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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

# WARTIME REPORT

ORIGINALLY ISSUED
February 1944 as
Restricted Bulletin 4B14

## THE LANDING STABILITY OF A POWERED DYNAMIC MODEL OF A FLYING BOAT WITH A 30° V-STEP AND WITH TWO DEPTHS OF TRANSVERSE STEP

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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

RESTRICTED BULLETIN

# THE LANDING STABILITY OF A POWERED DYNAMIC MODEL OF A FLYING BOAT WITH A 30° V-STEP AND WITH TWO DEPTHS OF TRANSVERSE STEP

By John B. Parkinson and Norman S. Land

## SUMMARY

Tests were made in NACA tank no. 1 of a powered dynamic model of a four-engine long-range flying boat with a 30° V-step and two different transverse steps of comparable positions and depths. The tests indicated that similar landing stability is obtained with a 30° V-step and a transverse step having the same depth as the 30° V-step at the keel.

## INTRODUCTION

It was concluded in reference 1 that variations in the plan form of the step of a flying boat have only a small effect on the lower trim limit of stability and on the range of stable positions of the center of gravity. The effects on the upper trim limit of stability and on the landing stability are attributed mainly to changes in the effective depth of step introduced by the variation in plan form.

Tests of a powered dynamic model of a four-engine long-range flying boat were recently made in NACA tank no. 1 to investigate the landing stability with a 30° V-step and with two transverse steps of comparable position and depth to those of the 30° V-step. The results are presented herein to supplement the information of reference 1 and to provide additional information on which to base the design of the step.

## MODEL AND PROCEDURE

The flying boat represented during the tests had a gross weight of 76,000 pounds, a gross-load coefficient of 1.02, a wing loading of 42.7 pounds per square foot, and a power loading of 10.5 pounds per horsepower. The model was 1/8 full size and was powered by scale propellers developing scale thrust.

The form and dimensions of the steps tested, as measured on the model, are shown in figure 1. The depth of the V-step, which was chosen arbitrarily, was more than sufficient for satisfactory landing stability. (A model with a step of half the depth of this step showed violent skipping characteristics.) The depth of the shallow transverse step, excluding chine flare, was equal to the depth of the V-step at the transverse section through its centroid (center of gravity of the plan form of the step, 1/3 the distance from the chine to the keel). The depth of the deep transverse step was equal to the depth of the V-step at its keel. Both transverse steps were located at the centroid of the plan form of the V-step because in reference 1 the stable range of positions of the center of gravity with the transverse steps in this location was shown to be the equivalent of that with the V-step.

The trim limits of stability of the model were obtained in the usual manner, as described in reference 2. The landing stability was further investigated by actual landings of the model while the towing carriage was being decelerated, as described in reference 1. Landings were made at various trims with the thrust corresponding to full power, and motion-picture records were made of the resulting behavior of the model.

## RESULTS AND DISCUSSION

The trim limits of stability obtained with the various steps are shown in figure 2. No significant change in the lower limit was obtained. The upper limits at high speeds are higher for the V-step than for the transverse steps. The spread between the two branches of the upper limit is greater for the shallow transverse step than for the deep transverse step or the V-step.

The curve of landing speed for various trims is included in figure 2 to show the relation of the upper limits, as usually obtained, to the flying speed. From preliminary tests of another model, it is believed at the present time that the lower branches of the upper limits also extend to flying speed.

A summary of the landing characteristics obtained with the different steps, as derived from the motion pictures, is given in table I. As referred to in the table, a skip is defined as a vertical motion of the model, subsequent to a landing, of such magnitude that the step comes clear of the water. If the number of skips is considered as an indication of the landing instability, the stability of the model with the deep transverse step is comparable with that of the model with the V-step; whereas the stability with the shallow transverse step is markedly less than that with either of the other two steps. These more unstable landing characteristics with the shallow transverse step are believed to be associated with the greater spread between the two branches of the upper limit for this step as noted in figure 2.

The frontal area and mean geometric depth (frontal area divided by the beam) are approximately 25 percent less for the V-step than for the deep transverse step having comparable landing characteristics. If it is assumed that the frontal area is a rough indication of the increment in aerodynamic drag caused by the step (reference 3), there would be an over-all advantage in using a moderate V-plan form for the step, in preference to a straight transverse plan form.

## CONCLUSION

The tests made on a powered dynamic model of a four-engine long-range flying boat indicated that similar landing stability is obtained with a 30° V-step and a transverse step having the same depth as the 30° V-step at the keel.

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# REFERENCES


1. Truscott, Starr, and Olson, Roland E.: The Longitudinal Stability of Flying Boats as Determined by Tests of Models in the NACA Tank. II - Effect of Variations in Form of Hull on Longitudinal Stability. ARR, NACA, Nov. 1942.

2. Olson, Roland E., and Land, Norman S.: The Longitudinal Stability of Flying Boats as Determined by Tests of Models in the NACA Tank. I - Methods Used for the Investigation of Longitudinal-Stability Characteristics. ARR, NACA, Nov. 1942.

3. Hartman, Edwin P.: The Aerodynamic Drag of Flying-Boat Hull Models as Measured in the N.A.C.A. 20-Foot Wind Tunnel - I. TN No. 525, NACA, 1935.

TABLE I.- LANDING CHARACTERISTICS OF MODEL

WITH THREE STEP CONFIGURATIONS

| Trim at contact (deg) | Speed at contact (fps) | Landing characteristics |
|---|---|---|
| V-step | | |
| 15.0 | 38.0 | Full stall, 1 skip |
| 11.0 | 39.8 | 1 skip |
| 9.0 | 41.0 | Stable |
| 8.5 | 42.4 | Stable |
| 7.0 | 46.0 | Stable |
| 6.0 | 49.0 | Stable |
| 5.0 | 53.0 | 1 skip |
| Shallow transverse step | | |
| 14.0 | 37.0 | Full stall, 1 skip |
| 11.0 | 40.0 | 3 skips |
| 9.0 | 43.2 | 4 skips |
| 7.0 | 46.5 | 5 skips |
| 6.0 | 49.5 | Stable |
| 5.0 | 53.4 | 1 skip |
| Deep transverse step | | |
| 14.0 | 39.6 | Full stall, 1 skip |
| 11.0 | 39.5 | 1 skip |
| 8.8 | 43.5 | 1 skip |
| 7.2 | 47.0 | Stable |
| 5.7 | 52.2 | Stable |

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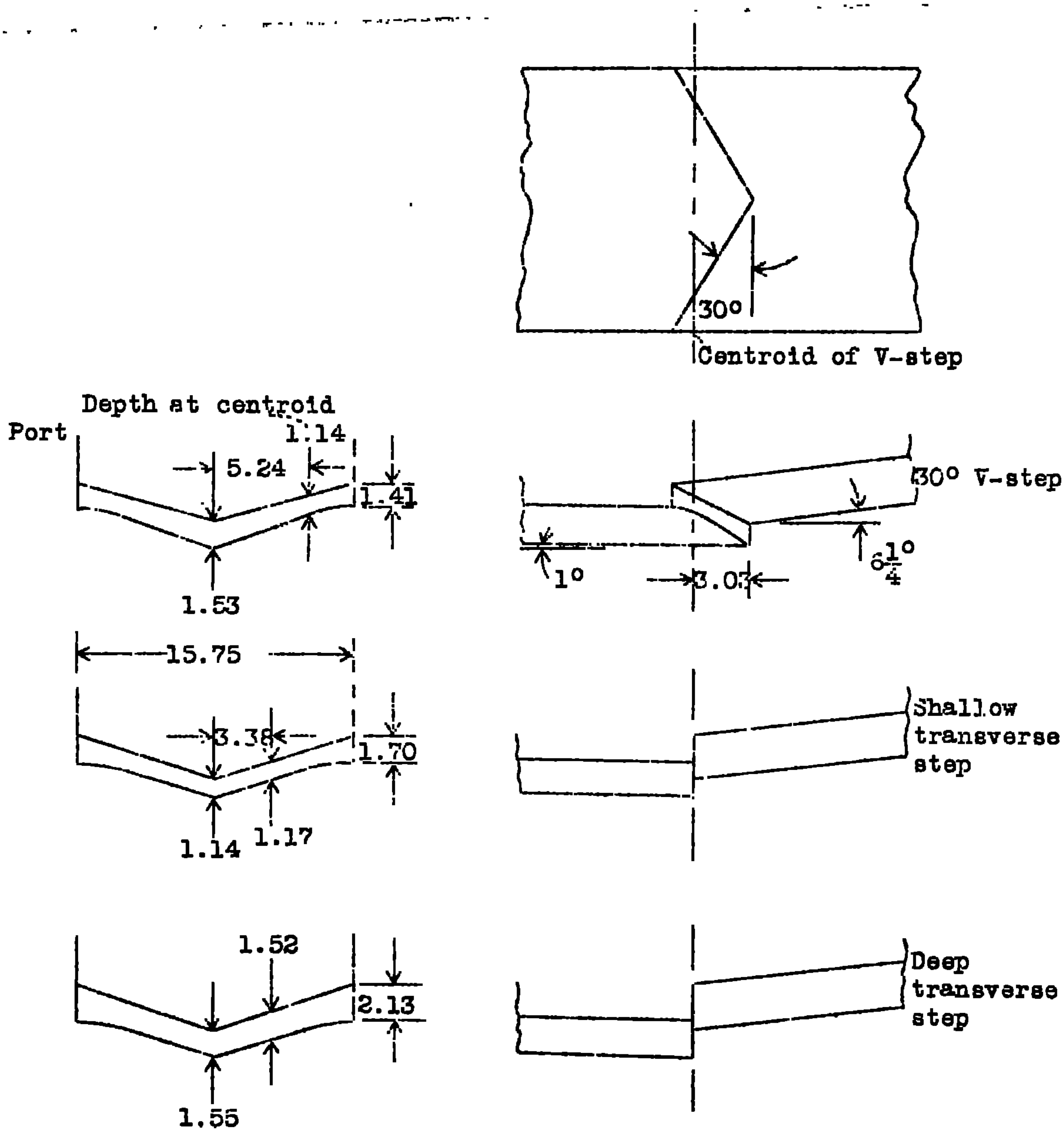


Figure 1.- Dimensions of V-step and transverse steps (inches).

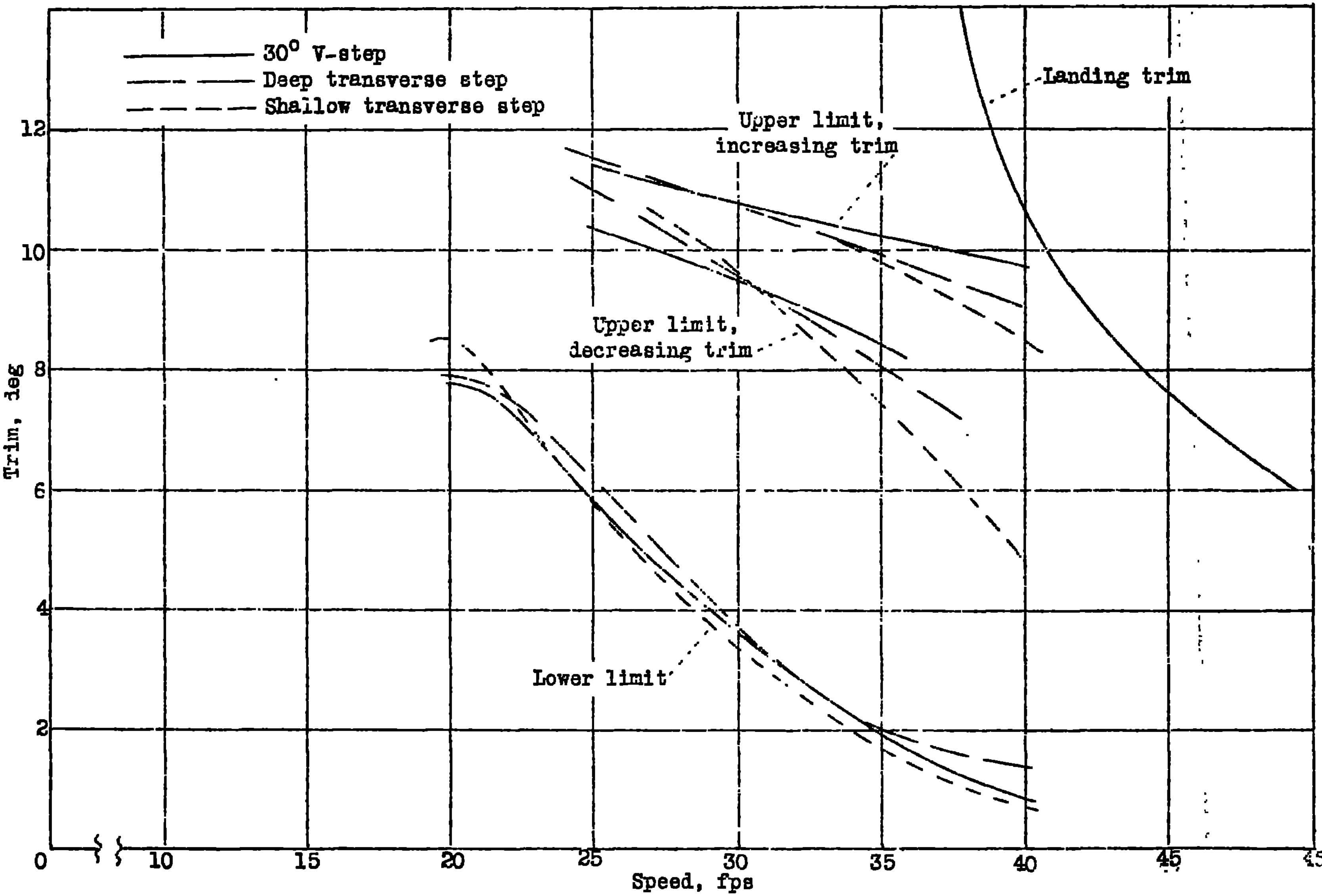


Figure 2.- Comparison of trim limits of stability for a 30° V-step and two transverse steps.

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AUTHOR(S): Parkinson, John B.; Land, Norman S.

ORIGINATING AGENCY: National Advisory Committee for Aeronautics, Washington

PUBLISHED BY: (Same)

ATI- 7576

DIVISION (None)

ORIG. AGENCY NO. RB-4B14

PUBLISHING AGENCY

| DATE | DOC. CLASS. | COUNTRY | LANGUAGE | PAGES | ILLUSTRATIONS |
|---|---|---|---|---|---|
| Feb '44 | Unclass. | U.S. | Eng. | 7 | table, graph, drwg |

ABSTRACT:

Hydrodynamic tests were made in an NACA tank of a powered dynamic model of a four-engined long-range flying boat with a 30° V-step and two different transverse steps of comparable positions and depths. Results of these tests indicated that similar landing stability is obtained with a 30° V-step and a transverse step having the same depth as the 30° step at the keel. Detailed results are presented graphically.

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DIVISION: Water-borne Aircraft (21) 1

SECTION: Stability and Control (6) 1C

SUBJECT HEADINGS: Seaplanes - Landing characteristics (84050)

ATI SHEET NO.: R-21-6-2

Air Documents Division, Intelligence Department Air Materiel Command

AIR TECHNICAL INDEX

Wright-Patterson Air Force Base Dayton, Ohio

ATI No: 13430

US Classification: Unclass.

OA No: RB-4E14

TITLE: Cancelled - Dupe of 7576

The Landing Stability of A Powered Dynamic Model of A Flying Boat With A 30° V Step and With Two Depths of Transverse Step

AUTHOR(S):

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OA:

National Advisory Committee for Aeronautics

Foreign Title:

Previously cataloged under No:

Translation No:

Subject Division:

Section:

WF-O-22 OCT 48 275M

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