BELLCOMM, INC.
955 L'ENFANT PLAZA NORTH, S.W. WASHINGTON, D.C. 20024

SUBJECT: APO Briefing September 24, 1969
Precision of Consumables Estimates
For Apollo - Case 320

DATE: September 24, 1969

FROM: S. S. Fineblum

[redacted]

To Distribution:

The subject briefing was presented today at the 8:30 APO meeting. Data on the demonstrated precision of Apollo consumables estimates were compiled as a guide to mission planning and consumable storage changes. The last pre-flight estimates as presented by MPAD in the consumables portion of the spacecraft operational trajectory documents were compared with the MSC Mission Evaluation Team's post-flight reports.

In general, consumables estimation precision:

a) improved with each succeeding mission,

b) was greater for larger quantities than with smaller quantities,

c) the LM with fewer missions has not yet equaled that of the CSM with more missions.

The differences between predicted and actual consumption, although small, have been generally identified as the consequences of mission changes or system anomalies.

In response to a question by Mr. Stoney, it was noted that the excess of the used DPS propellants over predicted was less than that allowed for dispersions and biases. The available propellant after the landing was 131 pounds greater than the planned-for margin.

Future missions, therefore, may be planned and tankage may be modified with confidence in the precision of the estimates for spacecraft consumables. Briefing charts are attached.

S. S. Fineblum

2031-SSF-jct

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Attachments

(NASA-CR-106877) APO BRIEFING, 24 SEPTEMBER 1969 PRECISION OF CONSUMABLES ESTIMATES FOR APOLLO (Bellcomm, Inc.) 18 p

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PRECISION OF CONSUMABLES PREDICTION

- IMPROVED WITH
  - MISSION EXPERIENCE
  - NOMINAL MASS
- DEGRADED WITH IDENTIFIED CAUSES
  - MISSION
  - SYSTEM

TOTAL CONSUMABLE MASS

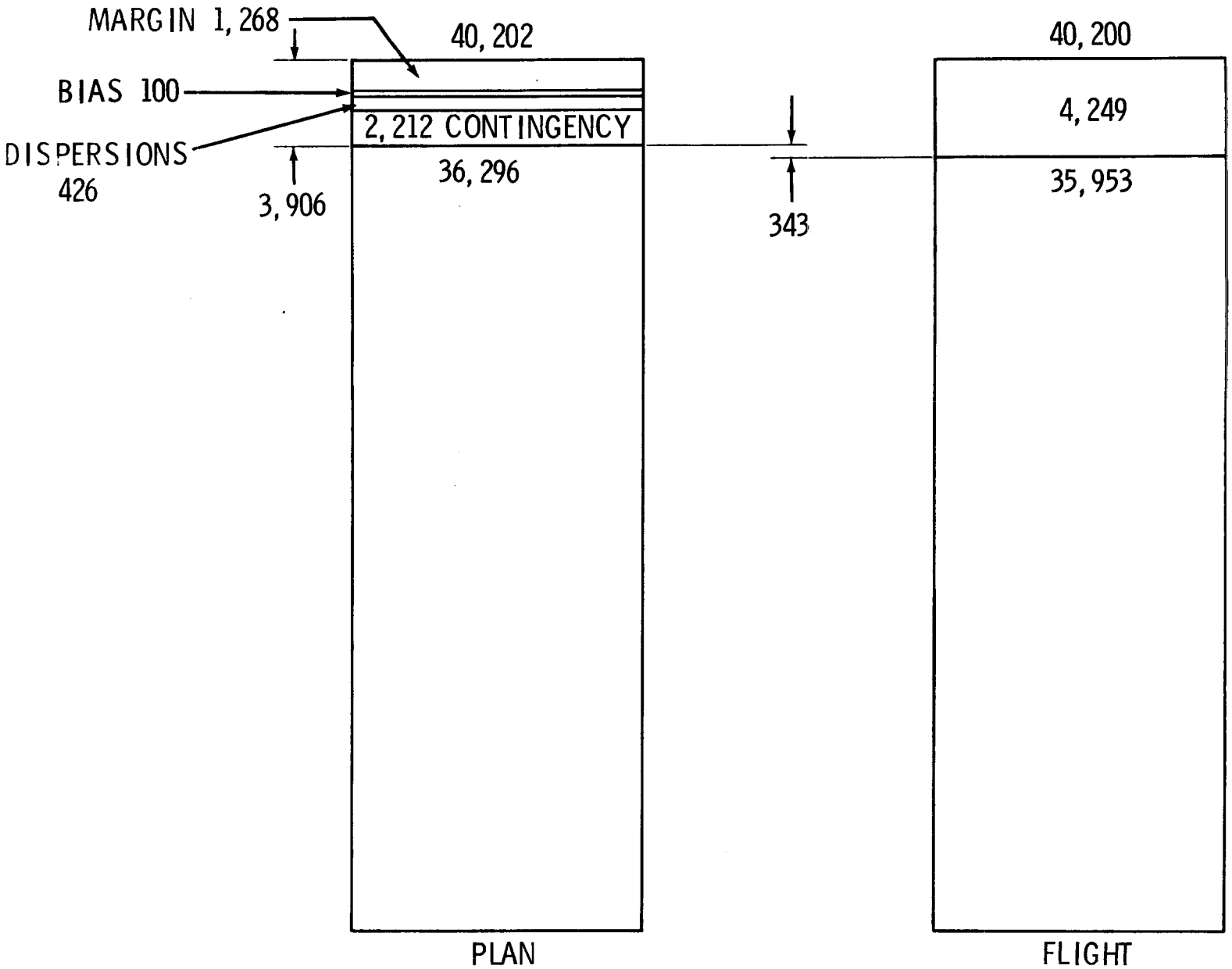
NOMINAL

ALLOWANCE FOR MISSION CONTINGENCIES

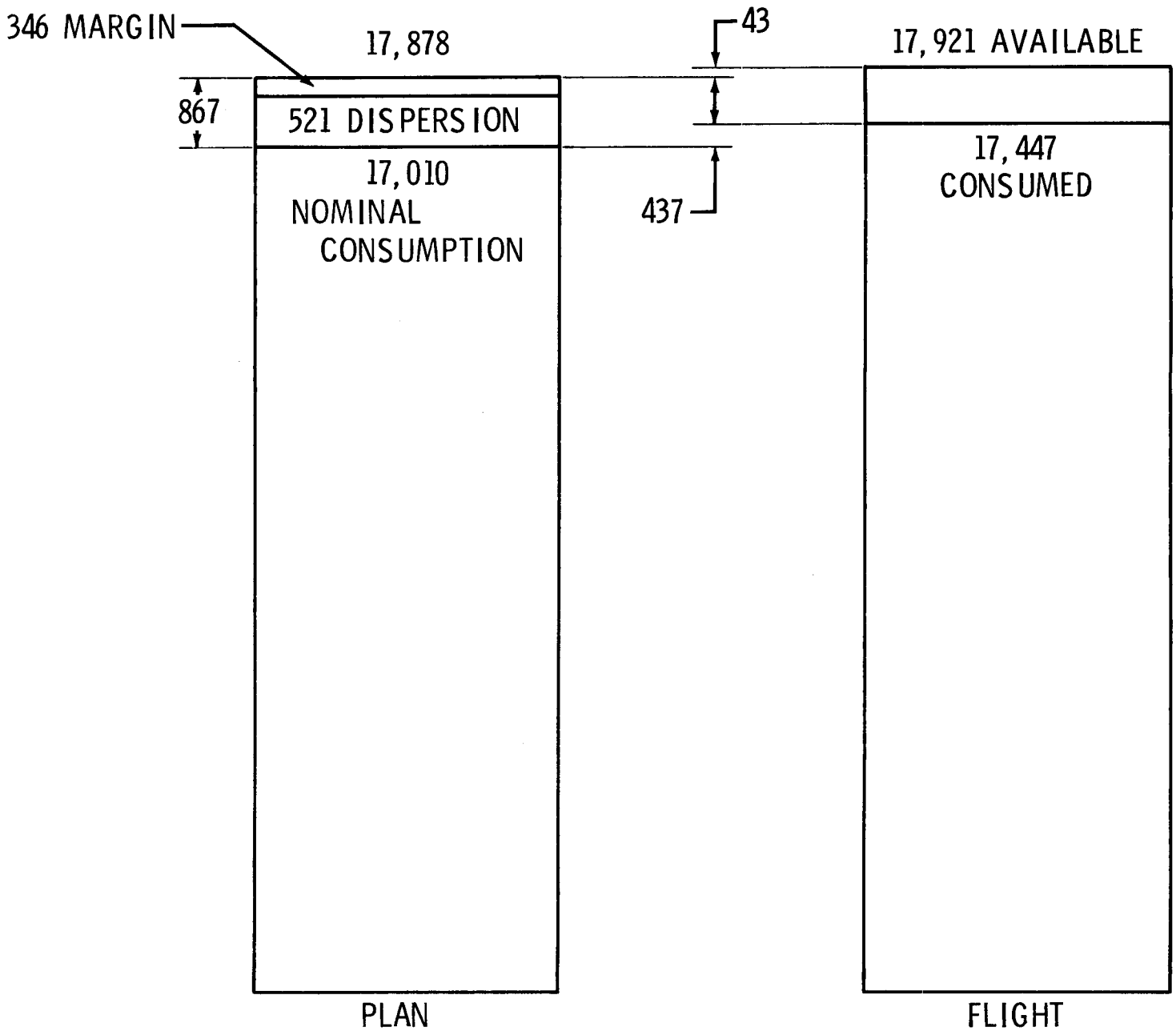
ALLOWANCE FOR DISPERSIONS & BIASES

ALLOWANCE FOR LOSSES & TRAPPED

SPS PROPELLANTS



LM DESCENT PROPELLANT



PRECISION OF CONSUMABLES

$$\Delta C = \text{PREDICTED} - \text{USED}$$

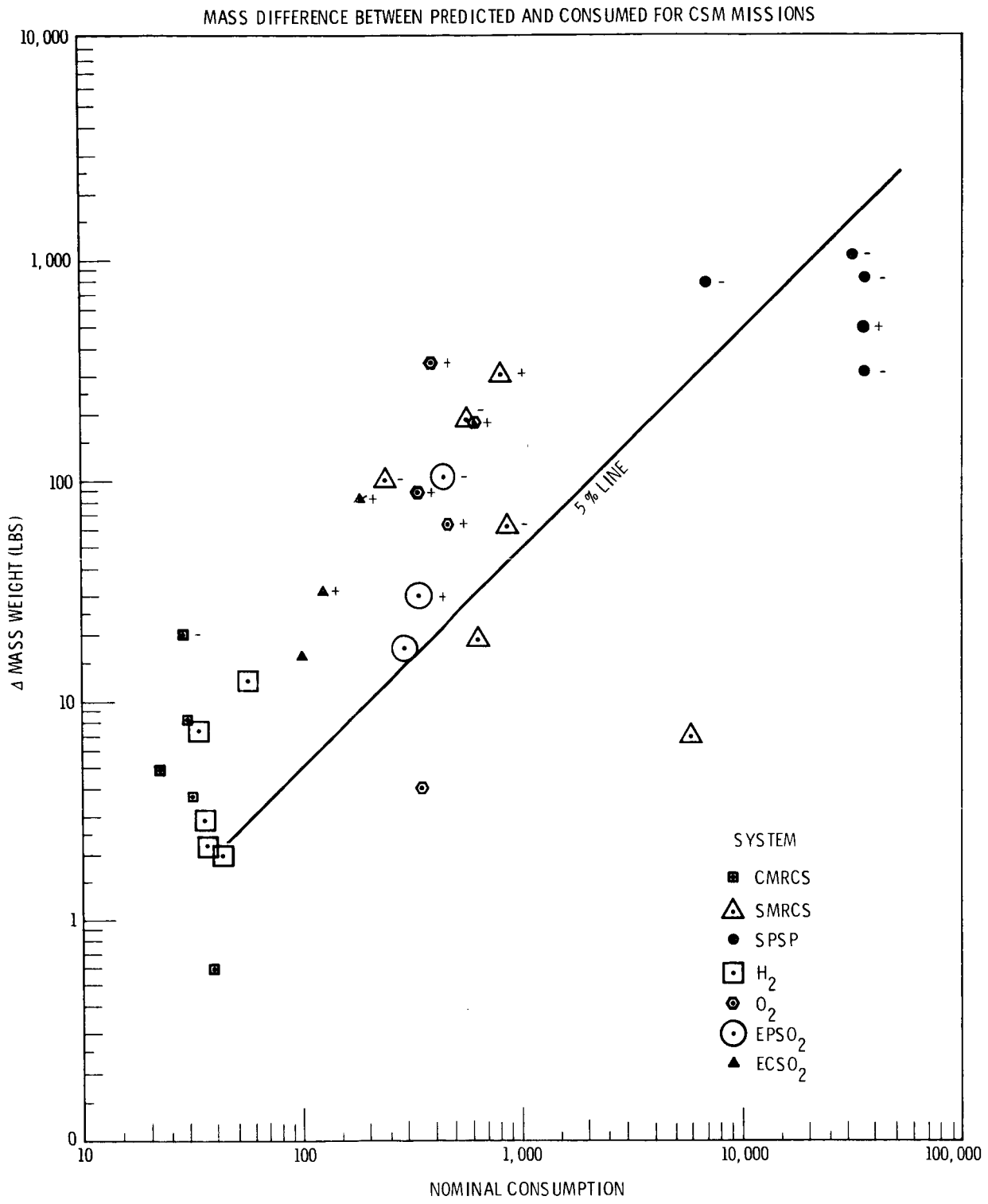
$$= f\,(\text{PREDICTED VS ACTUAL MISSION}) + \text{USAGE RATE SURPRISES}$$

$$\% = \frac{\Delta C}{\text{PREDICTED}} \; 100$$

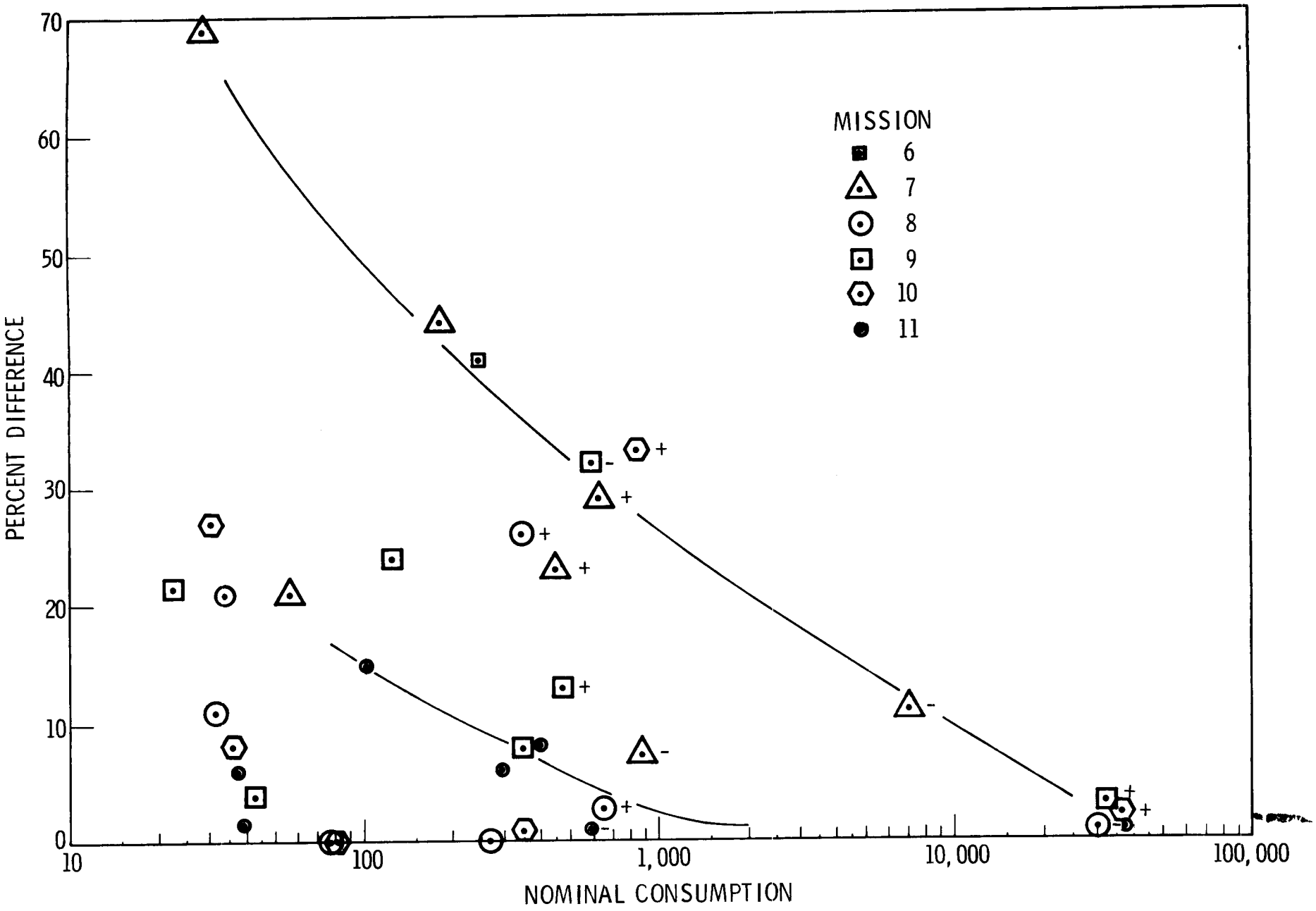
CSM CONSUMABLES, PREDICTED VERUS USED

MISSION		CMRCS	SMRCS	SPSP	H_2	O_2	$EPSO_2$	$ECSO_2$
6	P		245					
	U		345					
	ΔC		-100					
	%		-40.8					
7	P	29	880.4	7,031.5	57.1	640.7	453.0	187
	U	49.1	943.8	7,811.1	44.7	454.2	350.15	104
	ΔC	-20.1	-63.4	779.6	+12.4	+186.5	+107.15	+83
	%	- 69	-7.2	-11%	+ 21	+29	+23%	+44%
8	P	31.6	653.4	30,778.9	34.0	346		
	U	35.3	634.5	30,460.5	26.6	254.4		
	ΔC	-3.7	+18.9	+318.4	+7.4	92.4		
	%	-11	+2.9	+1.0%	+21%	+ 26		
9	P	22.6	597.3	32,494	43.5	475.3	346.5	128.8
	U	27.5	789	33,558	41.5	413.1	316.0	97.1
	ΔC	-4.9	-192	-1,064	+2.0	+62.2	+30.5	+31.7
	%	-21.6	- 32.1	3.2%	+ 4	+ 13%	8%	+24%
10	P	30.8	862.5	36,436	35.9	352.0		
	U	49.15	580	37,254	38.8	347.9		
	ΔC	-8.35	+282.5	-818	-2.9	+4.1		
	%	-29.9	+33.0	-2.25	-8%	+1.1		
11	P	39.3	596	36,296	37.0	397.5	296	101.5
	U	40.7	603	35,953	34.8	363.5	278.2	85.3
	ΔC	-0.6	- 7	+ 343	+2.2	+340	+17.8	+16.2
	%	-1.5%	-1.19	+ .8%	+5.95	+8%	+6%	+15%

P = PREDICTED, U = USED, ΔC = P-U


MASS DIFFERENCE BETWEEN PREDICTED AND CONSUMED FOR CSM MISSIONS
10,000
1,000
100
10
1
0
Δ MASS WEIGHT (LBS)
10
100
1,000
10,000
100,000
NOMINAL CONSUMPTION
5% LINE
SYSTEM
CMRCS
SMRCS
SPSP
H_2
O_2
$EPSO_2$
$ECSO_2$

VARIATION OF DIFFERENCE BETWEEN PREDICTED AND CONSUMED FOR CSM MISSIONS

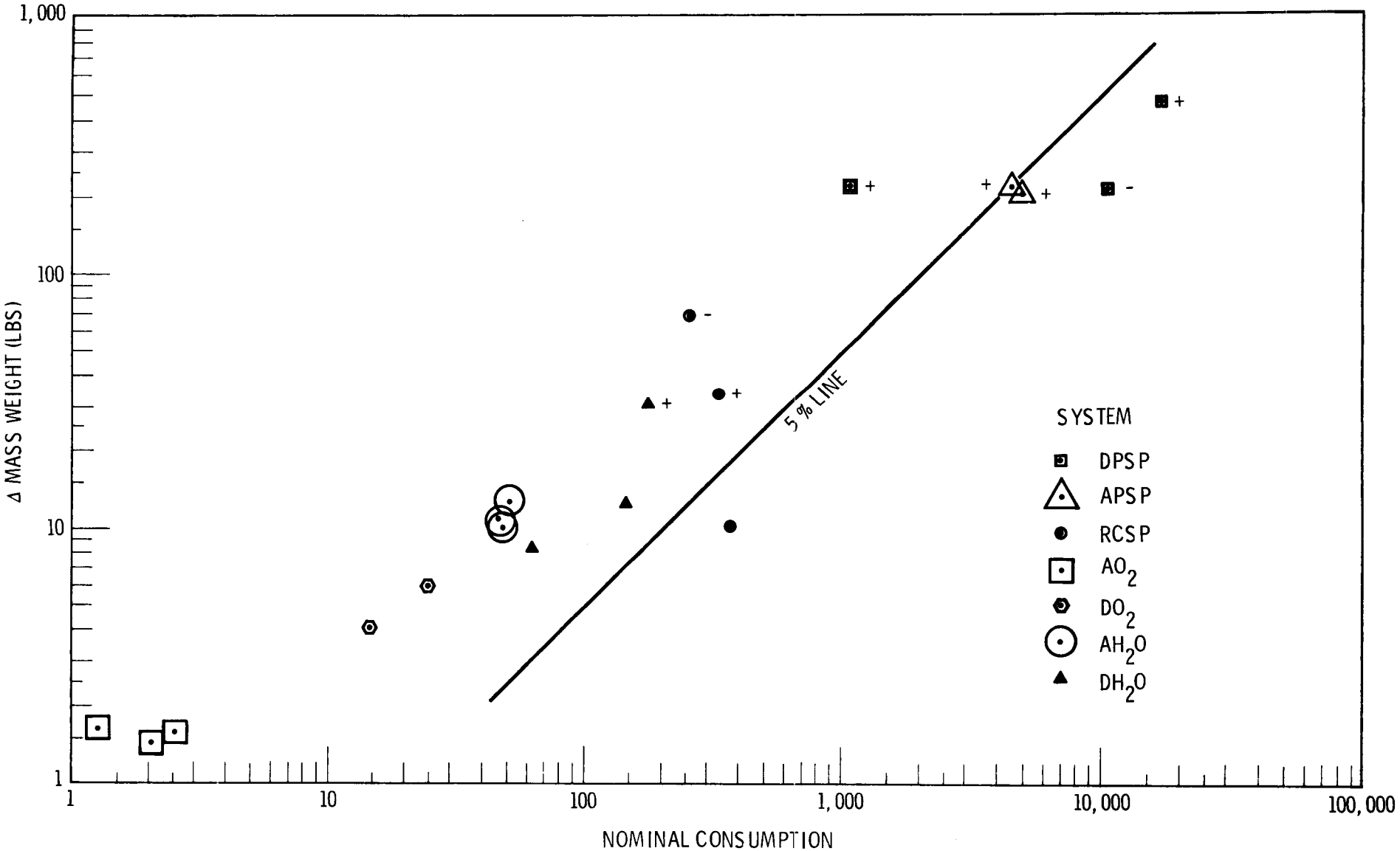


LM CONSUMABLES. PREDICTED VERUS USED

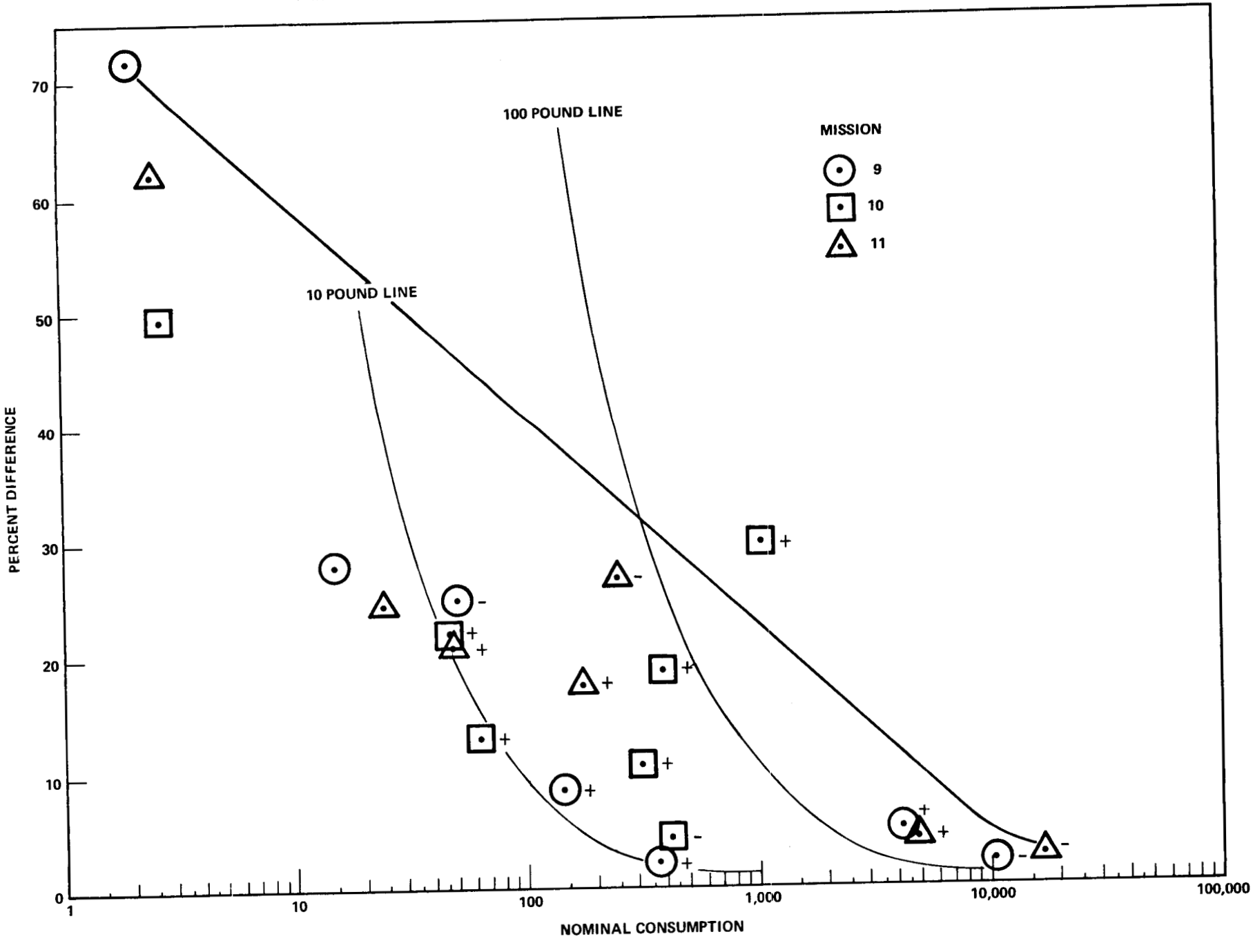
MISSION		DPSP	APSP	RCSP	AO_2	DO_2	AH_2O	DH_2O	ABAH	DBAH
9	P	10,461	4,294.1	377.4	2.03	14.93	51.21	147.6		
	U	10.671	4,082	367.0	.58	19.08	64.0	135.2		
	ΔC	-210	+212.1	-10	+1.45	-4.15	-12.8	+12.4		
	%	2.01	+4.94	+2.14	+71.4	-27.8	-24.8	+8.4		
10										
	P	1,076.0		318.2	1.27		47.67	63.75	391	423
	U	759		285.0	.64		37.30	55.40	318	440
	ΔC	+317.0		+33.2	+.63		+10.37	+8.35	+73	-17
	%	+29.5		+10.4	+49.6		21.75	13.1	+18.67	-4.02
11										
	P	17,010	4,966	253	2.54	24.4	48.5	174.8	430	1,138
	U	17.477	4,766	320	.94	18.5	38.4	144.4	255	1059
	ΔC	-467	+ 200	-67	+1.60	+5.9	+10.1	+30.4	+175	+ 79
	%	-2.75	+ 4.03	-26.5	+62	+24.2	+20.82	+17.39	+40.6	+6.94

P = PREDICTED, U = USED, $\Delta C = P - U$

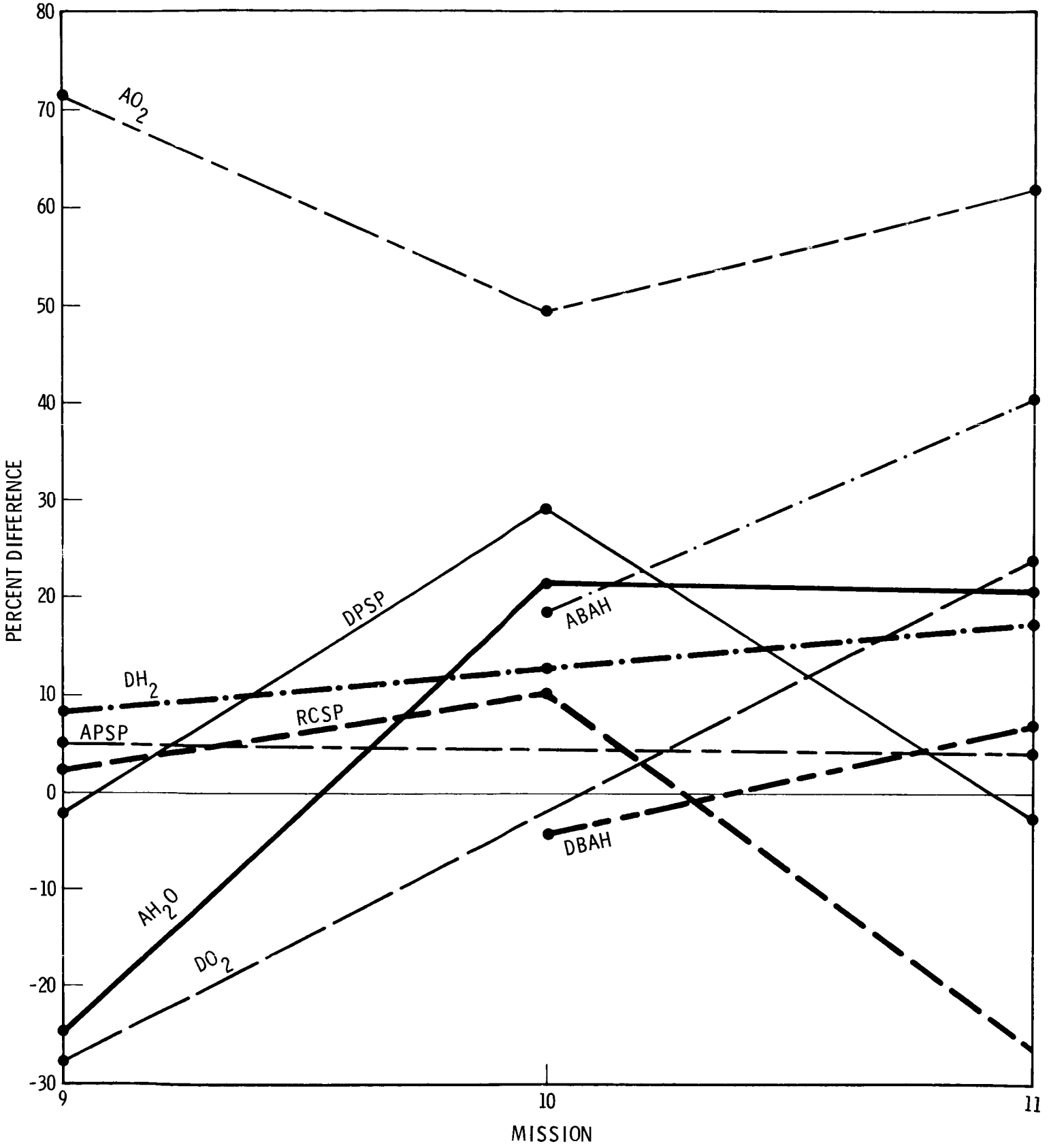
MASS DIFFERENCE BETWEEN PREDICTED AND CONSUMED FOR LM MISSIONS



VARIATION OF DIFFERENCE BETWEEN PREDICTED AND CONSUMED FOR LM MISSIONS



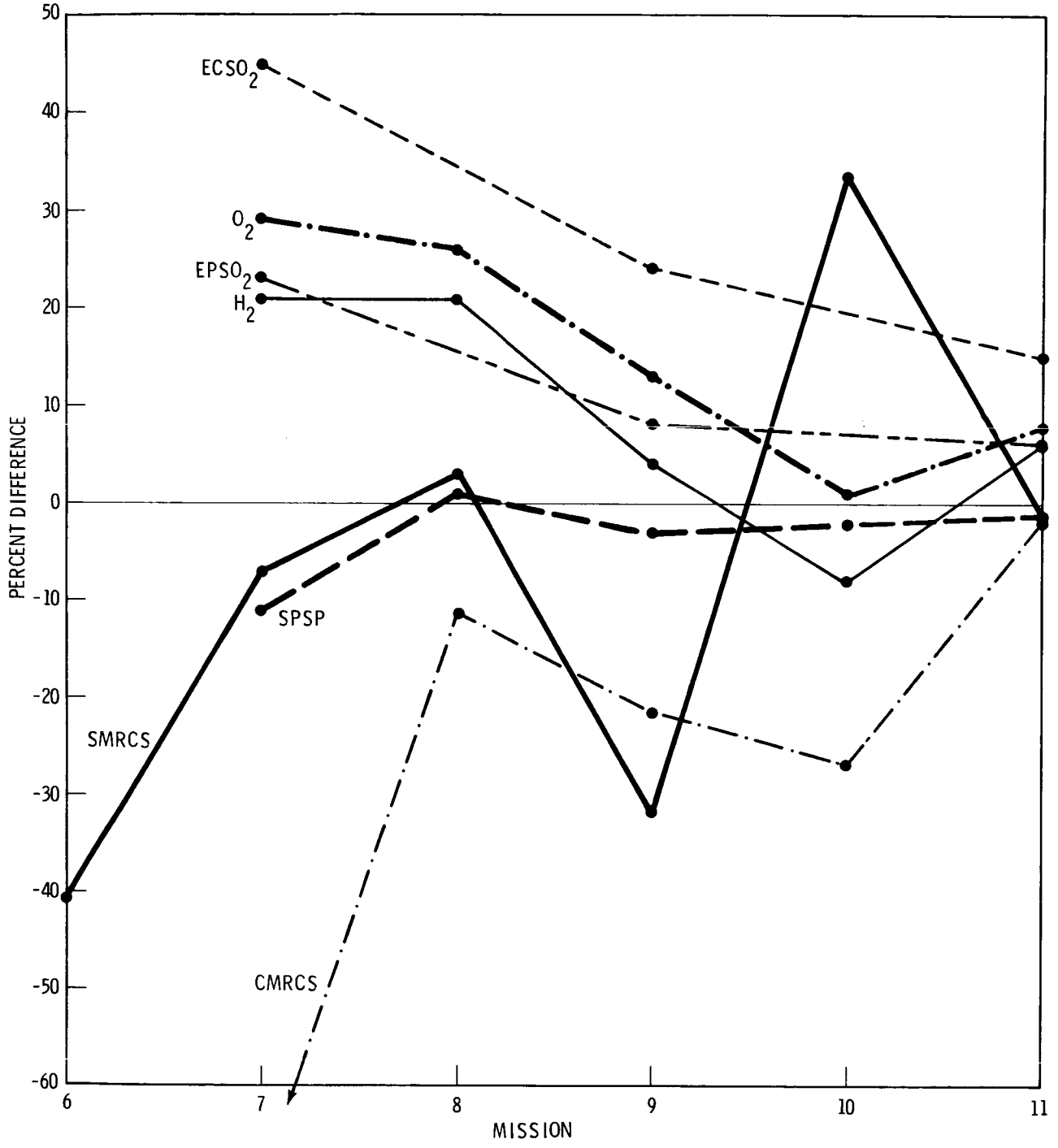
DIFFERENCE BETWEEN PREDICTED AND ACTUAL CONSUMPTION FOR LM MISSIONS



TYPICAL CAUSES FOR SIGNIFICANT DIFFERENCES

		MISSION	
CSM:	SMRCS	9	QUAD C, MANEUVERS, APS TRACKING
		10	MCC, IMPROVED PTC & MANEUVERS
	CMRCS	10	VENTING REQUIRED
	SPS	11	ONLY 2 MCC'S, MIXTURE RATIO
LM:	RCS	11	REDESIGNATION, OSCILLATION
	ABAH	11	RCS HEATERS
	AO_2	11	TIGHT CABIN

DIFFERENCE BETWEEN PREDICTED AND ACTUAL CONSUMPTION FOR CSM MISSIONS



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