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SATURN V GROUND WINDS PROGRAM

BY

ROBERT M. HUNT

GEORGE C. MARSHALL SPACE FLIGHT CENTER

A B S T R A C T

The concept on SATURN V was to "budget" an amount for the dynamic portion of the wind load as a factor on the steady state drag. Wind tunnel tests paralleled the development and fabrication phases. The results indicated that the system was unable to withstand the design winds; thus, a decision was made to implement a viscous damper "fix" on the facility vehicle at the Kennedy Space Center. Damping tests in the Vertical Assembly Building (VAB) will have been completed and response tests on the pad will be in progress at the time of this symposium. This paper will present the history and status of this program to date.

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Figure 1 shows the basic design criteria for Saturn V. There is no attempt here to predict response but 50% of the drag load is budgeted for this phenomenon .

Figure 2 shows how these vectors combine and that the dynamics portion in fact is given more consideration than the drag load.

Figure 3 shows the wind tunnel results superimposed on the design criteria. This graph indicates that the design limit was reached at a lower velocity than the design winds.

Figure 4 shows the Alternatives considered as possible solutions to the problem.

Waiving the wind criteria was never really given any serious consideration. The aerodynamic fixes will be given detailed treatment in a later paper at this symposium.

The mechanical fix was accepted but it evolved into two possible solutions. The first was to add an external support to the vehicle; thus, to add effective stiffness and increase the natural frequency of the system. This introduced large loads into the vehicle.

The second mechanical method was to add a viscous damper. This reduced the dynamic response to winds; thus, allowing the vehicle to traverse its critical response range without exceeding the design loads.

These approaches are shown in Figure 5.

The damper was begun 90 days before roll out of AS-500F and an unbelievable story on design, fabrication, testing, scheduling, transportation and erection followed. Figure 6 is an artist's conception of it installed at station 2560. Three hard points are provided in the vehicle and the rest is umbilical arm and tower equipment. Since AS-500F is a facility checkout and ground wind vehicle no provision is made for removing the arms except manually in the VAB. Figure 7 shows the vehicle during roll out. Note the umbilical arms and the damper arm.

The AS-500 Ground Winds Program consists of taking wind data simultaneously with vehicle response data. The wind data will be recorded both at the vehicle and at a remote tower some 4 miles away. The data obtained will be velocity and direction for the 60, 250, and 500 foot level.

The vehicle response will be measured by 2 horizontal mutually perpendicular accelerometers at 5 stations along the vehicle length and 3 mutually perpendicular accelerometers at the base of the vehicle. Strain readings will be taken at five stations. Three stations have 16 gages each located 22-1/2° apart and the other two stations have 16 gages per station with each of 2 gages located on the same hat section stringer every 45° circumferentially. One of these gages is on the crown, the other on the side of the hat. The third mode of data acquisition for vehicle response is optical. Four cameras approximately 90° apart will photograph targets at the same vehicle station in the payload area.

Attempts will be made to establish the vehicle response curve as a function of both wind direction and velocity. This in turn will be compared with the wind tunnel results. The damper was designed with variable orifices; thus, data may be acquired that shows response as a function of damping. Damping tests were run in the Vertical Assembly Building both before and after the dampers were installed. The values before ranged from 1.2 to 1.6% of critical and after the damper was installed they ranged around 4.5% of critical.

Pull tests were also run in the VAB in order to equate strain readings to bending moments.

The taking of data will continue on during the summer and end about August 25. These results will be collected and reported.

Bibliography

1. NASA SP-8008, NASA Space Vehicle Design Criteria - Prelaunch Ground Wind Loads - November, 1965.

2. Saturn V Ground Wind Loads Test Project Plan. MSFC I-V-TD No. 4, August 20, 1965, Rev March 31, 1966.

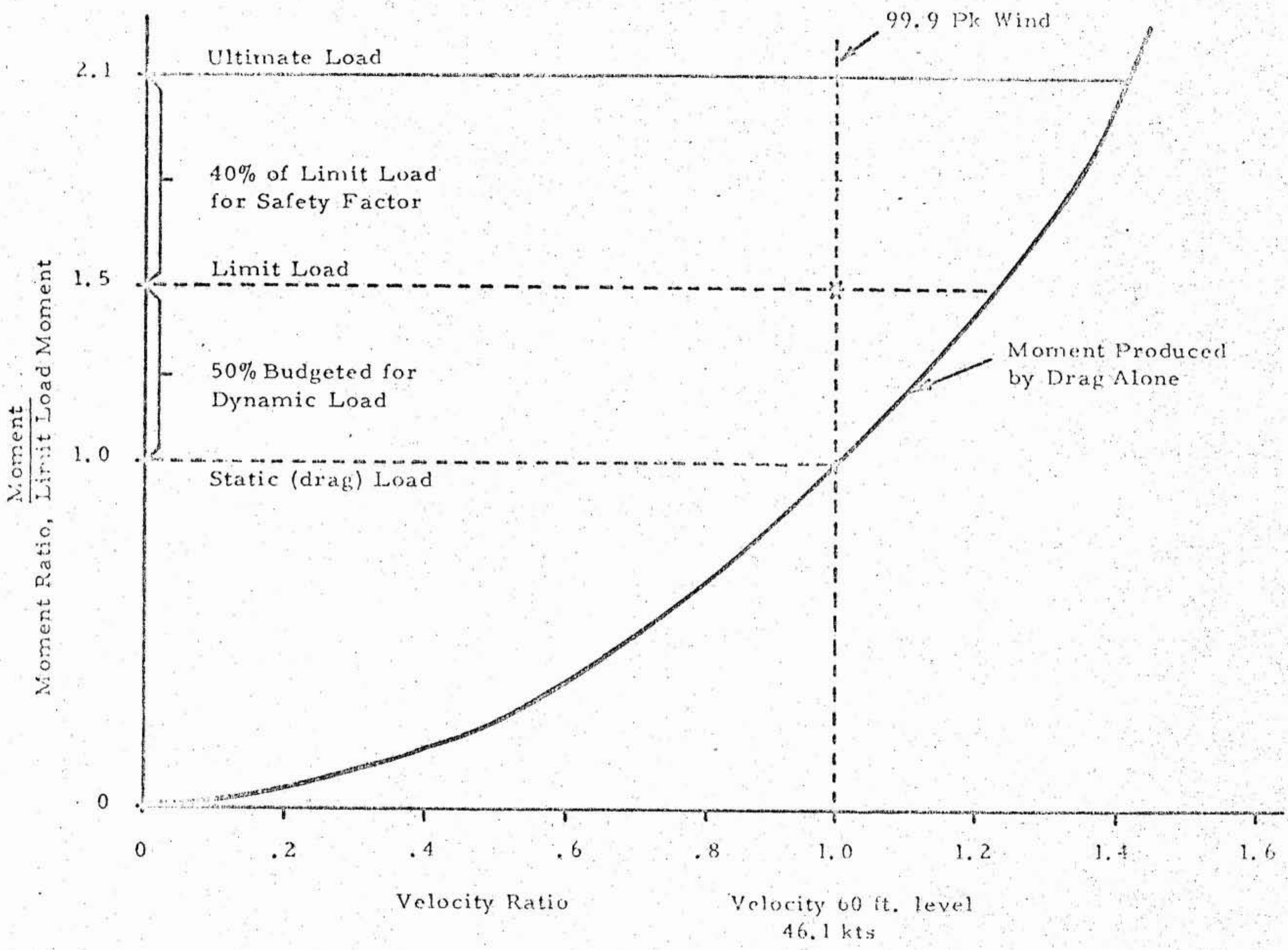

Figure 1. Schematic of Basic Structural Design Criteria Followed for Saturn V Related to Ground Wind Conditions

ASSUMPTIONS:
Drag is well defined load.

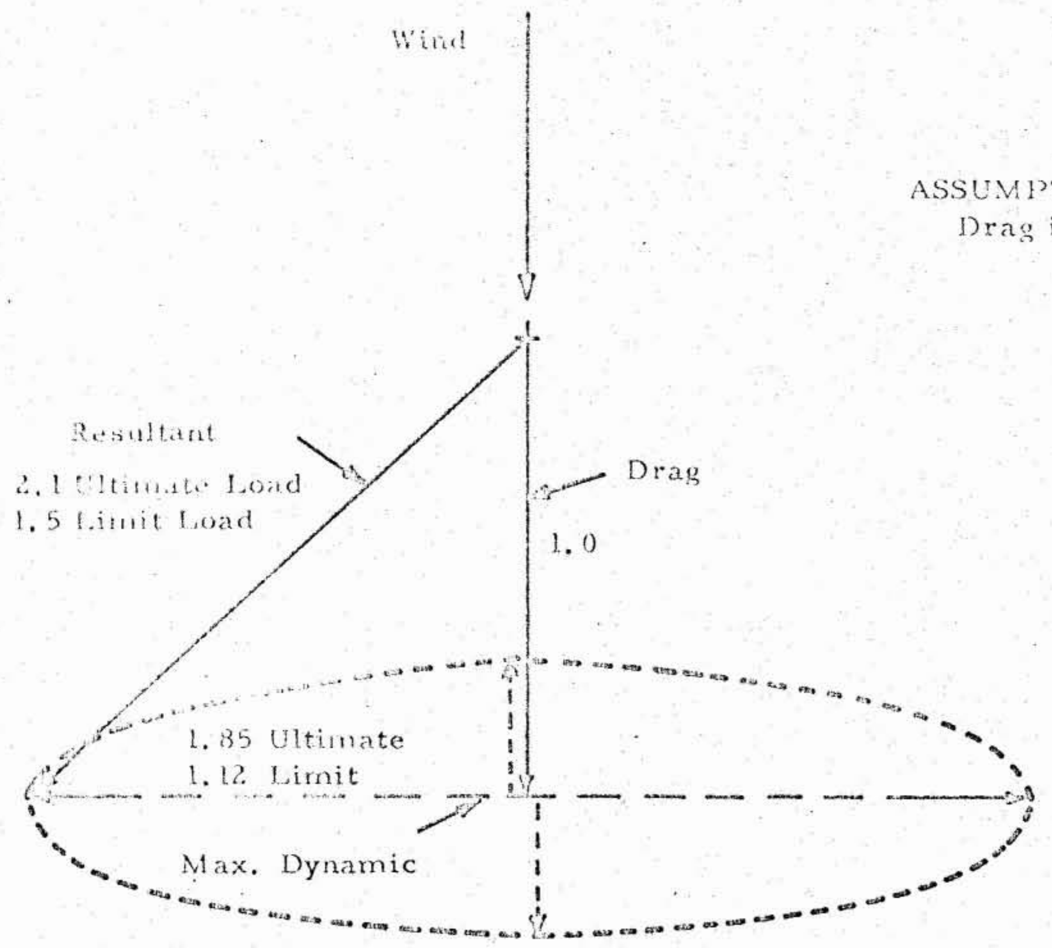

Figure 2. Schematic of Loads at Any Given Vehicle Station

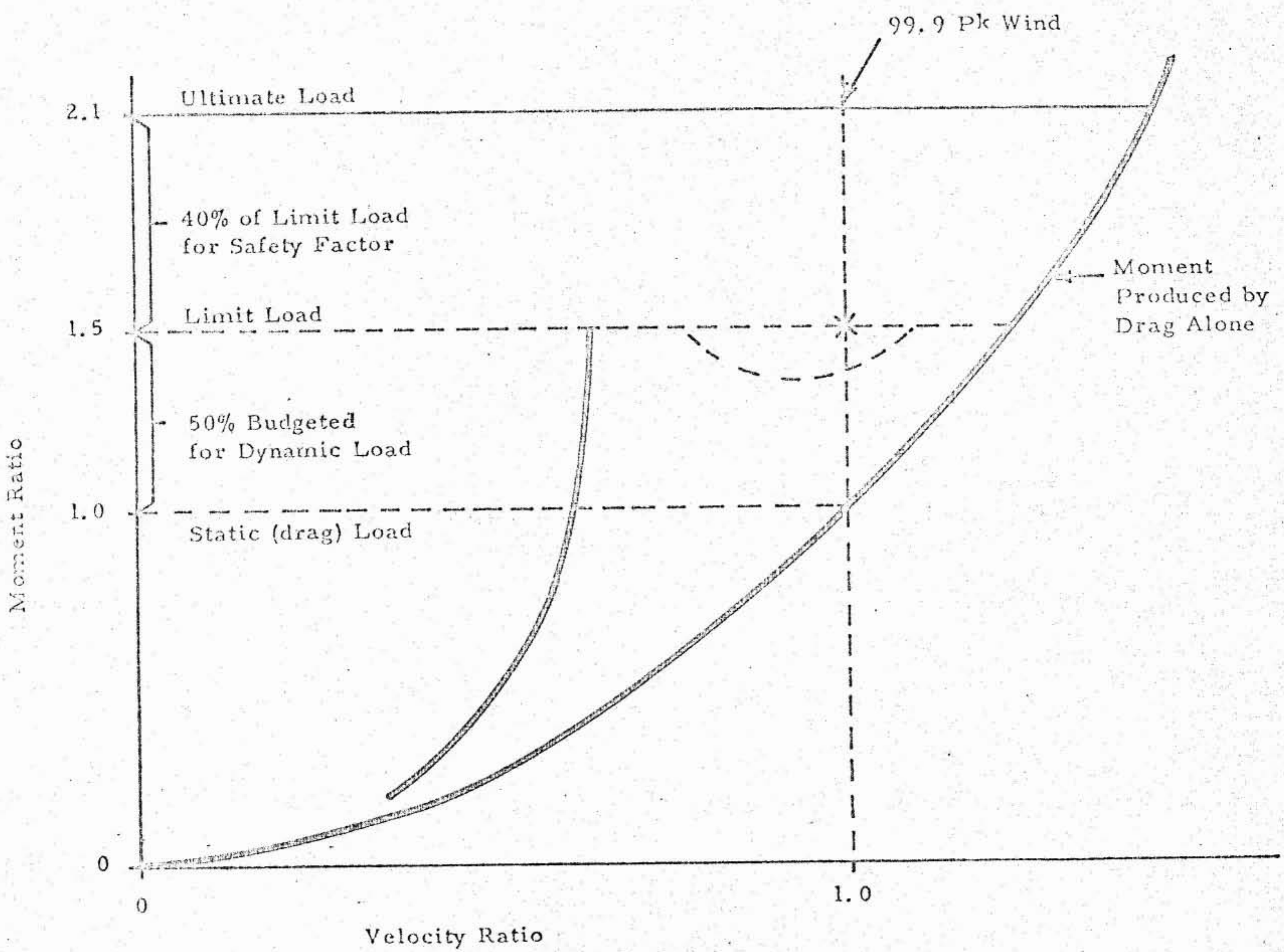

Figure 3. Schematic of Wind Tunnel Results

FIGURE 4

ALTERNATIVES CONSIDERED AS POSSIBLE SOLUTIONS TO FAILURE IN MEETING DESIGN CRITERIA:

WAIVE WIND CRITERIA THUS ACCEPT HIGHER RISK OF LOOSING VEHICLE ON PAD

DEVELOP AERODYNAMIC FIX

CRITERIA: (1) STABILIZE VEHICLE WITHIN DESIGN LIMITS AT ALL VELOCITIES BELOW DESIGN WIND CONDITIONS.

(2) OPERATIONALLY COMPATIBLE WITH LAUNCH AND FLIGHT FUNCTIONS.

DEVELOP MECHANICAL FIX

CRITERIA: (1) STABILIZE VEHICLE WITHIN DESIGN LIMITS AT ALL VELOCITIES BELOW DESIGN WIND CONDITIONS.

(2) OPERATIONALLY COMPATIBLE WITH LAUNCH AND FLIGHT FUNCTIONS.

(3) GROUND EQUIPMENT PREDOMINANTLY.

MAKE VEHICLE CAPABLE OF WITHSTANDING THE HIGHER LOADS

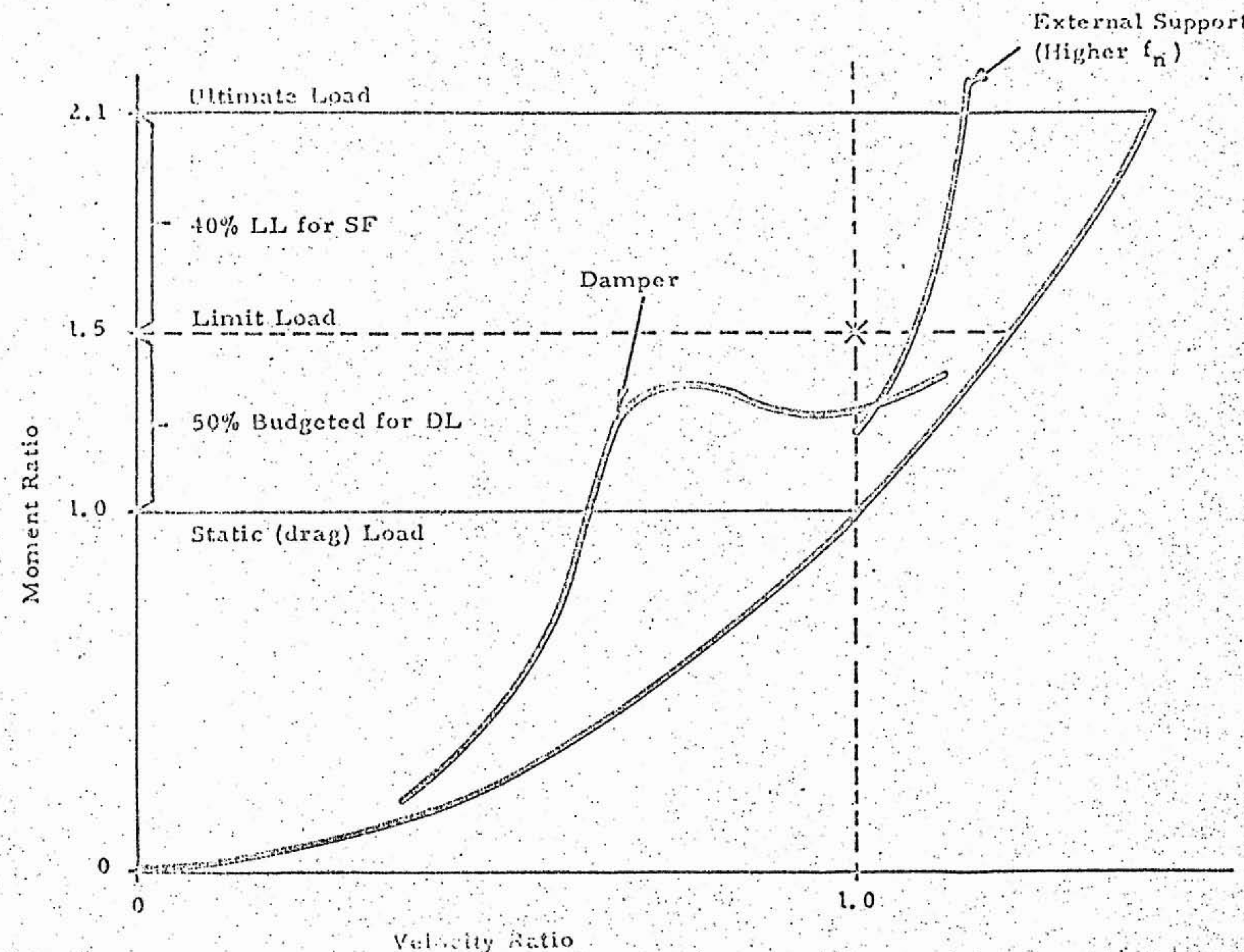

Figure 5. Comparison of Predicted Response Characteristics of Both the Damper and the External Support

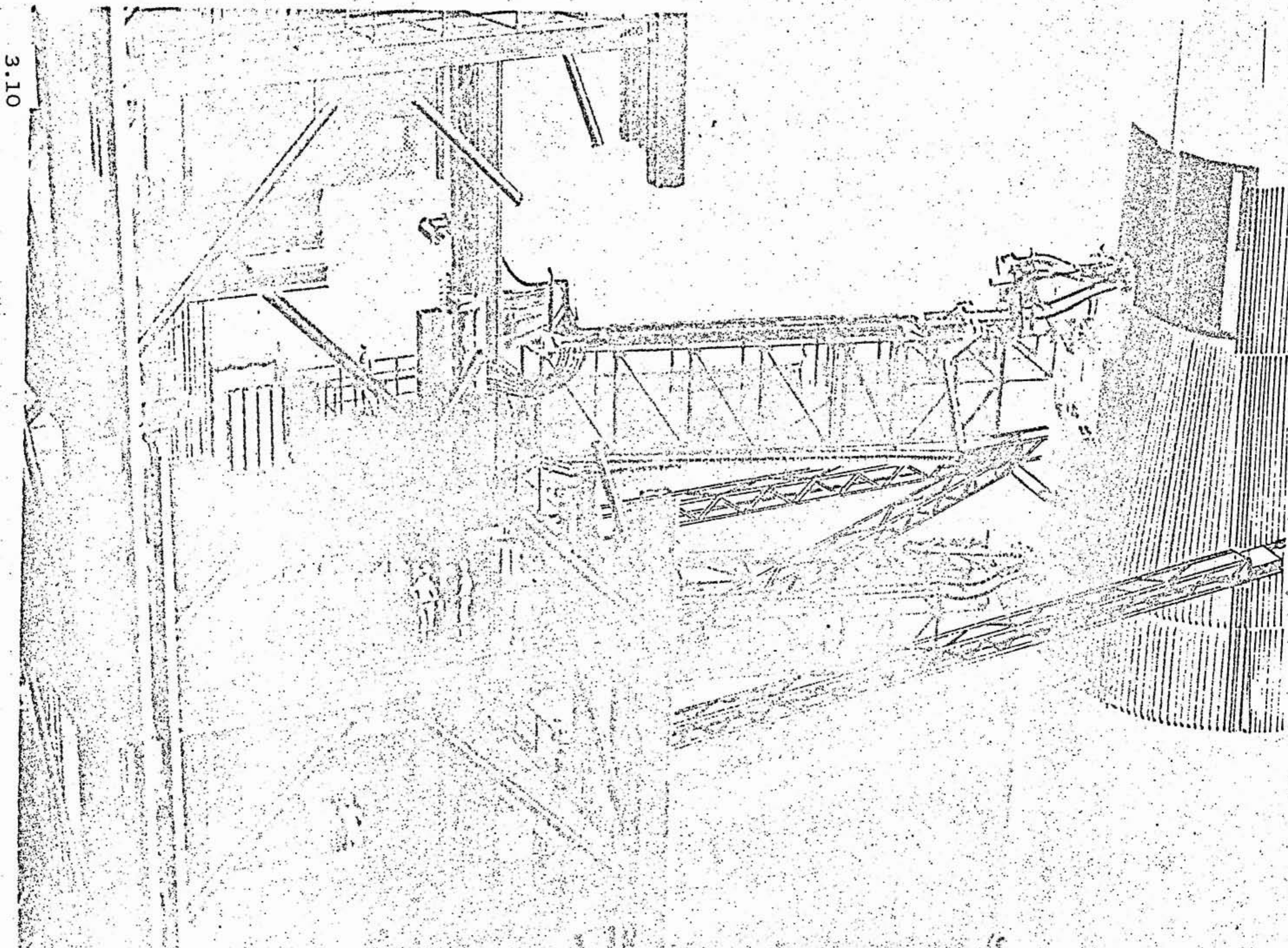

Figure 6 Artist's Concept of Damper Installation

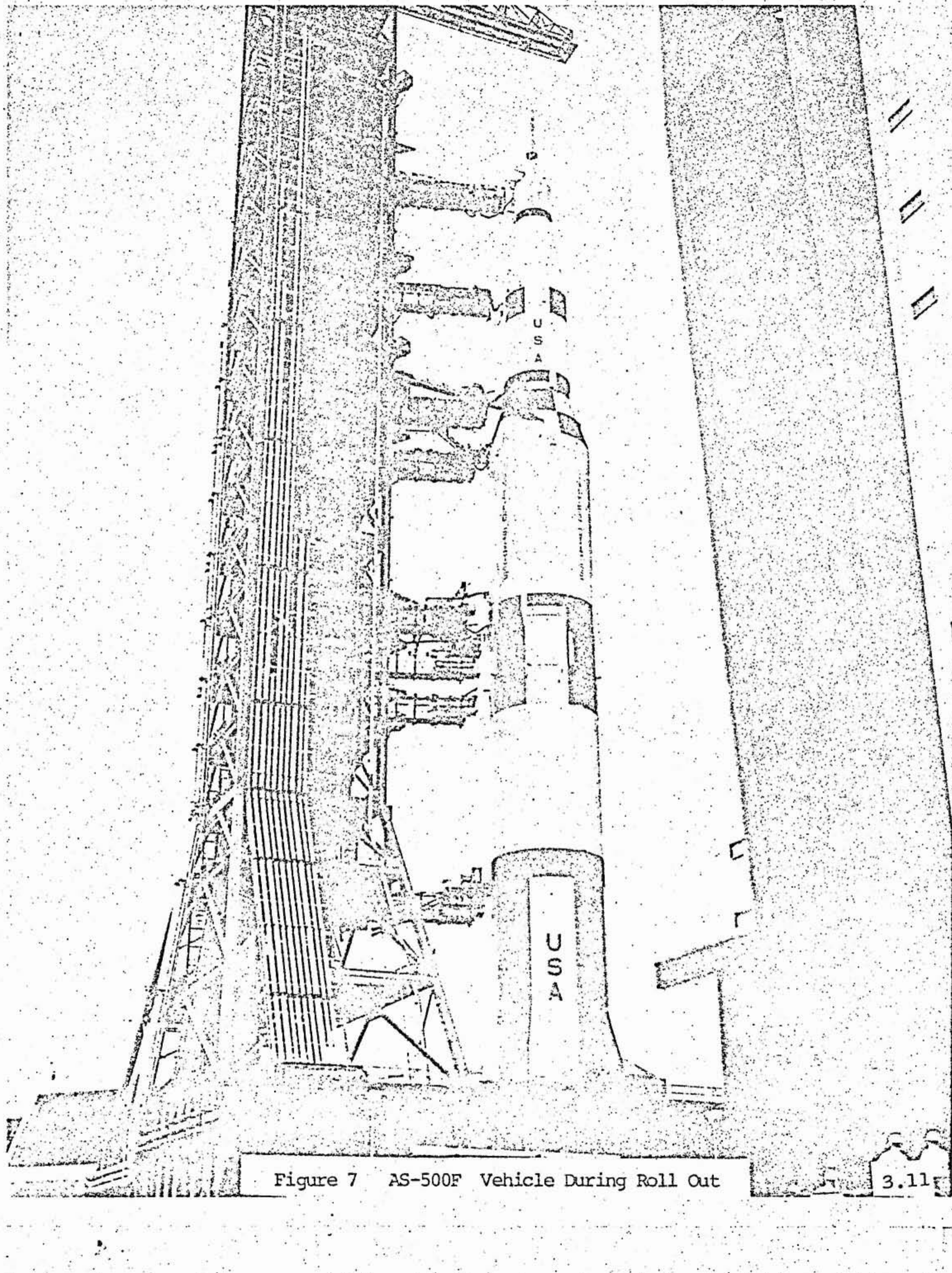

Figure 7 AS-500F Vehicle During Roll Out