BELLCOMM, INC.
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B69 11008

SUBJECT: Apollo 12 Wind and Weather Constraints - Case 320

DATE: November 4, 1969

FROM: W. O. Campbell

MEMORANDUM FOR FILE

Depending on magnitude and direction, winds can cause excessive vehicle bending moments, control law limitations, insufficient GSE clearance, and abort survival problems. To limit these relationships to safe values, constraints are placed on various facets of countdown, launch, and post-launch operations. These constraints are usually stated in the form of maximum wind magnitude and direction under the influence of which it is safe to proceed. Occasionally, bending moment limitation itself is quoted where the total effect is more easily assessed than the variety of causes.

Figure 1 is an overview of Apollo 12 specific wind constraints arising from consideration of these general classes of problems. The differences aloft between Apollo 12 and Apollo 11 values reflect seasonal changes in wind climatology. Other seasonal changes include surface winds in Figure 2, up about five knots from July.(1) Thunderstorm(2) probability is down to insignificance.

Table 1 propellant loading constraints are identical to Apollo 11, as is the 81.5×10^6 inch-pound vehicle bending moment launch constraint. If bending moment instrumentation fails, 30 knots may be used; wind speeds between 30 and 47 knots require simulation for launch decision. The one-hour exposure period probability(3) of exceeding 30 knots is about two percent at 0400 hours and nine percent at 1400 hours. Abort survival constraint is 25 knots to prevent excessive land landing impact velocity.

Hold down post and tower clearances(4) at liftoff are nonlinear functions of thrust vector offset and wind vector. Hold down post redlines are ± 0.29 degrees pitch or yaw offset for 50 knots from a crucial sector. Crucial sector location depends on offset polarity, as Figure 3 shows. Tower clearance is especially sensitive to positive yaw and winds from the 123 to 233 degree sector. Redlines are ± 0.09 degrees for 33 knots from this region. The Figure determines constraining relationships when redlines are exceeded. Note 6 calls attention to areas of insensitivity.

(NASA-CR-107147) APOLLO 12 WIND AND WEATHER CONSTRAINTS (Bellcomm, Inc.) 8 p

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The Figure 1 November wind rose[5] at 10 kilometers shows no head winds between 95 and 140 degrees. Limitations aloft are wind-biased to take advantage of this low probability. The 95 percentile winds most closely approach vehicle limitations at this level, making 10 kilometers the most critical altitude[6] for Apollo 12.

William O. Campbell

2032-WOC-tla W. O. Campbell

Attachments
Figures 1,2,3
Table 1

References

1. Terrestrial Environment (Climatic) Criteria Guidelines for use in Space Vehicles Development, 1966 Revision, NASA TM X-53328, Glen E. Daniels, James R. Scoggins, and Orvel E. Smith, May 1, 1966.

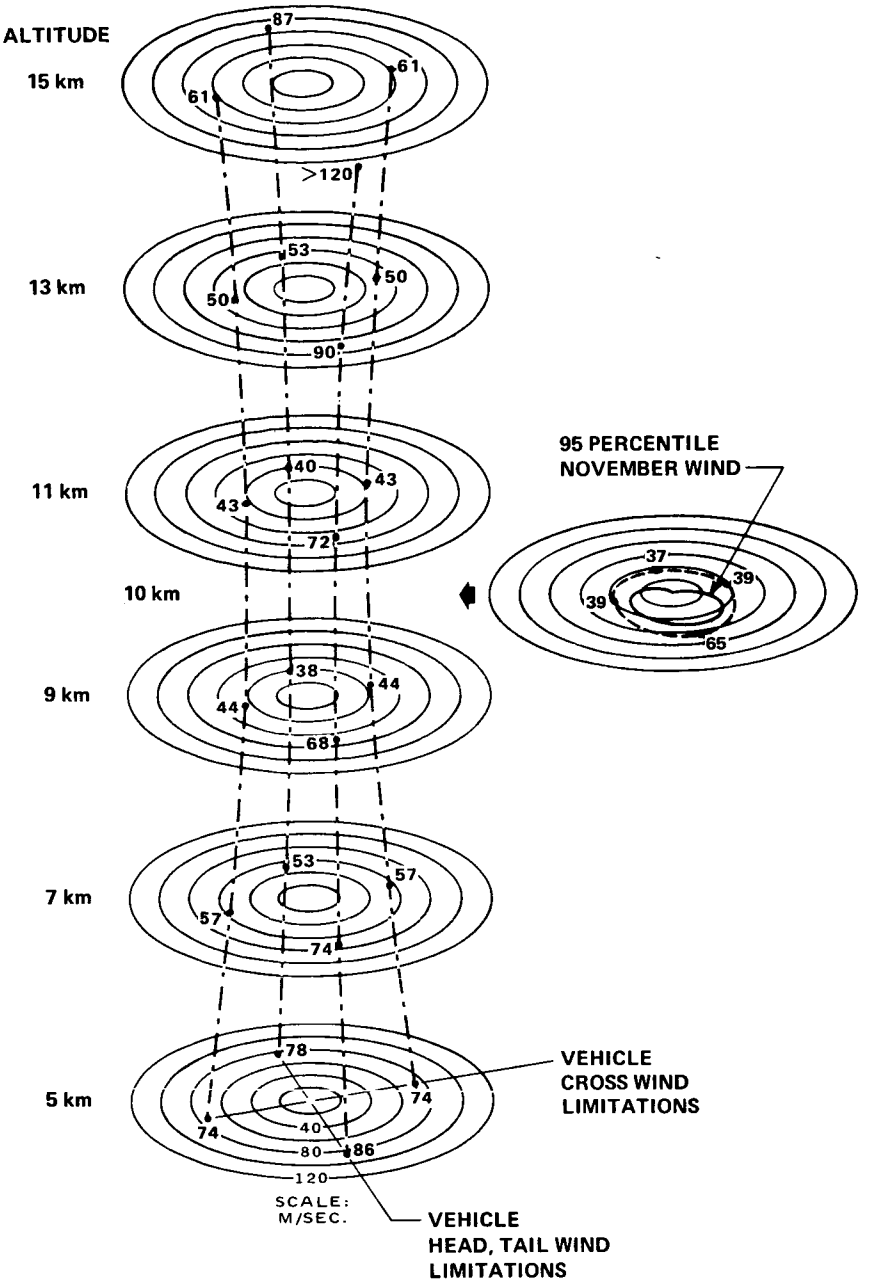
2. Apollo 11 Wind and Weather Constraints - Case 320, Bellcomm, Inc. Memorandum for File, W. O. Campbell, July 8, 1969.

3. Apollo 4 (SA-501) Launch Wind Restrictions - Case 320, Bellcomm, Inc. Memorandum for File, W. O. Campbell, November 8, 1967.

4. Launch Mission Rules Apollo 12 (SA-507/CSM-108/LM-6), KSC, October 2, 1969.

5. Saturn V Launch Vehicle Flight Dynamics Analysis AS-507, DS-15509(F)-7, The Boeing Company, July 24, 1969.

6. MSFC Conversations, R-AERO-FFA, J. E. Moore, October 27, 28, 30, and 31, 1969.



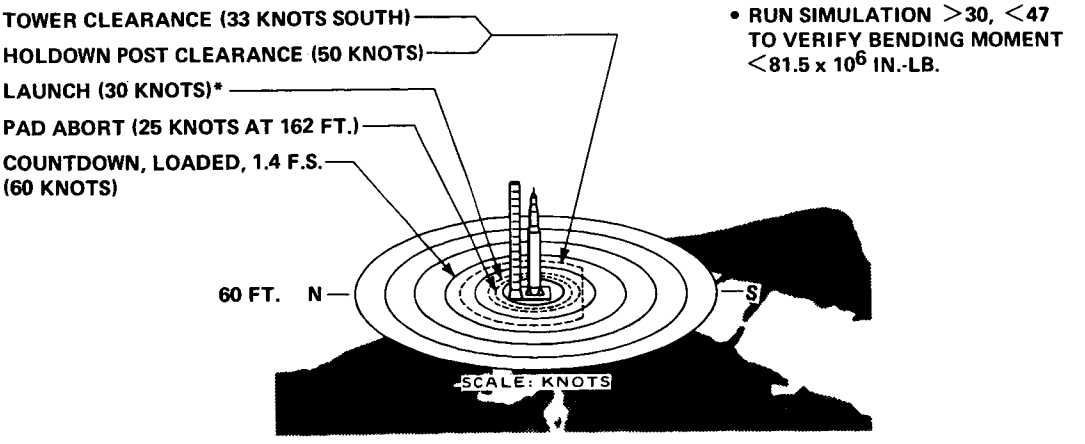


FIGURE 1 - APOLLO 12 WIND CONSTRAINTS

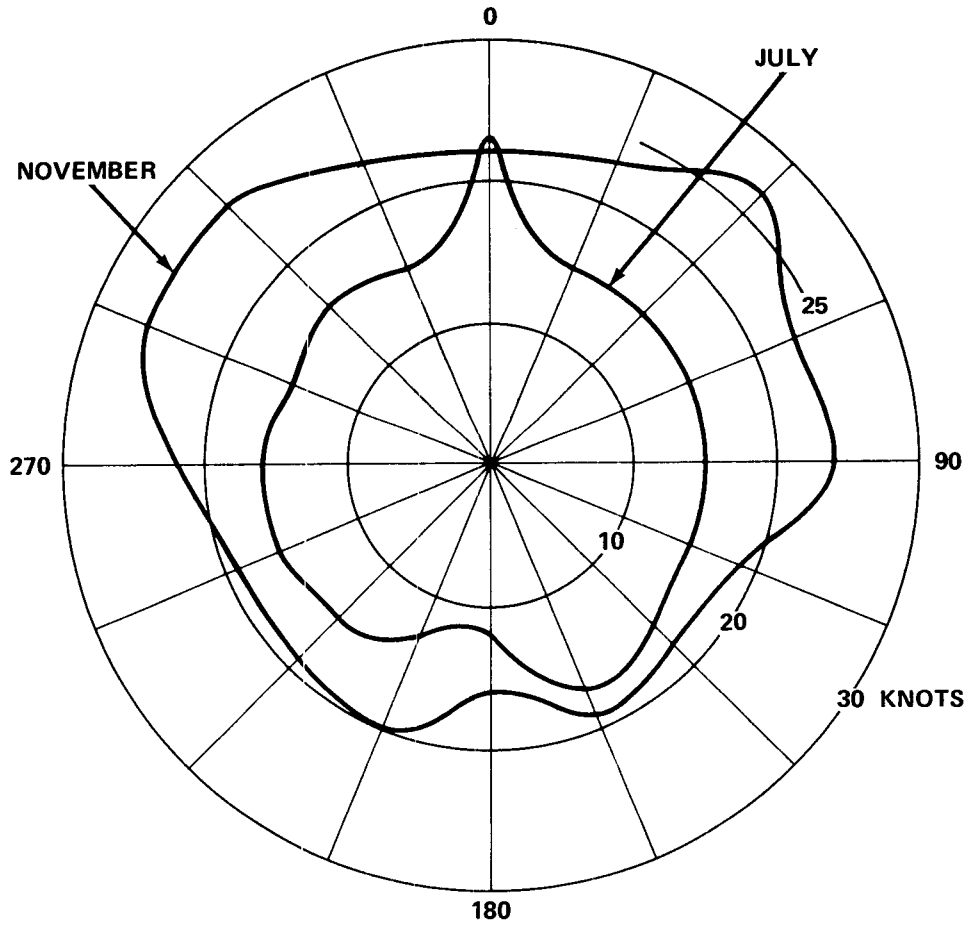
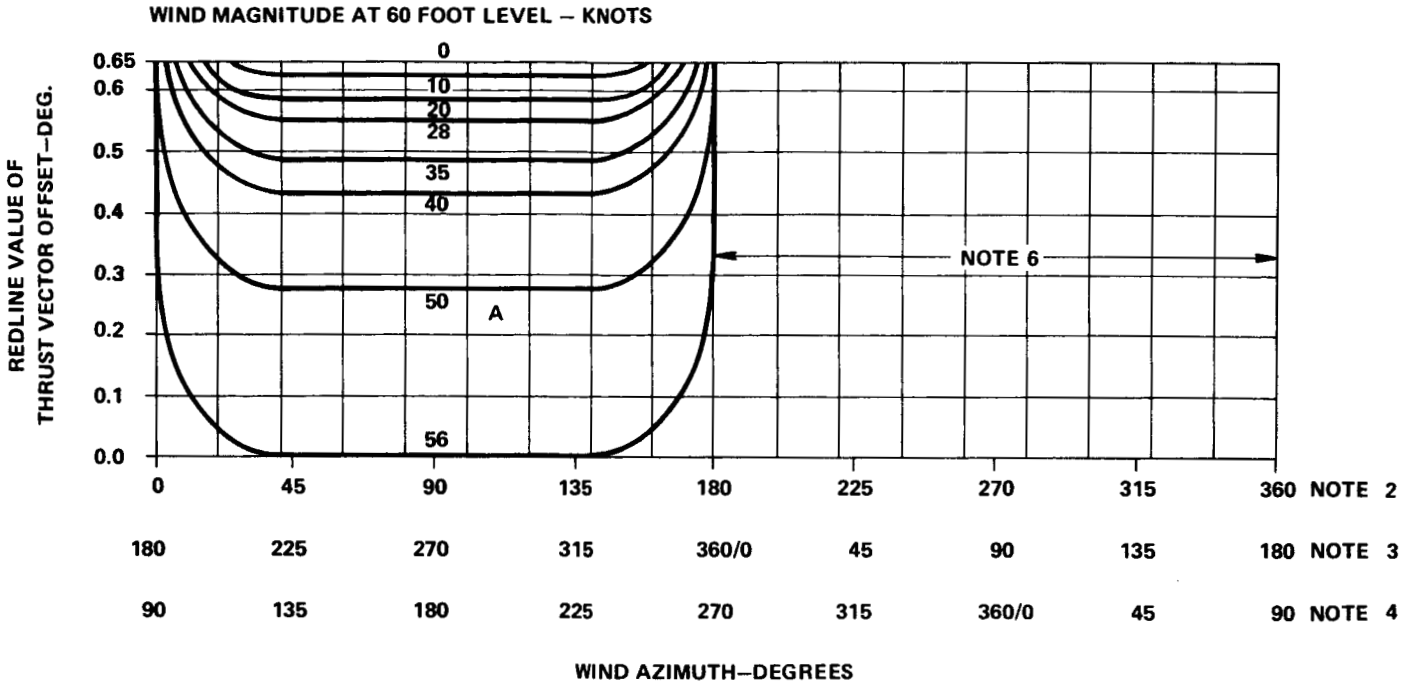
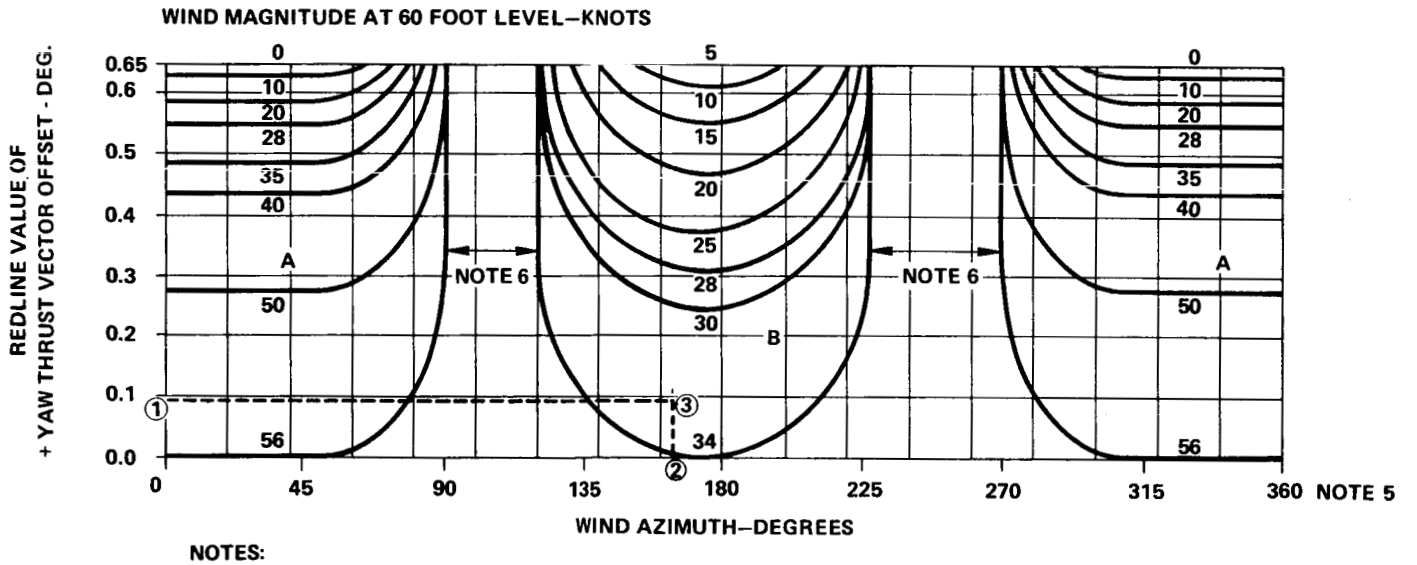


FIGURE 2 - KSC 2σ SURFACE (23.5 METER) WIND COMPARISON FOR APOLLO 11 AND 12.



TO DETERMINE CONSTRAINING RELATIONSHIP, PLOT MEASURED VALUE OF TWO OF THE THREE PARAMETERS, EXAMPLE: YAW + 0.09 DEG.①, WIND 163 DEG.②. THESE CONSTRAIN WIND TO 33 KNOTS MAX.③.



NOTES:

1. REDLINE VALUES: A: ± 0.30 DEG. MAX. ROLL. PITCH, YAW ± 0.29 DEG. MAX. AND WIND 50 KNOTS MAX. B: +0.09 DEG. YAW MAX. AND SOUTHERLY WIND (123 TO 233 DEG.) 33 KNOTS MAX. C: IF ANY A OR B MAXIMA EXCEEDED, SEE REMAINING NOTES.
2. WIND AZIMUTH SCALE FOR POSITIVE PITCH THRUST VECTOR OFFSET
3. ––AZIMUTH SCALE–––NEGATIVE PITCH–––.
4. ––AZIMUTH SCALE–––NEGATIVE YAW–––.
5. ––AZIMUTH SCALE–––POSITIVE YAW–––.
6. FOR AZIMUTH RANGE INDICATED, WIND 50 KNOTS MAX. PLUS PITCH OR YAW OFFSET 0.65 DEGREES MAX. ARE PERMISSIBLE.

FIGURE 3 – THRUST VECTOR REDLINES FOR HOLD DOWN POST AND TOWER CLEARANCES

TABLE I

APOLLO 12 COUNTDOWN WIND CONSTRAINTS

	COUNTDOWN CONFIGURATION							CONSTRAINTS			
								KNOTS*		10^6 IN-LB	
	S/F	LOX	LOX	LH_2	LOX	LH_2	DAMPER	AAA	S/V	AAA	S/V
MSS AT VEHICLE	1.25	0	0	0	0	0	ON	64	64	177	204
MSS AT VEHICLE	1.25	0	0	0	0	0	OFF	28**	30**	128**	177
MSS REMOVED	1.25	0	0	0	0	0	OFF	28**	30**	128**	177
MSS REMOVED	1.25	0	0	0	0	0	ON	64	64	177	240
S-IVB LOX LOADED	1.25	0	0	0	100	0	ON	64	64	162	162
S-II LOX LOADED	1.25	0	100	0	100	0	ON	64	64	183	183
S-IC LOX LOADED	1.25	100	100	0	100	0	ON	64	64	183	183
S-II LH_2 LOADED	1.25	100	100	100	100	0	ON	64	64	183	183
S-IVB LH_2 LOADED	1.25	100	100	100	100	100	ON	60	60	172	172
VEHICLE LOADED	1.40	100	100	100	100	100	OFF	60	60	172	172
LAUNCH RELEASE								NA	≤30*	NA	≤81.5

NOTES:

1. PRIOR LOADING OF S-IC RP-1, CSM CRYOGENICS, CSM/LM HYPERGOLICS, AND LM SHE.
2. SIGNIFICANT CHANGES IN CONFIGURATION UNDERSCORED.
3. AAA IS APOLLO ACCESS ARM. REMOVING AAA RAISES RESTRICTION TO S/V VALUE.
4. BENDING MOMENTS MEASURED AT VEHICLE STATION 790.
5. SIMULATION REQUIRED FOR LAUNCH RELEASE AT ≥30 KNOTS AND ABORT AT >25 KNOTS.

* USE ONLY IF BENDING MOMENT UNAVAILABLE.

** AZIMUTH-DEPENDENT CONSTRAINT; LOWEST VALUE SHOWN.

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