LAA/MOD 2 **MODIFICATION INITIAL PROPOSAL** Issue 6	Mod No. (Office use only)

This form is used to give notice of a proposed modification so that LAA Engineering can advise on the required minimum content of the Modification Application, see TL 3.01.
This form may be printed out, completed by hand and either posted to LAA Engineering or scanned and emailed to engineering@laa.uk.com, or it may be completed electronically, saved and emailed as an attachment to the same email address. If emailed without the owner's signature, it must be sent by the aircraft owner. Please retain a copy of the completed form for your records.

1. AIRCRAFT DETAILS

Registration	Type	Serial Number
G - *OUAV*	***TLAC Sherwood Scout***	***345-15480***

2. APPLICANT DETAILS (Note: Applicant must be a 'Full plus' member)

Applicant's Name	***Keith Towell***	Membership No.	***015778***
Name and address of person to be contacted regarding this modification:			
Prof J Scanlan, Faculty of Engineering and Physical Sciences, University of Southampton, University Road, Southampton S0171BJ			
Daytime Telephone Number:	***02380 592369***	e-mail:	***J.P.Scanlan@soton.ac.uk***

3. MODIFICATION DETAILS

Title:	***Variable Stability Demonstrator***	
Purpose :	***Modify longitudinal stabilty characteristics***	
Brief description of proposed modification: (30 words max)		
We will modify the Elevator control circuit to include two sets of servos. One to take the elevator input from the p2 control stick and provide force feedback though it. Another to output the modified elevator response to the elevator at the Idler.		
Does this mod appear on any similar aircraft?	YES ○	NO ◉
If yes, which one?		
Describe any variations to previous mod.		

4. PREDICTED WEIGHT AND BALANCE EFFECT ON AIRCRAFT

Date of current W&B report:	***18/12/2020***	Weight (lb/kg)	CG (in/mm)	Moment
A/C pre-mod		***289.1kg***	***228.1mm***	***65943.71kgmm***
+/- weight change		***20kg***	(moment arm) ***971.6mm***	***19431.74kgmm***
= A/C post-mod		***309.1kg***	***276.2mm***	***85375.45kgmm***

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5. DESIGN CONSIDERATIONS

Will the proposed modification affect any of the following? If 'yes', then submit proposals, in the section provided, for how you will demonstrate that the modified aircraft is nevertheless airworthy. Normally this involves showing compliance with applicable paragraphs of the design requirements, e.g. CS-VLA, BCAR Section T or Section S.

* In the case of additional equipment being installed, equipment qualification, proof of functionality, integrity of mountings and its operating environment must also be considered.

The integrity of the airframe	YES ○	NO ◉
The flying control system	YES ◉	NO ○
The occupant restraint system	YES ○	NO ◉
Aircraft crashworthiness	YES ◉	NO ○
Any part of the undercarriage installation	YES ○	NO ◉
Any part of the engine installation (including reduction drive)	YES ○	NO ◉
The fuel or oil system	YES ○	NO ◉
The engine control system	YES ○	NO ◉
The propeller and its installation	YES ○	NO ◉
The flight handling qualities	YES ◉	NO ○
Aircraft performance	YES ○	NO ◉
Aerodynamics	YES ○	NO ◉
Ground handling qualities	YES ○	NO ◉
Aircraft noise levels	YES ○	NO ◉
The electrical system	YES ○	NO ◉
The radio installation	YES ○	NO ◉
Instrumentation and systems setup	YES ○	NO ◉
Additional equipment*	YES ◉	NO ○
Pilot's Operating Handbook	YES ◉	NO ○
Maintenance Manual	YES ◉	NO ○

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Proposals for how modification details will be presented with modification application. e.g. text, drawings, photographs, etc.

See attached document

For each of the affected areas identified in section 5, describe your proposals for how the airworthiness of the modified aircraft will be demonstrated. e.g. compliance with a recognised design code, normal aviation practice, safety comparison with existing design, service experience in other countries.

See attached Document

6. IMPLEMENTATION

Is the proposed modification currently fitted to the aircraft? (Note that once installed, the aircraft may not be flown until permission given)		YES ○	NO ◉
If yes, briefly describe any other work needed for the aircraft to be ready for flight (e.g. finish re-build)			
If no, when do you intend to fit the modification?	***April***		

7. DESIGN SUPPORT

In many cases you will be required to obtain a declaration of "no technical objection" from the Designer of your aircraft regarding the modification that you intend to install.		
Has the designer agreed to co-operate with you over this modification?	YES ◉	NO ○
Do you have access to any other design capability?	YES ◉	NO ○
If yes, please give brief details.	***Messrs Paul Hendry-Smith, Mike Robins, Chris Burleigh, plus UoS engineering academics.***	

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8. INSPECTION SUPPORT

In many cases your inspector will be required to supervise testing and confirm compliance with the requirements. You must discuss your proposal with your inspector prior to submitting this form: we may contact him/her for their opinion.			
My inspector is: (Name)	***Fin Colson***	LAA inspector no.	***403***
Has your inspector agreed to co-operate with you over this modification?		YES ◉	NO ○

9. FUNCTION AND FLIGHT TEST PROPOSALS

In many cases a modification will require in-depth function and flight testing and this often requires the involvement of a suitably qualified test pilot and may dictate the standard of the airfield chosen. State your proposals for function and flight testing the modification.
Ground testing of system check, carry out test program, safety check and electrical check, load testing, capacity check of battery, cleck control laws and software check such as bit-dropping.

10. PROPOSED FLIGHT TEST DETAILS

Test Pilot	Total hrs PIC	Hrs on type	Airfield
Graham Bourns			***Popham***

11. OWNER'S DECLARATION

I declare that the foregoing information is correct and I agree to abide by any conditions pertaining to this modification. **I agree that this modification, if approved, can be used free of charge by others.**	
Name (owner): **(on behalf of all the owners)**	***Jim Scanlan***
Signature:	
Date:	

Note: a signature is not required if the owner is submitting this form by email; however, by submitting the application, you signify that you agree with the Owner's Declaration.

If this mod is successful, are you willing to allow potential applicants wishing to fit the same mod to their aircraft to contact you? ◉YES / NO○ If so, which means of contact is acceptable to be published on the LAA's web site? home phone □, mobile phone □, email ■, address □ [Tick whichever apply]

Data privacy: personal data submitted on this application form may be stored electronically but will only be used in relation to the application and to support the safety of any aircraft to which it relates. Statutory obligations excepting, personal data will not be passed on to third parties without your permission. The full LAA data protection policy can be found on our website at www.laa.uk.com

Variable Stability Demonstrator

Project Overview

This project aims to convert the Sherwood Scout (G-OUAV) light aircraft into a variable stability demonstrator in the pitch axis. This will be achieved by modifying the current elevator control system at both the control stick and the idler to allow for an independent elevator response to the pilot input as shown in Figure 1. The pilot input will be modified by means of the control system outlined in Figure 2 to make the G-OUAV's elevator response mimic the longitudinal stability characteristic of a target aircraft. The control system will also provide force feedback to the pilot via the control stick to allow them to feel the stability characteristics of the target aircraft.

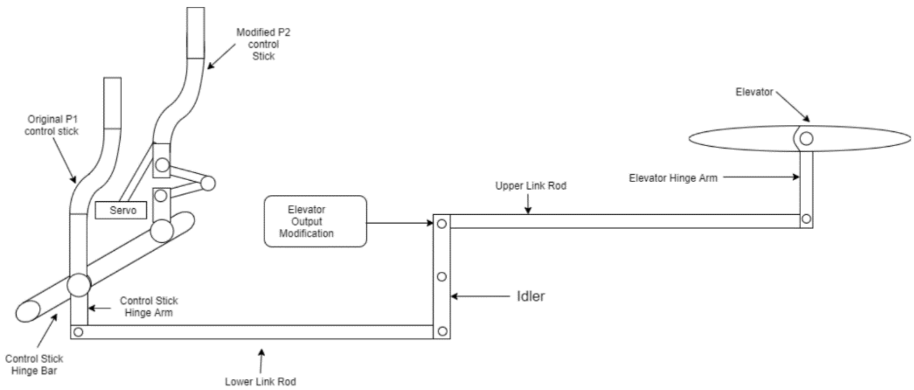


Figure 1 – Full elevator control system diagram

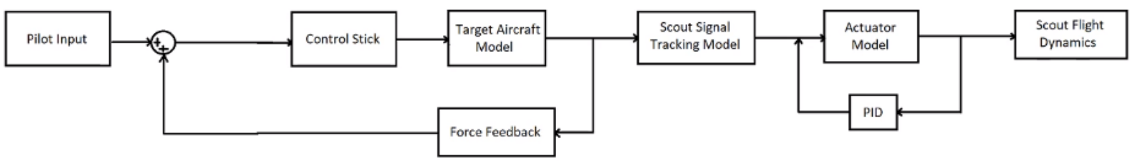


Figure 2 – Control system block diagram

To gather real time inputs needed for the control system we intend to use an Arduino based accelerometer and gyroscope module for orientation and a differential pressure senor with tapping for static and dynamic pressure via a pitot static tube attached onto the wing strut for airspeed.

Force Feedback System

This modification will see us replace the existing control stick mechanism shown in Figure 3 with the modified system shown in Figure 4. This will ensure independent motion on the control stick in the longitudinal direction against the main elevator control system, while directly transmitting the lateral motion to and from the existing aileron control circuit.

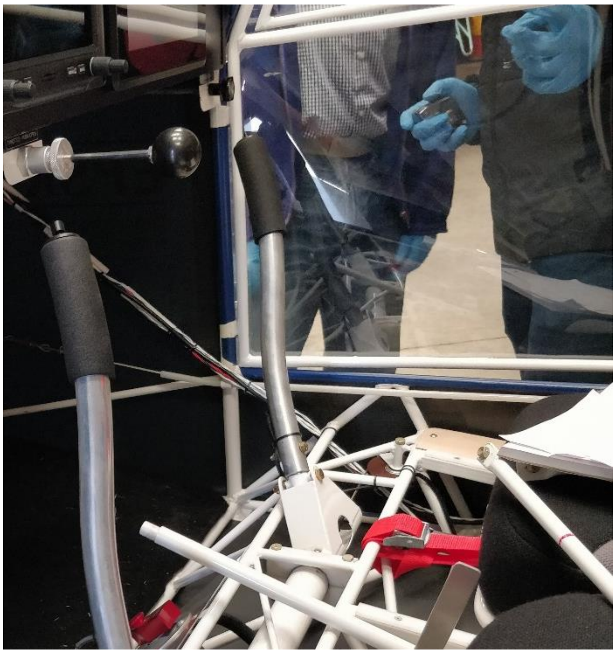


Figure 3 – Existing control stick mechanism

Figure 4 – Render of the proposed control stick mechanism

To provide the force feedback a single servo fixed to the floor of the P2 pilot footwell and control stick as per Figure 5 will be used to provide a variable resistance to a pilot input. This variable resistance will be altered to provide the pilot with the feel of the target aircraft stability characteristics. Further to this, a position sensor built into the servo will be used as the source for the pilot input into the control system.

The design shown in Figure 5 will be designed to ensure the pilots range of motion within the cockpit is not hindered.

Figure 5 - Render of proposed mechanism for attaching control stick to servo

Elevator Output system

High loads are expected on the elevator due to us trying to mimic more dynamic aircrafts and due to this our design entails coupling two servos, both fitted with electromagnetic clutches, and attaching them onto the existing control system at the top of the idler as shown in Figure 6.

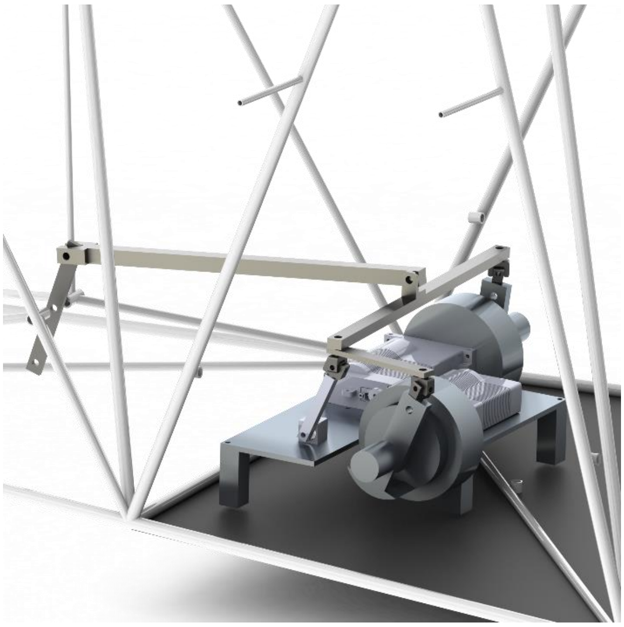


Figure 6 – Render of idler servo attachment

The servos will be fitted within the constraints of the baggage bay and connected via a link rod to the idler. This is to limit the effect on the centre of gravity position of the aircraft, given each servo weighs around 2kg.

Control System

The control system will follow the basic block diagram shown in Figure 2 and will run on an Arduino. The control system code itself will run with pre-determined flight parameters obtained through a linear aerodynamic and flight dynamic model developed as part of this project and will be precompiled to ensure robustness within the system.

Rack Mounted Electronics Tray

A 19-inch tray will be added to the existing rack fitted to the aircraft to hold the external battery, Arduino and all other electronic modules needed to control the dead man’s switches, pilot indication display, flight data sensing equipment and the servos themselves.

Pitot Static Tube system

To avoid interaction with the aircraft’s existing electrical system, we will use an external pitot static tube attached as per the illustrations shown in Appendix 1. This will be done by linking the pitot static tube to a differential pressure sensor connected to the Arduino, via a dynamic and static pressure tapping from the pitot static tube mounted on the wing strut.

Accelerometer and Gyroscope system

For the aircrafts angle of attack and pitch rate an Arduino accelerometer and gyroscope module will be used. This module will also be fixed onto the 19-inch rack.

Pilot Indication Display

To avoid any interaction with the existing aircraft displays, we intend to use a display module with a toggle switch and 4 LEDS to indicate to the pilot the status of the system. This module will be powered by the Arduino and will be fitted on top of the dashboard and attached to the V struts running to the windscreen as shown in Figure 7.

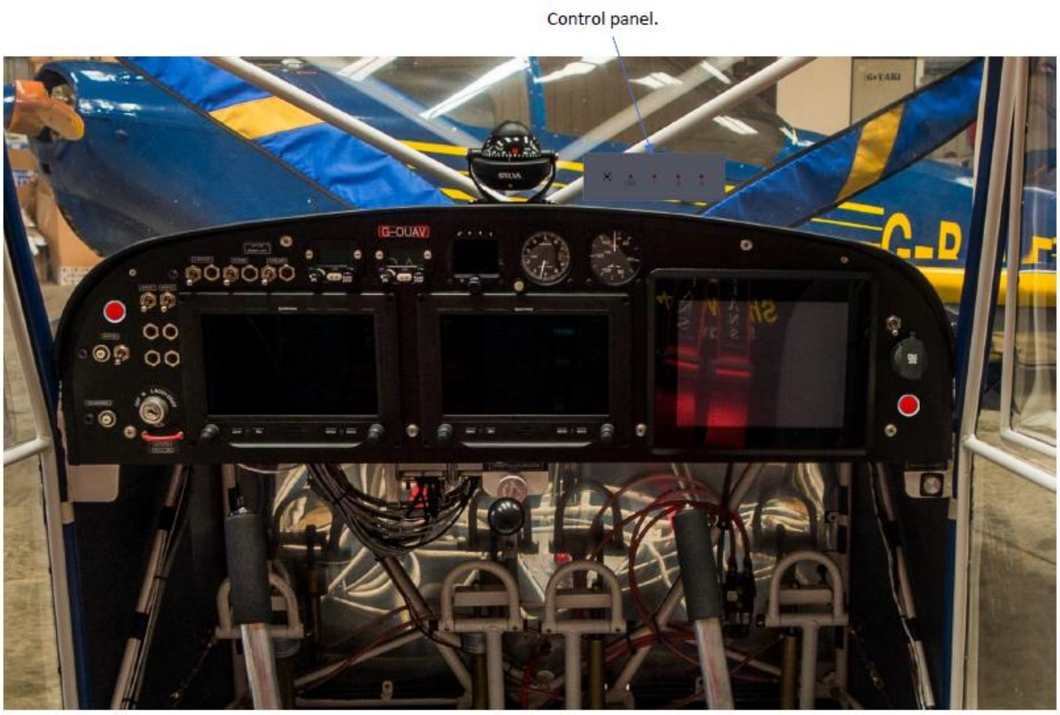


Figure 7 – Control Panel attachment

Dead Man's Switches

Two dead man's switches will be fitted to the dashboard as per Figure 8. This will ensure both pilots can shut down the system and hand control back over to P1, as when either of the switches are opened it will shut down the system. This will be achieved by wiring the switches in series from a 5V supply from the Arduino to a relay. The relay will then be able to interrupt the power supply to the electromagnetic clutch, therefore disconnecting the system.

Figure 8 – Location of the dead man's switches on the Scout's instrument panel

Electronic schematic

A schematic of our electrical system can be found in can be found in Figure 9.

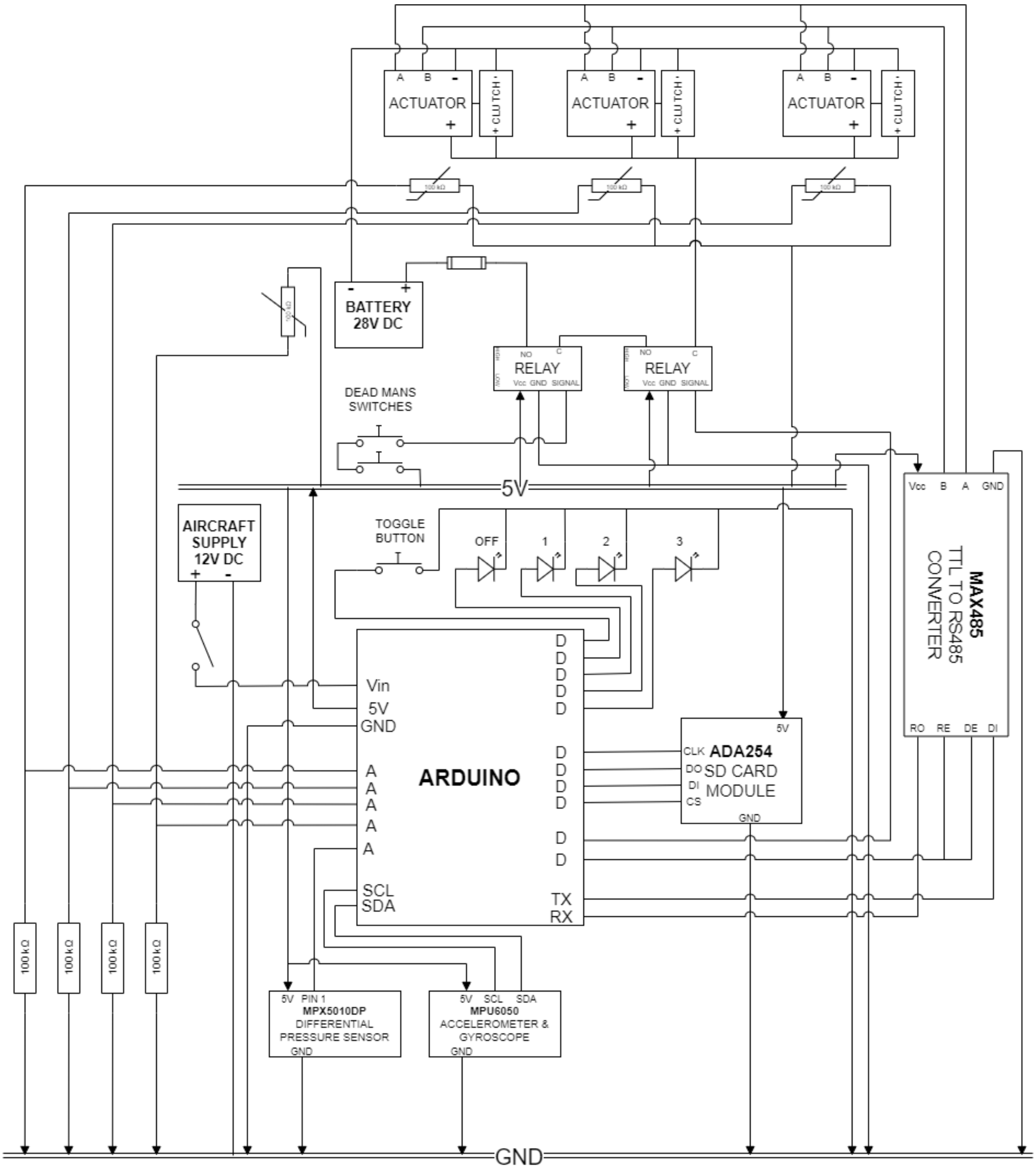


Figure 9 – Wiring schematic of electrical system

As can be seen in Figure 9, our Arduino microcontroller is powered directly from the aircraft's 12V DC power supply. We will then have a 5V rail, powered by the 5V pin from the Arduino. Most of our system will be powered by this rail, including our sensors and flight data recording module. All these components will be grounded to the aircraft power supply as well, including the Arduino. The only part of our system not powered by the aircraft supply is the actuator-clutch sub-circuit, which will be powered by a 28V battery. To ensure the power draw from the aircraft is not too large we will also carry out a power load analysis.

The toggle button and the 4 LED's in the centre of the schematic are the pilot's interface with the system during the flight. Either pilot will be able to use the button to switch the system On/Off, or to change the mode in which the system is operating. Before each flight, 3 target aircraft configurations will be programmed onto the Arduino, and whilst in the air, the pilots will be able to switch between these.

In order to verify that our system works, we will need flight data recording capability. The simplest way of doing this on an Arduino is via an SD card module. At a frequency suitable to the task, flight data, as calculated from the accelerometer, gyroscope and differential pressure sensor, will be written and saved to the SD card. This frequency will be variant, depending on the stage of flight and status of the system.

Flight safety mitigation measures

Servos

- The two proposed servos at the idler will be fitted with electromagnetic clutches. When power to the clutch is disconnected by the Arduino itself or through one of the pilots releasing the dead man's switch, it will disconnect the servo from the existing elevator control circuit. This will allow P1 to take over flight control, hereby forming a redundancy measure whereby the original flight control system and handling qualities of G-OUAV will be restored (apart from the P2 control stick being disconnected from the system).
- The P2 control stick will be connected to the servo via a pin joint and so if the pilot determines the system is not safe, they can physically disconnect the control stick from the servo.
- The force feedback Servo attached to P2 is only expected to provide a maximum aerodynamic load of 123N and given the maximum permissible pilot effort force according to CS-VLA 391 on control surface load is 740N, the pilots should be able to overpower the servo if needed.

Structural

- A structural load analysis will be carried out on all new parts added as part of the modification, using the ultimate structural loads expected at the relevant points in the elevator control circuit (with a safety factor of 1.5). This will ensure the flight control system is structurally sound, as the minimum safety factor defined by the LAA is 1.5 according to CS-VLA 303.
- A structural load analysis will be carried out on the mounting of any parts aft of the pilots. This is to ensure any structures we fit can withstand a 9g load in case of a head on impact as per the CS-VLA 561 General guidelines on aircraft crashworthiness.

Control system

- A hierarchy-based coding structure will be used to ensure robustness. This means that all functions will be ranked in terms of importance for system safety to be maintained, and timed interrupts will be used on the most safety critical parts of the code. Therefore, if an input is not received in time, or at all, the code does not crash and is able to deal with the situation.
- The Arduino will have a dedicated digital output safety pin, which if not high will disconnect the clutch and deactivate the system. This allows all 3 of the clutches (and therefore servos) to be disconnected instantaneously by the Arduino. The Arduino will disconnect the clutches if:
    - A set of conditions checked within the code at each timestep exceed the aircraft's pre-defined flight envelope.
    - At any timestep any input is above a pre-determined limit or is not received in time.
- A saturation block will be added to the elevator output to ensure the output is within the capabilities of the elevator's range of motion. If the desired output is larger than the maximum elevator deflection, the output is capped at the maximum elevator deflection.
- When the control system disconnects the system, it will alert the pilots via a flashing LED on the pilot indication display.
- The control system code will be pre-compiled onto the Arduino and will be tested on the ground to ensure all safety measures are working before every flight.

Electronics and Wiring

- All electronic components, such as relays, will be mounted to the tray in the 19-inch rack.
- All electrical connections will be strain relieved and connected using aerospace grade connectors.
- All wiring will also be shielded using fire resistant insulating material and will be colour coded to identify live and signal wires.
- All wiring will also be bundled together and run through the aircraft in a manner to avoid any interference with the existing wiring and to avoid hindering the pilot's range of motion.
- The wiring will all be grounded to the aircraft ground at a single point.
- To avoid any further interference with the aircraft electrical system the high-power servos will be run from an additional battery fitted in the 19-inch rack.
- We intend to use a Lithium-ion battery and for safety reasons will always monitor its temperature using a thermistor.

Other safety considerations

- The total weight of the modification added will not exceed 20kg and so should not exceed the baggage allowance on the aircraft. This means the additional equipment on the aircraft should not have an adverse impact on the weight balance of the aircraft.
- Since this system will affect the flight control system, we will write a supplement to the pilot's notes.
- As we intend to make this system removable, a maintenance manual supplement will be developed to instruct the installation and removal of the system.

Estimated Weight of Modification

The Estimated weight and balance of the aircraft can be seen in table 1 below. In Table 1, the CG location was taken to be positive aft of the datum.

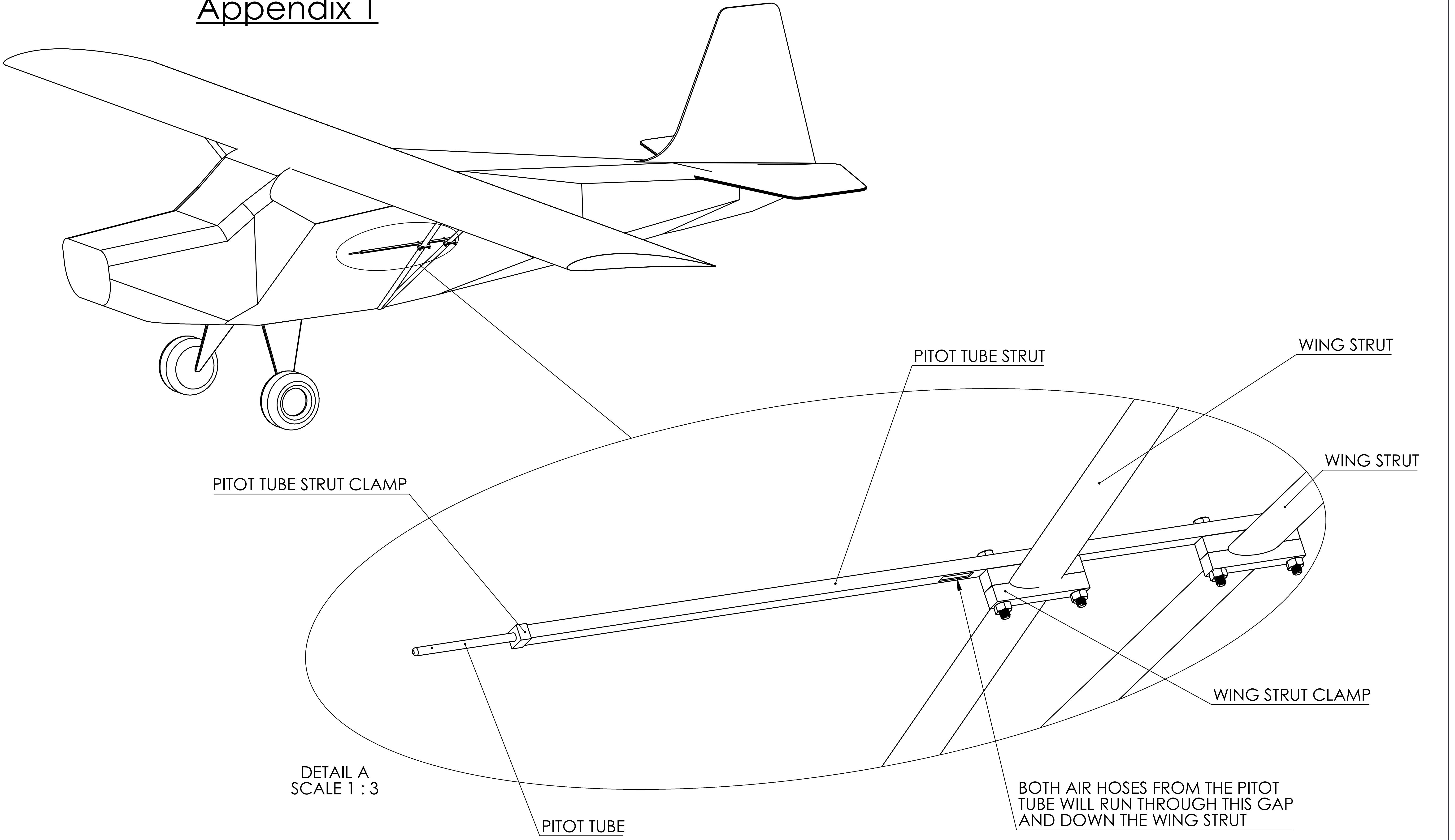
Table 1: Estimated Weight and Balance of Aircraft

Part	Weight	CG
Existing Aircraft	**289.1 Kg**	**228.1 mm**
Front Servo Assembly		
Servo	2 Kg	-315.95 mm
Servo Mounting Plate	1 Kg	-315.95 mm
Modified Control Stick Mechanism	1 Kg	-37.95 mm
Front Servo Link Rod	0.25 Kg	-139 mm
Rear Servo Assembly		
Servo $(\times 2)$	4 Kg	1562.05 mm
Electromagnetic Clutch $(\times 2)$	4 Kg	1562.05 mm
Rear Servo Mounting Platform	1 Kg	1562.05 mm
Servo Idler Link Mechanism	1 Kg	1562.05 mm
19 Inch Rack		
Battery	4 Kg	962.05 mm
Arduino	0.2 Kg	962.05 mm
All Arduino Modules and Attachments	0.25 Kg	962.05 mm
19 Inch Tray	0.5 Kg	962.05 mm
Pilot Interface		
Pilot Indication Display	0.25 Kg	-287.95 mm
Dead Man's Switch $(\times 2)$	0.025 Kg	-287.95 mm
Pitot Static Tube Attachment	0.5 Kg	312.05 mm
Total Additional Weight	20 Kg	971.6 mm
Post Modification Weight	309.1 Kg	276.2 mm

Appendices

Appendix 1	**Pitot Static Tube Mount Drawings**
Appendix 2	**Force Feedback System Assembly Drawings**
Appendix 3	**Rear Servo Assembly Drawings**

Appendix 1



DO NOT SCALE

A3

DRAWN BY: DAN NEWMAN-SANDERS

DESIGNED BY: DAN NEWMAN-SANDERS

EDMC JOB No | DEPARTMENT | DATE: 10/12/2020 | SCALE

TOLERANCES UNLESS OTHERWISE STATED
LINEAR DIMENSIONS
X = +/- 0.5mm
X.X = +/- 0.25mm
X.XX = +/- 0.1mm
ANGULAR DIMENSIONS
X = +/- 0.5mm
X.X = +/- 0.25mm
ALL DIMENSIONS IN mm UNLESS OTHERWISE STATED

PROJECT | SUPERVISOR | MATERIAL | TEXTURE | SURFACE FINISH: ALL OVER UNLESS OTHERWISE STATED

REMOVE ALL SHARP EDGES

IF IN DOUBT PLEASE ASK

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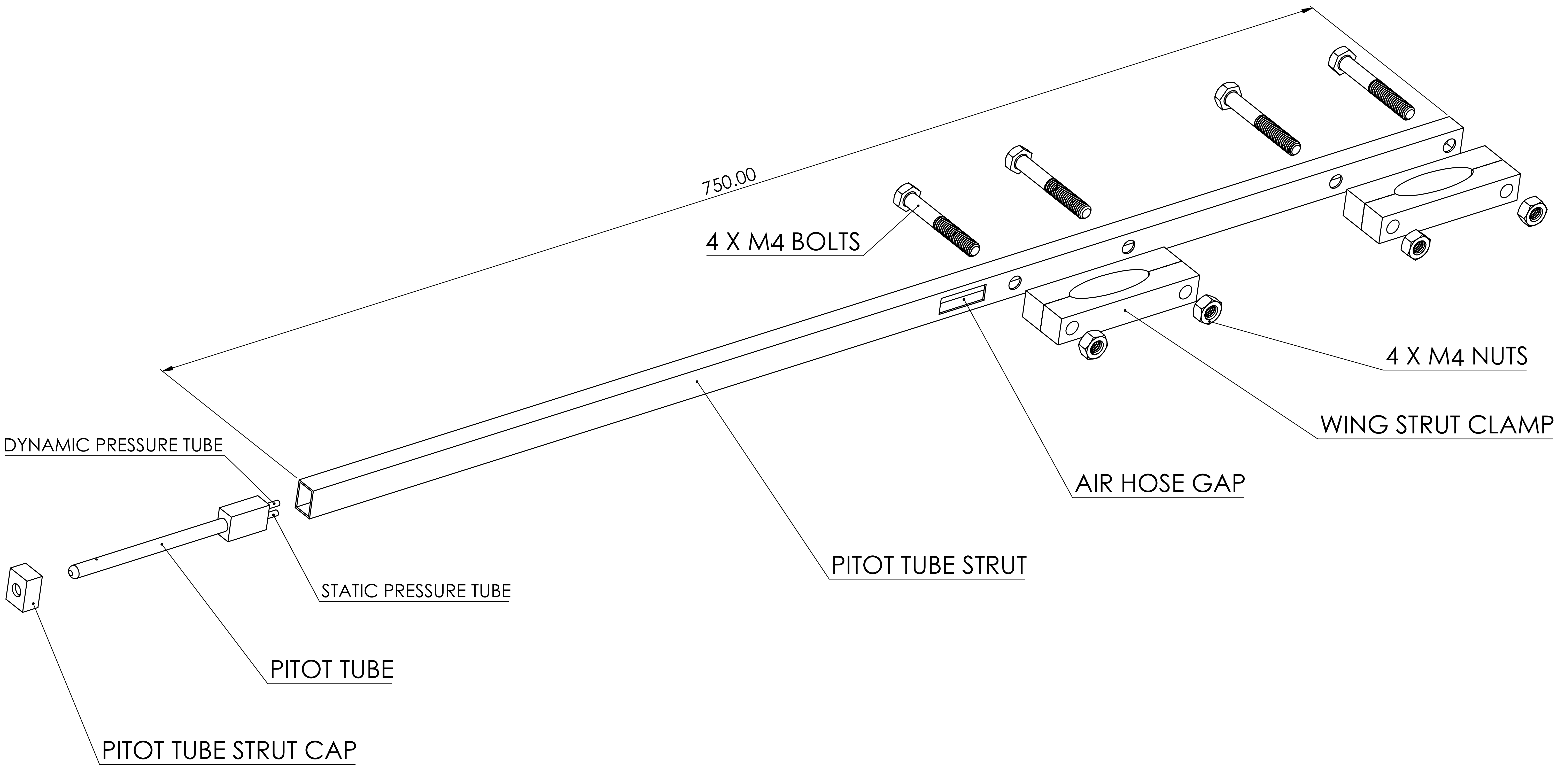
Faculty of Engineering and the Environment

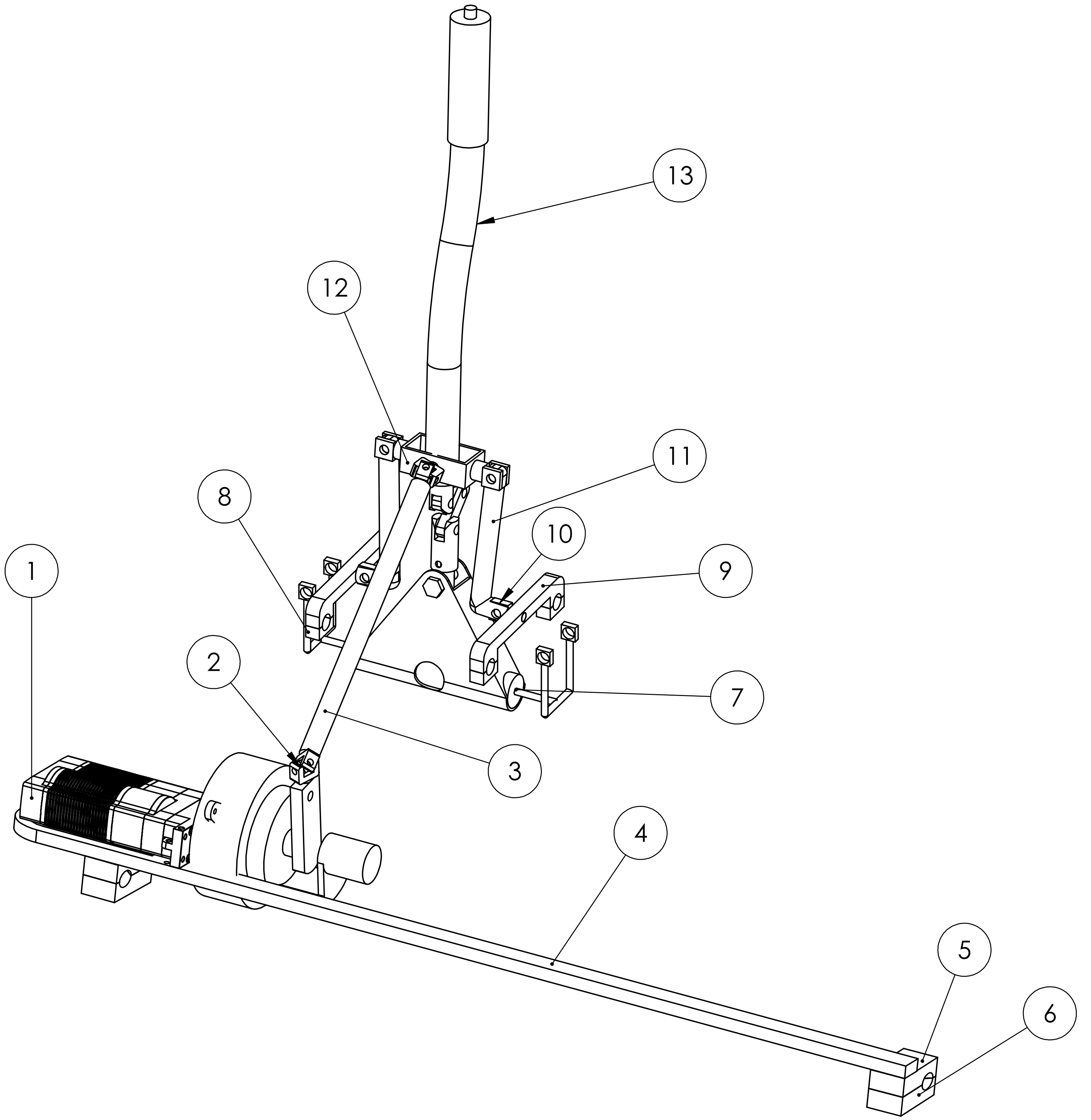
TITLE: PITOT TUBE MOUNT

SHEET | No OFF | ASSEMBLY NUMBER | DRAWING NUMBER | REVISION

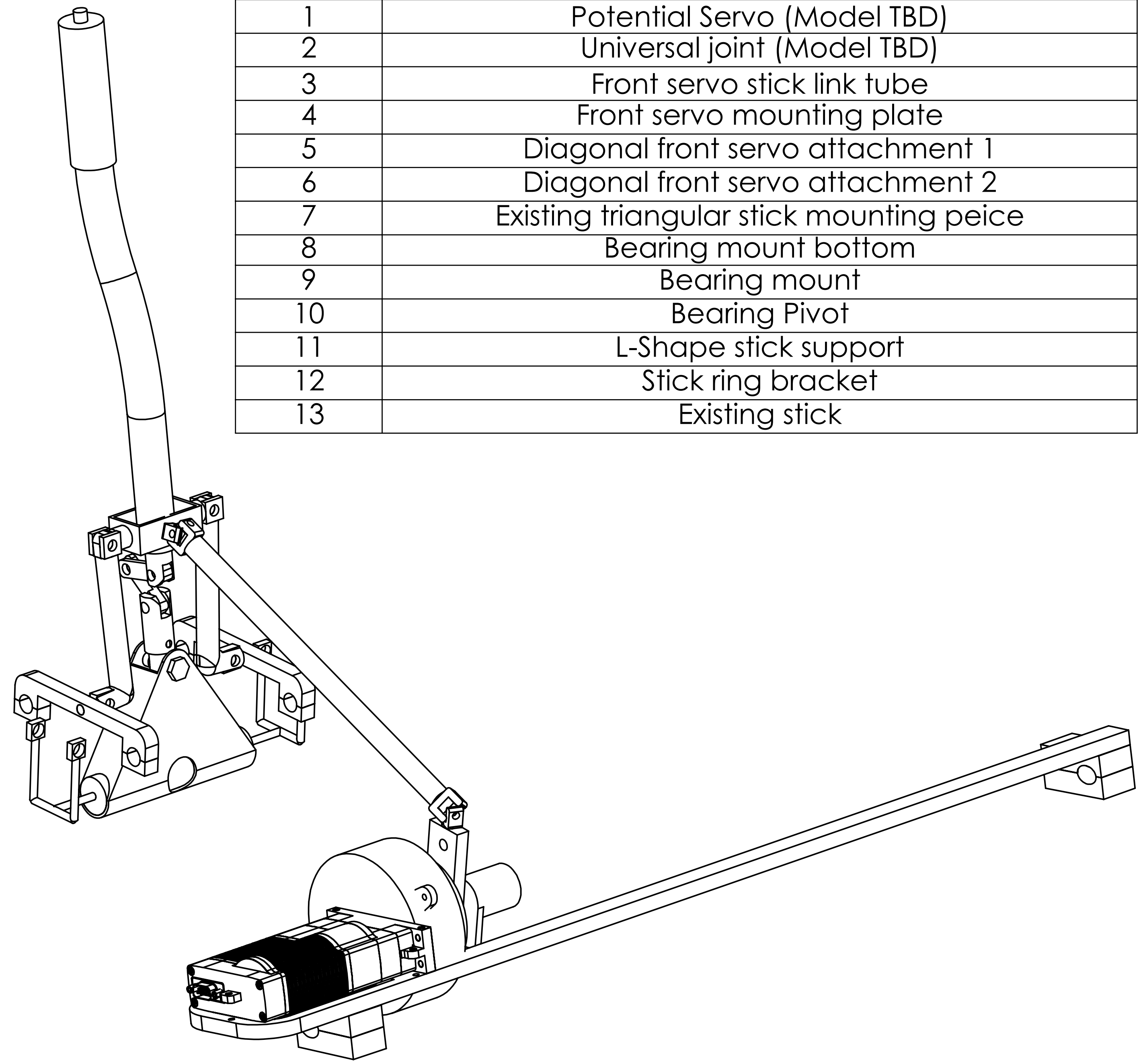


DO NOT SCALE		DRAWN BY DAN NEWMAN-SANDERS		TOLERANCES UNLESS OTHERWISE STATED LINEAR DIMENSIONS X = +/- 0.5mm X.X = +/- 0.25mm X.XX = +/- 0.1mm ANGULAR DIMENSIONS X = +/- 0.5mm X.X = +/- 0.25mm ALL DIMENSIONS IN mm UNLESS OTHERWISE STATED	UNIVERSITY OF Southampton Faculty of Engineering and the Environment
A3		DESIGNED BY DAN NEWMAN-SANDERS			
EDMC JOB No	DEPARTMENT	DATE 10/12/2020	SCALE		TITLE
PROJECT	SUPERVISOR	MATERIAL	TEXTURE	SURFACE FINISH ALL OVER UNLESS OTHERWISE STATED	PITOT TUBE MOUNT
REMOVE ALL SHARP EDGES IF IN DOUBT PLEASE ASK		THE INFORMATION CONTAINED IN THIS DOCUMENT IS THE PROPERTY OF THE UNIVERSITY OF SOUTHAMPTON DO NOT COPY WITHOUT WRITTEN PERMISSION.			SHEET | No OFF | ASSEMBLY NUMBER | DRAWING NUMBER | REVISION

Appendix 2 - Force Feedback System Assembly Drawing



Number	Part Name
1	Potential Servo (Model TBD)
2	Universal joint (Model TBD)
3	Front servo stick link tube
4	Front servo mounting plate
5	Diagonal front servo attachment 1
6	Diagonal front servo attachment 2
7	Existing triangular stick mounting peice
8	Bearing mount bottom
9	Bearing mount
10	Bearing Pivot
11	L-Shape stick support
12	Stick ring bracket
13	Existing stick



DO NOT SCALE	DRAWN BY Callum Breslin		TOLERANCES UNLESS OTHERWISE STATED LINEAR DIMENSIONS X = +/- 0.5mm X.X = +/- 0.25mm X.XX = +/- 0.1mm ANGULAR DIMENSIONS X = +/- 0.5mm X.X = +/- 0.25mm ALL DIMENSIONS IN mm UNLESS OTHERWISE STATED	UNIVERSITY OF Southampton Faculty of Engineering and the Environment
A3	DESIGNED BY Callum Breslin			
EDMC JOB No	DEPARTMENT	DATE 18/12/20	SCALE 1:4	TITLE Front Servo Actuation Assembly
PROJECT VSD	SUPERVISOR Keith Towell	MATERIAL	TEXTURE	SURFACE FINISH ALL OVER UNLESS OTHERWISE STATED
REMOVE ALL SHARP EDGES	THE INFORMATION CONTAINED IN THIS DOCUMENT IS THE PROPERTY OF THE UNIVERSITY OF SOUTHAMPTON DO NOT COPY WITHOUT WRITTEN PERMISSION.			
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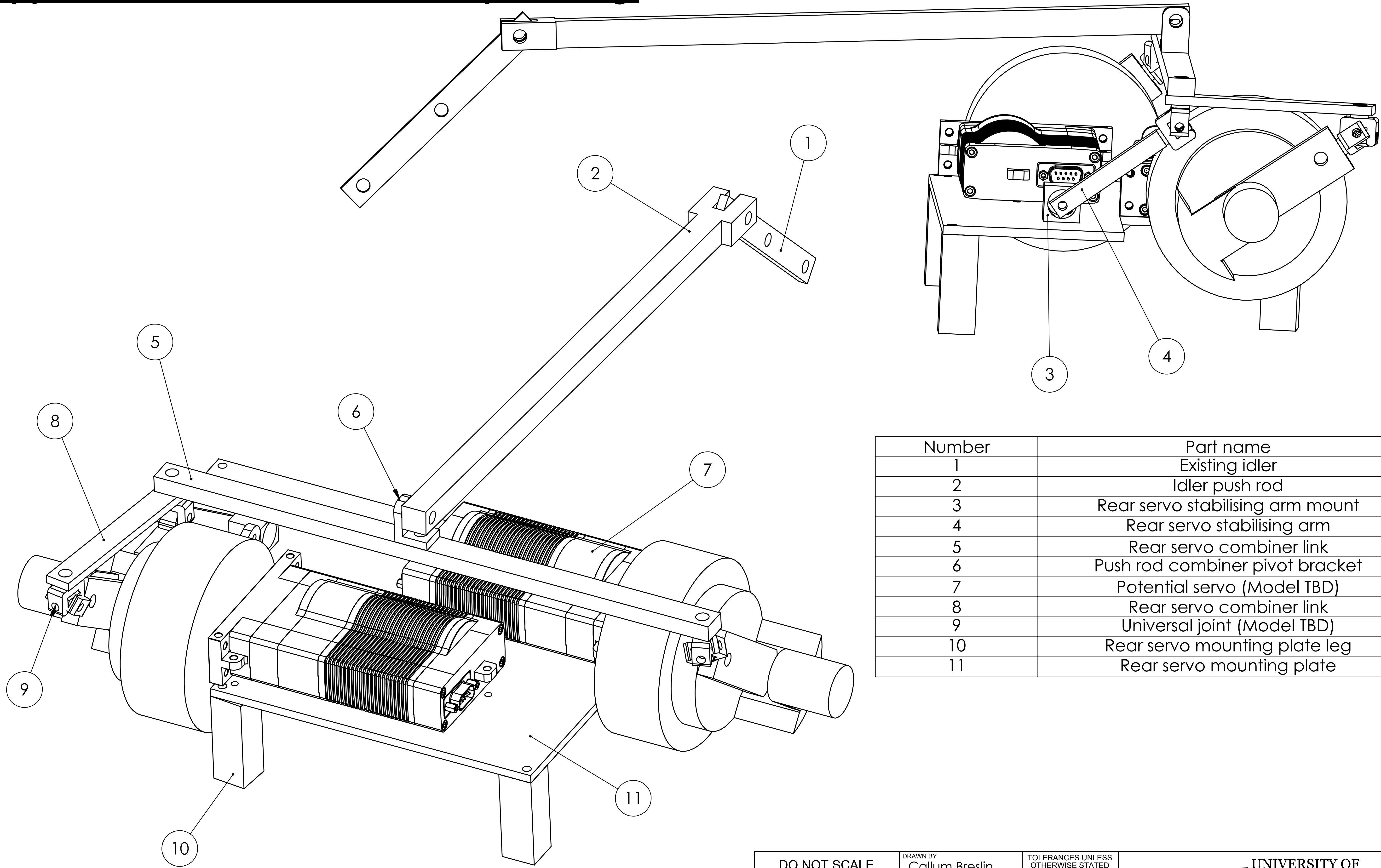
Appendix 3 - Rear Servo Assembly Drawing



Number	Part name
1	Existing idler
2	Idler push rod
3	Rear servo stabilising arm mount
4	Rear servo stabilising arm
5	Rear servo combiner link
6	Push rod combiner pivot bracket
7	Potential servo (Model TBD)
8	Rear servo combiner link
9	Universal joint (Model TBD)
10	Rear servo mounting plate leg
11	Rear servo mounting plate

DO NOT SCALE

A3

EDMC JOB No

DEPARTMENT

DRAWN BY Callum Breslin

DESIGNED BY Callum Breslin

DATE 18/12/20

SCALE 1:2

TOLERANCES UNLESS OTHERWISE STATED
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X = +/- 0.5mm
X.X = +/- 0.25mm
X.XX = +/- 0.1mm
ANGULAR DIMENSIONS
X = +/- 0.5mm
X.X = +/- 0.25mm
ALL DIMENSIONS IN mm UNLESS OTHERWISE STATED

UNIVERSITY OF Southampton
Faculty of Engineering and the Environment

PROJECT VSD

SUPERVISOR Keith Towell

MATERIAL

TEXTURE

SURFACE FINISH ALL OVER UNLESS OTHERWISE STATED

TITLE Rear Servo Actuation Assembly

REMOVE ALL SHARP EDGES

IF IN DOUBT PLEASE ASK

SHEET	No OFF	ASSEMBLY NUMBER	DRAWING NUMBER	REVISION
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