Europa Gross Weight Increase
An Analytical Approach

By Bud Yerly

While working at Flight Crafters I was part of the conversation on the Gross Weight Increase for the Europa.

The problem with most light aircraft is the aircraft design and the prototype were around a payload of 500 pounds maximum. However, most pilots and passengers are no longer 170 pounds each and fuel loads and payloads are always increasing. Worst yet, the aircraft undergoes mission creep. The designer proposed a light VFR aircraft with minimal equipment, no interior beyond a cushion, a small engine and fixed wood propeller. However, the builder (and the dealers) tend to load up the aircraft to meet the demands of the prospective buyer.

Buyers want all the doodads and bells and whistles, a comfy cushion, for their turbocharged engine, constant speed propeller, oxygen tanks for high altitude cruise, autopilots, external lighting, additional alternators, batteries for backup, additional fuel tanks, and a larger fully packed instrument panel completely packed with every instrument known to man. So the light weight 800 pound prototype grows to an 1100 pound empty weight experimental. However, the maximum gross weight stays at 1300 pounds.

Europa aircraft realized this and improved the structure, and maximum gross weight with Mod 52 to 1370. Unfortunately, even that wasn't enough.

In the US and other countries requests were made to Europa Aircraft to increase the maximum gross even higher. Andy Draper in emails and faxes commented that since the Europa was built with a superfactor (a load factor of 1.5 over the design G limit is standard as a maximum G load which the aircraft must demonstrate for 3 seconds prior to breakup, but the Europa was designed to a 1.5 times 1.5 safety factor or superfactor). This superfactor was to be an additional pad for amateur building errors. Essentially the 3.8 G standard maximum G for the Europa made for a design that is overly strong and the major wing and fuselage structure were designed and demonstrated at the following: 3.8 positive G X 1.5 X 1.5 which yielded a structure able to achieve 8.55 Gs if for only a moment for breakup.

This superfactor means one of two things. The aircraft gross weight can be increased or you can pull more Gs. But that is not sane. An increase in gross weight affects many other things also.

The stall speed will increase slightly, the CG range has to be tightened up for longitudinal stability, the tail force will be the same but its affect on the ability to raise the nose for the flare at the forward CG is significantly different. Landing gear attach points must be retested for heavier landing weight. Spin characteristics with different heavier loadings must be evaluated.

A heavier aircraft will have a longer takeoff and landing roll which must be computed, climb rate will be lower, with lower climb rates the aircraft will take longer to get to altitude and the engine will be stressed longer, cruise speeds will be lower due to a higher angle of attack at cruise. Final approach speed will be slightly higher, but the sink rate power off in a glide will be higher as will the sink rate on final requiring a bit more power on approach increasing residual thrust in the flare increasing landing roll. Wheels and brakes will be taxed more.

All this additional testing will also have to be approved in the UK and other countries. Flight and ground stress tests must be done at significant cost. Pilot handbooks will need to be modified. As a result, Europa Aircraft never pursued this gross weight increase.

When I began Custom Flight Creations in the USA, the FAA does not consider a change in GW to be a problem. The kit builder (an amateur) can make the change as in the US the kit manufacturer is only a component manufacturer and the builder is considered the manufacturer. It is beyond the scope of this paper to determine whether this is a smart policy.

At Custom Flight Creations, I went about the analytic and flight testing to see if a 1450 pound maximum takeoff weight was sane and rational. In my analysis I took a different option than simply assuming the structure superfactor would protect me and my clients. I also kept the maximum landing weight at 1370 pounds to keep landing gear and landing characteristics the same for the GA pilot flying the Europa.

In my analysis I reduce the maximum load factor in proportion to the GW increase. This allows the superfactor to still be present even at the higher weight. Of course all the other factors with the GW increase will still be a factor and must be analyzed and computed changes made.

The calculations are attached at the end of this document. To summarize:

Maximum takeoff weight (MTOW)to 1450 pounds XS or Classic aircraft. VEAS is within instrument tollerances if the pitot tube is placed IAW the XS manual.
Maximum Landing weight is maintained at 1370 pounds.

Aircraft G limit change at 1450 pounds +3.59 , -1.79
Vne: 165 KIAS for XS, 160 Classic.
Va: 96 KIAS
Vno: 125 KIAS based on updated gust load factors.
Vfe: 83 KIAS
Vso: 50 KIAS
Vsf: 45 KIAS
Vx: 61 KIAS
Vy: 75 KIAS
Vl/d: 75 KIAS

Takeoff Roll: 750 feet sea level standard day.
Landing Roll: 750 feet full flap, maximum braking no wind 1450 pound over gross landing.
Rate of Climb, constant speed propeller or fixed climb prop: 914: 900fpm, 912S: 650fpm, 912: 500fpm
Due to longer climb consider a 80-90 KIAS climb speed to enhance cooling.

Attached:

1. Europa GW increase considerations.xlsx
2. VN Diagrams.xlsx
3. Europa Aircraft Tech Andy Draper MTOW increase Fax discussion.

Attachment 1.

Europa Gross Weight Increase Data N12AY for the possibility of an increase in the GW to 1450 lbs.

The increase in Gross Weight (GW) requires more than just an arbitrary change to the GW limit posted in the Europa Pilots Handbook of 1370 lbs.

Considerations:

Increasing the GW from 1370 to 1450 MTOW analytically calculated.

Maximum ultimate strength

- No ultimate strength changes are considered.
- No ultimate load tests are to be conducted.
- This is an analytic exercise.

Current Design Load Limit.

3.8 G at 1370 lbs. From CG of 58-62.5 inches.

Over Gross Limit Changes Considered for This Exercise.

MTOW increase to 1450 lbs allows full fuel and takeoff only.
Maximum Landing Weight will remain at 1370 lbs.
Landing over 1370 lbs will require a hard landing over load landing inspection.

Adjusted Gross Weight (AGW)

The AGW of 1450 lbs increases the GW by 80 lbs.
The Maximum G Limit is adjusted as follows:

1370	is	X	X is the Adjusted G Limit		
1450	to	3.8	X equals	3.59	Positive G limit

3.59 Gs will allow the aircraft to structurally fly at low speed within its superfactor limits.
Negative G limits are changed also: 1.79 Negative G limit

CG Limitations with Gross Weight Increase.

Flight test indicates that the forward limit for full flap landing is limited to 59 inches CG.
At 58 inches and 13 degrees of LE down of the stab, barely allows the aircraft to flare out power off.
No affect on stall, pitch stability or spin recovery (one turn) occurs at 62.5 however, the Trigear landing gear position without pilots in the aircraft allows the aircraft easily be pushed on its tail.
An aft limit of 62 inches allows the aircraft to not fall on its tail and stay there for loading and ground handling.
At 62 inches the aircraft was stalled fully and cross controlled to enter a spin. Recovery was immediate.
The aircraft is still longitudinally stable at a CG of 62.5 inches, but with full baggage and fuel with no pilots, the planes CG is very close to the main gear.

VN changes with increase in Gross Weight.

During cruise in vertical gust conditions the aircraft may exceed its G limits inadvertantly.
However, at speeds below approximately 125 KIAS a vertical gust may stall the aircraft at low speed before the load factor is exceeded.

Landing gear component strength considerations:

Wheels: Matco Mfg. WHL 51 normal load min 1200, maximum load 3600 per wheel.

Gear legs: RV4 design based on load of 1550 lbs. normal max load. These are the legs used originally on the Europa Trigear.
Manufacturer of these gear legs was: Langair Machining Inc.

Gear leg attachment points: After 10 years of flying and landing overgross Europa aircraft at or near 1450 lbs without ever bending a gear leg or causing a deformation of the gear box, it seems strong enough. Analytically, the gear box 3/4 ply compression capability with the glass, exceeds a 4 G impact load at 1370 lbs with the gear as designed.
(Based on a 33 inch leg, 3/4 marine ply, and a max load at landing of 2900 lbs per tire. I estimate a **4 G** impact will still allow another 30% safety factor.
The steel sleeve and bolt holding the gear however may begin to elongate which is difficult to repair.

Attachment 1 contd.

Suggested Placard For MTOW of 1450 lbs.

G Limit 3.8 Gs at 1370 lbs, CG 58-62.5 inches
G Limit 3.5 Gs at 1450 lbs, CG 59-62 inches
Maximum Landing Weight 1370 lbs in all cases.
Landings above 1370 lbs may be accomplished provided an
inspection of the gear is accomplished.

Suggested over gross landing gear checklist:

Fuselage Area

Mono:

- Fuselage through bolt attachments of the main gear welded frame bolts and holes for elongation/ deformation or de-lamination.
- Landing gear and engine mount frame for deflections, cracks or out of alignment condition.
- Cockpit module wheel well for deformations, punctures or de-laminations.
- Inspect all Redux/Araldite 420A/B joints via tap method for hollow sound indicating de-lamination or failed joints.
- Check the belly sides and top for wrinkles or deformations in the fuselage.
- Wing attachment and lift pin for deformations.
- check the LG04 pin for straightness and all the mounting and swing hardware for deformations, looseness or cracks, mechanisms.

  Pay particular attention to the up and down lock
- Inspect the wheel for cracks and damage.
- Rear fuselage empenage for deformations/wrinkles or de-laminations.
- Inspect the tail spring attachment bolt and mount for straightness, deformations or elongations.

  Inspect the spring for straightness and cracks as well as security.

  Inspect the wheel fork and bearings for deformations or abnormalities. Inspect the wheel and tire.
- Examine the wing attachments and outriggers for deformations and cracks as in the Over G inspection.
- Examine the landing gear frame for cracks or deformation in the frame, overcenter lock and components.

Trigear:

Main Landing Gear Area:

Raise aircraft by the tail sufficient to check the gear for looseness.

- Inspect the aircraft for wheel toe in and alignment. There should be zero toe with weight off the wheels.
- Inspect the tracking with weight on the wheels.
- Jack the aircraft and check the leg for cracks, deformation, and the spindle and wheels for damage.
- Check the tire(s) for wear, cuts and flat spots.
- Inspect the wheel for cracks and damage.
- Check the wheel pants and brackets for cracks and deformations.
- Inspect the nose gear leg bolts and welds for deformations, cracks or misalignment. Check the pivot bushings for wear and soundness.

  Check the bump stop and leg for any defomation
- Check the engine mounts, gear frame and supports for cracks, elongated bolts or deformations.

Attachment 2

Effects of Gross Weight Increase from 1370 to 1450 lbs.

Added weight increases stall speed. Indicated below, the increase of 80 lbs raises stall speed by one knot.

GW	Stall Speed	Nominal G	Negative G
1450	50	3.6	-1.8
1370	49	3.8	-1.9
1100	45	3.05	-2.35
0	0	0	0

The velocity vs G loading of the aircraft are affected also.

	1370 Lb GW		1450 Lb GW
V	N	V	N
160	3.8	160	3.6
150	3.8	150	3.6
140	3.8	140	3.6
130	3.8	130	3.6
120	3.8	120	3.6
100	3.8	100	3.6
95	3.8	96	3.6
84	3	87	3
69	2	71	2
49	1	50	1
25	0.3	28	0.3
10	0.05	11	0.05
0	0	0	0
10	-0.05	12	-0.05
25	-0.29	29	-0.3
50	-1	52	-1
70	-1.9	67	-1.8
100	-1.9	100	-1.8
120	-1.9	120	-1.8
130	-1.9	130	-1.8
140	-1.9	140	-1.8
150	-1.9	150	-1.8
160	-1.9	160	-1.8

Gust factor on G loading:

A strong 50 fps or 3000 fpm up/downdraft vertical gust (about 39 Knots) affects the G limit significantly, and is a consideration on the manuevering of the aircraft above the maneuvering speed (Va) of the aircraft and the max structural cruising speed (Vno) green arc or rough air limit should be adjusted.

A crude but effective method is to use the delta lift by the gust factor on the lift curve slope. Then calculate the equivalent airspeed decrease for that load and plot on the curve below:

n= 1+ (Kg Vgust V *p S/2W)*   Kg=.88u/5.3+u   u= 2m/p C a S where a is the centrifical acceleration

Veas KTS	Ve fps	Vgust fps	Delta CL	Vd
50	84	50	stall	
75	126	50	stall	
100	168	50	16.6	
125	210	50	13	

u	Kg	n	
44.69	0.78	1.71	@ 1370 and 50 fps
44.69	0.78	1.87	@1450 and 66 fps

1370 Lbs. 50fps	
A/S	Gust Factor
0	1
125	2.78

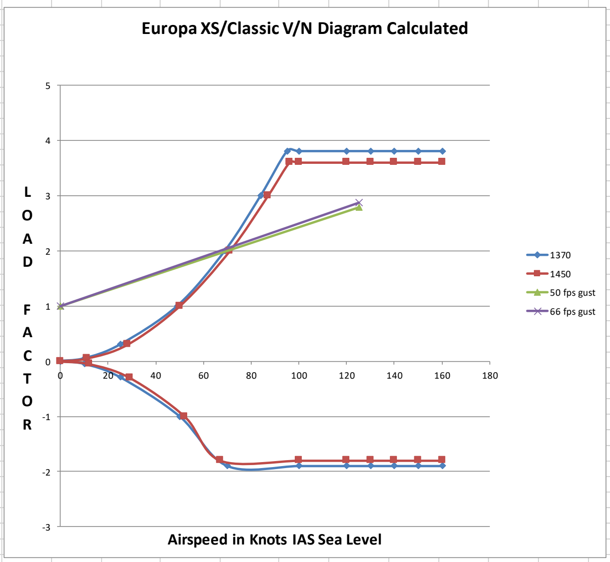
1450 Lbs. 66fps	
A/S	Gust Factor
0	1
125	2.87

A rough air penetration speed should be changed slightly from 131 to 125 KIAS

AS	Gust Factor		
0	1	0	1
125	2.78	125	2.87

Based on 100 sq ft wing area flaps up.

Cl of 1.67 clean wing



Veas KTS	Ve fps	Vgust fps	Delta CL	Vd
50	84	50	stall	
75	126	50	stall	
100	168	50	16.6	
125	210	50	13	

u	Kg	n	
44.69	0.78	1.71	@ 1370 and 50 fps
44.69	0.78	1.87	@1450 and 66 fps

Attachment 3

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FACSIMILE

	Stefan Ridderheim
FAX No.	0046 601 29117
FROM	Andy DrAper
DATE	22 November, 2000
No. Of Pages	1 (Including cover page)

Dear Stefam

The figures rye given you are estimates. which I believe to be realistic, conservative even, Don's figure of 4-5kts is based on the maximum cruise speed, I would expect the differenct to reduce proportionally as aircraft speed was reduced,

Don's comment to me was that the biggest differences you'd notice, as a result of weight increase, would be climb rate and acceleration hence my estimated 50% increase in take-of

The following are my estimates Pon has gone away until mid December), on a 14,301b aircraft, for the remaining cases that you ask for:-

Stall speed (flaps down) S Okts
Stall speed (flaps up) 55kts
Fuel consumption (economy) 1 livhr Range
(economy) std tank 600nm
R enge (economy) aux tank 90011m

These figures are only estimates: but I believe are as accurate as I can make them. They als are dependent on propeller and standard of build.

I hope that these figures are OK with you

004660129117 EUROPA AIRCRAFT

Kind regards

Andy Draper
"I echl)ical Manager
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FACSIMILE

F.A.O.	:	Staffam Ekström - EAA Chapter 22, Sweden
FAX NO.	:	0046 8751 9816
FROM	:	Andy Draper
DATE	:	14 November, 2000
No. Of Pages	:	2 (Including cover page)

Dear Sirs.

Increase in Europa XS gross weight from 1370lb to 1450lb

The Europa XS aircraft has been designed to have a maximum gross weight of i 3701b and the wings!fuseiage structure Has been tested to $.35g to qualify it to 3.8g, A faetor of -5 has been ug,eci in consideration of the structure being made using eomposite materials in addition to the normal safety factor of l.5.

Thus, 3Sg x i .5 x ! S= 8.55g.

A composite factor of 13 is •considered acceptable resulting in a test factored ultimate being 3 8 x x 1.3 = 7.4 lg.

Hence 8.55 =

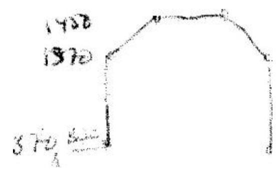
7t42

Therefore 13701b x 15751b*

However, with consideration •to the landing gear strength and aircraft performance it would be prudent to limit the maximum permitted gross weight in Sweden to 14501b,

When operating at weights above 3701b the centre of gravity limits should be revised from between 58.0" to 62.5 2 t aft Of datum (AOD) to between 59.0" to 61 S" (AOL)) to reduce effects of inertia during ground handling

A n'h(snugh we have not demonstrated this, the Europa .XS aircraft at 14501b, when fitted with the RoLax 914 engine and Warp I*ive propeller set to provide a minimiiin static rpm of 5200 in ISA conditions, should enable take-off within 300m on a hard uncontaminated n;nway and climb at greater than i 00ft/minute„



Kind regards

Andy Draper
Technical Manager

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FACSIMILE

	Stephane Ridderbeim
FAX NO,	0046 6012 9117
FROM	Andy Draper
DATE	14 November, 2000
No. Of Pages	2 (Includiug cover page)

Dear Stephane,,

Attached is a copy for your reference of the facsimile sent to Staffam Ekström in Sweden, regarding the suggested increase in Europa XS gross weight,

Kind regards

Andy Draper
Technicai Manager

S. I spoke to Don Dykins regarding the effect of the extra weight on speed and he estimates 4-5 Kts will be lost.