APPENDIX AN

KITPLANES FOR AFRICA

AMO: M660

AIRCRAFT
WEIGHT AND BALANCE
MANUAL

NOTE:	Please read through the entire Weight and Balance Manual before proceeding.

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PART 1. OVERVIEW

WARNING:	Aircraft weight and load distribution is vital for safe flight and if not properly calculated may result in hazardous instability and possible structural airframe damage due to loads outside of the design envelope.

CENTRE OF GRAVITY
All aircraft except the most sophisticated computer controlled fighters are designed to operate with a slight "nose heavy" centre of gravity location. This design trait ensures controllability in all normal phases of flight.
WEIGHT
The design weight of the airframe must never be exceeded. Not only is there the risk of structural damage to the airframe, but the aircraft performance will be tested and recorded at the maximum take off weight. Operation at weights greater than this will degrade those performance numbers, increasing the stall speed, increasing the take-off and landing roll, etc.

PART 2. DEFINITIONS

EMPTY WEIGHT (EW): The empty weight of an aircraft includes all operating equipment which is normally carried in the aircraft. Usable fuel is not included in the empty weight. Engine fluids are included in the empty weight.

MAXIMUM GROSS WEIGHT or all up weight (MAUW): Maximum allowable weight for the aircraft and its contents, determined by design limits: For the Bushbaby and Explorer this is 500kg.

USEFUL LOAD (UL): Useful load is the empty weight subtracted from the maximum gross weight of the aircraft. This load consists of the pilot, passengers, fuel, and baggage.

AIRCRAFT WEIGHT CHECK: A weight check done before each flight consists of checking the sum of the weight of the intended load against the allowable useful load of the aircraft to avoid overloading.

WEIGHING POINT: The weighing points of an airplane are the points by which the airplane is supported at the time it is weighed. For the Bushbaby and Explorer these are the main landing gear and tail or nose wheels.

TARE: The weight of the equipment necessary for weighing the airplane such as chocks, blocks, etc. that are included in the scale readings but not part of the actual weight of the airplane. TARE must be subtracted from the scale readings to obtain NET WEIGHT

CENTRE OF GRAVITY (CG): The point on the airplane about which the nose and the tail-heavy moments are exactly equal. If the aircraft were suspended from this point, the belly of the fuselage would hang level. The weight of the aircraft is concentrated at its CG. The ideal CG position of an average loaded Bushbaby or Explorer is 24% of the MAC or 307mm aft of the leading edge.

MEAN AERODYNAMIC CHORD (MAC): The cord (total width) of the wing. For weight and balance purposes it is used to determine the CG range of the aircraft. Because the flaperons generate some lift, they are used in the computation of the chord. The MAC is measured from the leading edge of the wing to the trailing edge of the flaperons. The MAC of the Bushbaby and Explorer is 1290mm.

CG RANGE: The allowable variation of the CG location over the MAC is called the “CG Range”. Since CG limits constitute the range of movement that the airplane CG can have without making the aircraft unstable, the CG of the loaded airplane must always remain within these limits. The CG range for the Bushbaby and Explorer is 265mm - 368mm aft of the leading edge or 20.5% - 28.5% MAC.

EXTREME FORWARD AND AF CG: The most forward allowable and most rearward allowable CG positions for the aircraft. These positions are determined by two separate computations.

DATUM: An imaginary vertical plane or line from which all horizontal measurements are taken for balance purposes with the aircraft in LEVEL FLIGHT ATTITUDE. The DATUM for the Bushbaby and Explorer is the wing leading edge, measured just inboard of the main wheels.

ARM (OR MOMENT ARM): The horizontal distance, in mm from the DATUM to the weight. A plus (+) ARM indicates the item is located to the rear of the DATUM (tail wheel) and a minus (-) ARM that it is forward of the DATUM (nose wheel).

MOMENT: The product of a weight multiplied by its ARM. The MOMENT of an item is determined by multiplying the weight of the item by its horizontal distance from the DATUM.

PART 3. WEIGHING THE AIRCRAFT

The aircraft should be weighed inside a closed building to avoid errors which may be caused by wind. The aircraft must be levelled longitudinally and laterally on its belly with the use of a spirit level. Rent or borrow three accurate scales with the proper load rating and establish the accuracy of the scales. The scales under the main wheels must be capable of weighing up to 250kg each. All items or equipment to be installed in the aircraft and included in the empty weight should be in place for weighing. Record the weight of the TARE for each scale.
Place the aircraft on 3 scales (one under each wheel). The main wheel scales should be level with one another so that the aircraft will be level laterally. Position a sturdy stand under the tail wheel and rear scale and adjust it so that the airplane is in level flight attitude (Belly level). Record the scale readings to a tenth of a kg:

Scale	Reading	Less Tare	Equals Net
Right Main			
Left Main			
Tail or Nose (+ or -)			
Total Net readings			

PART 4. CENTRE OF GRAVITY MEASUREMENTS AND CALCULATIONS

The object is to calculate the aircraft's CG range at different weights. Firstly the Empty weight, then a very lightly loaded flying weight to see how far forward the CG is and lastly a heavy flying weight with the baggage bay loaded and the aircraft as close to Max All Up Weight as possible.

CENTRE OF GRAVITY NOTES

It is desirable to have the empty CG of the airplane located as near as possible to the front limit of the GC envelope because fuel, pilot and passenger weight as well as baggage in the aft baggage compartment will move the CG backwards. With the empty CG somewhere in the centre of the envelope, a relatively small payload with fuel may result in the CG passing the aft limit, which is a very dangerous condition. This means that the aircraft may reach its aft CG limit before it is loaded up to max gross weight. An ideal CG will put the CG position to the front of the envelope with average pilot weight and about half tanks. Full tanks, passenger and baggage up to gross weight will move the CG back to a point still in front of the aft limit which is essential for the safe flying characteristics.

It is more desirable and safe to have a nose heavy airplane rather than a tail-heavy airplane. Place as much equipment as far forward as possible on the airframe. Rather have the plane too heavy in the nose than too light. Calculate exactly what CG will result with different payloads and fuel amounts on board to know when you will reach aft CG.

1. First find the ARM for each recorded weight.
With the aircraft level, drop a plumb line from the leading edge of the wing (DATUM) just inboard of the wheels.
Measure forward from the centre of the axles to the plumb lines in mm.

Right Wheel ARM ……………
Left Wheel ARM ……………..

Suspend a plumb line through the centre line of the tail wheel / nose wheel axle to the floor. Draw a straight line on the floor between the plumb lines on the left and right wing leading edges. Measure on the floor along the centreline of the aircraft between the DATUM line and the tail wheel / nose wheel axle to find the tail wheel / nose wheel arm in mm ……….
Record these arms as they will be used for all the calculations.

2. Compute Aircraft EMPTY (Unloaded) CG position: Multiply each scale reading (minus Tare) by its Arm:

TAIL DRAGGER

Location	Net Weight	X	Arm	=	Moment
Rt Main	…………	X	…………..	=	…………..
Lt Main	…………	X	…………..	=	…………..
Tail wheel	…………	X	(+)…………..	=	…………
Calculate TOTALS:	………..				…………

TRICYCLE GEAR

Rt Main	…………	X	…………..	=	……………
Lt Main	…………	X	…………..	=	……………
Nose wheel	…………	X	(-) ……………	= (-)	……………
Calculate TOTALS	………				…………..

Divide total MOMENT by total NET WEIGHT to obtain AIRCRAFT EMPTY CG position in mm aft of wing leading edge: = ……………..

Divide the empty CG by MAC to get EMPTY CG % = ………….. % MAC.

3. Determine extreme forward CG.
Record scale readings with one light weight pilot of about 55kgs in the aircraft and no baggage in the baggage compartment behind the seats. Load the fuel in the header tank only.
Record and calculate as before, this will be the practical extreme forward CG and should not exceed 265mm aft of the datum or 20.5 MAC.

4. Determine the extreme aft CG.
Load the aft baggage compartment to its maximum of 20kgs. Load a large pilot and passenger of about 90kgs each. Get the aircraft gross weight up to the maximum of 500kgs by adding fuel (it should require 25-30 litres in the wings if the header tank is full)
Record and calculate as before, this will be the practical extreme aft CG and should not exceed 368mm aft of the datum or 28.5 MAC.

Experiment with the above to find the maximum amount of baggage that can be carried in the compartment combined with the heaviest payload and baggage not to exceed the aft GC limit. Also determine the lightest pilot able to fly the aircraft without exceeding the forward CG limit.

5. When the weight and balance calculations are complete, transfer them to the aircraft documents to be carried on board.

PART 5. CG AND ENGINE INSTALLATION

If there is a very light or very heavy engine installed, the battery or other equipment may be moved forward or aft to find a more favourable CG position with average load.
The Bushbaby and Explorer can accommodate engines from 50hp and 50kg up to 100hp and 100kg total installation weight. The CG envelope however, will not tolerate differences as large in weight.
The frame was designed for the average weight of a Rotax 912 at 72.5kg. This engine will result in a properly balanced plane without any modifications to the rigging of the airplane.
Engines heaver than 85kg will require a 1 degree forward swept in the wings and engines lighter than 65kg like the Rotax 503 and 582 will require a 1 degree sweepback in the wings which will move the centre of pressure aft, shifting the CG range back and vice versa.
1 degree of sweep will equate to 78.5mm movement at the wing tip.
This will move the CG range 36mm forward or aft which should be adequate for the above-mentioned engines. If less than 36mm is required, only ½ a degree of sweep can be incorporated.

	FRONT LIMIT	AFT LIMIT
No sweep:	265mm	368mm
1-degree forward sweep:	229mm	332mm
1-degree aft sweep:	301mm	404mm