700913-1

Vol I – Summary Report

A. Scope of Study

A.1 Satellite design, costing and scheduling

A.2 Ground Interaction

1.2.1 – TV Channels

FWS 1.2.2 – Telecom Channels

A.3 Facilities Consideration

B. Specific Limitations

B.1 Non military

B.2 Secure Command and Telemetry avoided

C. ~~Study~~ Philosophy

C.1 Advanced Design

C.2 Use of Previous Results

D. Summary of ~~Study~~ Satellite Design

RN D.1 ~~TV Channel Specifications~~ Transponder Design

~~D.1.1 TV Channel Spec~~

~~D.1.2 Telecom Channel Spec~~

~~D.1.3 Transponder Recommended Design~~

D.3 Spacecraft Systems Design

D.3.1. Power System

~~D.2.1.1 Solar Array~~

~~D.2.1.2 Battery System~~

FWS D.3.2 Attitude Control System

D.3.3 Station Keeping ~~D.2.2.1~~

D.3.4 Telemetry System

D.3.5 Command System

~~D.2.5 Station Keeping~~

RN D.2 ~~Space Craft Configuration~~ Antenna Considerations

JK D.4 Space Craft Configuration

FWS D.5 Scheduling of Spacecraft Program

D.6 Costing Summary

E. Summary of Facilities Recommendations

FWS E.1 Research Capabilities

E.2 Manufacturing

E.3 Satellite Assembly Facilities

E.4 Satellite Testing Facilities

E.5 Ground Support.

F. Summary Conclusions

VOL II – STUDY REPORT

1. SATELLITE SPECIFICATIONS

RN

- 1.1 ~~TV DOWNLINK~~ COMMUNICATION LINK ANALYSIS
  - 1.1.1 CHANNEL REQUIREMENTS
    - 1.1.1.1 ~~TELEVISION~~ TYPES OF SERVICE { TV / TELECOM
    - 1.1.1.2 ~~1.1.1.1 FREQ ALLOCATIONS~~ STANDARDS OF SERVICE
    - ~~1.1.1.2~~
  - 1.1.2 FREQUENCY SELECTIONS
    - 1.1.2.1 TV CHANNELS
    - 1.1.2.2 TELECOM CHANNELS (INCLUDING COMMAND & BEACON)
    - 1.1.2.3 ALL INDIA RADIO
  - 1.1.3 GROUND RECEIVER REQUIREMENTS
    - 1.1.3.1 RECEPTION QUALITY
    - 1.1.3.2 EQUIPMENT SPECIFICATIONS
  - 1.1.4 SATELLITE ANTENNA SPECIFICATIONS
    - 1.1.4.1 UHF ~~[illegible]~~ ANTENNA
    - 1.1.4.2 C-BAND DISH
    - 1.1.4.3 C-BAND HORN
    - ~~1.1.4.4 UHF TLM OMNI~~
  - 1.1.5 LINK CALCULATIONS (BW, ~~[illegible]~~ POWER & NF)
    - 1.1.5.1 TV DOWNLINK
    - 1.1.5.2 TV UPLINK
    - 1.1.5.3 TELECOMM DOWNLINK
    - 1.1.5.4 TELECOMM UPLINK
    - 1.1.5.5 AIR DOWNLINK
  - 1.1.6 FREQUENCY STABILITY
  - 1.1.7 REDUNDANCY REQUIREMENTS
  - 1.1.8 FILTER REQUIREMENTS (5th Harmonic Suppression)
- 1.2 SPACECRAFT SUBSYSTEMS ANALYSIS

FWS

  - 1.2.1 POWER SYSTEM
    - 1.2.1.1 POWER BUDGET
    - 1.2.1.2 ECLIPSE POWER REQUIREMENTS
    - 1.2.1.3 LAUNCH POWER REQUIREMENTS
    - 1.2.1.4 SOLAR ARRAY B.O.L. REQUIREMENT.
  - 1.2.2 ATTITUDE CONTROL SYSTEM
    - 1.2.2.1 ~~POINTING ACCURACY~~ DEFINITION OF SATELLITE AXES AND ATTITUDE
    - 1.2.2.2 ~~GAS SYSTEM REQUIREMENTS~~ ESTIMATE OF DISTURBANCE TORQUES
    - 1.2.2.3 ~~1.2.2.1 INITIAL ORBIT TRIM~~ POINTING REQUIREMENTS
    - 1.2.2.4 ~~1.2.2.2 STATION ACQUISITION~~ MOMENTUM CORRECTION REQ.
    - ~~1.2.2.5 ATTITUDE CONTROL~~
    - ~~1.2.2.6 STATION KEEPING~~
  - ~~1.2.3 STATION KEEPING REQUIREMENT~~
  - ~~1.2.2.2~~

FWS

- 1.2.4 Telemetry System
  - 1.2.4.1 Type
  - 1.2.4.2 Word Requirements
  - 1.2.4.3 Parity Checks
  - 1.2.4.4 R.F. Links (Normal and Acquisition)
- 1.2.5 Command System
  - 1.2.5.3 Command Requirements
  - 1.2.5.1 Types & Definitions
  - 1.2.5.2 Encoding Techniques
  - ~~1.2.6~~ 1.2.5.4 Receiver Requirements (Normal and Acquisition)

JK

- 1.2.6 Stationkeeping Requirements
  - 1.2.6.1 Station Accuracy
  - 1.2.6.2 Gas Requirement (ΔV)
  - ~~1.2.6.3~~
- 1.2.7 Gas System
  - 1.2.6.1 5 year requirements
  - 1.2.6.2 ~~Station Acquisition~~ Orbit Acquisition
    - 1.2.6.2.1 Launch Uncertainties
    - 1.2.6.2.2 Station Acquisition
- 1.3 Launch and Deployment Requirements

2. Systems Realization

RN

- 2.1 Communications Transponder
  - 2.1.1. Transponder Block Diagram
  - 2.1.2. Receiver Section
    - 2.1.2.4 TDA's ~~6 GHz, 4 GHz~~ C-Band
    - 2.1.2.5 Transistor Amps ~~800 KH - 900 MH~~z UHF
    - 2.1.2.1 Mixers
    - 2.1.2.3 LO's
    - 2.1.2.2 Master Oscillators
    - 2.1.2.6. Filters
    - 2.1.2.7 Redundancy
  - 2.1.3. Transmitter Section (~~[illegible]~~ Pwr, Eff & Thermal)
    - 2.1.3.1. Solid State ~~800 MH~~ UHF Power Amps
    - 2.1.3.2 C-Band TWT Sections
    - 2.1.3.3 Air Transmitter
  - 2.1.4 Telemetry and Command Breakouts

- 2.2. Spacecraft Subsystems
  - 2.2.1 Power System
    - 2.2.1.1 Solar Array Design
      - 2.2.1.1.1 Array Sizing
      - 2.2.1.1.2 Array Drive
    - ~~2.2.1.2. Battery System~~
    - ~~2.2.1.3. Solar Array Shunt Regulator~~
    - ~~2.2.1.4.~~

2.2 Spacecraft Subsystems

FWS

2.2.1. Power System
- 2.2.1.1 Solar Array Design
  - ~~2.2.1.1.1. Array Size~~
- 2.2.1.5 Solar Array Drive ~~Array Size~~
- 2.2.1.6 ~~Slip Rings~~ ~~Solar~~ Slip Rings
- 2.2.1.2 Array Shunt Regulator (Direct Operation of UHF PA)
- 2.2.1.3 ~~Offset drive for excess~~ Power Reduction
- 2.2.1.4 Solar Array Drive Operational Loop.
  - 2.2.1.4.1. ~~Operation~~ Sun Sensor Operator
  - 2.2.1.4.2. Shunt Power Operation
  - 2.2.1.4.3. Open Loop Backup
- 2.2.1.7. Battery System.
- 2.2.1.8. Converter configuration and Design Techniques
  - 2.2.1.8.1 Standard Systems
  - 2.2.1.8.2 TWT Converters
- 2.2.1.9. Priority system.
- 2.2.1.10 Satellite Load Characteristic.

FWS
RN

2.2.2. Attitude Control System
- 2.2.2.1 Sensors.
  - 2.2.2.1.1. Interferometer
  - 2.2.2.1.2. IR Sensor (Nodding Function Generator) — FWS
  - 2.2.2.1.3. Polaris Sensor Off — FWS
  - 2.2.2.1.4. Backup off of Solar Array Drive — FWS
- 2.2.2.2 Wheel System — FWS
  - 2.2.2.2.1 Single Wheel
  - .2 Gimbal – Damper
  - .3 RVDT
- 2.2.2.3 Momentum Dumping — JK
  - 2.2.2.3.1 Gas System
  - 2.2.2.3.2 Electric Thrusters

FWS

2.2.3. Telemetry System.
- 2.2.3.1. Distributed Design
- 2.2.3.2 ~~Block Diagram~~ Word Length & Parity
- 2.2.3.3. ~~Block Diagram~~ Sync Techniques
- 2.2.3.4. ~~A/D Converter House Keeping Pro~~ Block Diagram
- 2.2.3.5 House Keeping Data
- 2.2.3.6 A/D Converter
- 2.2.3.7 Calibration
- 2.2.3.8 Word Requirement Estimate
- 2.2.3.9 Format

FWS

2.2.4 COMMAND SYSTEM
- 2.2.4.1 ~~[illegible]~~ ENCODER TECHNIQUES & DISTANCE
- 2.2.4.2 GROUND STATION BLOCK DIAGRAM
- 2.2.4.3 SATELLITE BLOCK DIAGRAM
  - 2.2.4.3.1 ~~[illegible]~~ DETECTION
  - .2 DIFFERENTIAL INTEGRATION
  - .3 TIMING
  - .4 COMMAND TYPE SEPARATION
  - .5 INTERFACING WITH OTHER SYSTEMS

2.2.5 STATION KEEPING
- 2.2.5.1 MANUAL
- 2.2.5.2 AUTONOMOUS
  - 2.2.5.2.1 SENSORS
  - 2.2.5.2.2 ~~[illegible]~~ EPHEMERIS CLOCK
  - 2.2.5.2.3 CONTROLLER – MULTISTATE

JK

2.2.6 GAS SYSTEM
- 2.2.6.1 TOTAL ΔV REQUIREMENT
- 2.2.6.2 SYSTEM CONSIDERATIONS
- 2.2.6.3 SYSTEM BLOCK DIAGRAM.

3. SPACECRAFT CONFIGURATION

FWS

3.1. THERMAL DESIGN
- 3.1.1 THERMAL DISSIPATION BUDGET
- 3.1.2 SATELLITE VIEW FACTORS
- 3.1.3 ~~[illegible]~~ SURFACE THERMAL DESIGN.
  - 3.1.3.1 ~~[illegible]~~ DISSIPATION
  - 3.1.3.2 SOLAR INPUTS.
  - 3.1.3.3 ECLIPSE TEMPERATURES

3.2. EARTH VIEWING FACE LAYOUT
- 3.2.1 C-BAND DISH
- 3.2.2 INTERFEROMETER
- 3.2.3 IR SENSORS
- 3.2.4 EARTH ACQUISITION SENSORS.
- 3.2.5 SUN SENSORS
- 3.2.6 EARTH COVERAGE HORN

RN

3.3 ~~[illegible]~~ UHF ANTENNA
- 3.3.1 BLOCKAGE
- .2 SIDELOBE CONSIDERATION
  - 3.3.2.1 FRENCH INTERFERENCE
  - .2 SQUINTING FOR IMPROVEMENT
  - .3 TAPERED FEED WITH 30 FT DISH
- .3 SUPPORT
- .4 DERIVATION FROM EXISTING ANTENNAS
- .5 DEPLOYMENT

FWS { 3.4 Solar Array
3.4.1 ~~Fold~~ up Considerations
3.4.2 Deployment and Booms

J.K. { 3.5 Launch Vehicle Configuration
3.5.1 ~~The~~ Comparative Costs and Payload Capabilities
3.5.2 Three Axis Launch Preferred
3.5.2.1 Cost
.2 Launch Sequence
3.5.3 AKS - Spin stabilized
3.5.3.1 Cost
.2 Disadvantages - ~~Operations Sequence~~
~~3.5.4~~ ~~.3 Reliability Aspects~~
3.5.3.2.1 Operations Sequence
.2 Moments of Inertia
.3 Possible Deployment of Truss
3.5.4 Reliability Aspects

FWS or JK 3.6. Internal Structural Considerations
~~3.7 Launch Sequence Deployment~~

4. Satellite Weight Estimates
4.1 Solar Array
4.2 UHF Antenna & Truss
4.3 Transponder — 4.3.1 Receivers
.2 UHF PA'S
.3 UHF Thermal Sinks
.4 TWTS
.5 TWT Heat Sinks
.6 TWT Converters
.7 Filters
.8 Plumbing
.9 Diplexers
.10 Master Oscillators
4.4 Subsystem Converters
4.5 Attitude Control
4.6 Telemetry
4.7 Command
4.8 Station Keeping
4.9 Gas System
4.10 Electric Thrusters
4.11 Earth Face Hardware
4.12 Polaris Trackers

? All

FWS 5. Satellite Scheduling

FWS 6. Satellite Costing Vol III

FWS 7. Backup Launch

FWS 8. Facilities Recommendation
8.1 Existing Facilities
8.2 Improvements in existing Facilities
8.3 Additional Facilities Required

1003.3

~~7.4 Scheduling~~

8.4 Scheduling ~~of additional f~~

8.4.1 Of improvements to existing facilities

.2 Of new facilities

8.5 Costing

8.5.1 Of ~~th~~ improvements to existing facilities

.2 Of new facilities

9.0. Personnel requirements of overall program ?

Orbit fitting should go somewhere

9:00 INTRODUCTION
SUMMARY — SPACECRAFT CONFIGURATION
L/V FEW REMARKS

[illegible] 10.00 BREAK.

10:15 Attitude Control (40MIN)
10:55 STATON KEEPING (20 MIN)
11:15 TLM & CMD (20 MIN)
11:35 PROPULSION (40 MIN)
12:15 DISCUSSION
12:30 LUNCH
1:30 POWERSYSTEMS

10:15 SYSTEM & LINK ANAYSIS (20MIN)
10:35 ANTENNA SYSTEM (20MIN)
10:55 TRANSPONDER BLOCK DIA (25MIN)
11:20 FRONT END (10 MIN)
11:30 UHF PA's (25MIN)
11:55 TWT's (20 MIN)
12:15 DISCUSSION
12:30 LUNCH
1:30 MULTIPLEXERS & FILTERS

2:00 SOLAR ARRAY (20MIN)
2:20 THERMAL (25)
2:45 SOLAR TORQUES & DYNAMICS
3:05 WEIGHT & LAYOUT
3:20 GROUND SYSTEMS
3:40 LAUNCH VEHICLES
4:30 SCHEDULING
5:00 INDIAN FACILITIES
5:30 BREAK
6:00 SMALL SATELLITE.
6:30 COSTING.

2.7 Telemetry System.

2.7.4 R-F transmission requirements.

(VHF portion only)

VHF telemetry is intended primarily for the launch phase during which NASA-STADAN* would be used. After the space craft is stationed at the required location VHF transmitter would be put off. The telemetry r-f frequency is 136 MHz.

The VHF telemetry system should follow the standards fixed by NASA regarding r-f emission and modulation characteristics. The standards are regarding bandwidth, frequency stability, guard bands, spurious emissions,

---

* National Aeronautics & Space Administration — Satellite Tracking and Data Acquisition Network.

modulation index, phase stability and linearity to cite a few parameters. These are given in Aerospace Data Systems Standards published by NASA Goddard Space Flight Centre. These might be changed in course of time and our telemetry system should follow the one prevalent at that time; (Changes from the present standards may not be drastic).

Telemetry transmitter requirements are specified as under:-

Frequency	136 MHz (exact frequency to be specified later)
Minimum R-F power	5 watts.
Modulation index, Bandwidth, Spurious emissions, Stability etc	As per NASA-STADAN requirements.
Bit rate	– 2.5 Kbits
Modulation	– PCM-PM or PCM-FM

~~No~~ The transmitter would

be available of the shelf, as many such had been flown on NASA missions.

LINK CALCULATIONS:

~~Ground Segment Data:~~

~~Receiver Noise Figure 4 db.~~

~~Feeder losses 1 db~~

~~Antenna temperature 1000°K.~~

X-322-73-120 Programmers manual for a modification of RAFAC program for use ~~with~~ NASTA
C. Jackson
X5275.

X-480-73-114 In orbit performance of the improved ITOS ACS sys W. Peacock
X6161

~~X-621-73-49~~

I-564-72-423 SMS-A data processing system for Sp-
T. Sutherland 5568

X-542-72-477 History of Spin axis attitude for OSO-5 satt
S.C. Dunker 5532

X-513-72-427 NASA GSFC Mission ops plan 7-72 Nimbus E
& W.F. Mack 5696

I-713-72-363 Estimating weights of Electronic package R.J. Cummings
X4502

✓ OK

X-322-73-173
Thermal Resistivity Measurement
C. P. Ashcraft X4115

X-646-73-172 A technique for high voltage distribution
✓ OK
J. F. McChesney x 4562

X-732-73-151 An users guide to Flexible S/c dynamics programs
J. Fedor 4361

X-732-73-23 Summary of Attitude dynamic analysis for RAE J Fedor 4361

X-322-73-132 Outgassing Charac. of two Nimbus S/c thermal blan
✓ ?
R. Krueger X4558

X-860-73-124 Slant Range vs alt. & elevation
F. Kalif X

Outdated

DRAFT 12th Nov 70

2.1.5(g)

VHF Command link Calculations

Data:

Ground VHF transmitter power output	:	2.5 KW
Ground antenna (30' dish) gain	:	+ 20 db
Spacecraft command receiver Noise figure	:	6 db.
Sensitivity		−110 dbm.
Bandwidth		60 KHz

Link Calculations:

Ground segment

(1) VHF transmitter output	:	34 dbW
(2) Feeder loss	:	− 2 db
(3) Antenna gain	:	+ 20 db
Ground EIRP		+ 52 dbW

196.6

	Normal	Worst case
(4) Path loss 150MHz	−168.8 db	−168.8 db
(5) Antenna gain	0.0	−10.0
(6) Polarization loss	−3.0	−3.0
(7) Feeder loss	−2.0	−2.0
(8) Scintillation	0.0	−6.0
Loss total	−173.8	−189.8

— — — [2

(9) Receiver Noise Figure 6 db.

(10) Mean spacecraft antenna temperature at 150 MHz 1000°K

(11) Feeder loss 2 db.

(12) System noise temperature referred to receiver input * 1600°K (32 db °K)

(13) Bandwidth 47.8 db Hz

(14) Boltzmann's constant −228.6 db(W/Hz/°K)

(15) Noise power at receive input −148.8 db W. (−118.8 dbm)

(16) Signal power :

	Normal	Worst
	−121.8 dbW	−137.8 dbW
	(−91.8 dbm)	(−107.8 dbm)

---

* $\alpha = 0.63$, $1-\alpha = 0.37$. T_0 of feeder = 290°K

T_1 (Receiver) = 860°K.

$T_S = 0.63 \times 1000 + 0.37 \times 290 + 860 \simeq 1600$°K

$\alpha T_A + (1-\alpha) T_1 + T_R$.

— — — 3

228.6
81.6
147.0

(3)

	Normal	Worstcase
(17) Carrier power to noise ratio at receiver input :	+27db	+11.0db

This is quite sufficient for any modulation schemes. The dynamic range of the receiver also would take care of normal and worst case values.

DR. SARLES:

I have written major electrical consideration ~~the~~ of UHF antenna §4.4

Things left out:

4.4.3 Antenna Truss design.

Few lines about reduction of reflection by choke like structures, I will write in a day. Rest is mainly mechanical, which I hope you would do.

4.4.4. I want to know the exact type of material to be put in

4.4.5. Deployment: Pl. do this part too

Table 4.4-1 Mechanical Details is incomplete.

Rajan

9th NOV '70

DRAFT

4.4 UHF Antenna

This provides adequate coverage, by its beam, to great portions of the Indian subcontinent. A half power beam width (HPBW) of 3.5° gives −3 db coverage to almost all the Indian regions excepting Assam and northern portions of Kashmir. These regions have to go for higher diameter (10 ft) ground receive antennas.

For UHF frequency (790 to 950 MHz) an HPBW of 3.5° is got by a parabolic dish of 23 ft diameter with normal illumination. This requires that the antenna be deployed at synchronous orbit due to space limitations in housing the payload in the launch vehicle.

A parabolic dish is selected as the UHF antenna because deployable parabolic dishes upto 20 ft diameters have been space qualified. And also the ATS-F experiment of NASA would be using a 30 ft dish (to be launched by 1973). Hence major developmental

- - - - [2

effort in deployment technology can be avoided by selecting this approach. The antenna will be contained in a hub of about 4 ft to 5 ft diameter and height about ~~3 ft~~ 2 to 4 ft and would be deployed at synchronous orbit. The effect of torque on control etc are discussed in - - - - . Here only the electrical parameters are discussed. Some mechanical features desired are given in Table 4.4 – 1

4.4.1 <u>Blockage</u>: The earth viewing module (EVM) is located in front of the UHF antenna (See Fig - - -). The blockage it encounters is from a cuboid of 46" x 46" x 600". To add to this high blockage, there is the truss connecting the EVM and UHF dish. Also the solar panel booms are present to add to some minor distortions in the field.

In the first order look the blockage is by a square of 46" x 46". This naturally does not have the circular symmetry and the effective blockage along diagonal planes could be more.

— — - ! [3

Thus the three dimensional contour plot could have some asymmetry. In our first order analysis of blockage effects a circle of 4' diameter was assumed to be blocking the parabola; further details such as square cross section, length of the satellite body etc were omitted because of uncertainties in trusses. Much of these effect can better be studied by 10:1 scale model studies. Blockage not only reduces main lobe gain, but also contracts HPBW.

4.4.2. Sidelobe considerations:

The EIRP per each UHF TV channel would be 54.2 dbW. At present there are no regulalations as to the allowable EIRP in this frequency band (as there is one in the 1 to 18 GHz range). In fact, this high EIRP makes the overall economics attractive as 500,000 receivers at ground need have only 4 ft diameter antenna. This being so the sidelobes of the satellite may radiate power in other regions of the world. For the synchronous position of the satellite selected, the first sidelobe

--- [4

falls in Europe, where there are existing commercial UHF AM/VSB TV stations. This may not be sharp due to the smearing effect of blockage. We had looked into this problem in detail with three approaches:

(i) Build protection margins from FCC and CCIR recommended field strength values.

(ii) Calculate the signal power for TASO II grade for AM/VSB receivers from typical system noise temperature of ground TV receivers and then work out the power entering into the same receive through the satellite side lobe. This will show the protection ratio

(iii) From figures regarding interference effectiveness of 'white noise' compare effect of FM signal.*

"Sharing the UHF between Space and Terrestrial Services" by John L. Hult, Rand Corp.

To fix ideas initially a sidelobe that −20 db of the main lobe peak was assumed and the protection margins were calculated for this case. When the peak of the sidelobe itself is protected for, then there is protection at all other angles. The calculations were quite conservative and many second order contributions such as extra path loss to Europe, ionospheric losses (which would be considerable because the side lobe ray passes a great deal ionosphere), atmospheric effects as they would be coming very near horizon are omitted. They would be mentioned.

Protection ratios is a subject where international agreement is not yet reached. It could be that we had been very conservative in which case detailed calculations can relax stringent sidelobe requirements. In any case, with the amount of blockage meted out, it will not be possible

--- [6

with available techniques to bring down the sidelobe below −20 db for the pencil beam parabola, as would discussed later (p. . . . .)

(a) European interference Calculations:

Fieldstrength approach:

CCIR Recommendation 417-1 stipulates +70 db($\frac{\mu}{m}$) median field strength for terrestrial television services in the upper UHF band.*

ITT Reference Data For Radio Engineers (Fifth Ed. p. 28-11) gives a value of +64 db(μ/m) for Grade B service as a FCC standard. Though FCC values are not followed in Europe, taking this lower value we proceed with our calculations:

---

* Television Broadcast Satellite Study by J. Jansen, P.L. Jordan et al. TRW Systems Group Prepared for NASA Lewis Research Centre NASA CR-72510, TRW No. 08848-6002-R0-00 (p. 2-42)

EIRP	=	+ 55 dbW
Sidelobe loss	=	− 20 db
Reduction in power due to 30 MHz spread of FM spectrum assuming AM/VSB bandwidth of 6 MHz	}	= − 7 db.

Effective interfering power to AM/VSB receiver, at satellite point = + 28 dbW. —— (1)

Converting to field strength:

$E\,db\left(\frac{\mu}{m}\right) = -16.2 + EIRP\ dbW(eff)$ —— (2)

$= -16.2 + 28$

$= 12.8\ db\left(\frac{\mu}{m}\right)$ —— (3)

Protection Ratio $= 64 - 12.8 = 51.2$ db. —— (4)

— — — — [8

Signal Power Calculations:

Typical Ground receiver assumptions:-

Noise figure = 10 dB

Feeder loss = 4 dB

Ambient noise at UHF = 2000°K

∴ Effective system noise of UHF TV ground receiver T_s = 3650°K = 35.6 db°K

Receiver Bandwidth B_n = 6 MHz

Antenna Gain = 12 dB.

Bandwidth weighted Effective EIRP from side lobe [from eq. (1)]	= +28 dbW
Path loss	= −183.2 db.
Ground antenna Gain	= +12 dB
Polarization loss	= −3 dB
Feeder loss	= −4 dB
Power at ground receiver input	= −150.2 dbW

(5)

kT_sB_n at the receiver input } = −126 dbW —— (6)

CNR for TASO II quality = 37.2 db

∴ Reqd carrier power for TASO II quality in 10db N.F. Receiver } = −88.8 dbW —(6a)

∴ Protection Ratio = −150.2 − (−88.8)

= 61.4 db —— (7)

(iii) Inteference effectiveness compared with that of white noise*

Noise figure = 10 dB

Cable Loss = 3 dB.

Antenna gain = 12 dB

Polarization loss = −3 dB

Bandwidth = 4 MHz

kTB_n = −128 dBW.

∴ Max permissible white noise interfering power } = −131 dbW —— (8)

*See J. L. Hult quoted before

——— [10

Max. permissible total spectral FM power $= -131 - 4$
$= -135$ dbW ——— (9)

Satellite FM total power at receiver input with parameters given as above $\} = 55 - 20 - 183.2 + 12 - 3 - 3$

$= -142.2$ dbW.

Synch interference effectiveness $= -142.2 - 11$
$= -153.2$ dbw ——— (10)

Picture interference effectiveness $= -142.2 - 1$
$= -143.2$ dbw ——— (11)

Thus we find both (10) and (11) are well below maximum permissible FM power.

Similarly the protection ratios (for FM interfering AM/VSB) are adequately above the usually recommended values of 37 to 47 dB. Other second order effects such as increased path loss, ionospheric loss,

——— — — (17)

atmospheric losses at low elevation angles, look angle losses etc would give 3 to 5 dB more. Much of the Calculations and assumptions were based on some experimental reports, answers by some countries to CCIR questioniarre etc. The major hitch would be an internationally accepted Solution.

Our calculations show that -20 db side lobe and and EIRP of +55 dbW adequatly protects AM/VSB receivers (for protection ratios, as reported, from 37 to 47 dB). In fact the calculations suggest that -20 db sidelobe goal could be relaxed; it could be looked in greater detail at a later stage. The documents referred are listed in the bibiliography (NOs. - -- - --) The results are listed in Table 4.4-2

(b) Effect of Tapered Illumination

With our known requirements of main beam EIRP, region coverage, sidelobe levels, the electrical parameters of the UHF antenna can be tabulated as in Table 4.4–3.

As pointed out in 4.4.1 the blockage is the main consideration in the selection of antenna to satisfy the electrical requirements.

A 23′ diameter parabolic dish with −10 db edge illumination taper would provide 3.5° HPBW and 33.7 db main lobe gain ($\eta = 60\%$) But the blockage of the order of 4 ft will reduce peak gain by 0.55 dB and HPBW by about 7% and this the gain at $\theta = 1.75°$ falls according to :-

$$G(\theta) = G(0) + P_0 \left(\frac{\theta}{\theta_0}\right)^2 \text{ in dB}$$

where Gain at angle θ_0 is P_0 dB (12) below peak ($\theta = 0$).

Thus the gain falls to 28.8 db at 1.75° angle and also side lobe goes to −19.3 db. so

- - - - [13

Our problem here is to have the same HPBW (ie 3.5°) and gain greater than 33 db at main peak; thus just an increase in diameter to compensate for loss of peak gain due to blockage will not satisfy our needs as this would correspondingly reduce HPBW, thereby reducing edge area gain according to eq. (12). Herein comes the idea of tapering the illumination.

Though there are various taper illuminations, a illumination of the type

$$A + B\left(1 - \frac{\rho^2}{a^2}\right)^P \quad \text{——— (13)}$$

was assumed to do some first order calculations. Many parameters for this has been worked out in a paper by A. F. Sciambi*, of R.C.A. Also

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* A. F. Sciambi, "The effect of Aperture Illumination on the Circular Aperture Antenna Pattern Characteristics" Microwave Journal, vol 8, #8, Aug 1965 pp. 79 - 84

in a report* on sidelobe suppression techniques A = 0.068, B = 0.932 and P = 3 to 3.5 have been reported with simple helices with chokes behind them. Thus with this illumination function would be looking into a possible design.

Calculations show that for A = 0.1 (−20db) B = 0.9 and P = 2 we would be coming very close to our specifications. Also with A ≃ 0.05 and B = 0.95, P = 2.5 we can get similar results for 27' In fact, these parameters A, B, & P can be manipulated to get an optimum illumination function. However, this will not fix the final

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* F. J. Goebbels, R. Meier, & R. K. Thomas "Analytical & Experimental investigation of sidelobe suppression techniques for reflector type space craft Antenna" Prepared for NASA by GE. NASA CR-72462 (1st sept 1968)

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design because we do not take into account the effect of truss design, which is at present unknown; even when know exact analysis of the electromagnetic problem is quite complicated. Moreover, actual illuminations obtained will not exactly follow the analytical functions assumed.

In view of these it is desirable that a scale model studies at X-Band (10:1 scale down) be conducted to fix the best illumination for the diameters ranging from 25' to 27'. Simultaneously a closer look on the antenna specifications (mainly the sidelobe) be given as mentioned earlier. With EVM, trusses etc as in actual case, scale models would fix the reasonably realisable designs.

Also in the report by Goebels et al, quoted before, a blockage compensation technique of radiating a field in the opposite direction to the primary feed in proper phase and amplitude to cancel the blockage effect is discussed. Details regarding the overall three dimensional contour plot, the application of this technique to circular polarization etc are lacking. This is referred here primarily to guide the future scale model studies, which may take advantage of similar techniques, though it looks, at the moment, that these suppression methods may not be easily achieved for circular polarization in three dimensional contour.

(C) Squinting the feed to reduce sidelobe at Europe.

Instead of specifying −20db for overall three dimensional case, we can restrict it only to the direction of land masses, ie in the direction of north and somewhat west of India. Low sidelobe levels can be provided in this region by translating the feed to the south

— — — —

so that the antenna beam squints to the north. Unblocked sidelobe levels of about 30 db can be achieved by squinting the beam by about 2.5°; for −10db tapered case; the southerly sidelobe goes up to 18 db. For other tapered cases the position of the sidelobes will change depending on illumination functions. Also smearing effect of blockage comes into play. These could be analysed or else scale model would offer a good picture of these. Also a detailed look can be given to analyse the angular regions where the land masses to be protected fall and where sea regions fall; this will give a detailed picture of the contour pattern and assist in scale model studies.

Shaping of the beam with four feeds can also offer a solution; but the losses involved in power division to four feeds etc should be weighed; of course, a model study with these could be done if needed.

4.4.3 Truss design

TABLE 4·4-II

Antenna Mechanical Characteristics

Parabolic dish diameter range	= 25′-27′
f/D Ratio	= 0·3 to 0·35

— Incomplete —

Written

TABLE 4·4-2 (a)

Protection Ratios

Field Strength Method:

Assumed Grade B field to be protected	$= +64\ db\left(\frac{\mu}{m}\right)$
Field through -20 db sidelobe both (assuming 30 MHz FM signal spread and 6 MHz AM/VSB Bandwidth for giving weightage to signal spread of FM TV signal)	$= +12.8\ db\left(\frac{\mu}{m}\right)$
Protection Ratio	$= 51.2$ db

TABLE 4.4 – 2 (b)

FM signal is assumed to spread over 30 MHz. AM/VSB Bandwidth 6 MHz. Ambient noise temperature = 2000°K

TASO II Carrier to noise ratio requirement = 37.2 db.

Ground antenna gain = 12 dB (linear polarization)

Cable loss = 4 dB

EIRP = +55 dbw (whole spectrum)   Sidelobe = −20 db Main peak

TV Receiver Noise Figure	Protection Ratio
10 db	61.4
12 db	63.1
15 db	65.8
20 db	70.5

Second order effects (which increase protection ratio) left out:—
Extra path loss due to slant range
Ionospheric losses, atmospheric losses due to low grazing angles.
Max. side lobe peak only is considered.

Recommended protection ratios range from 37 – 47 dB.

Sub: Allowance during my posting at NASA/GSFC for ATS-F project

Dear VAS,

During my long association with PRL-ISRO, I have not brought any monetary problems to you; major reason for this being my feeling of oneness with the organization. ~~Minor~~ ~~I felt~~ ~~[illegible] minor finan~~ I never ~~felt~~ had any liking for wrestling out minor financial concessions, because the challenge of work was much fascinating ~~[illegible]~~, and also ~~which~~ basic amenities could be had with the salary I drew. Recently the letter we had from Mr. Karthik to Mr. Kale regarding our allowance at GSFC was quite disturbing ~~to~~ as it mentions that ~~the~~ the allowance I ~~[illegible]~~ can get is only $450. ~~[illegible]~~ The earlier letter informing of our posting ~~however~~ ~~from~~ Mr [illegible] VC, ~~however~~, had written ~~the~~ the terms & conditions of our posting at GSFC would be similar to that Mr Kale and it would be for a year or two. He further had written that ISRO will assist if I had to bring my wife..

Leaving this exact quantum of allowance for a moment, I would like to point out to you, where this ~~pro~~ hurts me: As my stay here is going to be ~~for~~ an uncertainly long period of two years or more, ~~I it is very impractical to be separated from my wife and [illegible] child for such an uncertain period;~~ (it will raise some basic issues of priorities.) Despite intense idealism on my part, regardless (?) of my professional work, it would rather be difficult to suffer such a long & uncertain privation (?) & separation from wife & child, Especially while working for such ~~a~~ big programme as INSAT, ~~I at~~ during such a privation, ~~So~~ I as an individual, would feel about the fate of ~~an~~ an engineer who has to work for ~~these~~ such a big a project; it ~~would~~ shake some basic faith and assumptions due to the length of time. Though ISRO might pay transport charges for my wife, it is very clear that we cannot have even near-subsistence level of existence with $450 and ~~the~~ hence ~~the~~ my appeal to you regarding this.

I have written a letter regarding this to Mr EVC; Probably I can meet him at Washington. Still I have written to you to put my viewpoint and I would be very eager to learn whether any revision in this is possible as it is very clear that $450 would simply mean staying alone, which is a very serious decision, especially in view of uncertainly long time ~~it is~~ involved.

I feel very sorry to write this to you because it would cause perturbation in the INSAT programme to which I have contributed my mite and in turn ~~received~~ earned a good deal of good will & experience for the MIT-Lincoln Lab. ~~I~~, ~~I have~~ ~~still~~ a ~~great~~ poignant moral dilemma between ~~an~~ individual emotions and professional demand that might develope, in order that ~~a~~ I ~~clearer picture is go~~ can get a clearer picture

---

TABLE 4.4-3

Electrical Requirements of UHF Antenna

Frequency Band	: 790 – 955 MHz
Peak gain	$\geq$ 33 dB.
Gain at 1.75° off main axis	$\geq$ 30 dB.
Max. Side lobe within ±10° off axis	−20 dB.
Polarization	: Circular.
Axial Ratio within 2.5° off main axis :	

18th Nov 70

DRAFT

Note: This supersedes the one written 12th Nov 70
Reason: Format Change

2.1.5 (g)

VHF COMMAND LINK CALCULATIONS

DATA:

Ground Transmitter Power Output	2.5 KW
Ground antenna (30' dish) gain	+ 20 db
Space Craft Receiver Noise Figure	6 db
Sensitivity	-110 dbm
Bandwidth	60 KHz.

LINK CALCULATIONS:

Ground Segment:

(1) VHF Transmitter Output	34 dbW
(2) Feeder Loss	- 2 db
(3) Antenna gain	+20 db
Ground EIRP	+52 dbw

	Normal	Worst
(4) Path loss 150 MHz	-168.8 db	-168.8
(5) Antenna gain	0.	- 6.0
(6) Polarization loss	-3	- 3.0
(7) Feeder loss	-2	- 2.0
(8) Scintillation	0	- 6.0
Loss Total	-173.8	-185.8

- - - [2

(9) Receiver Noise Figure	6 db	
(10) Mean Spacecraft antenna temperature at 150MHz	1000°K	
(11) Feeder loss	2 db	
(12) System Noise Temperature referred to antenna terminal (Feeder at 290°K)	1000°K + 1450°K = 2450°K	
	= 33.8 db °K	
(13) Bandwidth	60 KHz = 47.8 db Hz	
(14) Boltzmann Constant	−228.6 db W/Hz/°K	
(15) Noise power	−147.0 dbW	
(16) Carrier Power at antenna terminal	Normal	Worst
	−121.8 dbW	−133.8 dbW
	(−91.8 dbW)	(−103.8 dbm)
(17) Carrier-to-noise power ratio at antenna terminals	+25.2 db	+13.2 db

This CNR is quite sufficient for any modulation scheme. The

(3)

dynamic range of the receiver also would take of handling normal and worst case values.

9:00 INTRODUCTION
SUMMARY – SPACECRAFT CONFIGURATION
L/V FEW REMARKS

10.00 BREAK.

10:15 Attitude Control (40MIN)
10:55 STATION KEEPING (20 MIN)
11:15 TLM & CMD (20 MIN)
11:35 PROPULSION (40 MIN)
12:15 DISCUSSION
12:30 LUNCH
1:30 POWERSYSTEMS

10:15 SYSTEM & LINK ANAYSIS (20 MIN)
10:35 ANTENNA SYSTEM (20 MIN)
10:55 TRANSPONDER BLOCK DIA (25 MIN)
11:20 FRONT END (10 MIN)
11:30 UHF PA'S (25 MIN)
11:55 TWT'S (20 MIN)
12:15 DISCUSSION
12:30 LUNCH
1:30 MULTIPLEXERS & FILTERS

2:00 SOLAR ARRAY (20 MIN)
2:20 THERMAL (25)
2:45 SOLAR TORQUES & DYNAMICS
3:05 WEIGHT & LAYOUT
3:20 GROUND SYSTEMS
3:40 LAUNCH VEHICLES
4:30 SCHEDULING
5:00 INDIAN FACILITIES
5:30 BREAK
6:00 SMALL SATELLITE.
6:30 COSTING.

Logic Design with IC's
W. E. Wickes. $9.95
John Wiley & Sons Inc
(1968)

Papers on Digital Signal Processing A. V. Oppenheim (Ed) MIT Press $5.95

Practical Gear Design
GE
L... or D...

~~A65 – 31024 19 – 2765~~

A65 – 34013 22 – 3245
(Mobile Sat com term.)

A65 – 10358 – 01 – 0022
(PM & varactor X^ln microckt)

Voltage controlled phase shift network where consts phase change is got at HF & VHF

A65 – 28255. 17 – 2440

ISRO – MIT

I (Phase I) → (out)
Phase II

] objective.

II Ground Rules. for achieving the obj—

III Participants

(1) ISRO Team
(2) MIT "
(3) NASA Rep.

$44129

GE upper limit.

IV ~~G E~~ This is what GE is supposed to do.

GE will not directly participate in the study but ISRO will assign specific tasks to GE (≤ $40,000)

The tasks to be done will be determined by the following factors:

(i) Composition of the team

Composition of MIT team
Communicated to Prof. EVC.

Mr PPK - Consult MIT. (Dr. Searle's) as to ~~how~~ whether G.E.(?) sh'd be consulted in particular areas. (where MIT/NASA expertise is limited or not available) If so what areas? To preserve. F.E.

→ (i) Internal consultation
(ii) MIT ,,
NASA

Computer Sciences etc
TRW } may be invited by MIT.

Then go to G.E.
Task sh'd be itemise.
within $40 K.

By this it is meant that

[Certain expertise.
~~most~~ other of than 6 people.

+ Lack of expertise after internal consultation. when

FE $44K.

We sh'd have:

(i) Reliable & Proven
(not necessarily novel)

Mailing & Cable address
of all people
Telephone: Res, Office
Timing
Mailing address

Reports. once in 10 to 12 days

2.1.5 (f)

VHF TELEMETRY DOWNLINK

GROUND SYSTEM DATA:

Ground antenna Gain	20 db
Receiver Noise Figure	4 db
Feed losses	1 db
Antenna temperature	1000°K
System temperature referred to antenna terminal	1000° + 625°
(Feeder at 290°K)	= 1625°K
Bandwidth	30 KHz

TRANSMITTER DATA:

Output power	5 watts.
Modulation	PCM-PM or FM

LINK CALCULATIONS:

Ground System temperature	32 db °K
Boltzmann Constant	−228.6 db(W/Hz/°K)
Bandwidth	44.8 dbHz
Noise power at antenna terminals	−151.8 db W

Transmitter Power	7 dbW	
Losses:	Normal	Worst case
Path loss	−168.8 db	−168.8 db
Polarization loss	–	−1 db

— — — [2.

(2)

	Normal	Worst
Scintillation	0	−6
Rain Cloud etc	0	−1
Direction mismatch losses	0	0
Spacecraft Antenna Gain	0	−6
Feed losses	−2	−2
Ground antenna gain	20	20
EIRP at ground antenna terminal. (carrier power)	−143.8 dbW	−159.8 dbW

− 228.6
32.0
− 196.6 → Noise [pow] density

+q

−143.8
1.4
−142.4 Normal recd pwr

Carrier to noise power density

−159.8
1.4
−158.4 Worst recd pwr

	Normal	Worst.
	54.2 db/Hz	38.2 db/Hz.

196.6
158.4
38.2

200 cps = 23 db Hz +12.6 = 35.6
2.5 KHz = 34 db Hz +12.6 = 46.6

Normal case for 2.5 KHz. 7.8 db above margin.

Worst case ~~+2.6 db bel~~ − 8.4 below.

For 200 bits. (worst case) + 2.6 db above margin.

AN INDIAN DOMESTIC SATELLITE SYSTEM

HUGHES AIRCRAFT COMPANY SSD 90205R

ERRATA

LOCATION	CHANGE	
	FROM	TO
P. 1-5, top	"beam width (-3db) = 2.7 degrees"	"beamwidth (-3db) = 2.6 degrees"
P. 2-6, Figure 2.1-3	70^o	50^o
P. 2-39, #5,b	"ground station station"	"ground station"
P. 2-41, #11	"EIRP (2^o)"	"EIRP (2.6^o)"
P. 2-55, Summary, line 2	"The pre-channel power"	"The per-channel power"
P. 3-11, top	"Transmit lasser"	"Transmit losses"
P. 3-17, Figure 3.3-1	"106 IN. DIA."	"93.5 IN. DIA."
	"SOLAR PANEL (110 IN.)"	"SOLAR PANEL (108 IN.)"
P. 3-36, Table 3.5-1		
Col. 3	"1*"	"1 @ 43.8 dbw*"
Col. 5	"3 or 4**"	"3 @ 44.8 dbw or 4**"
P. 4-24, middle	"Appendix A ... obtained."	Delete
P. 5-1, bottom	"optical system is rididly"	"optical system is rigidly"
P. 7-2, Table 7-1		
Row 2	"1250"	"1200"
	"2700"	"2450"
P. 7-4, Table 7-2	"Cost, thousands of dollars"	"Cost, dollars"
P. 2-6, Figure 2.1-3	50^o	70^o