



## WEIGHT AND BALANCE AND WARBIRDS

### I. INTRODUCTION

This article is written to alert warbird aviators to some considerations as relates to the operation of their aircraft concerning weight and balance.

While aircraft certificated as civilian aircraft in the last three decades include aircraft flight manuals replete with information required to compute the center of gravity for the airplane, many military flight manuals for aircraft flown during the Second World War provide little information in that regard. This article will discuss some considerations which relate to ensuring that your warbird is operated within its weight and balance envelope.

### THE STEARMAN

When I was checking out in the PT-17/N2S series aircraft many years ago, a review of the aircraft flight manual indicated there was no information in that document concerning how to calculate a weight and balance. The only weight and balance data associated with the Stearman was the placard on the side of the aircraft that said the maximum crew weight for the forward seat position and the rear seat position was 200 pounds. The placard also recited that the aircraft could accommodate 46 gallons of fuel and the baggage compartment had a placard stating it was restricted to 60 pounds of weight.



Having become accustomed to calculating the center of gravity and weight and balance for an aircraft when taking checkrides, I thought it would be instructive to find out what the center of gravity would be and how that could be calculated for the Stearman. This was accomplished, not by referring to the aircraft flight manual, but by obtaining a copy of the Type Certificate Data Sheet for the Stearman series of aircraft manufactured by Boeing including the Army PT-17, PT-13 and PT-18 aircraft; and the navy N2S series aircraft. In reviewing the Type Certificate Data Sheet, one finds that in a standard, military configuration, the maximum certificated weight for the aircraft was 2,950 pounds. However, certain commercial alterations and modifications of the aircraft after the war would allow the aircraft to be flown at weights up to 3,200 pounds. For this reason, it is important to know the category in which the pilot's aircraft is certificated as well as the maximum weight approved for the aircraft.

Something else of importance is the fact that the empty weight of the aircraft and its empty center of gravity impacts upon whether or not the aircraft can be flown solo from the front seat. In the Stearman, the datum line is the leading edge of the lower wing. The arm of any station forward of the datum line is a negative value, while the arm of any station aft of the leading edge of the lower wing is a positive value. As we recall from our early flight training days, the arm multiplied by the weight of the object at that particular station yields a moment. The sum of all moments when divided by the weight of the aircraft results in the aircraft's center of gravity.

A Stearman may be flown with a

center of gravity as far forward as negative 4.4 inches, *i.e.*, 4.4 inches ahead of the leading edge of the lower wing. However, if the empty center of gravity for the aircraft is between negative 1.5 inches and negative 4.4 inches, the aircraft can only be flown solo from the rear seat. Flying the airplane from the rear seat is necessary because of the forward center of gravity of the aircraft. After determining the aircraft's empty weight and empty center of gravity as referenced in the aircraft's airframe logbook and determining the arms of various stations in the aircraft and extracting a center of gravity envelope chart contained in the Type Certificate Data Sheet, I was able to construct a weight and balance chart to be employed for a Stearman I flew frequently. A copy of this chart is appended to this article as Appendix I.

### **III. WEIGHT AND BALANCE INFORMATION IN THE AIRCRAFT FLIGHT MANUALS OF THE TEXAN AND MUSTANG**

The AT6/SNJ series of aircraft, commonly known as the "Texan," contains the following language on pages 60 and 61 of the Aircraft Flight Manual (AFM):

Center-of-Gravity Limitations -- Any configuration of external load that the airplane is designed to carry may be installed without exceeding the CG limits. There is only one possible loading condition that could cause the airplane CG to exceed its limitation. This could occur when fuel supply is low in a solo flight with no baggage. The result would be a slightly nose-heavy condition. Therefore, when this situation is encountered, additional care must be exercised during the flare-out (to prevent a 2-point touchdown with the possibility of striking the propeller) and immediately after the touchdown (to prevent nosing over). However, this nose-

-heavy condition can be prevented by carrying a load of approximately 100 pounds in the baggage compartment to keep the CG within limits.

Weight limitations – The maximum allowable gross weight for the airplane cannot be exceeded. However, the baggage compartment should not be loaded in excess of maximum capacity of 100 pounds.

A sample weight and balance sheet for the Texan is Appendix II to this article. Appendix II to this article was provided by Col. Joe Broker of the Dixie Wing Commemorative Air Force.

Page 69 of the Aircraft Flight Manual of the P-51D Mustang provides:

*Center-of-gravity Limitations* – Any configuration of external load that the airplane is designed to carry may be installed without exceeding the CG limits. To prevent the possibility of an adverse aft CG condition, which would cause unsatisfactory flight characteristics, the fuselage fuel tank capacity is restricted to 65 gallons maximum. No flight should be permitted with more than 65 gallons in the fuselage fuel tank because of the possibility of a stick force reversal during an accelerated maneuver such as a dive pull-out. A forward CG condition exists when less than 25 gallons of fuel remains in the fuselage fuel tank. In this case, landings should be performed with caution, particularly during



**Mustang**

flare-out and immediately after touchdown, to prevent nosing over.

*Weight Limitations* – There are no weight limitations to observe, since the external mounting provisions prevent overloading.



**Texan**

Page 25 of the Mustang Aircraft Flight Manual contains the following language:

*Weight and Balance* – Refer to Section V for weight and balance restrictions. Refer to Handbook for Weight and Balance data TO1-1B-40 for loading information. Before each mission, make the following checks:

- ⇒ Check take-off and anticipated landing gross weight and balance.
- ⇒ Check that fuel, oil, armament, and special equipment carried are sufficient for the mission to be accomplished.
- ⇒ Check that weight and balance clearance (Form F) is satisfactory.

#### IV. CONCLUSION

FAR Section 91.9(a) requires that we, as pilots, not operate our aircraft beyond the placarded operating limitations specified in the aircraft flight manual and/or in markings and placards contained or displayed in the aircraft. Further, we are to engage in certain pre-flight planning under FAR Section 91.103 including an evaluation of the weather, the weather forecast, fuel requirements, alternates, and takeoff and landing distances at our point of departure and destination taking into account the field elevation of the airport, the runway slope, the aircraft gross weight, the wind and the temperature.

It is true there is no literal requirement that we as pilots who fly military aircraft calculate the precise center of gravity for the aircraft. Nonetheless, it does appear to be advisable to at least have an awareness of the center of gravity of the aircraft, since the operation of an aircraft without such awareness could be viewed as careless or reckless conduct under FAR Section 91.13(a).

As one reviews the aircraft flight manuals of planes used for training and combat during World War II, the weight and balance information contained in the aircraft flight manuals appears to be minimal. The information contained in the military AFMs does not appear to be as detailed and thorough as that available today in modern, civilian aircraft. Nevertheless, these military aircraft are operated in a civilian environment by civilian pilots subject to civilian regulations. Accordingly, it may be necessary to go beyond the AFMs to obtain the data required to evaluate whether or not the aircraft is operated within its weight and balance and center-of-gravity limitations. This article was written in the hope that it will give pilots an appreciation for these realities.

**Alan Armstrong is engaged in the general practice of law with an emphasis in the following areas:**

**Aviation Matters, Personal Injury,  
Professional Negligence (Malpractice),  
Products Liability**

**Phone: (770) 451-0313 Fax: (770) 451-0317  
Email: [alan@alanarmstronglaw.com](mailto:alan@alanarmstronglaw.com)**

**Please contact us at  
[flightwatch@alanarmstronglaw.com](mailto:flightwatch@alanarmstronglaw.com)  
with any questions, comments, or if you no longer wish to receive Flightwatch  
via email.**

**All previous volumes of Flightwatch can be found at our website:  
[www.alanarmstronglaw.com](http://www.alanarmstronglaw.com)**

**© 2003, Alan Armstrong.  
All rights reserved.**



**N73552 WEIGHT AND BALANCE DATA**

**Aircraft Model: PT-17/N25-3**

	<b>Weight</b>	<b>Arm</b>	<b>Moment</b>
Aircraft	2,005	-1.6	-3208
Propeller	30	-69	-2070
Oil (4.4 gal. @ 7.5 lbs./gal.)	33	-26	-858
Fuel (46 gal. @ 6 lbs./gal)	276	-5	-1380
Baggage (60 lbs. max)	-0-	+84	-0-
Front Pilot	150	+19	+2850
Back Pilot	<u>150</u>	<u>+55</u>	<u>+8250</u>
	2644		+3584

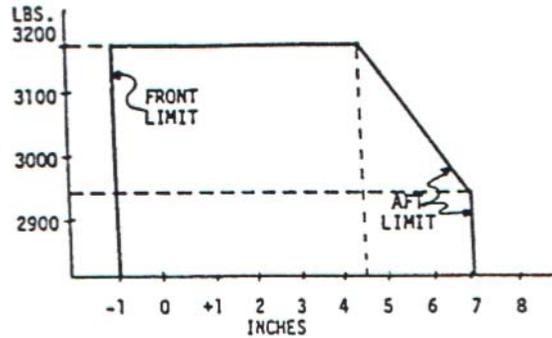
$$2644 \mid 3584 = 1.355 \text{ c.g.}$$

- Notes: (1) Maximum aircraft gross weight is 2,950 lbs.  
 (2) Maximum crew weight is 400 lbs.

**C.G. Range**

	<b><i>Maximum Weights</i></b>		
	<b><u>2950 lbs. or less</u></b>	<b><u>3200 lbs.</u></b>	<b><u>(-1.0)</u></b>
Fwd. C.G. Limit	(-1.0)	(-1.0)	(-1.0)
Aft C. G. Limit	(+7.1)	(+4.5)	(+4.5)

Note: Straightline variations of aft C.G. limit above 2,950 lbs. with Item 601 not installed.



Empty Weight C.G. Range: (-1.3) to (-0.4) Solo from either seat.  
 (-3.7) to (-0.4) when front cockpit  
 placarded: "Solo from rear seat only.\*"

When empty weight C.G. falls within this range, computation of critical fore and aft C.G. positions is unnecessary. Ranges are not valid for non-standard arrangements or for crop duster or sprayer installations.

**Maximum Weight Takeoff:** NC certification, 3200 lbs.  
 \*\*\* NR certification (Prior to October 11, 1950), 3520 lbs.

Landing: 3200 lbs.

### Placards

1. "Intentional spins prohibited at weights above 2950 lbs.\* with Item 601 not installed.
2. "Intentional spins prohibited" if elevator up-travel is more than 24\*.
3. For NR certification (Prior to October 11, 1950): "Maneuvering speed at maximum weight not to exceed 115 m.p.h.\*"

**Required Equipment** Item 1(f); 105(a), (b) or (c); 204(a) or (b); 205(a) or (b); 401(a) or (b); 402

**APPENDIX II**

*Rev. April 28, 2003*

**N3771M WEIGHT AND BALANCE DATA**

**Aircraft Model: SNJ-5**

<b>Amount</b>		<b>Weight</b>	<b>Arm</b>	<b>Moment</b>
Empty Weight		4,106.5	28.9	110,464.86
Fuel 6 lbs. Gal.	92	552	35	15,872
Oil @ 7.5 lbs. Gal.	9	67.5	-9	607.5
Front Cockpit		170	45	7,650
Rear Cockpit		200	97	19,400
Baggage 100 lbs. max.		<u>20</u>	<u>126</u>	<u>2,520</u>
<b>Totals:</b>		5,116	321.9	160,514.36

$$5,116 \div 160,514.36 = 31.374972$$

**Center of Gravity Limits: 27.5 to 32.5**