DESIGN: Not known

COST CONTRACTING TECHNIQUES (INCENTIVES, ETC.): Not known

DEVELOPMENT PHASE: 18 Months

FLIGHT HARDWARE PHASE: 12 Months

FIRST LAUNCH DATE: Early 1977 or late 1976

SOURCES OF INFORMATION: Paper by Sonoyama, G.E. Contacts

BIBLIOGRAPHY: G. Sonoyama, Radio Regulatory Bureau, Japan
"Communications Broadcast Satellites"

EMBS NOTES

(1) 37 dBW quoted for Japanese Mainland; 28 dBW is quoted for all of Japan including Islands.

2.5 EMCS

SYSTEM OWNER: Government of Japan

SYSTEM CONTRACTOR: Mitsubishi-Philco-Ford - System

FREQUENCIES-UP: 28 GHz, 6 GHz bands

FREQUENCIES-DOWN: 18 GHz band, 4 GHz band

NUMBER OF CHANNELS: 8 - See Note (1)

BW PER CHANNEL: 200 MHz

EIRP PER CHANNEL: 37 and 29.5 dbw

ANTENNA TYPE: Despun, Horn Fed Flat Plates

ANTENNA SIZE: 2 - 3'

STABILIZING METHOD: Spin

POINTING ACCURACY: ± 0.3° EW, NC

BEAMWIDTHS: 4-6 GHz - 4° x 6°; 18-28 GHz - 1° x 3°

ATTITUDE SENSING TECHNIQUES: Earth and Sun

LAUNCH VEHICLE TYPE: Delta 2914

LIFT-OFF WEIGHT OF S.C.: 1490 pounds

IN-ORBIT WEIGHT OF S.C.: 770 pounds

TOTAL DC POWER: 420 EOL

ECLIPSE PERFORMANCE: 100%

STATION KEEPING METHOD: EW, NS - Hydrazene thrusters

STATION KEEPING ACCURACY: ±0.1° NS, EW

DESIGN LIFE: 3 Years

ACTUAL OPERATION LIFE REALIZED: N/A

ACTUAL OBSERVED DEFICIENCIES: N/A

S.C. DEVELOPMENT COSTS: No Quote Available

GROUND CONTROL SYSTEM COSTS: No Quote Available

COST PER ADDITIONAL COPY OF S/C: No Quote Available

COMM. CONTROL SYSTEM COST: Not Available

COMM. TERMINAL COSTS: Estimated 30K

ORIGINAL OR DERIVED DESIGN: Derived - See Note (2)

COST CONTRACTING TECHNIQUES (INCENTIVES, ETC.): Fixed Price Incentive

DEVELOPMENT PHASE: Approximately 12 Months - See Note (3)

FLIGHT HARDWARE PHASE: Approximately 12 Months - See Note (3)

FIRST LAUNCH DATE: Fall 1976

SOURCES OF INFORMATION: Philco-Ford, Paper by Sonoyama

BIBLIOGRAPHY: G. Sonoyama, Radio Regulatory Bureau, Japan "Communications Broadcast Satellites)".

EMCS NOTES

(1) 6 channels in the 18 - 28 GHz band and 2 channels in 4 - 6 GHz band.

(2) This spacecraft is almost identical in the Philco-Ford produced NATO-3, except for Antenna and Transponder and as such may be considered a "bus",NATO-3 to be launched late 1975.

(3) The Japanese contract calls for a total of 30 months, however Philco-Ford estimates the time at 24 months under normal conditions (Japan asked for stretch-out.)

2.6 LES-6

SYSTEM OWNER - USAF

SYSTEM CONTRACTOR: MIT-Lincoln Labs

FREQUENCIES-UP: 302.7 MHz

FREQUENCIES-DOWN: 249.1 MHz

NUMBER OF CHANNELS: 1

BW PER CHANNEL: switchable, 100 or 500 KHz

EIRP PER CHANNEL: (890 Watts) 29.5 dBW BOL

ANTENNA TYPE: Electronically Despun - See Note (1)

ANTENNA SIZE: See Note (1)

STABILIZING METHOD: Spin Stabilized - See Note (2)

POINTING ACCURACY: Spin Axis Held to ± 0.16°

BEAMWIDTHS: (34° x 54°)

ATTITUDE SENSING TECHNIQUES: Earth and Solar Sensors - See Note (3)

LAUNCH VEHICLE TYPE: TITAN III C

LIFT-OFF WEIGHT OF S.C.: 398 pounds

IN-ORBIT WEIGHT OF S.C.: Same as lift-off weight - See Note (4)

TOTAL DC POWER: BOL 220 Watts

ECLIPSE PERFORMANCE: Shut Down - See Note (5)

STATION KEEPING METHOD: EW only - ion Engine - See Note (6)

STATION KEEPING ACCURACY: ± 2° EW

DESIGN LIFE: 5 Years

ACTUAL OPERATIONAL LIFE REALIZED: Still Operating, Almost Six Years

ACTUAL OBSERVED DEFICIENCIES: Solar Panel - See Note (7)

S.C. DEVELOPMENT COSTS: $16M - See Note (8)

GROUND CONTROL SYSTEM COSTS: N/A - See Note (9)

COST PER ADDITIONAL COPY OF S/C: 16M + Inflation

COMM. CONTROL SYSTEM COST: N/A

COMM. TERMINAL COSTS: N/A - See Note (10)

ORIGINAL OR DERVIED DESIGN: Original

COST CONTRACTING TECHNIQUES (INCENTIVES, ETC.): Cost Plus Fixed Fee

DEVELOPMENT PHASE: 12 - 18 Months

FLIGHT HARDWARE PHASE: 12 - 18 Months

FIRST LAUNCH DATE: 26 July 1968

SOURCES OF INFORMATION: Phil Waldron, MIT Project Mgr.

BIBLIOGRAPHY: "Lincoln Experimental Satellites 5 and 6"
AIAA 3rd Comm. Sat. Conference, 6 - 8 April 1970

LES-6 NOTES

(1) Electronically despun, circularly polarized. Dipole antennas radiate an axial polarization and slot antennas (excited in phase quadrature) radiate an orthangonal circumferential polarization to produce the circularly polarized wave. 8 - 9 dB gain.

(2) The spacecraft is spin stabilized, however it is noteworthy that orientation was accomplished by a magnetic torquing system. Control is exercised through a cold ammonia gas reaction control system, using earth and solar sensor inputs. (See Note 3)

(3) The system uses the coincidence of narrow beam earth and sun sensor inputs which occur at points in orbit defined by the relative placement of the sensors around the satellite view band.

(4) The S/C carries no orbital propulsion - it flew along with 3 other spacecraft.

(5) During eclipse, only an oscillator is kept alive by a small battery.

(6) The time of a given event (such as the coincidence of sun and earth sensor observations) is compared to the time at which the event showed have happened as seen by the on-board clock. The time difference equates to a longitude position error which is corrected by firing an ion thruster.

(7) 1 solar panel not delivering power, thought related to a spin axis "wobble" of 2.2^{o}.

(8) The costs quoted, $16M, include the development of LES-5 as well as LES-6. Approximately $12M may be attributed to LES-6 as an ROM cost. MIT was the system integrator and did most of the work in-house.

(9) MIT estimates that if they had to build a station, it would cost less than $1M.

(10) Digital system with sequential decoding.

2.7 TACSATCOM

SYSTEM OWNER: USAF

SYSTEM CONTRACTOR: Hughes Aircraft Corporation - Spacecraft

FREQUENCIES-UP: 300 MHz band; 8.0 GHz band - See Note (1)

FREQUENCIES-DOWN: 250 MHz band; 7.2 GHz band - See Note (1)

NUMBER OF CHANNELS: 1 UHF; 1 SHF - See Note (2)

BW PER CHANNEL: 50 kHz to 10 MHz - See Note (2)

EIRP PER CHANNEL: 38 dBW for UHF; 31 dBW for SHF

ANTENNA TYPE: 5 Element-Helix for UHF, Conical Horn - SHF, Despun

ANTENNA SIZE: 4 Helixes 8', 1 helix 6'

STABILIZING METHOD: Spin, Gyrostat

POINTING ACCURACY: $\pm$ 0.3° EW, NS

BEAMWIDTHS: SHF Earth Coverage, 19° UHF

ATTITUDE SENSING TECHNIQUES: Earth Sensors

LAUNCH VEHICLE TYPE: Titan III C

LIFT-OFF WEIGHT OF S.C.: Approximately 1600 pounds

IN-ORBIT WEIGHT OF S.C.: Approximately 1600 pounds

TOTAL DC POWER: 750 EOL - (Estimated)

ECLIPSE PERFORMANCE: 100%

STATION KEEPING METHOD: EW only, Hydrogen Peroxide thrusters.

STATION KEEPING ACCURACY: $\pm$ 5° EW

DESIGN LIFE: 5 Years

ACTUAL OPERATIONAL LIFE REALIZED: 3.8 Years

ACTUAL OBSERVED DEFICIENCIES: UHF Loss of EIRP - No Explanation
Nutation up to 1.2°
SHF TWT - 2 dB degradation
Brush on Despin Motor Failed

S.C. DEVELOPMENT COSTS: $30M

GROUND CONTROL SYSTEM COSTS: Approximately 4M

COST PER ADDITIONAL COPY OF S/C: 15 - 18M

COMM. CONTROL SYSTEM COST: Less Than 1M

COMM. TERMINAL COSTS: Approximately 30K

ORIGINAL OR DERVIED DESIGN: Original

COST CONTRACTING TECHNIQUES (INCENTIVES, ETC.): Cost Plus Fixed Fee

DEVELOPMENT PHASE: 18 Months

FLIGHT HARDWARE PHASE: 12 Months

FIRST LAUNCH DATE: August 1969

SOURCES OF INFORMATION: TACSAT Documentation HAC, Mr. Joel Emanuel HAC

BIBLIOGRAPHY:(1)SCF Familiarization Program/TACSAT 1;

(2)"The Tactical Communications Satellite"
Brandes, IEEE Transactions, Vol. AES-6
No. 4, July 1970.

TACSATCOM NOTES

(1) UP Frequencies are: UHF: 303.4 and 307.5 MHz

SHF: 7982.5 MHz

Down Frequencies are: UHF: 249.6 MHz

SHF: 7257.5 MHz

(2) UHF/SHF cross-strap made available in both directions. Variable bandwidths, 50 KHz to 10 MHz options. Number of channels at wideband dependent upon terminal characteristics.

2.8 AEROSAT - See Note (1)

SYSTEM OWNER: Consortium - Canada, ESRO, U.S. Corporation

SYSTEM CONTRACTOR: COSMOS - See Note (1)

FREQUENCIES-UP: 1.655 to 1.660 GHz; 5.0 to 5.125 GHz - See Note (2)

FREQUENCIES-DOWN: 1.540 to 1.545 GHz; 5.125 to 5.250 GHz - See Note (2

NUMBER OF CHANNELS: 2 to 6 Depending on Configuration - See Note (3)

BW PER CHANNEL: 8 KHz; 50 KHz

EIRP PER CHANNEL: 35 dBW

ANTENNA TYPE: Varying Options - See Note (Note (4)

ANTENNA SIZE: Varying - See Note (4)

STABILIZING METHOD: Spin or 3 Axis - See Note (5)

POINTING ACCURACY: See Note (6)

BEAMWIDTHS: See Note (7)

ATTITUDE SENSING TECHNIQUES: See Note (8)

LAUNCH VEHICLE TYPE: Delta 2914

LIFT-OFF WEIGHT OF S.C.: Approximately 1400 pounds

IN-ORBIT WEIGHT OF S.C.: Approximately 700 pounds

TOTAL DC POWER: 300-400 W EOL

ECLIPSE PERFORMANCE: 50%

STATION KEEPING METHOD: EW Only - Hydrazene Thrusters

STATION KEEPING ACCURACY: $\pm 2°$EW

DESIGN LIFE: 7 Years

ACTUAL OPERATIONAL LIFE REALIZED: N/A

ACTUAL OBSERVED DEFICIENCIES: N/A

S.C. DEVELOPMENT COSTS: $60M Approximately - See Note (9)

GROUND CONTROL SYSTEM COSTS: $3.0M Including S/C Control

COST PER ADDITIONAL COPY OF S/C: $6.5 - 7.0 M

COMM. CONTROL SYSTEM COST: $1M

COMM. TERMINAL COSTS: $70 - 80 K

ORIGINAL OR DERIVED DESIGN: Partial

COST CONTRACTING TECHNIQUES (INCENTIVES, ETC.): Fixed Price Incentive

DEVELOPMENT PHASE: 30 Months

FLIGHT HARDWARE PHASE: 15 Months

FIRST LAUNCH DATE: Unknown

SOURCES OF INFORMATION: Study Report

BIBLIOGRAPHY: "System and Design Study of a Preoperational Aeronautical Satellite System", Phase I Report, COSMOS, 1970

AEROSAT NOTES

(1) This is one of 3 proposed configurations for the Aerosat S/C, it is not the Aerosat S/C and does not reflect the latest performance specs.

(2) 1.655 to 1.660 GHz to be utilized by mobile (aircraft) terminal for uplink.
5.0 to 5.125 GHz will be utilized by the Earth Terminal for Uplink.
1.540 to 1545 for mobile terminals downlink.
5.125 to 5.250 for Earth station downlink.

(3) Latest is 7 channels, not verified.

(4) Likely spot beam antenna will be a multiple feed parabolic dish approximately 6', and a quad helix array for widebeam coverage.

(5) The COSMOS study does not recommend a specific stabilizing technique, but the choice hinges on the capability of mobile terminals. If a 10 dB mobile terminal antenna is available, COSMOS recommends a spinner; for a 4 dB antenna they prefer 3 axis stabilization.

(6) For a spin configuration, the accuracy requirements are 0.7° NS, 0.3° EW.
For a 3 axis configuration, the accuracy requirements 0.6° NS, 0.3° EW.

(7) No hard conclusion was reached by the study, however pricing was based on one broad beam earth coverage plus seven - 6.1° spot beams.

(8) Discussion of sensors is limited in the study; for the spin configuration IR earth sensors are mentioned briefly. For the 3 axis configuration it is presumed that both earth and sun sensors as well as a rate gyro will be required.

(9) Estimated in 1970 dollars.

2.9 INTELSAT IV

SYSTEM OWNER: Intelsat

SYSTEM CONTRACTOR: Hughes Aircraft Corporation

FREQUENCIES-UP: 6.0 GHz band

FREQUENCIES-DOWN: 4.0 GHz band

NUMBER OF CHANNELS: 12 - See Note (1)

BW PER CHANNEL: 36 MHz per Transponder

EIRP PER CHANNEL: 23 dBW/Transponder, 34.5 dBW for Spot Beams

ANTENNA TYPE: 2 Despun, Steerable Parabolic Dish; Conical Horns

ANTENNA SIZE: APPROX 3.5'

STABILIZING METHOD: Spin

POINTING ACCURACY: $\pm$ 0.35° EW and NS

BEAMWIDTHS: 17°; 4.3° Spotbeam

ATTITUDE SENSING TECHNIQUES: Earth Sensors Only

LAUNCH VEHICLE TYPE: Atlas Centaur

LIFT-OFF WEIGHT OF S.C.: 3100 pounds

IN-ORBIT WEIGHT OF S.C.: 1610 pounds

TOTAL DC POWER: 365 W EOL

ECLIPSE PERFORMANCE: 100%

STATION KEEPING METHOD: EW and NS - Hydrazene Thrusters

STATION KEEPING ACCURACY: $\pm$ 0.5° EW and NS

DESIGN LIFE: 7 Years

ACTUAL OPERATIONAL LIFE REALIZED: Not available

ACTUAL OBSERVED DEFICIENCIES: None as of December 1972

S.C. DEVELOPMENT COSTS: Not Available

GROUND CONTROL SYSTEM COSTS: Not Available

COST PER ADDITIONAL COPY OF S/C: Not Available

COMM. CONTROL SYSTEM COST: Not Available

COMM. TERMINAL COSTS: Not Available

ORIGINAL OR DERVIED DESIGN: Not Available

COST CONTRACTING TECHNIQUES (INCENTIVES, ETC.): Not Available

DEVELOPMENT PHASE: Not Available

FLIGHT HARDWARE PHASE: Not Available

FIRST LAUNCH DATE: Not Available

SOURCES OF INFORMATION: See Bibliography

BIBLIOGRAPHY: COMSAT Technical Review, Vol. 2, No.2, Fall 72

INTELSAT IV NOTES

(1) There are 12 transponders, allowing greater than 1000 multiplexed voice channels per transponder for earth station G/T of 41.7 dB/K.

2.10 FLTSATCOM - Classified - See Addendum

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2.11 RCA HYBRID

SYSTEM OWNER: N/A - See Note (1)

SYSTEM CONTRACTOR: RCA Limited

FREQUENCIES-UP: 400 MHz; 2.7 GHz

FREQUENCIES-DOWN: 300 MHz, 2.5 GHz

NUMBER OF CHANNELS: 33 UHF, 4 S Band - See Note (2)

BW PER CHANNEL: 20 kHz at 300-400 MHz; 250 kHz at 2.5 - 2.7 GHz

EIRP PER CHANNEL: 27 & 17 dbw for UHF channels, 25 & 35 dbw for SHF channels - See Note (3)

ANTENNA TYPE: Despun, Parabolic 2 Feed Dish

ANTENNA SIZE: 130"

STABILIZING METHOD: Spin

POINTING ACCURACY: $\pm 0.5^{\circ}$ EW, NS

BEAMWIDTHS: $4^{\circ} \times 8^{\circ}$

ATTITUDE SENSING TECHNIQUES: Earth Sensors Only

LAUNCH VEHICLE TYPE: Delta 3914

LIFT-OFF WEIGHT OF S.C.: 1890 pounds

IN-ORBIT WEIGHT OF S.C.: 963 pounds

TOTAL DC POWER: 360 W EOL

ECLIPE PERFORMANCE: 100% - See Note (4)

STATION KEEPING METHOD: EW and NS - Hydrazene thrusters

STATION KEEPING ACCURACY: $\pm 1.6^{\circ}$ NS, EW

DESIGN LIFE: 7 years

ACTUAL OPERATIONAL LIFE REALIZED: N/A

ACTUAL OBSERVED DEFICIENCES: N/A

S.C. DEVELOPMENT COSTS: $27.4M

COST PER ADDITIONAL COPY OF S/C: $6.6M - $7.0M

GROUND CONTROL SYSTEM COSTS: Approximately $3M

COMM. CONTROL SYSTEM COST: 1.2M

COMM. TERMINAL COSTS: 25K in Quantity

ORIGINAL OR DERIVED DESIGN: Derived

COST CONTRACTING TECHNIQUES (INCENTIVES, ETC.): N/A

DEVELOPMENT PHASE: } 30 Months
FLIGHT HARDWARE PHASE: }

FIRST LAUNCH DATE: N/A

SOURCES OF INFORMATION: RCA Limited

BIBLIOGRAPHY: RCA Study -"Feasibility Study of a 2-Band UHF Communication Satellite"

Report to DOC, DSS Contract P2 3610-1-0622 Dec 72

RCA HYBRID NOTES

(1) This S/C concept is a product of a study conducted by RCA under a DOC contract and is not actually a system in the sense of the other systems reported in this document.

(2) At 300 MHz there are 3 high power channels, 30 lower power channels. In the 2.5 GHz band there are 3 high power channels (program) and 1 wideband channel capable of 90 low power channels (fixed).

(3) 3 UHF high power channels at 27 dbw
30 UHF low power channels at 17 dbw
3 SHF high power channels at 25 dbw
1 Wideband channel at 35 dbw split to 90 channels at 15.4 dbw each

2.12 RCA - DND CLASSIFIED - SEE ADDENDUM

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2.13 OTS

SYSTEM OWNER: ESRO

SYSTEM CONTRACTOR: MESH

FREQUENCIES-UP: 14 GHz Band

FREQUENCIES-DOWN: 11 GHz Band

NUMBER OF CHANNELS: 5 - See Note (1)

BW PER CHANNEL: 40 MHz, 120 MHz, 5 MHz - See Note (1)

EIRP PER CHANNEL: 38.2 dbw, 47.6 dbw, 47.2 dbw - See Note (2)

ANTENNA TYPE: FIXED AND STEERABLE PARABOLIC DISHES - See Note (3)

ANTENNA SIZE: 6-7'

STABILIZING METHOD: 3 axis - momentum wheels

POINTING ACCURACY: ±0.2° EW, WS

BEAMWIDTHS: 7 1/2° x 4 1/4°; 2.5° Spot; 5° x 3.5° - See Note (2)

ATTITUDE SENSING TECHNIQUES: Sun and Earth

LAUNCH VEHICLE TYPE: Delta 2914

LIFT-OFF WEIGHT OF S.C.: 1500

IN-ORBIT WEIGHT OF S.C.: 714

TOTAL DC POWER: 520 W EOL

ECLIPSE PERFORMANCE: 25%

STATION KEEPING METHOD: EW & NS Hydrazene thrusters

STATION KEEPING ACCURACY: ± 0.1° EW, NS

DESIGN LIFE: 5 years

ACTUAL OPERATIONAL LIFE REALIZED: N/A

ACTUAL OBSERVED DEFICIENCIES: N/A

S.C. DEVELOPMENT COSTS: Not Available

GROUND CONTROL SYSTEM COSTS: Not Available

COST PER ADDITIONAL COPY OF S/C: Not Available #12-15m

COMM. CONTROL SYSTEM COST: Not Available

COMM. TERMINAL COSTS: Not Available

ORIGINAL OR DERIVED DESIGN: Partial

COST CONTRACTING TECHNIQUES (INCENTIVES, ETC.) FPI

DEVELOPMENT PHASE:

30 months approximately

FLIGHT HARDWARE PHASE:

FIRST LAUNCH DATE: March 77

SOURCES OF INFORMATION: ESRO Wash. DC - Melors

BIBLIOGRAPHY: The OTS Spacecraft Description ESRO, Circa 72

OTS NOTES

(1) 2 channels 40 MHz

2 channels 120 MHz

1 channel 5 MHz

(2) 40 MHz channels EIRP 38.2 dbw Antenna gain 26.5 db.

120 MHz channels EIRP 47.6 dbw Antenna gain is 35.5 db.

5 MHz channels EIRP 47.2 dbw Antenna gain 29.1 db.

(3) There are actually 6 antennas on the S/C. There are 2 redundant identical receive dishes for full European coverage with beam width of 7.5 and 4.25° and 40 MHz bandwidth. The Transmit " Eurobeam" antenna has a gain of 26.5 db. The transmit antenna used to transmit the turn 120 MHz channels is steerable with circular beam-width of 2.5°. The steerable antenna gain is 35.5 db.

Two fixed antennas, one receive and one transmit have beamwidths of 5° and 3.5° and a bandwidth of 5 MHz. The antenna gain is 29.1 db.

2.14 COMMUNICATIONS TECHNOLOGY SATELLITE

SYSTEM OWNER: DOC-NASA

SYSTEM CONTRACTOR: CRC

Sub: RCA Ltd - Electronics

SPAR - Structure

FREQUENCIES-UP: 14 GHz Band

FREQUENCIES-DOWN: 12 GHz Band

NUMBER OF CHANNELS: 2 channels (1 transponder)

BW PER CHANNEL: 85 MHZ

EIRP PER CHANNEL: 59 dbw, 49 dbw - See Note (1)

ANTENNA TYPE: 2 Steerable Parabolic single feed dishes

ANTENNA SIZE: 28" each

STABILIZING METHOD: 3 axis - momentum wheels

POINTING ACCURACY: ± .2 NS & EW

BEAMWIDTHS: 2.5° each dish

ATTITUDE SENSING TECHNIQUES: Earth & Sun - See Note (3)

LAUNCH VEHICLE TYPE: Delta 2914

LIFT-OFF WEIGHT OF S.C.: 1486 pounds

IN-ORBIT WEIGHT OF S.C.: 771 pounds

TOTAL DC POWER 948 W EOL - See Note (4)

ECLIPSE PERFORMANCE - None S/C - Keep-Alive TT&C

STATION KEEPING METHOD: EW only - hydrazene thrusters - See Note (5)

STATION KEEPING ACCURACY: ± 0.2° EW

DESIGN LIFE: 2 years

ACTUAL OPERATIONAL LIFE REALIZED: N/A

ACTUAL OBSERVED DEFICIENCES: N/A

S.C. DEVELOPMENT COSTS
GROUND CONTROL SYSTEM COSTS
COST PER ADDITIONAL COPY OF S/C
COMM. CONTROL SYSTEM COST
} Costs not readily amenable to these cost divisions

COMM. TERMINAL COSTS: N/A - See Note (6)

ORIGINAL OR DERIVED DESIGN: Original

COST CONTRACTING TECHNIQUES (INCENTIVES, ETC.) - Development cost plus fixed fee

Mfg phase - fixed price incentive

DEVELOPMENT PHASE: 36 mos

FLIGHT HARDWARE PHASE: 25 mos

FIRST LAUNCH DATE: 17 Dec 75

SOURCES OF INFORMATION: CTS Project
Systems Group, W.M. Evans

BIBLIOGRAPHY: "Configuration Control Baseline Document" SY 0104
21 June 1974

COMMUNICATIONS TECHNOLOGY SATELLITE NOTES

(1) 59 dbw achieved with 200 W TWT on one channel, 49 dbw achieved with 20 W TWT on 2nd channel.

(2) Each dish is capable of ± 8.5° rotation in both azimuth and elevation.

(3) There are two complements of sun & earth sensor - one for the spin mode (transfer orbit), and one for the 3-axis stabilized mode.

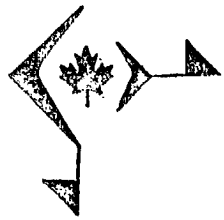
(4) DC power allotted to communications is 768 watts, 180 watts reserved for housekeeping TT&C

(5) NS stationkeeping not required, however the inclination will be biassed 0.9° and the ascending mode selected so that time near zero inclination degrees will be maximized.

(6) The CTS Terminals are for experimental purposes and the cost involved are not applicable to this present survey. However for the record, the following costs are involved:

Two 10' terminals	1 trailer transportable	$430,000
	1 air transportable	$576,000
Seven 8' terminals	@$93,000 each	
Three 3' terminals	@$80,000 each	

It is to be noted that the above costs do not include spares or redundancy features required for operational use.



Section 3 - Summary

3. SUMMARY OF DATA

Tables I through VI present the S/C capability and cost data in Matrix form.

Table II lists system descriptive factors and program status.

Table III presents communication characteristics.

Table IV presents spacecraft characteristics.

Table V presents cost and cost associated characteristics of each system.

Table VI presents schedule and contractual data.

From the Tables listed aboveit is possible to reach some generic conclusions. These conclusions are reached without consideration of the question of Canadian content. In this regard only the RCA Satcom presents an option of relatively high Canadian content.

AVAILABLE TECHNOLOGY

Development of technology for either a UHF or Hybrid (UHF - SHF) operational spacecraft system would not be extensive. This statement extends to S/C housekeeping, transponder, antennas, and Earth station subsystems, and includes both software and hardware. The launch vehicle applicable could be the Delta 3914.

COSTS AND DEVELOPMENT TIME

Non-recurring costs for development of a specific spacecraft from one of the existing "Bus" designs (Satcom, NATO-3 for example) would not exceed $10M including military features, and could be accomplished within and not exceeding 18 months.

Recurring costs for a S/C system, (cost per spacecraft copy) would not exceed $11M including orbital incentives and the time from development effort completion to delivery of flight models would not exceed 12 months.

The time from contract award to first launch would not exceed 30 months.

The costs for a "partial" or original S/C design would range from $30M to $50M including one flight copy. The lower end of the range would apply if "off-the-shelf" design components were integrated into a new structure; the higher end of the range would apply to a design effort for most of the S/C.

TABLE II

SYSTEM DESCRIPTION AND STATUS

SYSTEM NAME	OWNER	CONTRACTOR	S/C WT LIFT-OFF LBS	S/C WT IN-ORBIT LBS	LAUNCH VEHICLE	TYPE	STATUS
MARITIME	COMSAT	Hughes	1445	700	Delta 2914	Maritime OPT'L	DVPT
ANIK	TELESAT	Hughes	1242	655	Delta 1914	Domestic OPT'l	In Orbit
SATCOM	RCA GLOBECOM	RCA-US RCA-CAN	1890	963	Delta 3914	Domestic OPT'L	DVPT
EMBS	JAPAN	TOSHIBA GE	1480	728	Delta 2914	EXPT'L Domestic	DVPT
EMCS	JAPAN	MITSOBISHI PHILCO-FORD	1490	771	Delta 2914	EXPT'L Domestic	DVPT
LES-6	USAF	MIT	39B	398	Titan III-C(3)	EXPT'L MIL	In Orbit
TACSATCOM	USAF	Hughes	1600	1600	Titan III-C	Nil Opt'l	In Orbit
AEROSAT	CANADA ESRO US CORP.	Not Chosen	1400	700	Delta 2914	Aeron. OPT'L	Plan
INTELSAT IV	INTELSAT	Hughes	3100	1610	Atlas Centaur	Int'l OPT'L	In Orbit
FLEETSAT COM	USN	TRW	3900	1740	Atlas Centaur	MIL OPT'L	DVPT
RCA HYBRID	N/A	RCA Ltd.	1890	963	Delta 3914	Domestic OPT'L	Plan
RCA DND	N/A	RCA Ltd.	2000	1000	Delta 3914	Mil OPT'L	Plan
OTS	ESRO	MESH	1500	714	Delta 3914	Maritime OPT'L	Plan
CTS	DOC	CRC	1486	771	Delta 2914	Domestic Expt'l	Dvpt

TABLE III

COMMUNICATIONS ASPECTS

SYSTEM	FREQUENCIES UP	FREQUENCIES DOWN	BEAM-WIDTH (DEG.)	NO. OF CHANNELS	EIRP/ CHANNEL dbw	BAND-WIDTHS	ANTENNA
MARISAT	300 MHz 6.0 GHz 1.65 GHz	250 MHz 4.0 GHz 1.55 GHz	UHF 30 SHF 19	3 UHF 1 C BAND 1 L BAND	28, 23 UHF	25 KHz 500 KHz 4 MHz	DESPUN TRI HELIX - 6' QUAD HELIX - 3' CON. HORN
ANIK	6.0 GHz	4.0 GHz	8 x 3	12	34	36 MHz	DESPUN PARABOLIC - 5'
SATCOM	6.0 GHz	4.0 GHz	8 x 4 2.6 x 1	24	26 - WIDEBEAM 34 - SPOT	36 MHz	FIXED PARABOLIC - 7'
EMBS	14.0 GHz	16.0 GHz	-	2	37 - MAINLAND 28 - JAPAN	50 MHz 80 MHz	FIXED PARABOLIC
EMCS	28 GHz 6.0 GHz	18.0 GHz 4.0 GHz	1 x 3 4 x 6	8	37 29.5	200 MHz	DESPUN FLAT PLATES 2-3'
LES-6	300 MHz	250 MHz	65	1	29.5	100 MHz OR 500 MHz	
ACSATCOM	300 MHz 8.0 GHz	250 MHz 7.2 GHz	UHF 19 SHF 30	1 UHF 1 SHF	38 UHF 31 SHF	50 KHz TO 10 MHz	DESPUN 5 ELEMENT HELIX 4-8', 1-6'
AEROSAT	1.6 GHz 5.0 GHz	1.5 GHz 5.2 GHz	19 WB 6.1 SB's	2 TO 6	35	8 KHz 50 KHz	QUAD HELIX, PARABOLIC
INTELSAT IV	6.0 GHz	4.0 GHz	17 WB 4.3 SB	12	23 - WB 34.5 - SB	36 MHz	DESPUN STEERABLE PARABOLIC, CON. HORN
FLEETSAT COM			CLASSIFIED				
RCA HYBRID	400 MHz 2.7 GHz	300 MHz 2.5 GHz	8 x 4	33 UHF 4	27, 17 UHF 25, 35 SHF	20 KHz 250 KHz	DESPUN PARABOLIC
RCA DND			CLASSIFIED				
OTS	14 GHz	11 GHz	7.5 x 4.3 2.5 5 x 3.5	5		40 MHz 120 MHz 5 MHz	TWO STEERABLE PARABOLIC - 7'
CTS	14 GHz	12 GHz	2.5	2	59, 49	85 MHz	TWO STEERABLE PARABOLIC - 2.5' 8.5° SWING

TABLE IV

SPACECRAFT CHARACTERISTICS

SYSTEM	STAB. TECHN.	POINTING ACCURACY Deg.	ATT. SENS. TECHN.	EOL DC POWER Watts	ECLIPSE PERF. %	STATION KEEPING
MARISAT	SPIN	± 0.65° NS, EW	EARTH, SUN	300	100	EW ONLY, HYDRAZENE ± 0.5°
ANIK	SPIN	0.1 EW 0.35 NS	EARTH, SUN	250	100	EW, NS HYDRAZENE ± 0.05°
SATCOM	3 AXIS STAB.	± 0.15 EW ± 0.21 NS	EARTH, SUN RATE GYRO	650	100	EW, NS HYDRAZENE ± 0.05°
EMBS	3 AXIS STAB.	± 0.1 EW, NS	EARTH, SUN	767	—	—
EMCS	SPIN	± 0.3 EW, NS	EARTH, SUN	420	100	EW, NS HYDRAZENE ± 0.1°
LES-6	SPIN	± 0.16 EW, NS	EARTH, SUN	220	0	EW ONLY ± 2.0° ION E AMMONIA GA.
ACSAT COM	SPIN GYROSTAT	± 0.3 EW, NS	EARTH	750	100	EW ONLY H_2O_2 ± 5°
AEROSAT	NOT CHOSEN	APPROX 0.3 EW APPROX 0.7 NS	NOT CHOSEN	300-400	50	EW ONLY HYDRAZENE ± 2.0°
INTELESAT IV	SPIN	± 0.35 EW, NS	EARTH	365	100	EW, NS HYDRAZENE ± 0.5°
FLEETSAT COM		CLASSIFIED				
RCA HYBRID	SPIN	± 0.5 EW, NS	EARTH	360	100 (2 S/C)	EW, NS HYDRAZENE ± 1.6°
RCA DND		CLASSIFIED				
TS	3 AXIS STAB.	± 0.2 EW, NS	EARTH, SUN	520	25	EW, NS HYDRAZENE ± 0.1°
CTS	3 AXIS STAB.	± 0.2 EW, NS	EARTH, SUN RATE GYRO	948	0	EW ONLY HYDRAZENE ± 0.2°

TABLE V

COST AND COST ASSOCIATED ASPECTS

(1) APPLIES TO SHF VERSION; MAX. DVPT COST FOR UHF VERSION ESTIMATED AT $10.0M

SYSTEM	DESIGN LIFE (YRS)	LIFE REALIZED (YEARS)	S/C COST $M		GROUND COSTS $M		OBSERVED DEFICIENCI
			DVPT	COPY	COMM & CONTROL	TERM	
MARISAT	5	N/A	13.0	7.0	1.0	—	N/A
ANIK	7	STILL OPT'G 2 YEARS	40.0	7.6	NOT AVAILABLE	NOT AVAIL.	BATTERIES
SATCOM	8	N/A	13.0 (1)	10.0	1.5-2.0M	.025	N/A
EMBS	3	N/A	NOT AVAIL.	NOT AVAIL.	NOT AVAILABLE	NOT AVAIL.	N/A
EMCS	3	N/A	NOT AVAIL.	NOT AVAIL.	NOT AVAILABLE	.030	N/A
LES-6	5	STILL OPT'G 6 YEARS	16.0	16.0+	N/A	N/A	SOLAR PANEL
TACSAT COM	5	3.8	30.0	15-18	4-5	.030	EIRP LOSS NUTATION TWT DEGRADE DESPIN MOTOR
AEROSAT	7	N/A	60.0	7.0	4.0	.075	N/A
INTELSAT IV	7	NOT AVAILABLE	NOT AVAIL.	NOT AVAIL.	NOT AVAILABLE	NOT AVAIL	NOT AVAIL.
FLEETSAT COM		CLASSIFIED					
RCA HYBRID	7	N/A	27.4	7.0	4-5	.025	N/A
RCA DND		CLASSIFIED					
OTS	5	N/A	NOT AVAIL.	NOT AVAIL.	NOT AVAILABLE	NOT AVAIL.	N/A
CTS	2	N/A	NOT AVAIL.	NOT AVAIL.	NOT AVAILABLE	.5; .08 .09	N/A

TABLE VI

SCHEDULE AND CONTRACT DATA

SYSTEM	DUPT PHASE (Mos.)	FLT HW (Mos.)	DESIGN ORIGIN	CONTRACT TYPE	COMMENTS
MARISAT	12	6	DERIVED ANIK	FIXED PRICE INCENTIVE	LAUNCH FEB 75 OTHER S/C DSGN'S AVAIL.
ANIK	18	18	DERIVED INTELSAT IV	FIXED PRICE INCENTIVE	LAUNCHED NOV. 72
SATCOM	15-18	12	DERIVED TIROS M	FIXED PRICE INCENTIVE	LAUNCH NOV 75
EMBS	18	12	NOT AVAIL.	NOT AVAIL.	LAUNCH LATE 76 OR EARLY 77
EMCS	12	12	DERIVED NATO-3	FIXED PRICE INCENTIVE	LAUNCH FALL 76
LES-6	12-18	12-18	ORIGINAL	COST PLUS FIXED FEE	LAUNCHED JULY 68 ION-ENGINE USED
ACSAT COM	18	12	ORIGINAL	COST PLUS FIXED FEE	LAUNCHED AUG. 69
AEROSAT	30	15	PARTIAL	FIXED PRICE INCENTIVE	RFP NOT WRITTEN MOU NOT SIGNED-OFF
INTELSAT IV	NOT AVAIL.	NOT AVAIL	ORIGINAL	NOT AVAIL.	NONE
FLEETSAT COM		CLASSIFIED			
RCA HYBRID	← 30 →		PARTIAL	N/A	FEASIBILITY STUDY
RCA DND		CLASSIFIED			
OTS	← 30 →		PARTIAL	FIXED PRICE INCENTIVE	LAUNCH MAR 77
CTS	36	25	ORIGINAL	DVPT - CPFF MFG - FPI	LAUNCH DEC 75