Team 514 Flight Simulator Operations Manual

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Project Overview

Lockheed Martin sponsored our team to create flight controls for the F-35 jet simulator. The F-35 jet has a cockpit with fewer buttons than usual and more information displayed on computer screens, making it different from other planes and needing extra training time for pilots. Lockheed Martin wants a package that allows more pilots the chance to train in various environments around the world. Our goal is to make a low-cost portable set of flight controls for a desktop computer or 3D-printed cockpit.

We focused on the joystick, throttle, and rudder pedals as the most important parts a pilot needs for simulator training. The joystick and rudder pedals change the direction the plane flies. The throttle changes the engine thrust. The buttons on the controls provide easy access to the flight display computers, aircraft weapons, and other features of the jet. We included parts of the controls from previous senior design teams' projects. We picked a design with simple parts which are easy to replace if needed. We also made them strong enough to withstand repeated use for training. The flight controls are compatible with many different computers because they connect to Universal Serial Bus (USB) ports. The joystick, throttle, and rudder pedals weigh less than 35 pounds each making them easy for the average person to move.

To keep the production cost low, we used 3D printers for some mechanical parts. Our team created a small microcontroller with circuits to measure the control movements and send button signals to the computer. We wrote the program code and designed the printed circuit board for the microcontroller. The cases containing the moving parts and electronics of the joystick and throttle protect them and make sure they work well for a long time.

Component Description

Note that the bill of materials that includes all purchased items for this project is in Appendix A.

Rudder Pedal System (RPS)

The RPS consists of an aluminum pedal system designed by graduating class of 2022's Senior Design T510. The CAD for these parts is in their project's basecamp which Dr. McConomy has access to.

Throttle

The throttle is 3D printed in two sections out of PLA. The front half and back half are joined together by heat gun. The shape of the throttle imitates the cowpie throttle shape that is currently used in the F-35. The 12 buttons on the throttle were purchased or sourced from other suppliers. The placement of each button is shown in Appendix B. The assembly of the inner workings are also shown in Appendix B.

Joystick

Our joystick is 3D printed in two halves that are joined together by a heat gun. The 10 buttons were purchased or sourced from other suppliers and their placement is shown in Appendix C.

The two-plane gimbal is an adapted design that integrates wave springs and an over-constrained push plate for recentering.

Desktop Computer

Need to list the requirements the computer needs to meet to run prepared and the number of USB inputs it should have.

The computer should have Lockheed Martin's flight simulator software, Prepar3D, installed on it.

Integration

The joystick, throttle, and rudder pedal modules are connected individually to the computer via USB. Each component has its own USB output for a total of 3 USB connections that need to be made to the computer with the Prepar3d software.

Operation

The user should plug the three components in via USB, and then open the Prepar3D system. The components should register immediately, but if not, troubleshooting details can be found in the following section.

When the user presses the left or right rudder pedal, the airplane will turn left or right when driving on the ground. The left and right toe brakes are at the top of each respective rudder pedal.

The throttle should directly correlate to the jet thrust, and stay in its location if the hand is removed from the controls. Each button should correspond to each F-35 function, with certain weapon limitations in this version of Prepar3D.

The joystick should deflect under lateral forces and return to center when released. Pulling back on the stick should induce a climb, with a push on the joystick starting a dive. Turning the joystick laterally should respectively roll the jet in that direction. These effects do not apply when jet is grounded, traveling any slower than takeoff speed. Each button and switch should also correlate to F-35 function, with weapon limitations.

Troubleshooting

Electronics

Calibration errors: open windows settings for configuring a game controller, as pictured in Figure 1. This allows for testing of buttons and different axes to make calibration adjustments.

Device not registered by computer or Prepar3D: It is recommended to unplug and plug the devices back in. Check that the device is recognized by windows and configures properly. Open windows device manager to see if the parts are listed and listed properly.
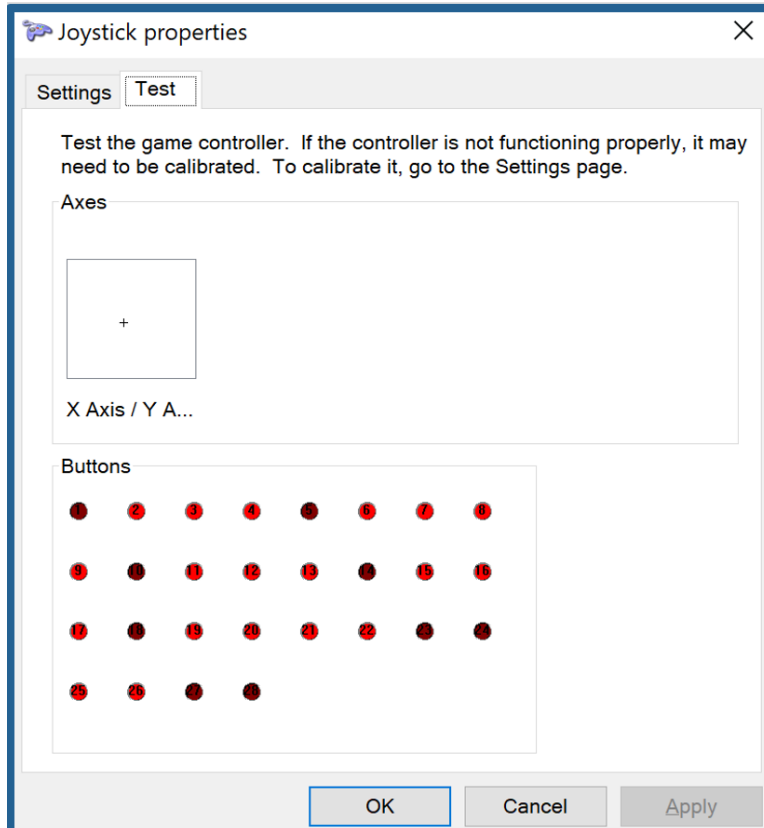
Figure 1: Windows Calibration Screen

Joystick Gimbal

The multiplane gimbal should not be disassembled for normal use. If joystick movement is no longer smooth, grease can be applied to the required component without the use of any special tools. Assuming the joystick container lid is removed, a petroleum-based lubricant can be applied to the push plate's flat bottom surface, which is shown below.
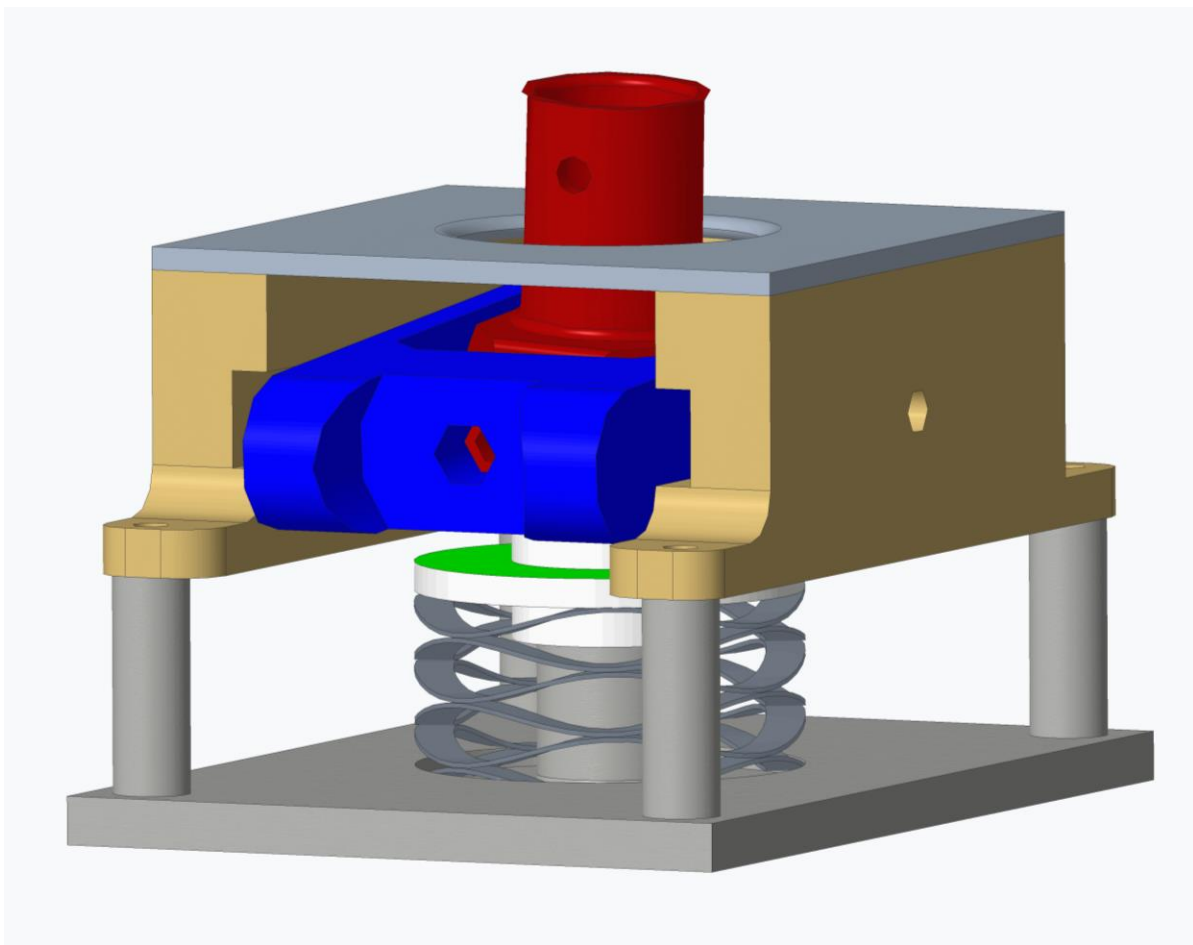
Figure 2 - Gimbal with Greased Surface Colored Neon Green

The petroleum-based lubricant should be applied to the neon green surface. It is part of the white push plate. The surface can be accessed when the joystick lid is removed, where the gap in the gold-colored housing has the opening and the potentiometer back is facing forward. The push plate and wave spring can be compressed slightly to give space between the green surface and the bottom of the rotating gimbal.

<u>In the event of part failure in gimbal assembly:</u>

The following exploded view show the different components of the assembly. Use them to find the proper part file to send to the 3D printer.
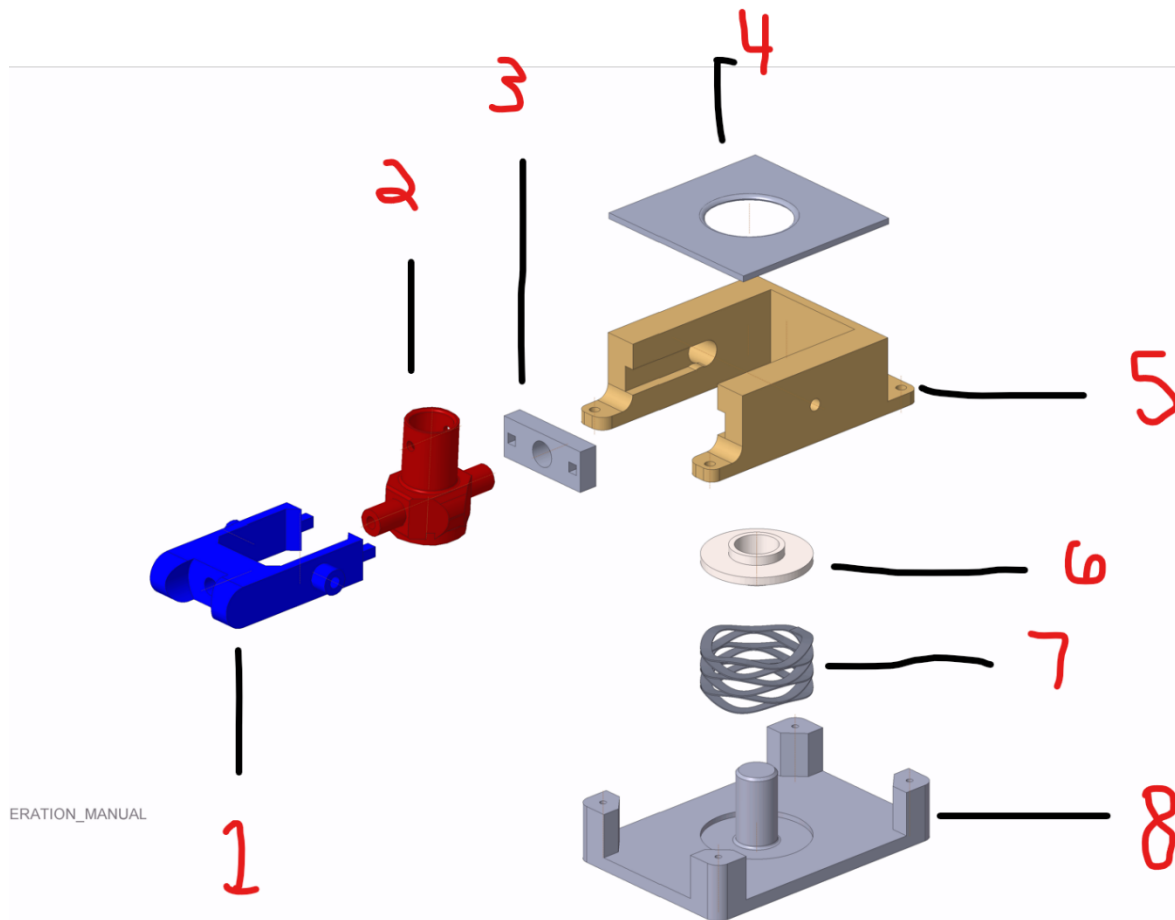
1. Outer_gimbal_1
2. Inner_gimbal_1
3. Outer_gimbal_wall_piece
4. Gimbal_lid
5. Gimbal_housing
6. Push_plate
7. Wave_spring
8. Gimbal_base

Throttle

In the event of a throttle lock-up, open the assembly case and inspect the rack and pinion assembly. Gears may become misaligned and over constrained, or potentiometer shaft may have sheared. Realign gears in the event of a mechanical lock-up and test fluidity of potentiometer by making a few manual turns dispatched from model. If shaft is broken, disconnect wires, loosen fastening, and replace sensor. Reattach in reverse order.

In the event of handle breaking, disassemble housing and detach handle bolts and handle. Open handle by removing screws and disconnect all wires from buttons. Remove individual

buttons and place in secure location. Ensure all broken pieces are removed from assembly and insert new, printed model. Reassemble throttle assembly in reverse order.

Appendix A

Joystick	Mnf	Vendor	Vendor part #
S1 Single Button	OTTO	Mouser	999-P5-111221
S2 5-way, 4 way jog	OTTO	Mouser	999-TK-5K4312
S3 5-way, hat	OTTO	Mouser	999-TK-5G4312
S4 & S6 4-way , castle	OTTO	Mouser	999-TK-4J4312
S5 Single Button	C&K	Digikey	CKN10768-ND
S7 2-stage trigger	OTTO	Mouser	999-U2-016
S8-5 way switch, stadium	OTTO	Mouser	999-T5-CH2212

| Throttle			
T1 & T10 Single Button	OTTO	Mouser	999-P5-115222
T2 & T7 5-way, castle	OTTO	Mouser	999-TK-5J4312
T3-xy cursor (joystick)	SparkFun Electronics	Digikey	1568-1526-ND
T4 2 pos switch, rocker	OTTO	Mouser	999-T1-CC2112
T5 & T9 3 pos switch	Nidec Copal	Mouser	229-MFS101EA-Z
T6-single push button	C&K	Digikey	CKN10768-ND

Electrical Components			
Microcontroller	Microchip	Digikey	PIC18F4550-I/P
Potentiometer	Precision Electronics	Digikey	RV4NJ103C-ND
USB Cable	USBGear	Digikey	USBG-AB10CC
custom pcb	bittele	bittele	
Molex connectors	elechawk	Amazon	B07S18D3RN

| Hardware/ misc.			
L-brackets	Keystone Electronics	Digikey	36-611-ND
Slide Rail	ReliaBot	Amazon	MGN15C
Black Spray Paint	Rust-Oleum	Amazon	
filament	polymaker	Amazon	B09LV83DK1
throttle bristles	tripp lite	Amazon	B00AO1W2J2
steel sheet 12"x12" 0.075" thick		McMaster	6544K56
steel sheet 24"x24" 0.075" thick		McMaster	6544K54

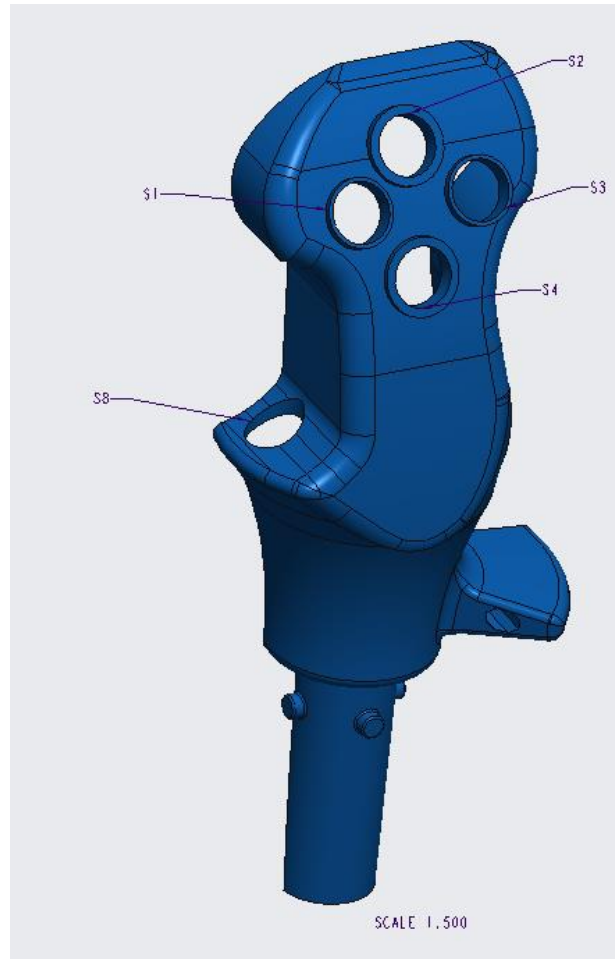# Appendix B - Throttle CAD

Front Grip
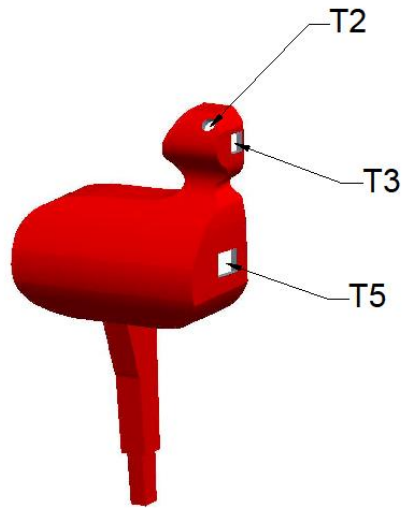
Rear Grip
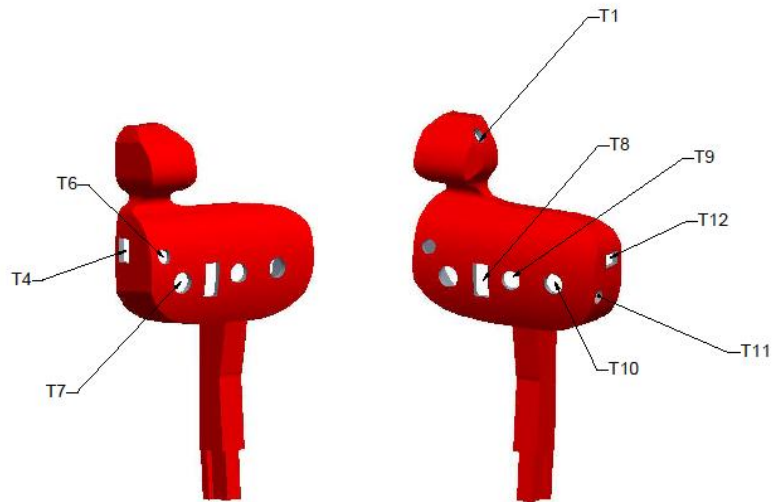
Exploded View
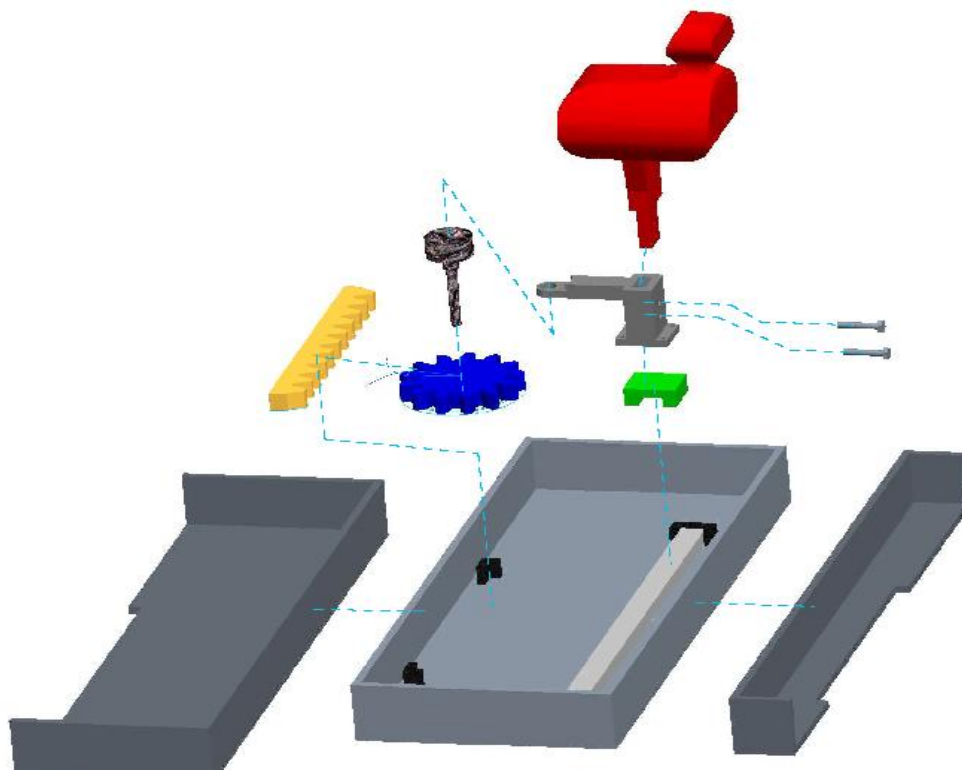
Appendix C - Joystick CAD

Front view

Back View