(NASA-CR-119077) MSFN COVERAGE FROM EOI TO TLI FOR J-MISSIONS, 72 DEG TO 100 DEG (Bellcomm, Inc.) 21 p

N79-72281

Unclas
00/17 12071

Bellcomm

955 L'Enfant Plaza North, S.W.
Washington, D. C. 20024

B71 06021

date: June 17, 1971

to: Distribution

from: S. C. Wynn

subject: MSFN Coverage from EOI to TLI for J-Missions - 72° to 100° Launch Azimuths -- Case 310

ABSTRACT

The MSFN earth orbital coverage requirement of two contacts per revolution for the initial three earth revolutions of at least four minutes, assuming 5° antenna masking, can only be fully met for launch azimuths from 72° to 84°. Using real antenna masking, two contacts of at least four minutes on each of the first two revolutions and one contact of at least four minutes on the third revolution can be obtained. For 5° masking the same is true except for three minutes not four.

The requirement of one contact of four minutes above 5° elevation between 90 and 30 minutes before injection cannot be met for every azimuth in the 72° to 100° range. Changing to one contact of at least 3 minutes or to real masking would be satisfactory for all Pacific injections. For Atlantic injections the time limit would have to be changed to read 95 to 30 minutes or 90 to 25 minutes prior to injection.

The prime launch day for the Apollo 15 mission to Hadley and for the Apollo 16 mission to Descartes are used for illustration.

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MEMORANDUM FOR FILE

The current MSFN coverage requirements (Apollo Program Specification, Revision B, dated 4/7/70) are as follows:

1. Three minutes of tracking coverage after insertion into earth orbit.

2. Two contacts per revolution for the initial three earth revolutions of at least four minutes assuming 5° antenna masking.

3. One contact of four minutes above 5° elevation between 90 and 30 minutes before injection.

4. Partial coverage during the injection burn.

As discussed in the reference,* the first requirement can be met by proper placing of the insertion ship and the fourth requirement can be satisfied by using the Apollo Range Instrumentation Aircraft. The second and third requirements will be discussed here for launch azimuths from 72° to 100° for a 5° masking angle and for terrain masking around each MSFN station listed in Table I. The 5° masking information was obtained from the reference and the terrain masking from Mr. W. L. Austin of Department 1025. An orbital altitude of 90 nm was used.

The coverage contacts for the first three revolutions using a constant 5° elevation masking angle about each station (plus antenna keyhole affects) are shown in Table II by launch azimuth. Table III shows the same coverage using terrain masking.

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*"MSFN Coverage From Insertion Through Injection Burn for Apollo 15," J. P. Maloy, Bellcomm Memorandum for File, B70 12081, Case 320, December 30, 1970.

Figures 1-4 represent a graphical representation of Tables II and III (1st and 2nd opportunity injection for 5° masking and 1st and 2nd opportunity injection for terrain masking).

Second Requirement

The second requirement calls for two contacts of at least four minutes for each of the first three revolutions. Tables II and III show that this requirement is easily met for the first revolution using 5° masking and for both the first and second revolutions using terrain masking.

For 5° masking the requirement is not fulfilled on the second revolution for launch azimuths of 96° to 100°. For each azimuth, however, there are five contacts with at least three exceeding 3 minutes (one exceeds 4 minutes). On the third revolution for 5° masking there are at least two 4-minute contacts for launch azimuths of 72° to 84°, at least one 4-minute and one 3-minute contact on azimuths 86° through 96°, and a 3-minute and a 2-minute contact on azimuths 98° and 100°.

For terrain masking the requirement is not fulfilled on the third revolution for launch azimuths of 96° to 100°. For these azimuths there is one contact greater than 5 minutes and one greater than 2 minutes.

Third Requirement

The third requirement for one contact of at least four minutes between 90 and 30 minutes prior to injection is illustrated in Figure 5. Overlaying Figure 5 on Figures 1-4 gives the EOI to TLI times that have at least four minutes of coverage between 90 and 30 minutes prior to TLI for an azimuth range of 72-100° (see Table IV).

So far everything discussed has been mission independent. Table V lists the translunar injection times (measured from insertion) for the Apollo 15 mission to Hadley and a candidate mission for Apollo 16 (Descartes). Comparing Tables IV and V shows that the third MSFN coverage requirement is met for a 5° masking angle on first opportunity injection and for terrain masking on first and second opportunity for both Hadley and Descartes. The question remains as to what launch azimuths meet the third requirement for second opportunity injection using 5° masking. Figures 6 and 7 (derived from Figures 2 and 5 plus Table V) show that the missions to Hadley and Descartes meet the third requirement for launch azimuths of 72° to 95°. Descartes also meets the third requirement for a 100° launch azimuth.

Summary

The second requirement, two contacts of at least four minutes above 5° elevation for the first three revolutions, can only be fully met for launch azimuths of 72° to 84°. The requirement of two contacts on the third revolution is for the case where injection was not possible at the second opportunity. A modified requirement of two contacts of at least four minutes on the first two revolutions and one contact of at least four minutes on the third revolution could be met for all azimuths using terrain masking. Alternately, a requirement of two contacts of at least three minutes on the first two revolutions and one contact of at least three minutes on the third revolution can be met for all azimuths using 5° masking or terrain masking.

The third requirement, one contact of at least four minutes above 5° elevation between 90 and 30 minutes prior to injection, cannot be met for second opportunity for a launch azimuth range of 72° to 100°. Changing the requirement to read terrain masking instead of 5° masking would mean that there would be no problem satisfying the requirement for most missions. The same results could be achieved by changing the requirement to read one contact of at least three minutes. The missions still not meeting the requirement would be second opportunity Atlantic injection missions (for an example see Figure 8). For this type of mission the pre-injection checkout would have to occur 95 to 30 minutes or 90 to 25 minutes prior to injection.

S C Wynn

2013-SCW-jab

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Attachments

TABLE I

NETWORK

	STATION	SYMBOL	LATITUDE	LONGITUDE
1.	CANARY IS.	CYI	27.7644N	15.6347W
2.	ASCENSION	ACN	7.9547S	14.3272W
3.	CARNARVON	CRO	24.9066S	113.7255E
4.	GUAM	GWM	13.3106N	144.7369E
5.	HONEYSUCKLE	HSK	35.5837S	148.9783E
6.	HAWAII	HAW	22.1264N	159.6656E
7.	GOLDSTONE	GDS	35.3417N	116.8733W
8.	TEXAS	TEX	27.6539N	97.3783W
9.	MILA	MLA	28.5083N	80.6934W
10.	BDA	BDA	32.3506N	64.6581W

TABLE II

ORBITAL COVERAGE (MINUTES)

(5° MASKING)

LAUNCH AZ		72°		80°		84°		86°		90°		94°		96°		98°		100°	
		S* TART	LENGTH	START	LENGTH	START	LENGTH	START	LENGTH	START	LENGTH	START	LENGTH	START	LENGTH	START	LENGTH	START	LENGTH
REV 1	CYI	6.0	4.6	6.8	2.8	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	ACN	--	--	--	--	--	--	--	--	--	--	--	--	--	--	11.6	2.3	11.0	3.4
	CRO	42.1	2.5	41.5	4.0	41.4	4.4	41.4	4.5	41.3	4.6	41.3	4.6	41.3	4.6	41.3	4.5	41.4	4.3
	GWM	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	HSK	49.1	3.1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	HAW	--	--	--	--	--	--	68.1	1.1	66.7	3.6	66.2	4.4	66.1	4.6	66.1	4.6	66.1	4.5
	GDS	--	--	--	--	78.0	1.7	77.7	2.1	77.2	2.8	76.9	3.3	76.7	3.5	76.6	3.7	76.5	3.8
	TEX	80.5	4.5	80.5	4.6	80.6	4.6	80.6	4.6	80.6	4.7	80.6	4.7	80.6	4.7	80.6	4.7	80.6	4.7
	MLA	84.4	4.2	84.3	4.6	84.3	4.8	84.3	4.7	84.4	4.5	84.4	4.3	84.5	4.1	84.5	3.9	84.6	3.7
	BDA	87.7	4.7	88.0	4.1	88.4	3.2	88.7	2.5	--	--	--	--	--	--	--	--	--	--

*Start time given in minutes from insertion

TABLE II (CONTINUED)

ORBITAL COVERAGE (MINUTES)

(5° MASKING)

LAUNCH AZ	72°		80°		84°		86°		90°		94°		96°		98°		100°	
	S* TART	LENGTH	START	LENGTH	START	LENGTH	START	LENGTH	START	LENGTH	START	LENGTH	START	LENGTH	START	LENGTH	START	LENGTH
REV 2 CYI	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
ACN	--	--	--	--	--	--	104.5	2.3	103.5	4.1	103.2	4.6	103.2	4.5	103.4	4.2	103.7	3.6
CRO	134.7	3.4	134.2	4.6	134.3	4.5	134.4	4.3	134.7	3.5	135.6	1.4	--	--	--	--	--	--
GWM	--	--	--	--	--	--	--	--	--	--	--	--	146.9	2.3	146.2	3.5	145.8	4.1
HSK	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
HAW	160.1	2.7	159.2	4.3	159.0	4.6	159.0	4.6	159.0	4.5	159.3	4.2	159.4	3.8	159.7	3.4	160.0	2.9
GDS	169.6	4.1	169.7	3.6	169.7	3.4	169.7	3.2	169.7	3.0	169.8	2.6	169.8	2.4	169.8	2.3	169.9	2.0
TEX	173.7	3.9	173.5	4.6	173.5	4.7	173.5	4.6	173.5	4.5	173.7	4.1	173.7	3.9	173.9	3.5	174.0	3.1
MLA	177.3	4.4	177.2	4.6	177.4	4.1	177.6	3.6	178.3	2.0	--	--	--	--	--	--	--	--
BDA	180.6	4.2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

*Start time given in minutes from insertion

TABLE II (CONTINUED)

ORBITAL COVERAGE (MINUTES)

(5° MASKING)

LAUNCH AZ	72°		80°		84°		86°		90°		94°		96°		98°		100°	
	S*TART	LENGTH	START	LENGTH	START	LENGTH	START	LENGTH	START	LENGTH	START	LENGTH	START	LENGTH	START	LENGTH	START	LENGTH
REV 3 CYI	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
ACN	197.7	1.7	196.2	4.5	196.2	4.5	196.3	4.3	196.9	3.0	--	--	--	--	--	--	--	--
CRO	227.0	4.6	227.7	3.1	--	--	--	--	--	--	--	--	--	--	--	--	--	--
GWM	--	--	--	--	239.8	2.3	239.1	3.4	238.6	4.4	238.4	4.6	238.6	4.4	238.8	3.9	239.1	3.2
HSK	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
HAW	251.8	4.5	252.2	4.2	252.3	4.0	252.5	3.8	252.7	3.5	253.0	3.1	253.2	2.9	253.4	2.6	253.6	2.4
GDS	261.9	4.5	262.4	3.4	262.9	2.1	--	--	--	--	--	--	--	--	--	--	--	--
TEX	266.4	4.4	266.4	4.5	266.7	3.8	267.0	3.1	--	--	--	--	--	--	--	--	--	--
MLA	269.9	4.5	271.5	1.2	--	--	--	--	--	--	--	--	--	--	--	--	--	--
BDA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

*Start time given in minutes from insertion

TABLE III

ORBITAL COVERAGE (MINUTES)

(TERRAIN MASKING)

LAUNCH AZ		72°		76°		80°		84°		88°		92°		96°		98°		100°	
		START*	LENGTH	START	LENGTH	START	LENGTH	START	LENGTH	START	LENGTH	START	LENGTH	START	LENGTH	START	LENGTH	START	LENGTH
REV 1	CYI	4.9	6.45	5.0	6.18	5.3	4.65	5.0	2.68	---	---	---	---	---	---	---	---	---	---
	ACN	---	---	---	---	---	---	---	---	---	---	---	---	11.4	2.74	11.5	3.19	11.6	3.46
	CRO	40.6	4.67	40.4	5.13	40.3	5.47	40.3	5.69	40.2	5.84	40.2	5.89	40.2	5.86	40.3	5.81	40.3	5.75
	GWM	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	HSK	48.4	4.39	49.1	2.34	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	HAW	---	---	---	---	---	---	67.6	2.17	65.8	4.40	65.6	5.39	65.2	5.84	65.6	5.39	65.1	6.05
	GDS	---	---	---	---	77.8	1.39	77.1	2.22	76.6	3.30	76.3	3.70	76.1	3.94	76.0	4.07	75.6	4.47
	TEX	79.3	6.22	79.3	6.24	79.3	6.25	79.3	6.26	79.3	6.28	79.3	6.28	79.3	6.28	79.3	6.28	79.3	6.29
	MLA	83.2	5.87	83.2	6.02	83.2	6.11	83.1	6.13	83.1	6.09	83.2	5.98	83.2	5.80	83.2	5.60	83.3	5.54
	BDA	86.9	6.32	86.9	6.22	87.0	5.92	87.2	5.37	87.5	2.57	88.1	2.03	---	---	---	---	---	---

*Start time given in minutes from insertion.

TABLE III (CONTINUED)

ORBITAL COVERAGE (MINUTES)

(TERRAIN MASKING)

LAUNCH AZ		72°		76°		80°		84°		88°		92°		96°		98°		100°	
		S* TART	LENGTH	START	LENGTH	START	LENGTH	START	LENGTH	START	LENGTH	START	LENGTH	START	LENGTH	START	LENGTH	START	LENGTH
REV 2	CYI	98.2	3.43	99.9	1.07	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	ACN	---	---	---	---	---	---	104.2	2.73	102.9	4.92	102.7	5.45	102.8	4.62	103.7	4.36	103.2	4.76
	CRO	133.4	5.04	133.1	5.64	133.0	5.88	133.0	5.87	133.2	5.57	133.4	3.22	134.0	2.65	134.4	2.31	135.3	.91
	GWM	---	---	---	---	---	---	---	---	---	---	146.6	1.68	146.6	3.21	144.8	5.27	144.5	5.75
	HSK	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	HAW	160.1	3.09	158.4	5.33	158.3	5.49	158.0	5.81	158.4	5.36	158.0	5.89	158.2	4.82	158.3	4.70	158.8	4.21
	GDS	168.9	4.36	168.9	4.09	168.9	3.99	168.9	3.89	168.9	3.49	168.9	3.24	168.9	3.14	168.9	3.09	168.9	2.72
	TEX	172.2	5.80	172.1	6.07	172.1	6.24	172.1	6.30	172.1	6.24	172.1	6.08	172.2	5.82	172.2	5.63	172.3	5.43
	MLA	176.0	5.93	175.9	6.13	175.9	6.08	176.0	5.79	176.2	4.99	176.6	2.75	177.4	2.02	---	---	---	---
	BDA	179.5	6.03	179.8	5.29	180.5	2.37	---	---	---	---	---	---	---	---	---	---	---	---

*Start time given in minutes from insertion.

TABLE III (CONTINUED)

ORBITAL COVERAGE (MINUTES)

(TERRAIN MASKING)

LAUNCH AZ		72°		76°		80°		84°		88°		92°		96°		98°		100°	
		START*	LENGTH	START	LENGTH	START	LENGTH	START	LENGTH	START	LENGTH	START	LENGTH	START	LENGTH	START	LENGTH	START	LENGTH
REV 3	CYI	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	ACN	197.0	3.24	195.6	5.15	195.5	5.49	196.3	4.63	195.9	4.87	196.6	2.03	198.0	.78	---	---	---	---
	CRO	225.7	5.91	225.8	5.79	226.1	5.18	226.8	2.65	---	---	---	---	---	---	---	---	---	---
	GWM	---	---	---	---	239.3	2.03	239.3	3.19	237.3	5.66	237.3	5.90	237.5	5.68	237.6	5.55	237.8	5.11
	HSK	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	HAW	250.7	5.37	250.7	5.21	250.9	4.94	251.0	4.83	251.1	4.71	251.5	4.26	254.7	2.65	253.1	2.66	253.4	2.3[illegible]
	GDS	261.8	4.08	261.4	4.20	261.4	3.85	261.7	3.11	262.0	1.77	---	---	---	---	---	---	---	---
	TEX	264.9	6.09	264.8	6.30	264.8	6.21	265.0	5.79	265.3	3.30	265.9	2.75	---	---	---	---	---	---
	MLA	268.5	6.10	268.7	5.61	269.2	4.64	270.3	1.94	---	---	---	---	---	---	---	---	---	---
	BDA	273.4	2.21	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

*Start time given in minutes from insertion.

TABLE IV

EOI TO TLI TIMES THAT HAVE FOUR MINUTES OF COVERAGE BETWEEN 90 TO 30 MINUTES PRIOR TO TLI FOR AN AZIMUTH RANGE OF 72 TO 100° AND THE MSFN STATION(S) THAT PROVIDE THE COVERAGE

Type of Masking	Opportunity	EOI to TLI Times That Have Four Minutes of Coverage Between 90 to 30 Minutes Prior to TLI for all Azimuths in the Range of 72 - 100°	MSFN Station(s) That Provide the Coverage
5°	1st	111 to 170 hours	TEX
	2nd	---	---
Terrain	1st	109 to 169 hours	TEX
		164 to 193 hours	ACN, CRO
	2nd	189 to 223 hours	CRO, HAW
		202 to 262 hours	TEX
		268 to 285 hours	ACN, CRO, GWM

TABLE V

TRANSLUNAR INJECTION TIMES (MEASURED FROM INSERTION IN MINUTES)

Launch Azimuth	Hadley 7/26/71 1st Opportunity	Hadley 7/26/71 2nd Opportunity	Descartes 3/17/72 1st Opportunity	Descartes 3/17/72 2nd Opportunity
72°	163.2	251.0	141.7	229.5
80°	161.2	249.0	136.7	224.5
84°	159.9	247.7	134.1	221.9
86°	159.0	246.8	132.9	220.7
90°	157.4	245.2	130.8	218.6
94°	155.6	243.4	129.4	217.2
96°	154.6	242.4	128.8	216.6
98°	153.7	241.5	128.4	216.2
100°	152.7	240.5	128.1	215.9

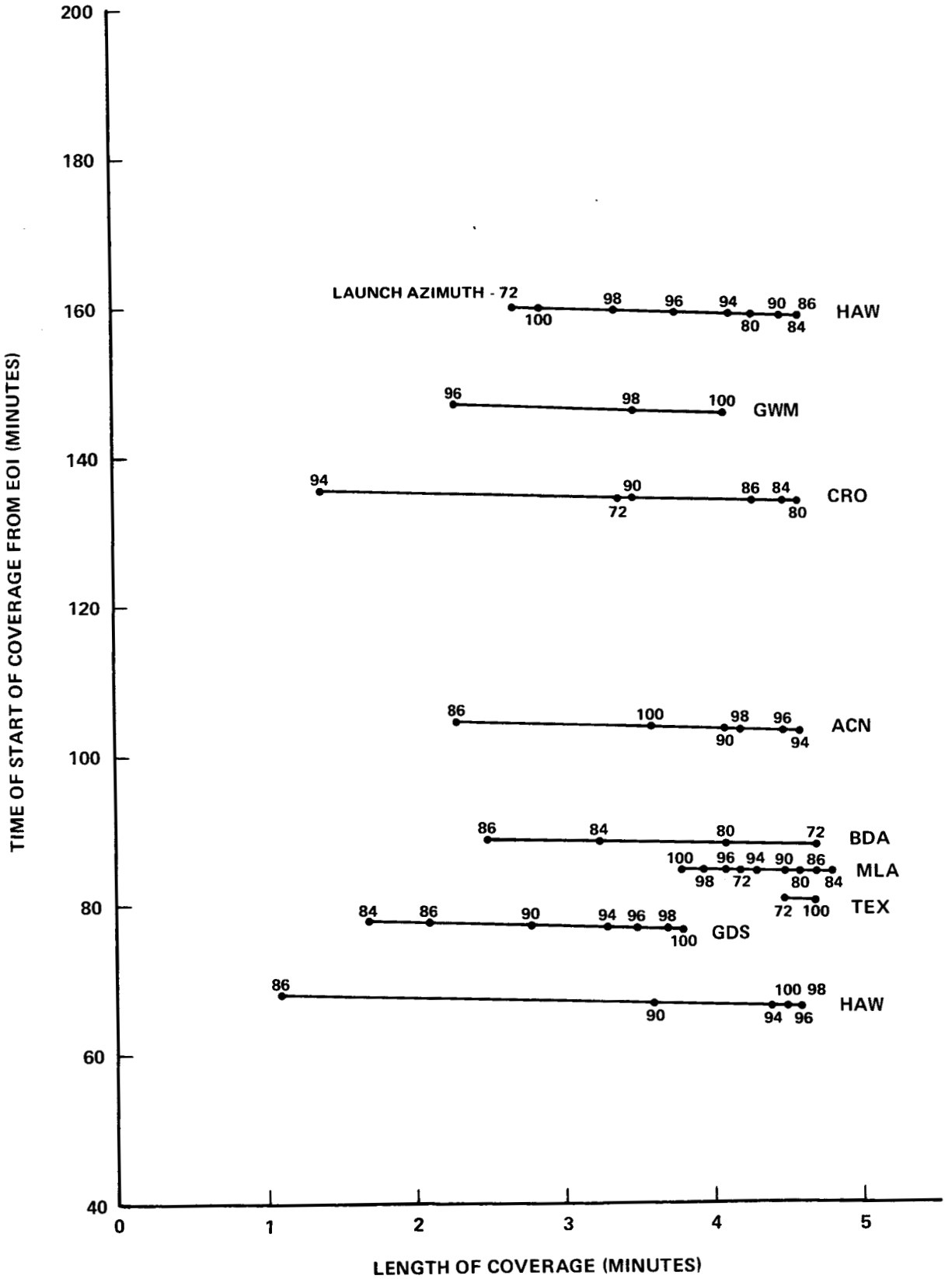

FIGURE 1 - STATION COVERAGE SUMMARY FOR 1ST OPPORTUNITY (5° MASKING) FOR LAUNCH AZIMUTHS OF 72 TO 100°

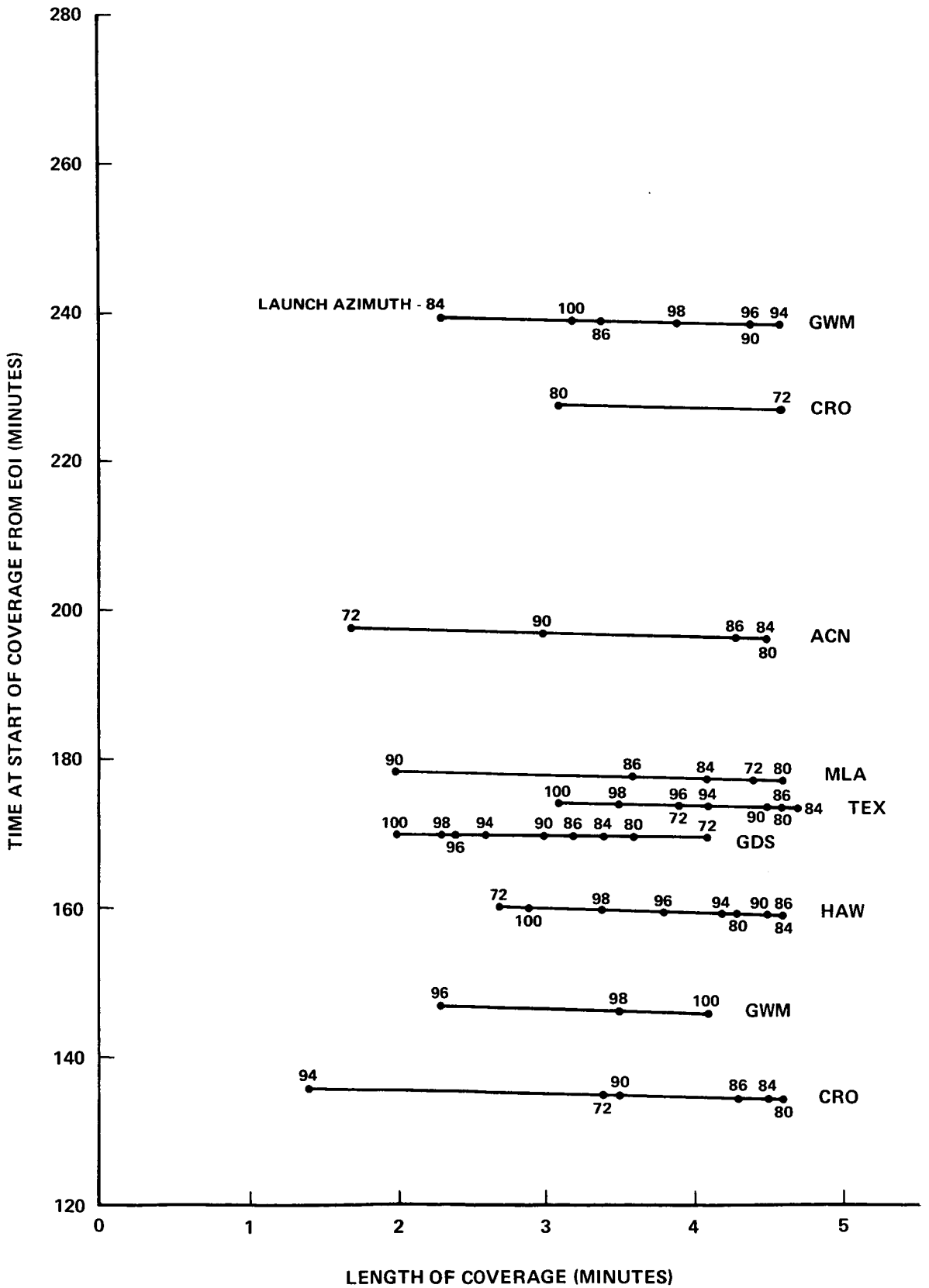

FIGURE 2 - STATION COVERAGE SUMMARY FOR 2ND OPPORTUNITY (5° MASKING) FOR LAUNCH AZIMUTHS OF 72 TO 100°

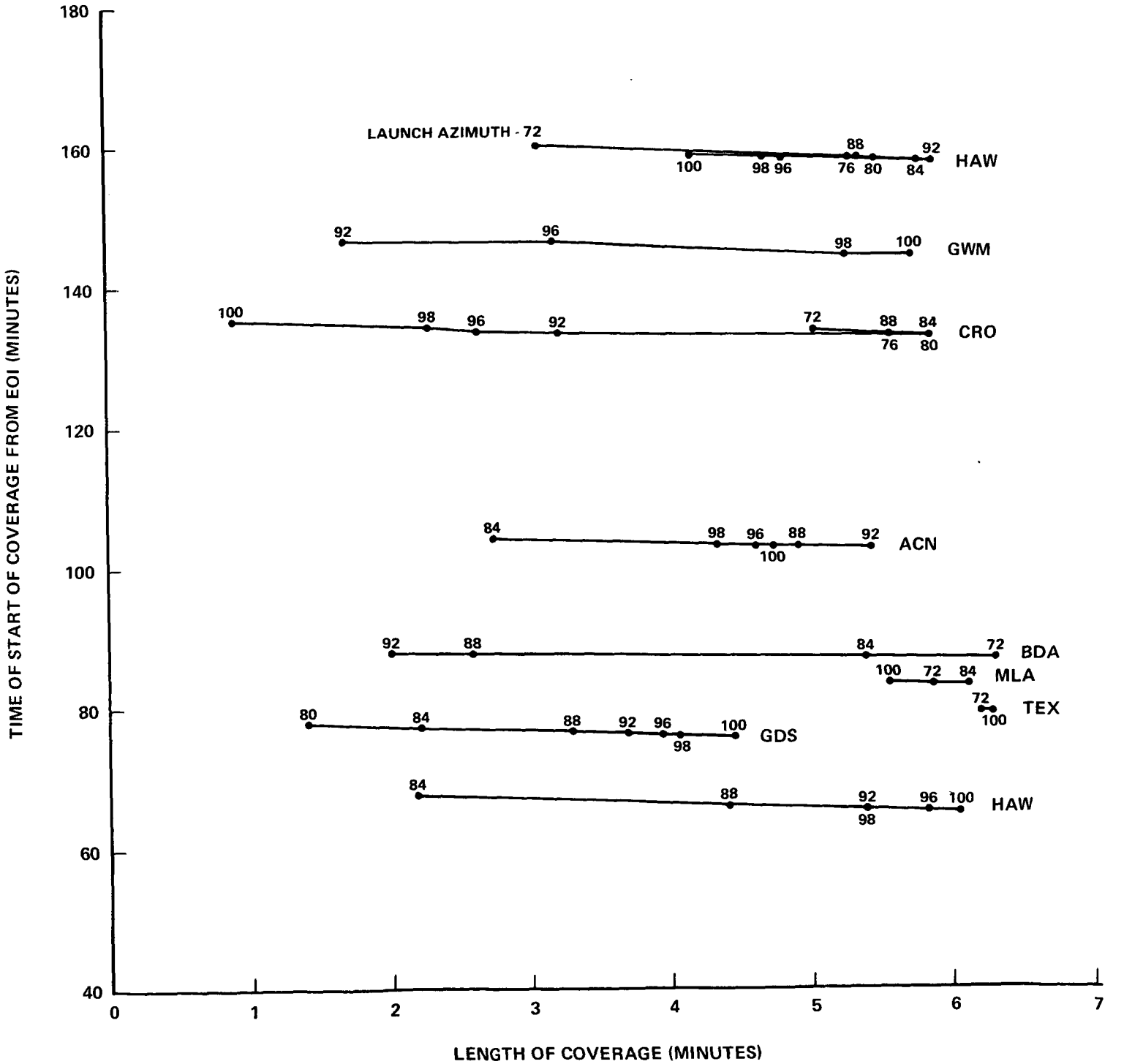

FIGURE 3 - STATION COVERAGE SUMMARY FOR 1ST OPPORTUNITY (TERRAIN MASKING) FOR LAUNCH AZIMUTHS OF 72 TO 100°

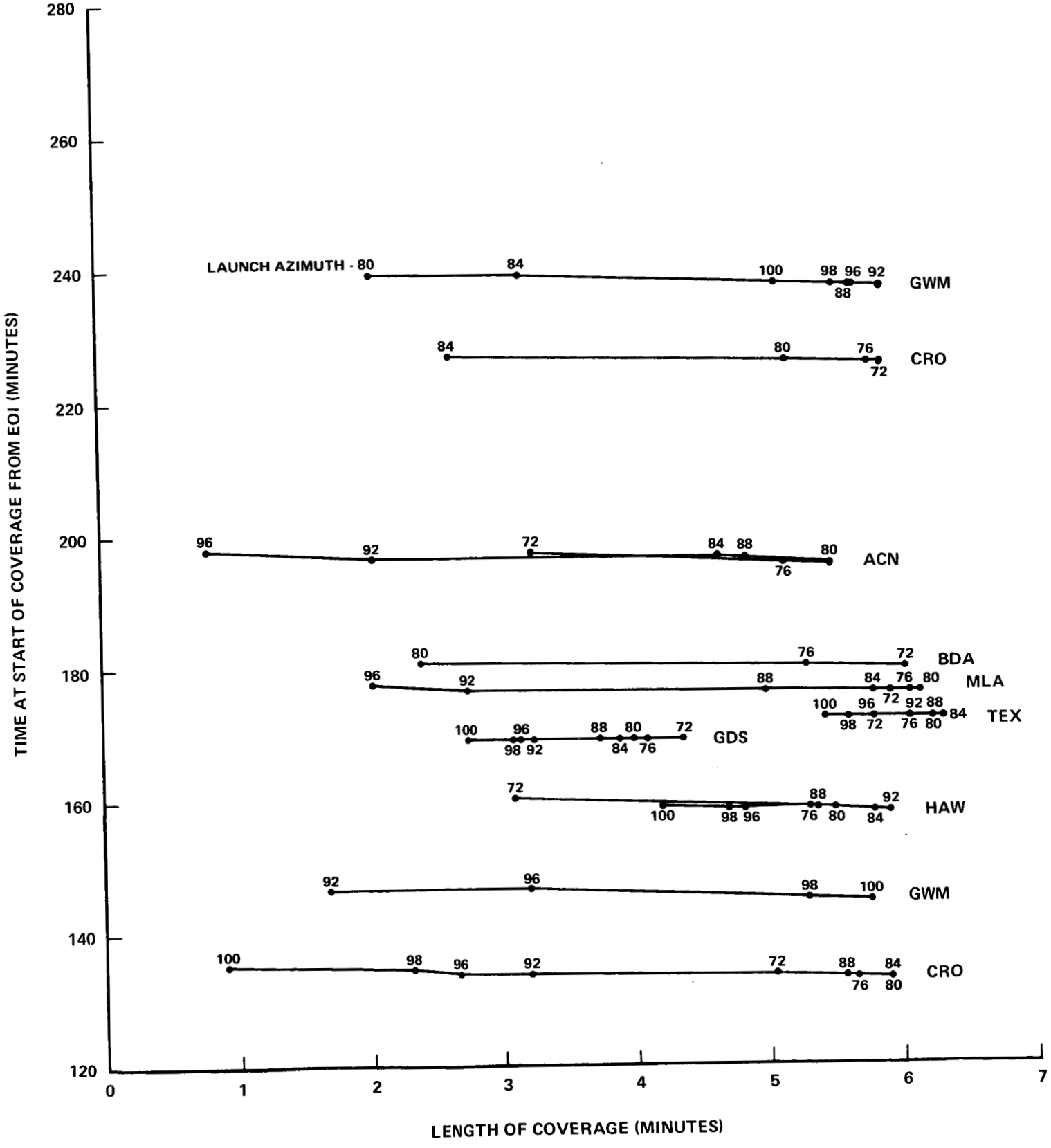

FIGURE 4 - STATION COVERAGE SUMMARY FOR 2ND OPPORTUNITY (TERRAIN MASKING) FOR LAUNCH AZIMUTHS OF 72 TO 100°

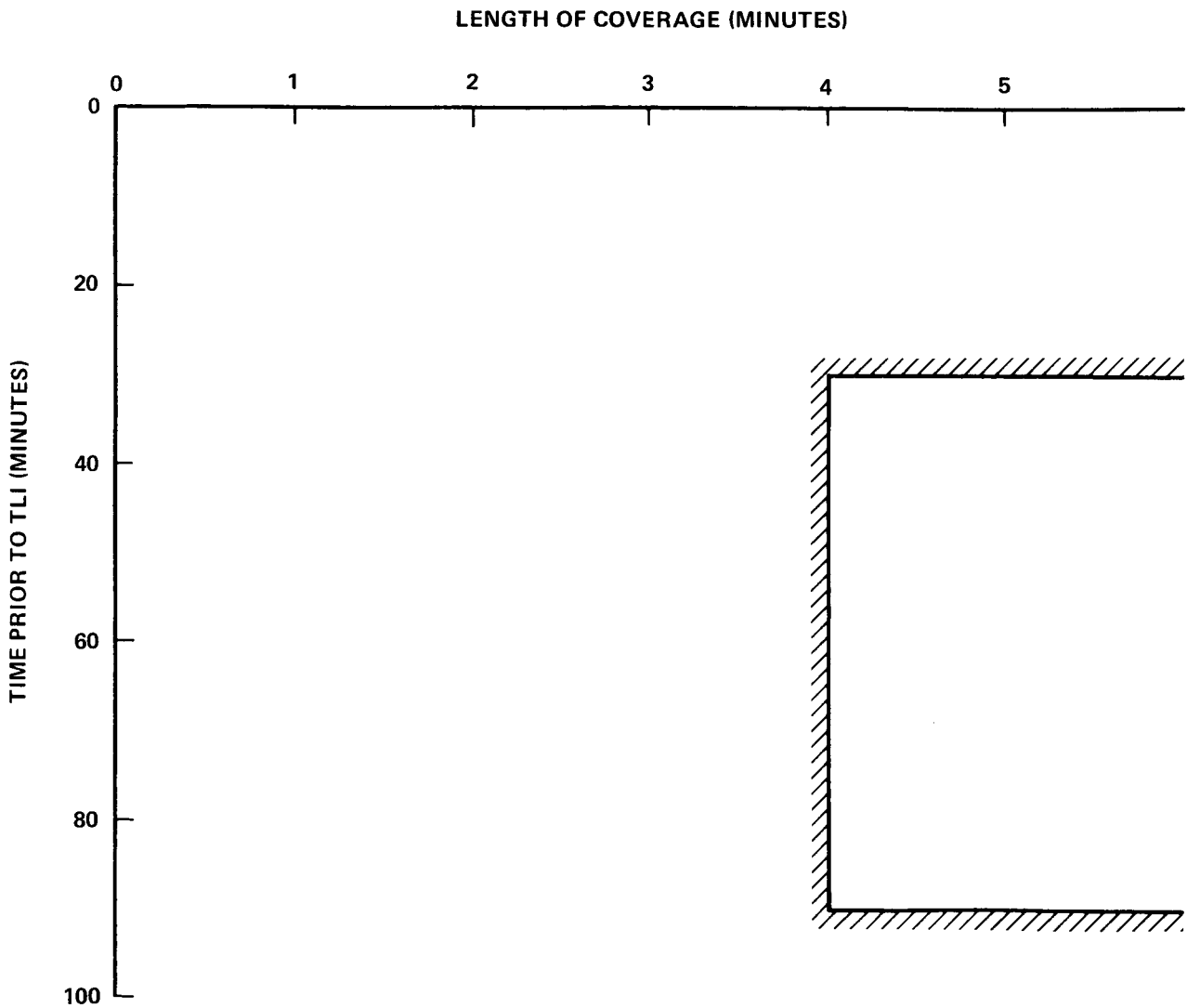

FIGURE 5 - MSFN COVERAGE REQUIREMENT OF ONE CONTACT OF AT LEAST FOUR MINUTES BETWEEN NINETY AND THIRTY MINUTES PRIOR TO TLI

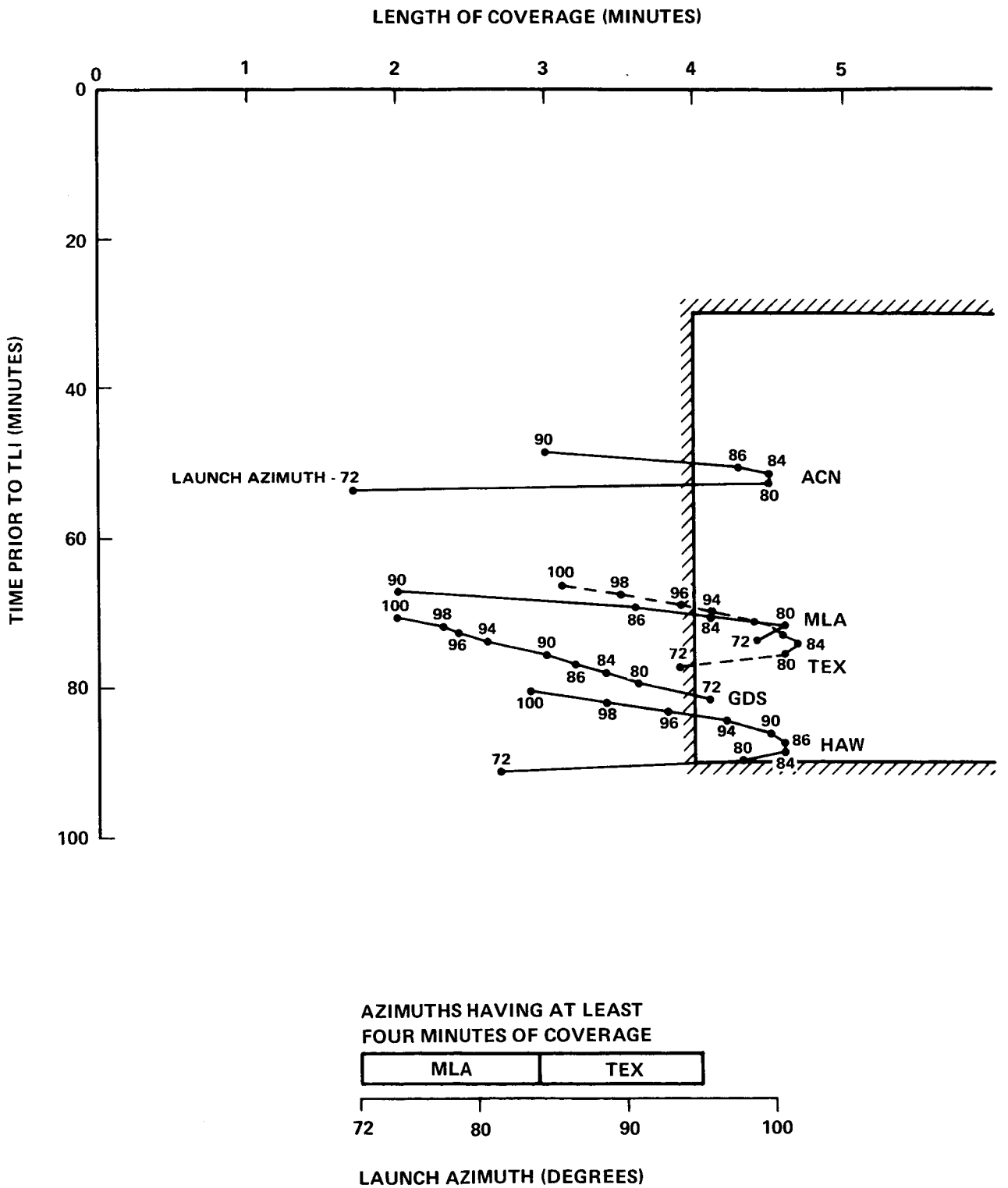

FIGURE 6 - HADLEY 7/26/71 LAUNCH – 2ND OPPORTUNITY (5° MASKING)
FOR LAUNCH AZIMUTHS OF 72 TO 100°

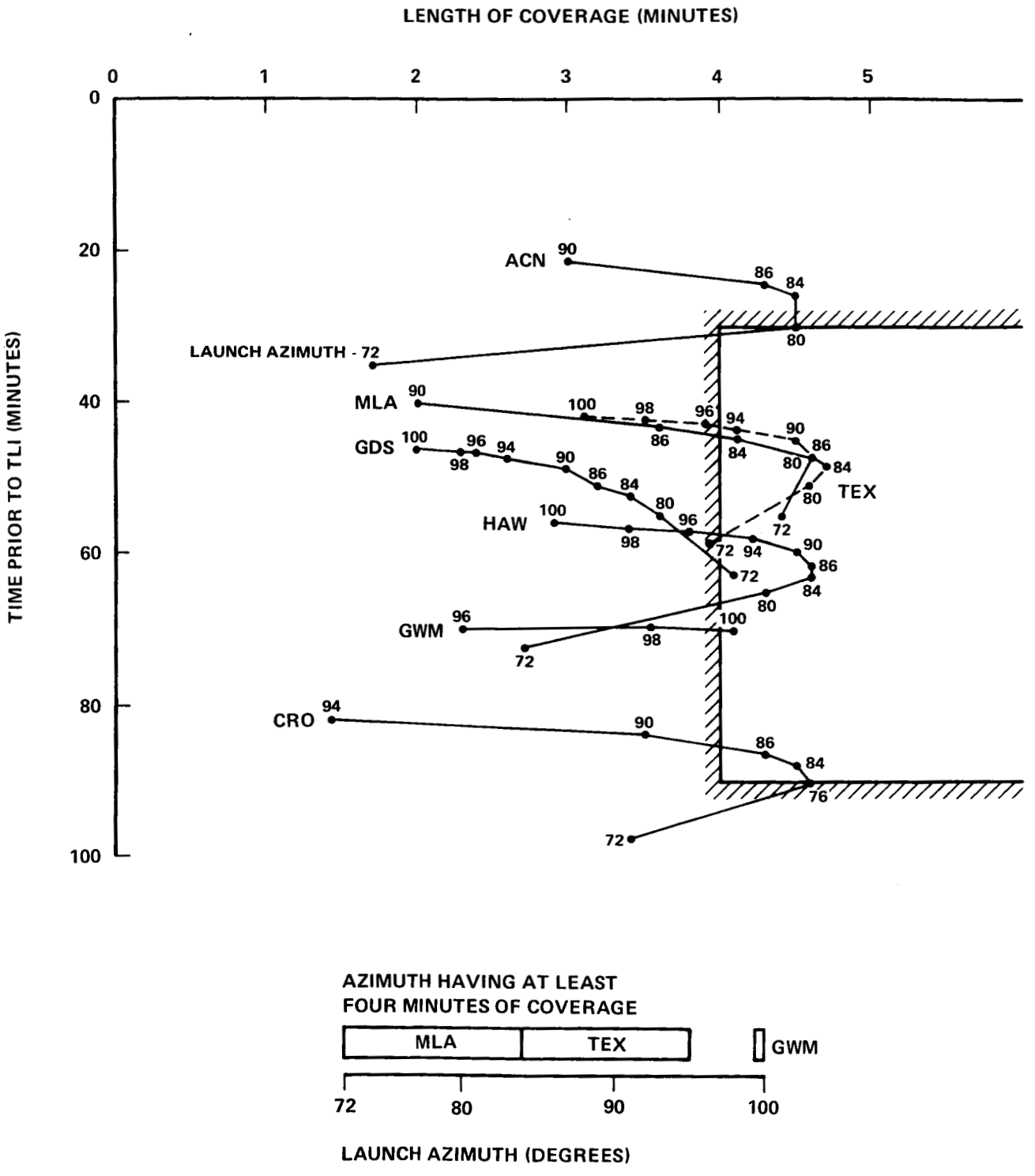

FIGURE 7 - DESCARTES 3/17/72 LAUNCH – 2ND OPPORTUNITY (5° MASKING)
FOR LAUNCH AZIMUTHS OF 72 TO 100°

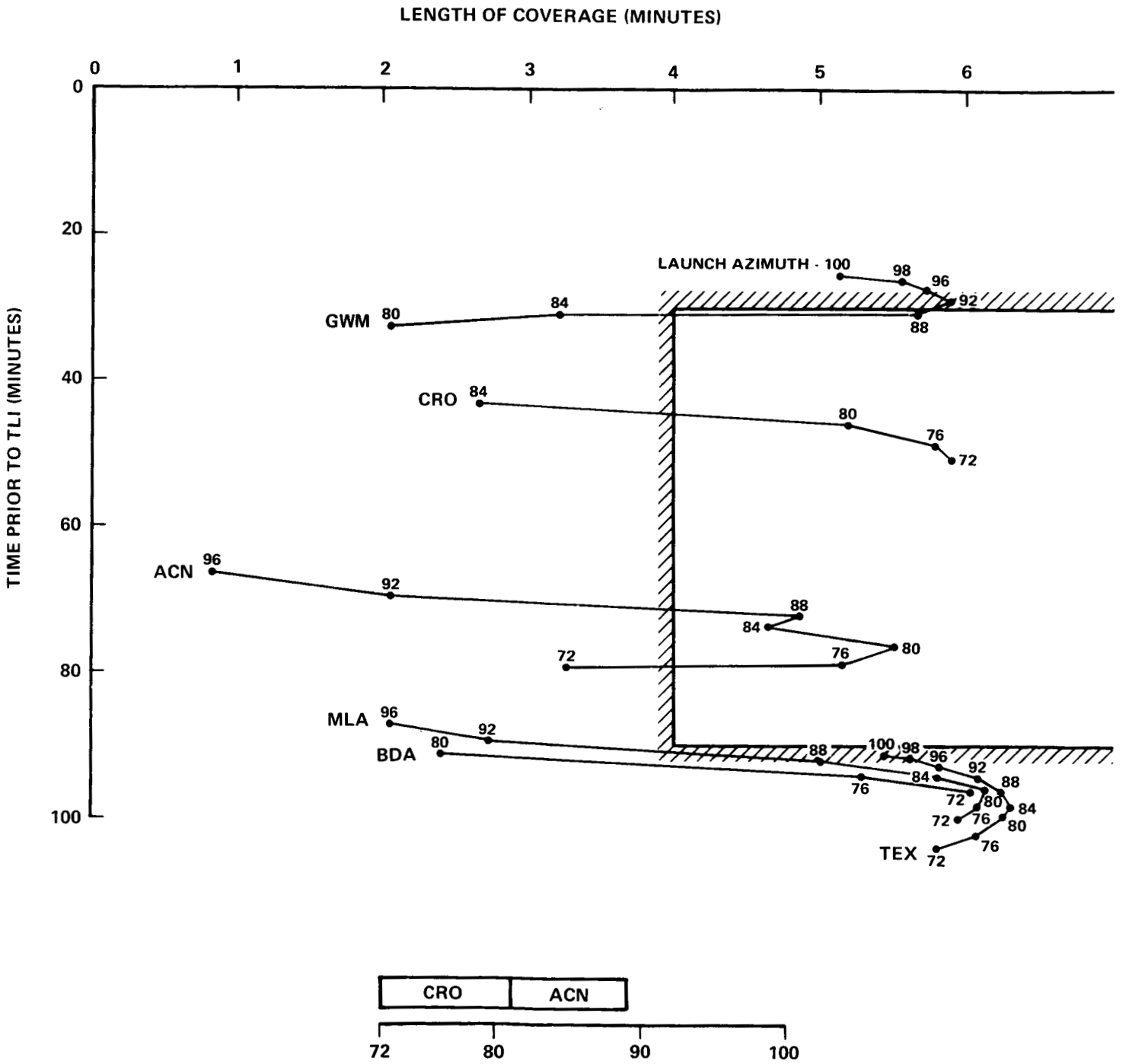

FIGURE 8 - HADLEY 10/23/71 LAUNCH – 2ND OPPORTUNITY ATLANTIC INJECTION (TERRAIN MASKING) FOR LAUNCH AZIMUTHS OF 72 TO 100°