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6 February 1969

WIDE BAND DATA READ OUT

THE ENCLOSED BRIEFING MATERIAL, PREPARED BY THE MOL ADVANCE PLANS OFFICE, REPRESENTS A STATUS REPORT ON WIDE BAND DATA READ OUT APPLICATIONS FOR POSSIBLE BLOCK II MOL USE.

THE STUDY WAS INFORMALLY REVIEWED WITH MAJ. GEN. STEWART AND STAFF AT AEROSPACE ON 29 JANUARY 1969.

IT IS CONCLUDED THAT CURRENT TECHNOLOGY PERMITS FROM 10 TO MORE THAN 50 2"X2" FRAMELETS TO BE SECURELY RETURNED TO THE USER PER DAY, IN A DIRECT MOL-TO-GROUND MODE, FOR A TOTAL COST OF UNDER 30 M\$. IT IS FURTHER CONCLUDED THAT SHARED UTILIZATION OF A SATELLITE DATA LINK WOULD PERMIT TRANSFER OF DATA AT A RATE EQUIVALENT TO 1000 2"X2" FRAMELETS PER DAY FOR A TOTAL COST OF LESS THAN 45 M\$.

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BACKGROUND

- IS THERE A "POOR MAN'S" WBDRO FOR MOL?
  
- PREVIOUS PROGRAM WB HARDWARE AND STUDY CONTRACTS
  - ✓ CBS - BTL - DOUGLAS
  - ✓ DEFERRED LATE '67. SPACE AND WEIGHT ALLOCATIONS MAINTAINED
  
- AEROSPACE PRELIMINARY SURVEY STUDY
  - ✓ APPARENTLY MANY CHEAP WAYS TO GO, DESERVES SIGNIFICANT EFFORT
  
- GENERAL ELECTRIC PRELIMINARY BRIEFING (OCT. - NOV.)
  - ✓ EQUIPMENT AND CAPABILITY FOR DATA DELIVERY APPEARS FEASIBLE
  
- GENERAL ELECTRIC IN-HOUSE STUDY (NOV., DEC., JAN.)
  - ✓ COMPONENTS APPEAR AVAILABLE
  - ✓ STATE-OF-THE-ART DELIVERY VIA SGLS VERY WORTH WHILE
  - ✓ EITHER RTS DELIVERY OR VIA IDCSP OR DCS PHASE II

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- WEST COAST AF/Ⓐ INTERIM RECOMMENDATIONS

POTENTIAL BENEFITS OBTAINED FROM A WIDE BAND SYSTEM CAPABILITY

1. EARLY GROUND USE
2. HEALTH CHECK
3. PROGRAM INSURANCE
4. OPERATIONAL FLEXIBILITY
5. IDEAL MATCH FOR RELAY LENS
6. GROWTH POTENTIALS
7. MAXIMUM CREW INVOLVEMENT
8. POSSIBLE OTHER MISSION USES

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WIDEBAND SYSTEM SURVEY CONSIDERATIONS

- ELEMENT DEVELOPMENT STATUS
- DATA GENERATION AND REDUCTION IMPACT
- DATA LINK POSSIBILITIES
- SECURITY ASPECTS
- SELECTED ALTERNATIVES
- R. O. M. COSTS

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WIDEBAND SYSTEM ELEMENTS STUDIED

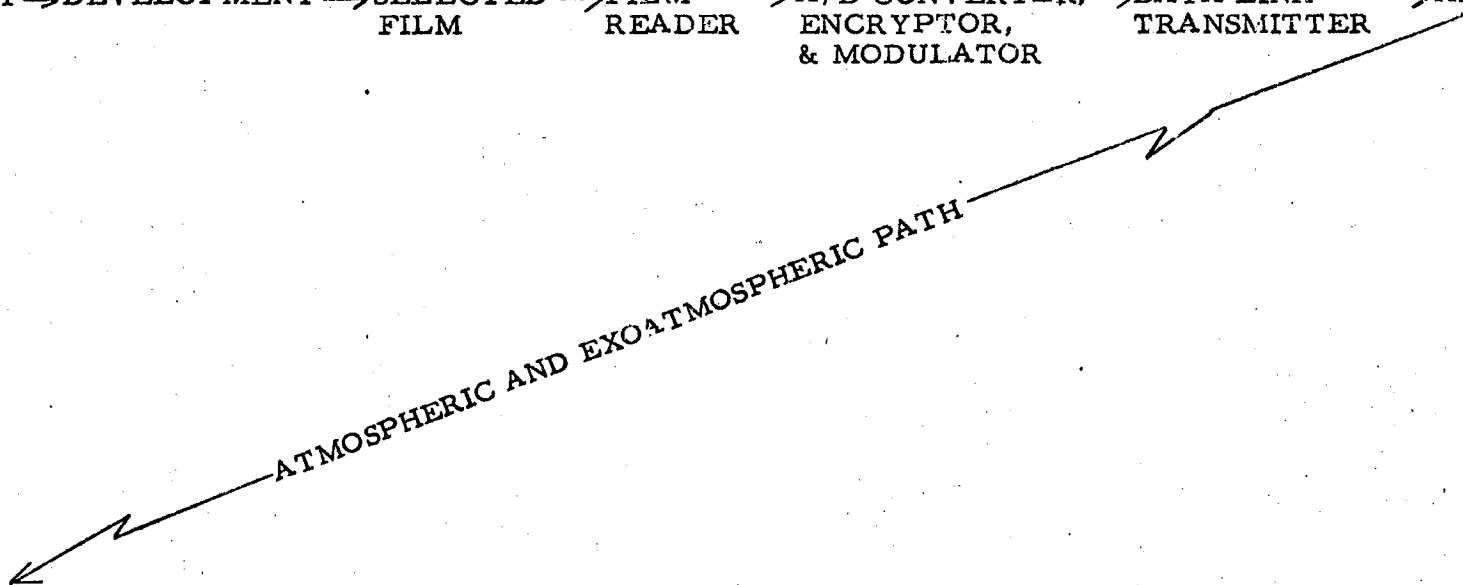
- READERS: LUNAR ORBITOR RCA LASER BEAM  
CBS SPOT SCANNER LASER FREQUENCY CHOICES
  
- LINKS: MODIFICATIONS (5 SETS) TO SGLS  
S-BAND EHF - BAND  
X-BAND OPTICAL BAND, FAR IR  
THRU VISIBLE TO NEAR UV  
K<sub>A</sub>-BAND RELAY SATELLITES, ALL  
BANDS ABOVE
  
- SITE SELECTION: WEATHER EFFECTS, SPACECRAFT TO GROUND  
CONTACT TIMES, GROUND TO USER LINKS
  
- SPACECRAFT SPACE ALLOCATION REQUIREMENTS

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BASIC WIDE-BAND DATA RELAY SYSTEM


LATENT IMAGE → DEVELOPMENT → SELECTED FILM → FILM READER → A/D CONVERTER, ENCRYPTOR, & MODULATOR → DATA LINK TRANSMITTER → ANT.



DATA LINK RECEIVING APERTURE → RECEIVER & AMPLIFICATION → DEMODULATION, DECRYPTION, & D/A CONVERSION → FILM WRITER → FILM → DEVELOPED IMAGE

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ELEMENT DEVELOPMENT STATUS

<u>ELEMENT</u>	<u>STATUS</u>	<u>REMARKS</u>
● PRIMARY OR SECONDARY/BI MAT	AVAILABLE	CHOICE DEPENDS ON OPERATIONAL FACTORS
● PROCESSOR	REPACKAGE	COULD BE BATCH OR CONTINUOUS
● VIEWER	REDESIGN	SHOULD BE COMPATIBLE WITH QUANTITY
● SELECTOR/CARRIER	NEW DESIGN	HUMAN FACTORS IMPORTANT TO DESIGN
● READER/WRITER	LUNAR ORBITOR/ COMPASS LINK/RCA UNIT (DERIVATIVE)	PACKAGING AND/OR QUALIF. REQ'D. HIGH RATES REQUIRE UPGRADING
● ENCRYPTOR		CTAK (20 MBPS) REQUIRES ~ \$5M
● A/D & D/A CONVERTERS	< 5 MBPS DESIGNED	PACKAGING & QUAL. REQ'D
● MODULATORS/TRANSMITTERS	REPACKAGE & QUAL.	ALL TYPES AVAILABLE < 24 MOS.
● BUFFER/MULTIPLEXER	REPACKAGE & QUAL.	SOME DESIGN REQ'D > 5 MBPS
● RECEIVER/DEMODULATOR	BREADBOARD DESIGNS	DETAIL DESIGN & PKG. REQ'D
● SPACE-TO-GROUND LINK	RF DESIGNS S & X; LASER LINK BREADBOARDS	ALL COMPONENTS DESIGNED. PACKAGING & QUAL. REQ'D
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SECURE COMMUNICATION

- SECURITY OF TRANSMISSION ASSURED BY ENCRYPTION (RF)  
OR EXTREMELY SMALL "FOOT-PRINT" (LASER)
- NSA DEFINITION OF NON-ENCRYPTED, "PRIVATE" COMMUNICATIONS  
DOES NOT EXIST.

RF ENCRYPTION CAPABILITY	
CURRENT	1-2 MB CAPACITY [REDACTED]
UPGRADE	✓ [REDACTED] TO 20 MB ✓ 12 MO. LEAD TIME ✓ \$3-6 MILLION DEVELOPMENT

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GROUND TRANSMISSION OF DATA TO USER

- DATA FROM "REMOTE" GROUND STATIONS CAN BE TRANSFERRED TO WDC "USER" VIA AIRCRAFT, SATELLITE, OR LEASED LANDLINES.

CONUS LANDLINES

TYPE	CAPACITY		LIMITING S/C RATE TO GROUND* (250 SEC. TRANS.)	LEASE COST
	PER SEC/	PER DAY		
STANDARD MODEMS	250 KB/SEC	22 X 10 <sup>9</sup> BITS	86 MB/SEC	~ \$25/MO/MI
TV LINES	2-4 MB/SEC	> 173 X 10 <sup>9</sup> BITS	> 700 MB/SEC	

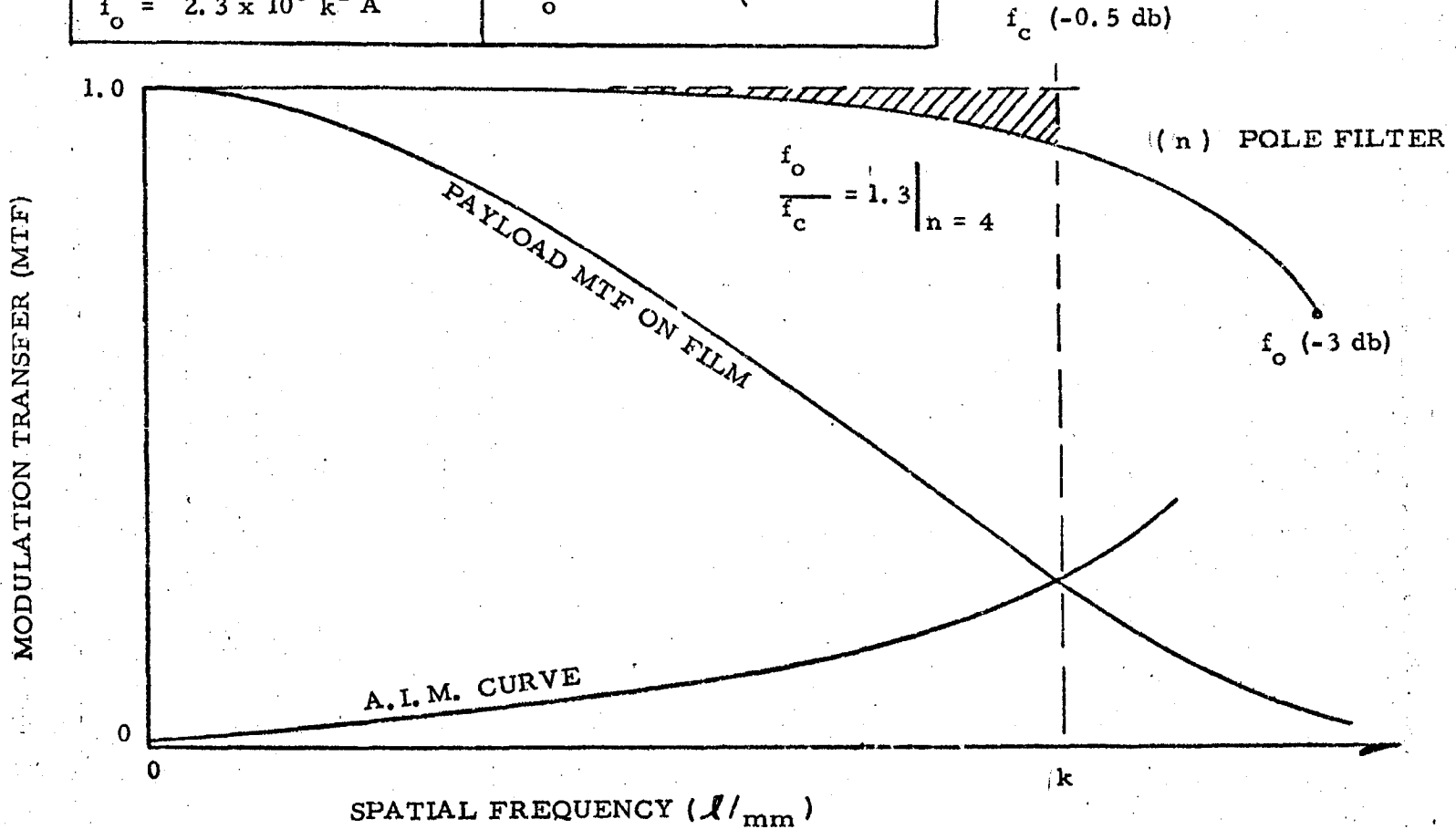
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\*ASSUMES SINGLE PASS/DAY

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REQUIRED CHANNEL RESPONSE

$f_c = 1.76 \times 10^3 \text{ k}^2 \text{ A}$	$\frac{H}{f_o} = 17$ for $\begin{cases} 27 \text{ db SNR} \\ 5 \text{ b. SAMP.} \end{cases}$
$f_o = 2.3 \times 10^3 \text{ k}^2 \text{ A}$	



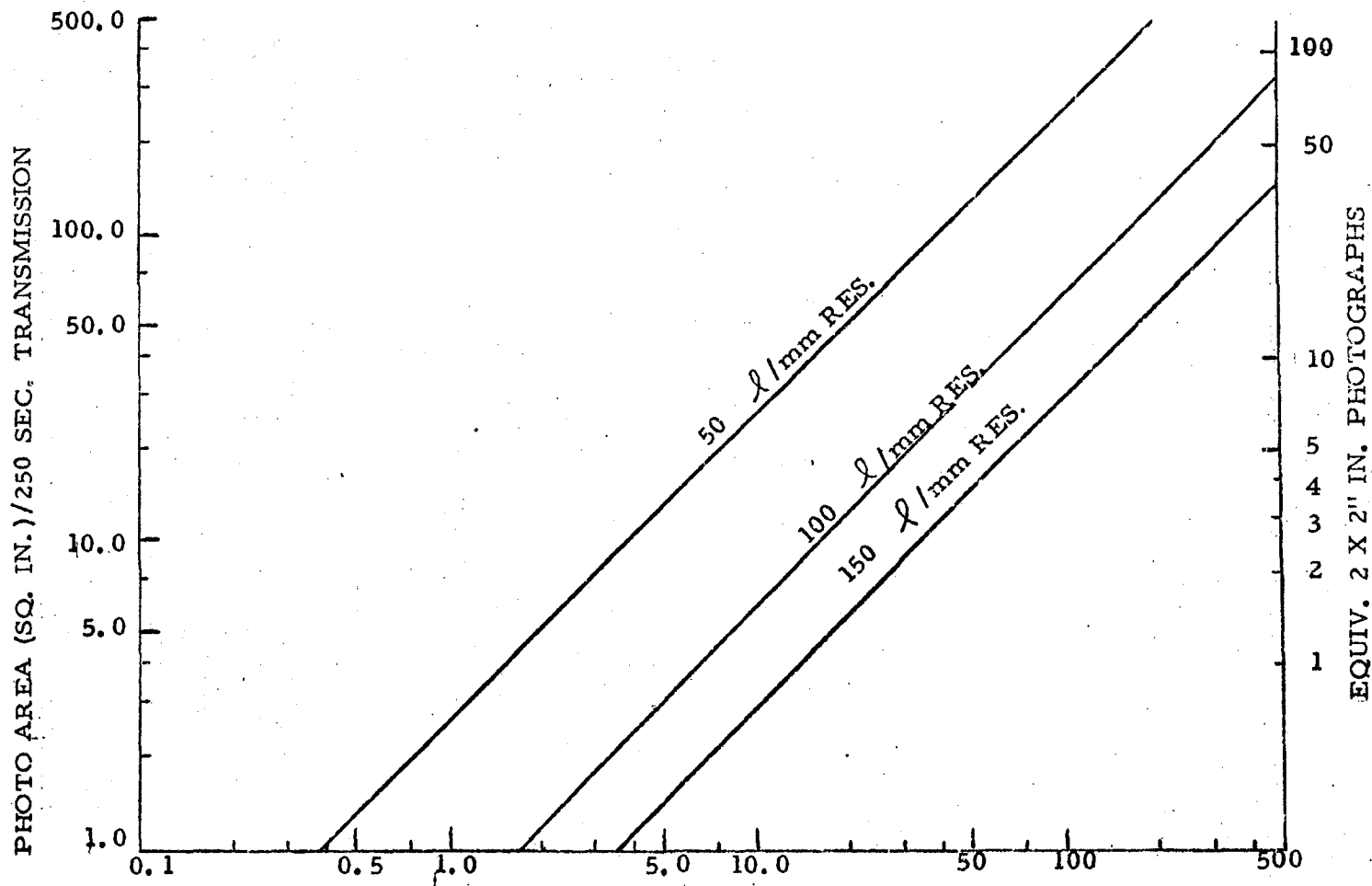
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### REQUIRED SYSTEM CAPACITY



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BIT RATE (MB/SEC)

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SUMMARY OF CHARACTERISTICS  
HIGH RESOLUTION DATA READ-OUT SYSTEMS

THIS CHART STARTS AT THE BOTTOM WITH THE LOWEST COST, MOST READILY PROCURED, LEAST CAPABILITY SYSTEM. WHILE THE COSTS FOR ATTAINING THIS ~ 2 SQ. IN (4,000 SQ. FT.) PER DAY SYSTEM ARE APPROXIMATELY HALF THAT OF EITHER THE S OR X BAND SYSTEMS, THERE WOULD BE LITTLE IF ANY CARRY-OVER TOWARD ATTAINING THEIR 40-60 SQ. IN. /DAY CAPABILITY BY INITIALLY EXERCISING THIS OPTION. THE ONLY GROWTH AVENUE FOR THIS LIMITED SYSTEM IS IN CONJUNCTION WITH A DATA RELAY SATELLITE WHICH IS DISCUSSED ON ANOTHER CHART. THE DATA RATE IS FUNDAMENTALLY LIMITED BY THE [REDACTED] ENCRYPTER TO ABOUT 2 MBPS.

THE TWO SYSTEMS IN THE MIDDLE OF THE CHART DEPEND ESSENTIALLY UPON THE SAME LEVEL OF ADVANCED DEVELOPMENT: NAMELY A RELATIVELY HIGH SPEED RELIABLE READER AND WRITER TOGETHER WITH AT LEAST A 20 MEGABIT PER SECOND ENCRYPTER. THE 40 MBPS SYSTEM UTILIZES TWO 20 MB ENCRYPTORS IN PARALLEL WHILE THE 60 MB SYSTEM REQUIRES THREE.

THE OPTICAL COMMUNICATION SYSTEM SHOWN IN THE UPPER PORTION OF THE CHART COULD INHERENTLY EXCEED 500 MBPS IF NOT LIMITED BY READER AND WRITER CAPABILITIES. WHILE RATES OF ABOUT 100 MBPS CAN BE ENVISIONED WITH FORESEEABLE IMPROVEMENTS IN THE PRESENT R/W TECHNIQUES, IT APPEARS THAT ANOTHER QUANTUM STEP WOULD BE REQUIRED TO EXCEED RATES OF ABOUT 250 MBPS. EVEN IF ENCRYPTION DEVICES EXCEEDING 100 MBPS DO NOT MATERIALIZE, IT MAY BE POSSIBLE TO UTILIZE THE OPTICAL LINK TO A SECURE GROUND TERMINAL BECAUSE OF THE EXTREMELY SMALL FOOTPRINT IT PROVIDES. THE LASER TECHNOLOGY REQUIRED TO ACHIEVE SUCH CAPABILITIES MAY BE MADE AVAILABLE TO THE AF THROUGH THE DEVELOPMENT STUDIES CURRENTLY BEING CONDUCTED BY THE NASA FOR THE ATS.

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SUMMARY OF CHARACTERISTICS  
HIGH RESOLUTION DATA READ-OUT SYSTEMS

<u>OPTICAL BAND</u>	<u>LIMITATIONS</u>	<u>DEVELOPMENT REQUIREMENTS</u>	<u>COMMENTS</u>
100-250 MBPS 25-68 FRAMES/DAY (PRIVATE) 36 MO. - ~30 M\$ ?	R/W (ENCRYPT)	<ul style="list-style-type: none"> <li>• ADVANCE TECHNOLOGY R/W</li> <li>• AUTOMATED FILM CARRIER</li> <li>• TV GROUND LINK TIE IN ?</li> <li>• (IF X BAND, LSI ENCRYPT. ?)</li> </ul>	<ul style="list-style-type: none"> <li>• NASA LASER COM. LINK PRESENTLY IN DEVELOPMENT</li> <li>• WEATHER SENSITIVE (S. W. U.S. RECEIVING STATION)</li> </ul>
<u>X BAND</u> 60 MBPS 15 FRAMES/DAY (SECURE) 24 MO ~ 25 M\$	ENCRYPTION	<ul style="list-style-type: none"> <li>• IMPROVED R/W</li> <li>• 20 MBPS ENCRYPT. (TRIPLE)</li> <li>• IMPROVED FILM CARRIER</li> <li>• 6 Ø MODULATION (40' DISH)</li> </ul>	<ul style="list-style-type: none"> <li>• LESS SENSITIVE TO BAND ALLOCATION THAN "S"</li> </ul>
<u>S BAND</u> 40 MBPS 10 FRAMES/DAY (SECURE) 24 MO ~ 23 M\$	ENCRYPTION (BAND ALLOCATION)	<ul style="list-style-type: none"> <li>• IMPROVED R/W</li> <li>• 20 MBPS ENCRYPT. (DUAL)</li> <li>• IMPROVED FILM CARRIER</li> <li>• 4 Ø MODULATION (60' DISH)</li> </ul>	<ul style="list-style-type: none"> <li>• R/W CAPABLE OF GROWTH TO 60 MBPS</li> </ul>
<u>SGLS</u> 2 MBPS 1/2 FRAME/DAY (SECURE) 18 MO ~ 10 M\$	ENCRYPT. (READER)	<ul style="list-style-type: none"> <li>• COMPASS LINK WRITER REPACKAGE - REQUAL.</li> <li>• AUGMENTED SGLS MODULATOR/BUFFER</li> </ul>	<ul style="list-style-type: none"> <li>• MINIMUM COST/ MINIMUM CAPABIL. SYSTEM</li> <li>• LIMITED GROWTH</li> </ul>

NOTES:

- 1) LASER READER ASSUMED ON ALL SYSTEMS
- 2) FRAME SIZE 2 IN X 2 IN; CONTACT TIME/DAY = 500 SEC.

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BUILDING BLOCK SYSTEM COST ESTIMATE  
(S-BAND, 40 MBPS SYSTEMS)

	<u>NON-RECURRING</u> (M\$)	<u>RECURRING</u> (M\$)
● <u>SYSTEM DESIGN</u>	(8.95)	(0.28)
✓ READER	2.10	0.28
● R & D (1.1)		
● PACKAGING & QUAL. (1.0)		
✓ WRITER	1.85	
● R & D + HARDWARE (1.85)		
✓ GE - DESIGN INTEGRATION & COMPONENT PACKAGING	2.50	
✓ MDAC - VEHICLE INTEGRATION & TEST	2.50	
● <u>ANCILLARY EQUIPMENT</u>	(1.45)	(0.60)
✓ A/D CONVERTER	0.30	0.20
✓ FILM PROCESSOR	0.20	0.15
✓ VIEWER & SELECTION	0.30	0.10
✓ CARRIER	0.40	0.15
✓ D/A CONVERTER (GROUND)	0.25	
} (AVE)		
● <u>LINK EQUIPMENT</u>	(9.30)	(0.25)
✓ 20 MBPS ENCRYPTORS (AVE/GRND)	5.10	0.10
✓ 40 MBPS MOD/DEMOD (AVE/GRND)	0.35	0.05
✓ BUFFER/MULTIPLEXER (AVE/GRND)	0.22	0.10
✓ NEW WDC STATION - 60 FT ANT.	3.63	

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TOTALS  
TOTAL COST (3 FLTS)

19.70

23.09

1.13

BUILDING BLOCK SYSTEM COST ESTIMATE  
(X-BAND, 60 MBPS SYSTEMS)

	<u>NON-RECURRING</u>	<u>RECURRING</u>
	(M\$)	(M\$)
● <u>SYSTEM DESIGN</u>	(9.40)	(0.30)
✓ READER	9.40	0.30
○ R & D (1.2)	2.45	0.30
○ PACKAGING & QUAL (1.25)		
✓ WRITER	1.95	
○ R & D + HARDWARE (1.95)		
✓ GE - DESIGN INTEGRATION & COMPONENT PACKAGING	2.50	
✓ MDAC-VEHICLE INTEGRATION & TEST	2.50	
● <u>ANCILLARY EQUIPMENT</u>	(1.60)	(0.65)
✓ A/D CONVERTER	0.40	0.30
✓ FILM PROCESSOR	0.20	0.15
✓ IMPROVED VIEWER, SELECTOR AND CARRIER	0.75	0.20
✓ D/A CONVERTER (GROUND)	0.25	
● <u>LINK EQUIPMENT</u>	(9.48)	(0.30)
✓ 20 MBPS ENCRYPTORS (AVE/GRND)	5.15	0.15
✓ 60 MBPS MOD/DEMOD (AVE/GRND)	0.40	0.05
✓ BUFFER/MULTIPLEXER (AVE/GRND)	0.30	0.10
✓ NEW WDC STATION - 40 FT ANT.	3.63	
	<u>20.48</u>	<u>1.25</u>

TOTALS

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TOTAL COST (3 FLTS)

24.03

COMPARISON OF DIRECT CONTACT VS. RELAY SATELLITE LINK

- DIRECT CONTACT SPACECRAFT-TO-SINGLE-GROUND STATION  
AVERAGE USEABLE SECONDS/DAY = 500
  
- SPACECRAFT-TO-STATIONARY-SATELLITE CONTACT 45% OF EACH  
90 MINUTES ORBIT
  - ✓ 2,400 SECONDS/ORBIT
  - ✓ 38,400 SECONDS/DAY
  
- SINCE STATIONARY SATELLITE ALWAYS SEES GROUND STATION  
$$\text{CONTACT RATIO} = \frac{\text{SATELLITE RELAY TIME}}{\text{DIRECT CONTACT TIME}} = \frac{38,000}{500} \approx 75 \text{ TIMES FACTOR}$$
  
- CONCLUSIONS:
  - ✓ USE OF PRESENT SGLS QUALIFIED COMPONENTS AND A SINGLE RELAY  
COULD PROVIDE CAPABILITY EQUIVALENT TO A 150 MBPS DIRECT  
SPACECRAFT-TO-GROUND LINK. (150 SQ. IN.)/DAY = 38 FRAMLETS
  - ✓ READER AND WRITER CAPABILITY TO MATCH THIS 2 MBPS CAPACITY  
SHOULD BE AVAILABLE FROM THE "COMPASS LINK!"

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POTENTIAL DATA RELAY SATELLITE CAPABILITY

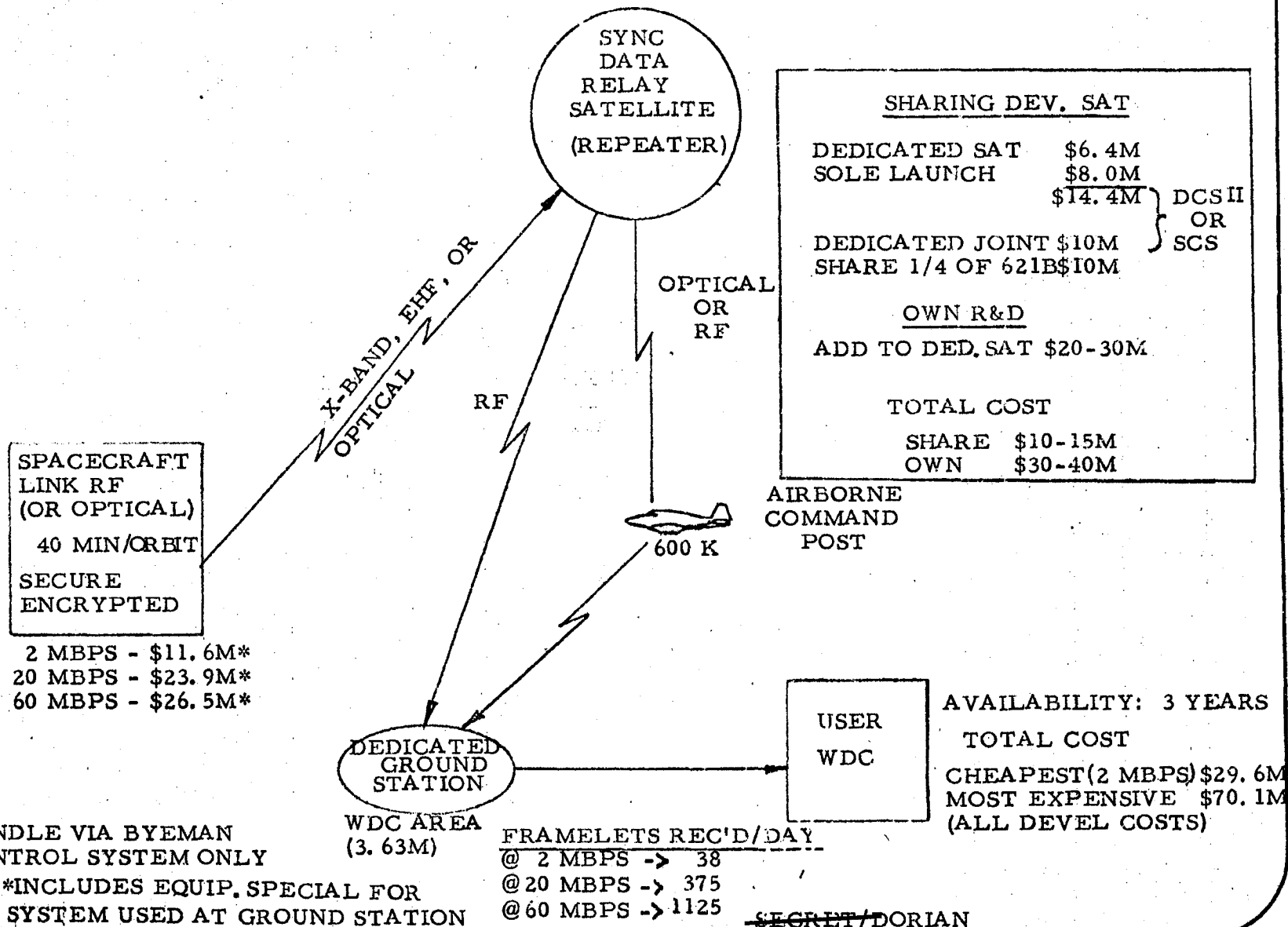
A DATA RELAY SATELLITE LOCATED AT SYNCHRONOUS ALTITUDE AT ABOUT 100°W WOULD HAVE CONTINUOUS VISIBILITY TO ANY POINT IN CONUS. SINCE THE MOL SPACECRAFT IS IN POLAR ORBIT, IT WILL SEE THE DATA RELAY SATELLITE FOR OVER 45% OF EVERY ORBIT. THIS PROVIDES A FACTOR OF OVER 75 TIMES GREATER CONTACT TIME THAN THE DIRECT SPACECRAFT-TO-GROUND LINK CAPABILITY, AS SHOWN ON THE PREVIOUS CHART.

COMMUNICATIONS RELAY SATELLITES OF VARIOUS TYPES ARE EITHER CURRENTLY IN OPERATION OR ARE BEING PLANNED FOR THE EARLY 70'S SUCH AS THE COMSAT, TACSAT, DCS, SCS, 621B, ETC. IT APPEARS REASONABLE TO ASSUME THAT THE MOL PROGRAM COULD EITHER OBTAIN A DEDICATED SATELLITE OR CLEAR CHANNEL FROM ONE OF THESE PROGRAMS FOR THE RECURRING COSTS INVOLVED. THIS HAS BEEN ESTIMATED BY VARIOUS PROGRAMS TO RANGE FROM \$10M TO \$15M. IF THE MOL PROGRAM HAD TO SHARE PART OF THE DEVELOPMENT COSTS FOR THE WHOLE SATELLITE SYSTEM, THIS MIGHT ADD ANOTHER \$10M OR SO TO THE COSTS. IN THE UNLIKELY EVENT THAT THE WHOLE DEVELOPMENT COSTS WOULD BE BORNE BY MOL, SUCH A DATA RELAY WOULD COST IN THE RANGE OF \$30 - 40 M.

SINCE THE DATA RELAY COMMUNICATIONS LINK COULD TERMINATE ANYWHERE IN CONUS, IT APPEARS MOST CONVENIENT FOR THIS SECURE TERMINAL TO BE CLOSE TO THE USER. COSTS FOR SUCH A FACILITY HAVE BEEN COMPUTED BY SEVERAL OTHER PROGRAMS AT ABOUT \$3.6M. THIS COST IS INCLUDED ON THIS CHART. IT IS POSSIBLE THAT SUCH COSTS MAY BE REDUCED BY COST SHARING BETWEEN SEVERAL PROGRAMS.

COST FIGURES SHOWN FOR THE SPACECRAFT FOR THE 2, 20 AND 60 MBPS ENCRYPTED SYSTEMS ACTUALLY ARE COMPOSED OF NOT ONLY THE SYSTEM PECULIAR COSTS FOR THE SPACECRAFT, BUT ALSO INCLUDE THOSE SYSTEM PECULIAR COSTS REQUIRED FOR BOTH THE DATA RELAY SATELLITE AND THE DEDICATED GROUND STATION.

POTENTIAL DATA RELAY SATELLITE CAPABILITY



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ESTIMATED COST/CAPABILITY SUMMARY

WIDEBAND DATA SYSTEMS

- 10 - 15 M\$ COST PREDICTED FOR SYSTEM CAPABILITY  
< 1 FRAME\*PER DAY (DIRECT SPACECRAFT TO GROUND)
- 25 - 30 M\$ COST PREDICTED FOR SYSTEM CAPABILITY  
RANGE FROM 10 TO > 68 FRAMES\*PER DAY (DIRECT S/C TO GND)
- 25 - 45 M\$ COST PREDICTED FOR SATELLITE RELAY SYSTEM  
CAPABILITY RANGE FROM 38 TO > 1,100 FRAMES\*PER DAY

\*FRAME SIZE 2"X2"

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RECOMMENDATIONS

- GUIDANCE REQUIRED TO SELECT MODES OF GREATEST INTEREST TO SPO AND "COMMUNITY"
- FURTHER SPO/ (A) STUDY REQUIRED TO NARROW RANGE OF OPTIONS AND SUBSTANTIATE AVAILABLE EQUIPMENT COST AND CAPABILITY.
- UPON COMPLETION OF SPO/ (A) STUDY, FUNDED INVESTIGATIONS OF SELECTED WIDE-BAND SYSTEM ALTERNATIVES IS REQUIRED.

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