DC Design – F5-E Tiger II Flight Model

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General info

The F-5E Tiger II is a supersonic fighter aircraft developed in the 1960s by the American aerospace company Northrop Corporation. It is renowned for its agility, cost-effectiveness, and ease of maintenance. Here are some key points about the F-5E fighter aircraft:

Development: The F-5E Tiger II was developed as a lightweight, highly maneuverable, and inexpensive fighter aircraft. It was designed to be a reliable and easy-to-maintain platform.

First Flight: The F-5E made its first flight in 1972 and quickly became popular for its performance capabilities and versatility in air combat.

Performance: Powered by twin General Electric J85 engines, the F-5E Tiger II can achieve speeds in excess of Mach 1.6 (more than 1,200 mph) and can operate at altitudes above 51,000 feet.

Armament: The F-5E is equipped with a variety of weapons, including missiles, rockets, and cannons. It can carry a combination of AIM-9 Sidewinder missiles and AIM-120 AMRAAM missiles, making it a capable air-to-air combatant.

Service: The F-5E Tiger II has been used by several air forces around the world, including the United States, Switzerland, South Korea, and Taiwan. It has seen combat in various conflicts and has proven its effectiveness in aerial engagements.

Agility: One of the key features of the F-5E is its exceptional agility, which allows it to outmaneuver opponents in dogfights. Its lightweight design and powerful engines contribute to its maneuverability.

Training: In addition to its combat roles, the F-5E Tiger II has been widely used as a training aircraft. Many air forces use modified versions of the F-5E to train pilots in air combat tactics and techniques.

Legacy: While newer and more advanced fighter aircraft have been developed since the F-5E Tiger II, it remains an important part of military aviation history. Its cost-effectiveness and reliability have contributed to its longevity in service with various countries.

Picture of the F-5E

Overall, the F-5E Tiger II is a highly regarded fighter aircraft known for its agility, affordability, and versatility in both combat and training roles.

Files

The scope of the project is to model the aircraft as accurate as possible by using the built-in MSFS systems, engine, and flight model logic. These are defined via configuration files, which are presented here.

flight_model.cfg

[WEIGHT AND BALANCE]

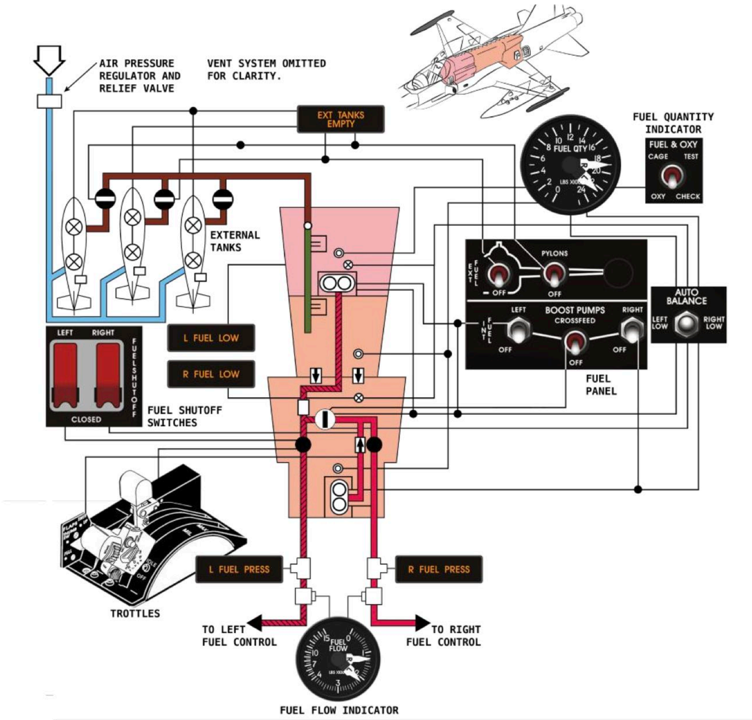
- Aircraft's max take-off weight is: 24.675 Lbs.
- Aircraft's empty weight is: 9.583 Lbs.
- Reference datum is positioned for the nose cone = 27.3 ,0 ,4.5 (Model reference)
- Empty cg positioned at = -25.5, 0, 0 (Model reference)
- CG_forward_limit =0.05 (5% MAC Forward CG limit – POH does not gives exact limit for this type)
- CG_aft_limit =0.17 (17 % MAC Afterward CG limit) – POH does not gives exact limit for this type)
- empty_weight_pitch_moi = 27000; (This value have been tuned for pitch stability)
- empty_weight_roll_moi = 5000; (This value have been tuned for roll stability)
- empty_weight_yaw_moi = 27000; (This value have been tuned for yaw stability)
- empty_weight_coupled_moi= 0

[CONTACT_POINTS]

- Nosewheel steering: 70 degrees with a descending turning ability on ground while the airspeed increases. (Max nosewheel turning radius after 65 kts of IAS is 15%)
- Wheels:
- Scrape points: Left and Right wing, Vertical tail, under-belly, upper-body, nose, and other possible scraping points when in upset (crashed on the ground) position.

[FUEL_SYSTEM]

The fuel system is modelled accurately according to the flight manual. The following drawing depicts the system architecture, which is implemented in MSFS.



Fuel system MSFS model – F5E

The fuel system consists of three fuel cells in the fuselage divided into two independent systems. The forward cell supplies fuel to the left engine; the center and aft cells supply the right engine. If required, either system can supply fuel to both engines. Additionally, jettisonable external tanks may be installed on the aircraft. Fuel is transferred from external tanks to the internal systems thru the single-point manifold by air pressure supplied by the compressor ninth stage of each engine. (In our model, we use electronic pumps due MSFS cannot simulate compressor pressurized fuel lines).

Each engine fuel system contains its individual fuel boost pump, fuel shutoff-valve, fuel flow indicator, and low fuel and pressure caution lights. A dual pointer fuel quantity indicator on the instrument panel indicates the quantity of remaining fuel in each engine fuel system.

[CONTROL SURFACES]

Ailerons are tuned to obtain full aileron travel of 35
degrees up and 25 degrees down. (POH – Page 83 – Aileron limiter)

Elevator is tuned to obtain a maximum horizontal tail travel 17 degrees up
and 5 degrees down. (5 degrees down modified to 10 down due to insufficient elevator force) (POH – Page 83 – Elevator limiter)

Rudder is tuned to achieve a maximum rudder deflection is 30 degrees either side of neutral with the landing gear extended or retracted; however, the amount of deflection during flight is a function of dynamic pressure force on the rudder surface and varies with airspeed and altitude. Maximum rudder deflection in flight is possible at 250 KIAS or less. (POH – Page 83 – Rudder limiter)
Control surface areas are not given in the aircraft's document, thus why we measured it from the aircraft's 3D model and tried to achieve the most accurate area information.

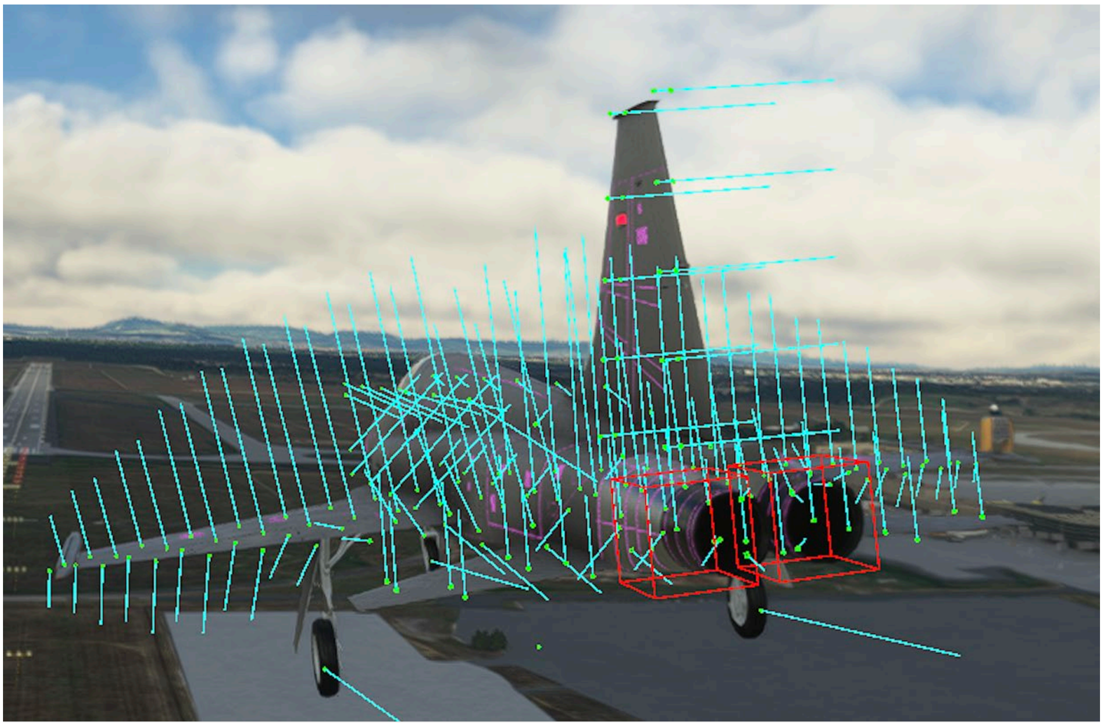
[AIRPLANE_GEOMETRY]

Airplane geometry is accurate as possible, we had very little information about the wing and other airframe components, thus why we used our skills and high understanding in aircraft systems.

We assume the aircraft's wing root is 13 feet and has a dihedral of -1 degrees. Some wing tip twist is added to have more stability for the aircraft.

Vertical tail is around 120 square feet with a rudder of 12 feet. Rudder deflection angle is 30 degrees up to 250 kts (after 250 kts the aircraft will limit the maximum deflection angle to protect the airframe).

Engines are positioned at the middle of the nozzles and the tip of the engine outlet.



G-Loading:

figure 1-52 for location and function of controls and indicator.

AILERON LIMITER

An aileron limiter, which is mechanically positioned by retraction of the landing gear, provides a spring stop which limits the aileron to one-half travel. To obtain full aileron travel of 35 degrees up and 25 degrees down, additional stick force must be applied to override the aileron spring stop. The aileron limiter is disengaged when the landing gear is in the extended position, allowing full aileron travel.

RUDDER TRAVEL

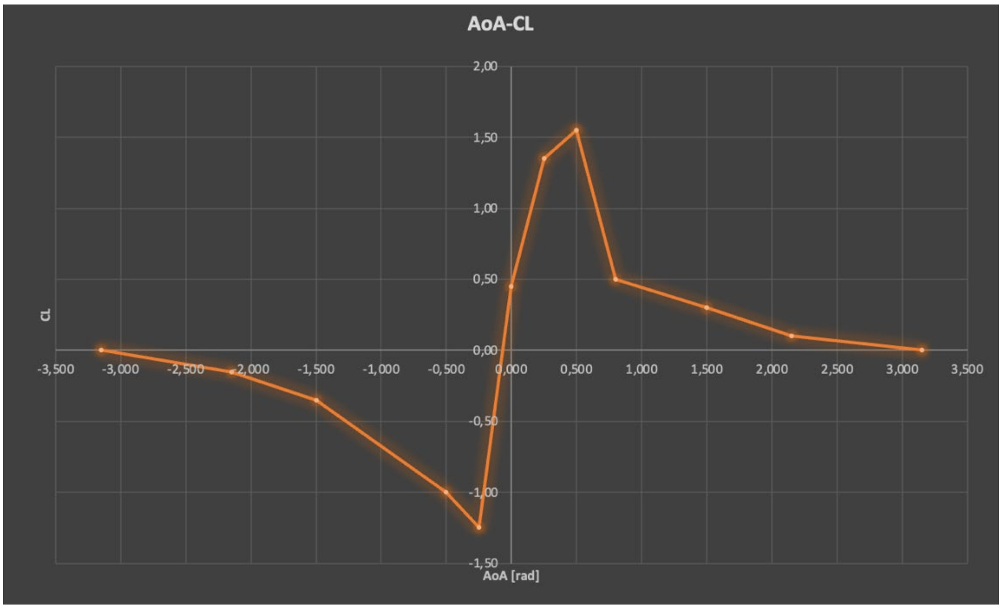
Maximum rudder deflection is 30 degrees either side of neutral with the landing gear extended or retracted; however, the amount of deflection during flight is a function of dynamic pressure force on the rudder surface and varies with airspeed and altitude.

HORIZONTAL TAIL TRAVEL

Maximum Ⓔ horizontal tail travel is 17 degrees up and 5 degrees down. Maximum Ⓕ horizontal tail travel is 20 degrees up and 5 degrees down.

[AERODYNAMICS]

- The main aerodynamics parameters to tune are the following:
  `lift_coef_aoa_table = -3.15:0,-2.15:-0.15,-1.5:-0.35,-0.5:-1,-0.25:-1.25,0:0.45,0.25:1.35,0.5:1.55,0.8:0.5,1.5:0.65,2.15:0.1,3:15`
- Climb performance is calculated, see Test cases section.



- `lift_coef_at_drag_zero` = 0.02; define Cl0, which is the lift coefficient that is generated when the plane produces minimum drag
- `lift_coef_at_drag_zero_flaps` = 0.1
- `drag_coef_zero_lift` = 0.038 ; The zero lift drag polar. Using this value based on the SDK documentation recommendations.
- `drag_coef_flaps` = 0.025 ; Defines the target drag added when flaps are fully extended.
- `drag_coef_gear` = 0.04 ; Defines the drag of the gears that will be applied at the location of the gear contact points. (SDK doc recommended value)
- `compute_aero_center` = 0
- `aero_center_lift` = 1.5 (Wing leading edge position)

[FLIGHT_TUNING]

[REFERENCE_SPEEDS]

- Full flaps stall speed: XXX kts (MTOW)
- Cruise speed: Mach 0.8 (Referred TOW weight)
- Take off speed: 160-170 kts (approximation)

[FLAPS.N]

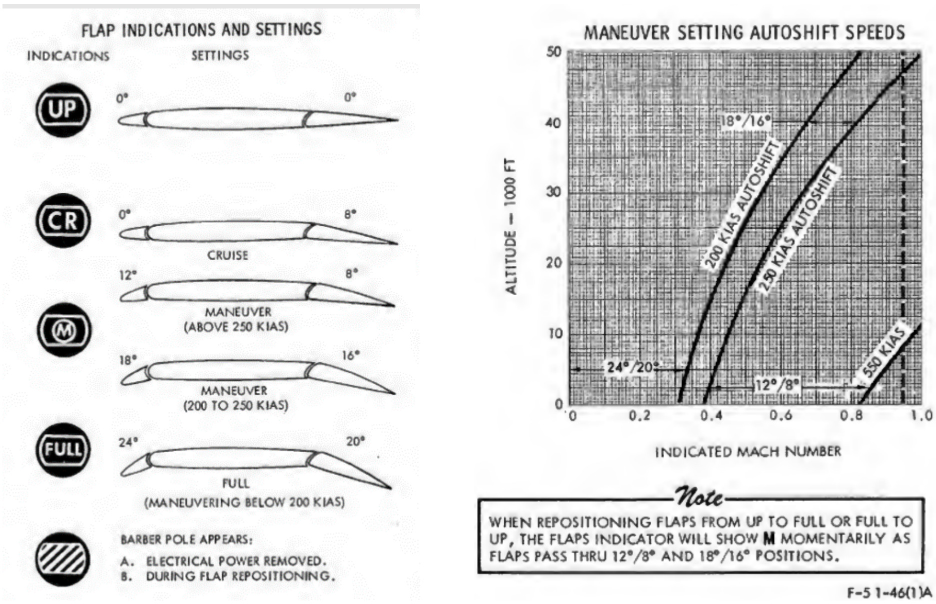
The aircraft is equipped with auto flap system. Flap system consists of leading and trailing edge flaps used for safe takeoff, in-flight maneuvering, long-range flight, and landing. Each flap is operated by an AC-powered electrical actuator. The left and right leading-edge flaps (slats) and the left and right trailing edge flaps are mechanically interconnected to prevent their asynchronous operation, and mechanically interconnected to the horizontal tail to maintain pitch trim during flaps operation.

With AUTO selected, flaps are automatically positioned depending on AOA and/or signals from the CADC. The flaps can be positioned to:

- 0°/0°
- 0°/8°
- 12°/8°
- 18°/16°
- 24°/20°

Above 550 KIAS or 0.95 M, the CADC prevents slat/flap extension.

Slats are not implemented in the MSFS aerodynamics engine, they are only animated. Flaps and slat extension logic (animation) must be implemented separately. See extract from the Flight Manual below.



[AOA Indicator]

The angle-of-attack (AOA) system consists of a vane transmitter mounted on the right side of the fuselage, an AOA indicator and indexer in the cockpit. The system provides AOA information to auto flap system (controls flaps position in AUTO setting) and to the CADC for use by the optical sight system. With landing gear up, the AOA information is displayed only on the AOA indicator. With landing gear down, the system automatically provides AOA information through the AOA indexer.

[STALL PROTECTION]

- Aural warning audible when the AOA and power are not correct during landing and takeoff.

engine.cfg

[GENERALENGINEDATA]

- The position and basic properties of the engine have been set in this section.

[JET_ENGINE]

Afterburner system

- MIL thrust up to 72% of the thrust lever, then afterburner stages
- 28 stages are modelled to distribute the afterburner effect in 1% increments
-

systems.cfg

[BRAKES]

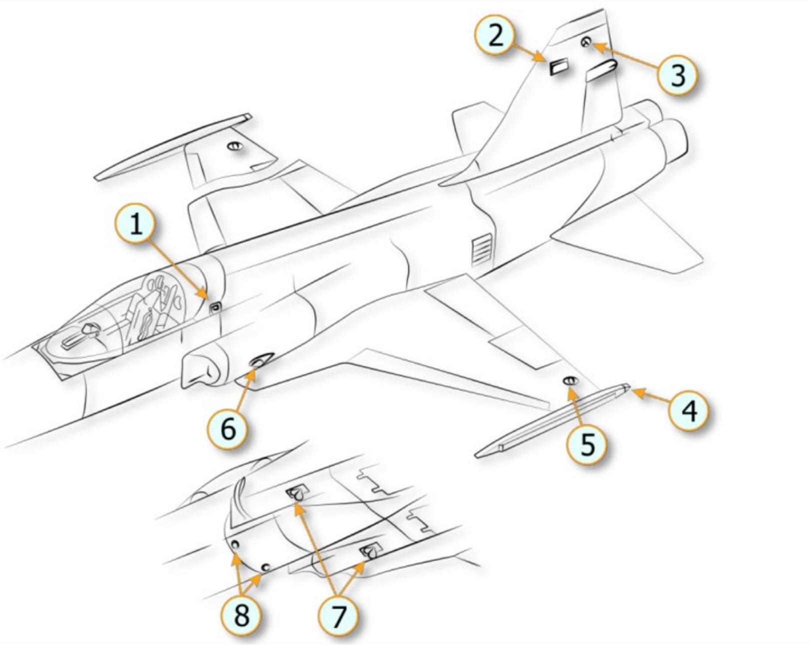
Each main wheel is equipped with hydraulically operated multiple-disk power brakes. Brakes are operated by conventional toe-type brake pedals (rudder pedals) and use utility hydraulic system pressure to operate brake control valves. Should the utility system fail, the brake valve acts as a brake master cylinder, and brake pressure is proportional to the amount of foot pressure applied to the brake pedal.

[GEAR_WARNING_SYSTEM]

Not implemented.

[LIGHTS]

1. Formation Light (each side) (white)
2. Rotating Beacon (each side) (red)
3. Tail Position Light (each side) (white)
4. Formation Light (right green) (left red)
5. Auxiliary Position Light (top & bottom) (right green, left red)
6. Primary Position Light (each side) (right green, left red)
7. Landing-Taxi Lights
8. Fuselage Lights (white)

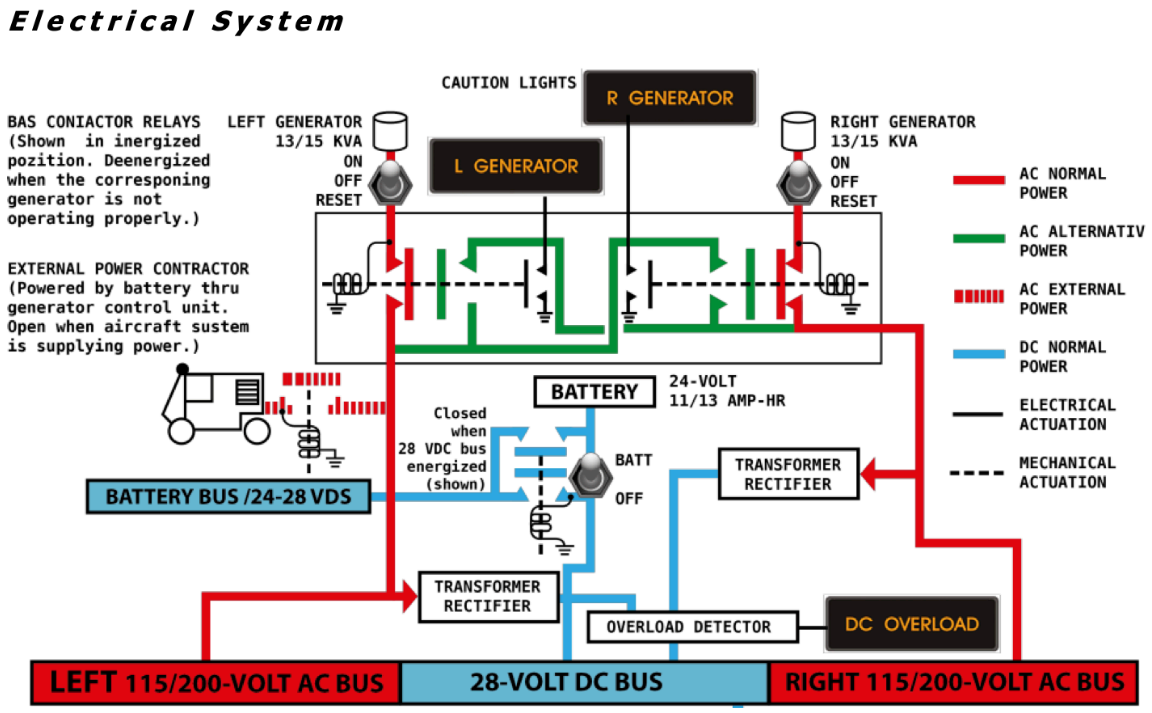


- Rotation, EffectFile, PotentiometerIndex, EmMesh must be defined.
- All lights according to the Flight Manual have been defined (navigation, taxi, landing, inspection, cabin, and panel) except for warning and signal lights.
- The position and rotation of the lights will be defined in the Aircraft Editor.

[ELECTRICAL]
Electrical power is supplied by two ac systems and one dc system. An external receptacle is provided for ac power input to the aircraft when the engines are not in operation. DC power is supplied by a battery and two 33-ampere transformer-rectifiers.

Two three-position switches placarded L GEN and R GEN are on the right vertical panel, each switch has a RESET position, permitting the pilot to reset the generators if necessary. Generator caution lights, placarded L GENERATOR and R GENERATOR, on the caution light panel come on any time the respective generator is off.

The architecture of the electrical system used in the simulator is the following:



Electrical system MSFS model – F5E Tiger

[HYDRAULIC_SYSTEM]
Hydraulic power is supplied by two independent systems, the flight control hydraulic system and the utility hydraulic system (figure 1-49). Each system is powered by a positive displacement piston-type pump. The right airframe-mounted gearbox drives the flight control hydraulic system pump, and the left airframe-mounted gearbox drives the utility hydraulic system pump. Both systems operate at 3000 psi. The flight control and utility hydraulic systems both provide the hydraulic power for the flight controls. In addition, the utility hydraulic system provides the hydraulic power to operate the landing gear, gear doors, speed brake, wheel brakes, stability augmenter, nosewheel steering, two-position nose gear strut, gun gas purge doors, and gun gas deflector doors.

In the simulator this precise hydraulics system configuration is not possible. In the aircraft the flaps and gears are operated by the hydraulics system.

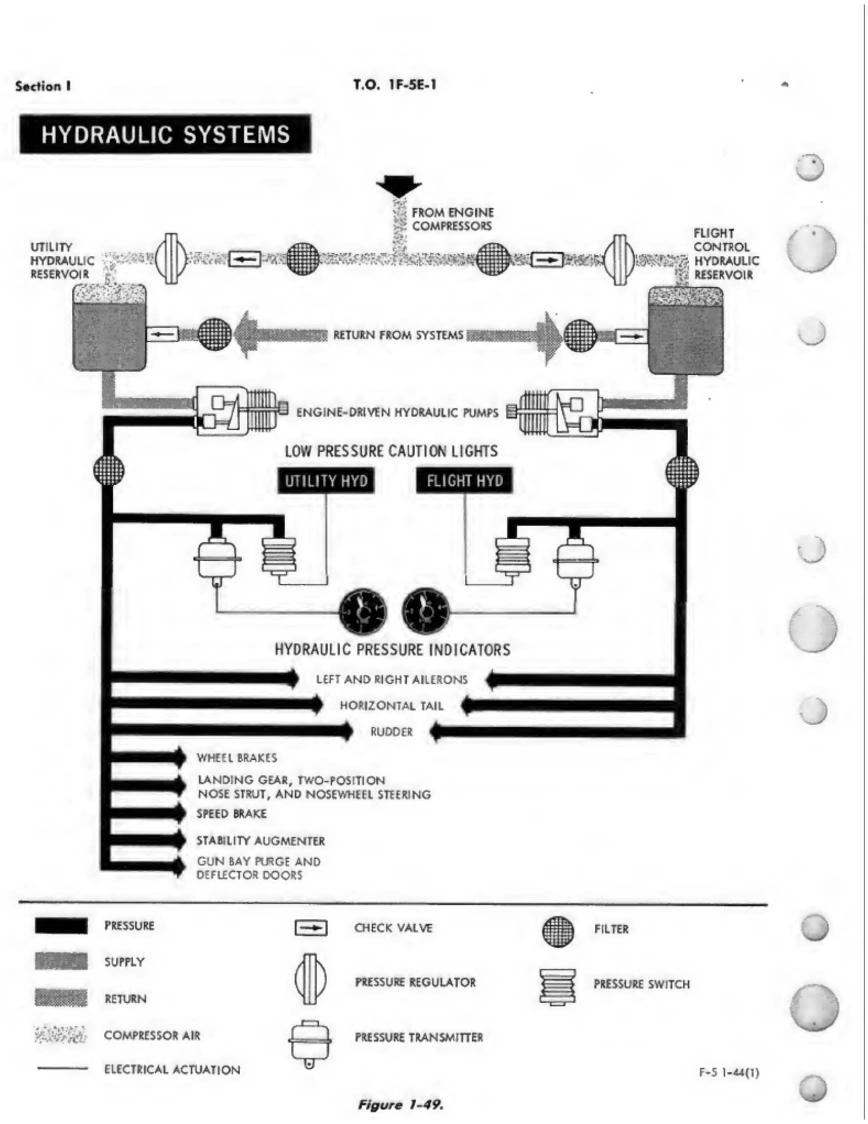


Figure 1-49.

[PNEUMATIC_SYSTEM]

Basic system for the pneumatics instruments.

[VACUUM_SYSTEM]

No vacuum system implemented.

[PITOT_STATIC]

The pitot-static system supplies both impact and static air pressure to the CADC and the airspeed/ Mach indicator. The altimeter and vertical velocity indicator receive only static pressure from the system.

Pitot tubes are heated in the aircraft.

[DEICE_SYSTEM]

The engine anti-ice system directs engine ninth- stage compressor hot air to the engine inlet guide vanes (IGV), T2 sensor, and the bullet nose of each engine. An electrically controlled engine anti-ice valve controls the flow of hot air to each engine. Both anti-ice valves are activated by an anti-ice switch on the right vertical panel ((g) front cockpit) (figures 1-15 thru 1-19) and actuated by engine compressor discharge pressure. The switch has two positions: ENGINE and OFF. A caution light placarded ENGINE ANTI-ICE ON on the caution light panel illuminates when the switch is at ENGINE.

[RADIOS]

The aircraft are equipped with UHF and VHF radios and special military TACAN system. (Currently in MSFS only UHF and VHF are simulated, TACAN simulation is not possible.)

- APX-72, APX-101 IFF/SIF. 1-94
- ARA-50ADF. 1-88
- ARC-150 UHFradio. 1-83
- ARC-164 UHFradio. 1-83
- ARN-65TACAN. 1-88
- ARN-84TACAN. 1-89
- ARN-118TACAN. 1-89
- ARN-127VOR/ILS. 1-89
- Control transfer (comm/nav)(f). 1-83
- Intercom system. 1-83
- SST-181 Skyspot X-Band radar

Communication and Navigation Equipment. 1-83 (POH)

[AUTOPILOT]

The aircraft has a Stability Augmenter System (p81, 1-67 in the Flight Manual). This provides yaw and pitch damper function. However, no autopilot will be modelled for the aircraft, hence no damper function will be connected to the switches.

Assumptions prior to test flights

Engine

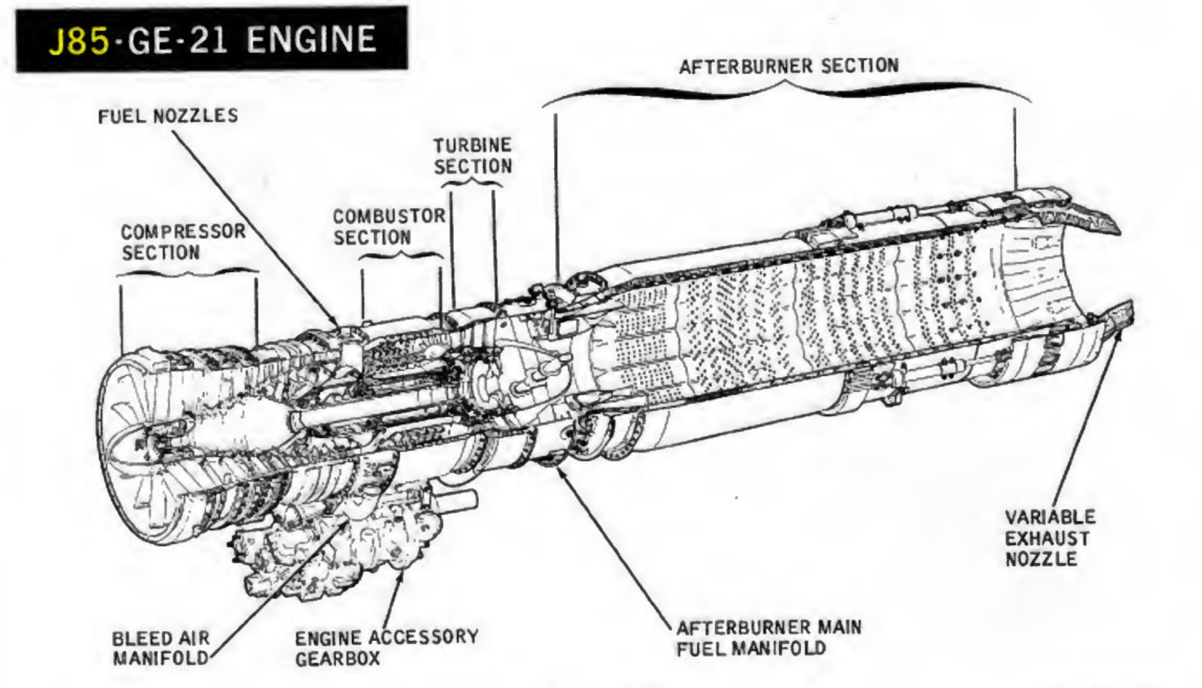


Figure 1-30.

Start sequence

70-80% nozzle

EGT: minimum 140, preferably in green

Above 10% RPM start button + fuel

Flight model

Drag index

The F5E performance manual assumes different accessory configurations by using a so-called drag index. Performance charts use this index to determine flying characteristics of the aircraft.

Assumed (most complex) configuration:

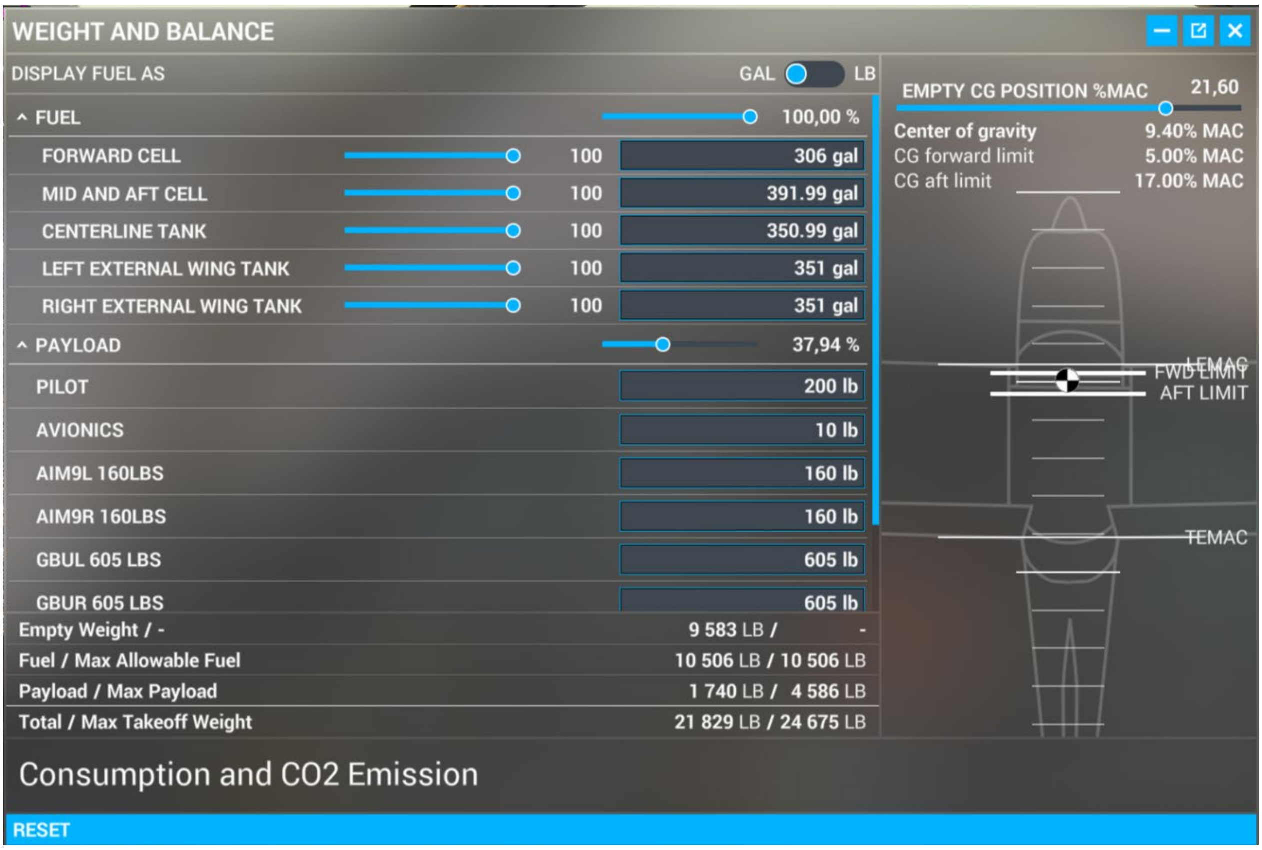
- 32 units (2xAIM9 Wingtip missile)
- 32 units (275G CL Tank)
- 268 units (2x GBU 360 LBS on outboard pylons + 2x 275 Wing Tank on inboard pylons)

TOTAL drag index: 332 units. This is the highest achievable drag index with the modelled configuration.

A drag index of 80 units is assumed for a relatively low weapons/pylons/external tanks configuration – this is to model high performance in climb and maximum speed. This value will be used for all performance calculations.

Takeoff weight

Assumed configuration:



TANKS AND FUEL

	EMPTY TANK WT – LB	USABLE FUEL WT – LB	TOTAL WT – LB
INTERNAL FUEL	—	4400 (4536)	4400 (4536)
(1) CL PYLON TANK – 275-GAL	229	1775 (1829)	2004 (2058)
(2) INBD PYLON TANKS – 275-GAL	454	3549 (3658)	4004 (4112)
(1) CL PYLON TANK – 150-GAL	148	975 (1005)	1123 (1153)
(2) INBD PYLON TANKS – 150-GAL	306	1950 (2010)	2256 (2316)

MISSILES, ROCKETS, BOMBS AND FLARES		
MISSILES:		**WT — LB**
(1) AIM-9B		165
(1) AIM-9E		171
(1) AIM-9J		170
(1) AIM-9J-1		166
ROCKETS:		
(1) 2.75-INCH FFAR	MK1 WARHEAD	18
	M151 WARHEAD	21
	M156 WARHEAD	21
	WDU-4 WARHEAD	21
(1) TDU-11/B TARGET ROCKET		215
BOMBS:		
(1) MK-82 LD		531
(1) MK-82 SE		570
(1) MK-84 LD		1970
(1) GBU-12/B, A/B (LGB-HS)		605
(1) GBU-12A/B (LGB-LS)		619
(1) M129E2 LEAFLET		203
(1) MK-36 DESTRUCTOR		572
(1) CBU-24B/B OR -49B/B		822
(1) CBU-52B/B		785
(1) CBU-58/B OR -71/B		818
(1) BLU-1/B, B/B, OR C/B FIRE BOMB	FINNED	717
	UNFINNED	702
(1) BLU-27/B FIRE BOMB	FINNED	854
	UNFINNED	839
(1) BLU-27A/B, B/B, OR C/B FIRE BOMB	FINNED	797
	UNFINNED	782
(1) BLU-32A/B, B/B, OR C/B FIRE BOMB	FINNED	597
	UNFINNED	582
(1) BDU-33 SERIES PRACTICE		24
(1) MK-106 PRACTICE		5

Page 275 – F5/E Tiger II POH

The external tank empty weights have been modelled by **increasing the fuel capacity with an unusable capacity that equals the tank empty weight.** The total station load will equal the tank empty weight plus the usable fuel. For a 275 USG tank this means 76 USG (456 lb) plus 275 USG (1650 lb), in total 2106 lb per external tank.

The maximum weight for the aircraft model is 21.829 lb. This is the maximum value for the complete configuration assumed above.

Test cases

An automated virtual flight testing of the aircraft is intended to showcase the flight characteristics of the model in a reproduceable way. The values might not be following factory behaviour perfectly but give an idea of the basic handling and show potential improvement areas. Developers of the actual flight model intend to match existing flight data as closely as possible, but no acceptance criteria will be based on the results found in this section.

All test cases assume a MTOW of … lb (… kg). The tables below represent the test case scenarios with input and output conditions. Input conditions are for example altitude, power setting, configuration, and environment settings. Output can be any desired performance metric of the aircraft.

The Propair flight test software is used to fly the test cases and the results for each are plotted and calculated in the cloud. The flight test software flies the aircraft according to the input conditions of each test case and the next phase is activated only if the input and output variables have been stabilized. In case of dynamic tests, only the initial conditions must be stable, the dynamic test period is specified for each test. Test case definition files can be found here: [FlightTestDefinitions]

The output parameters are not known in advance; thus, their change must remain within a specified range in the evaluation period (for "static" test cases). If the input or output parameters cannot be brought into the specified tolerance zone, the test case is skipped after 300 s (5 minutes).

The blue filled table cells represent output values that could be determined from the Aircraft Manual, POH, or any other technical data source. Meanwhile, the orange-coloured cells are output conditions that are based on pilot experience and may be provided as a range of plausible values (a good example of this is aircraft pitch values in different flight scenarios).

Test cases written with light grey colour had not been run. However, they can be tested in a later refinement round.

Take-off

Definition

This scenario is testing the aircraft ground roll and takeoff distance to a height of 50’ above the runway. Two different thrust settings are tested: MIL and MAX thrust. Parameters are the following:

- MIL thrust for take-off (without AB): factor 8. (p301 FA2-4). MIL thrust equals 3.200 lb / engine.
- MAX thrust for take-off: factor 12. MAX thrust equals 4.450 lb / engine.

Factor 12, 22.000lb, CG22%:

- TORR 3600 ft (ca. 1100m) (p302 FA2-5)
- TODR 5500 ft (ca. 1700m) (p303 FA2-6)

Factor 8, 22.000 lb, CG22%:

- TORR 6200 ft (ca. 1900m) (p302 FA2-5)
- TODR 9400 ft (ca. 2900m) (p303 FA2-6)

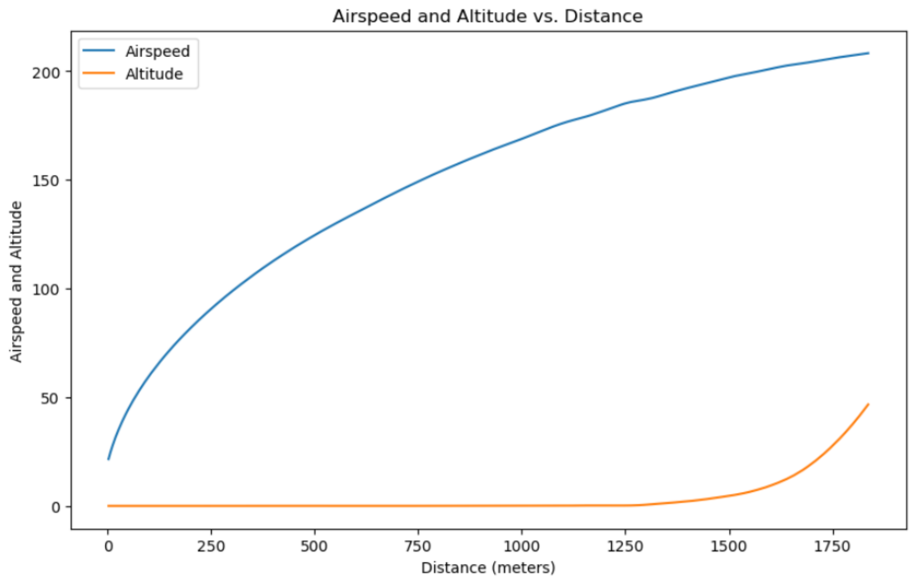
	Input				Output		
Name	**Weight [lb]**	**Thrust**	**Pres.Alt. [ft]**	**Configuration**	**Take-off run [m]**	**Take-off distance (50’) [m]**	**Fuel flow [lb/h]**
1.1 MIL thrust (without AB)	22.000	MIL – 7.200 lb (without AB)	Sea level	Full flaps	1900	2900	7.936*
1.2 MAX thrust (full AB)	22.000	MAX – 10.000 lb (with AB)	Sea level	Full flaps	1100	1700	18.957*

Reference tables: F5E Flight Manual, p302-303, FA2-4, FA2-5, FA2-6

* General Electric J85 - Wikipedia – fuel flow values calculated from specific fuel flow times thrust
Additional parameters: ISA, sea level.

Results

Takeoff distance: 1856.8561106354412
Takeoff roll distance: 1295.641893154451



Climb

Definition

This scenario is testing the climbing performance with following parameters:

- Input parameters: configuration, IAS (+-2 kts).
- Output variables: V/S (20 ft/min tolerance), Pitch (1˚ tolerance)

	Input				Output	
Name	**Thrust**	**Weight [lb]**	**Configuration**	**IAS [kt]**	**Time**	**V/S [ft/min]**
2.1 MIL Climb 0-10.000'	MIL	22.000	Clean	330	02:15	4450**
2.2 MAX Climb 0-10.000'	MAX	22.000	Clean	515	01:15	8000**

Reference table: F5E Flight Manual, p317-318, FA3-6

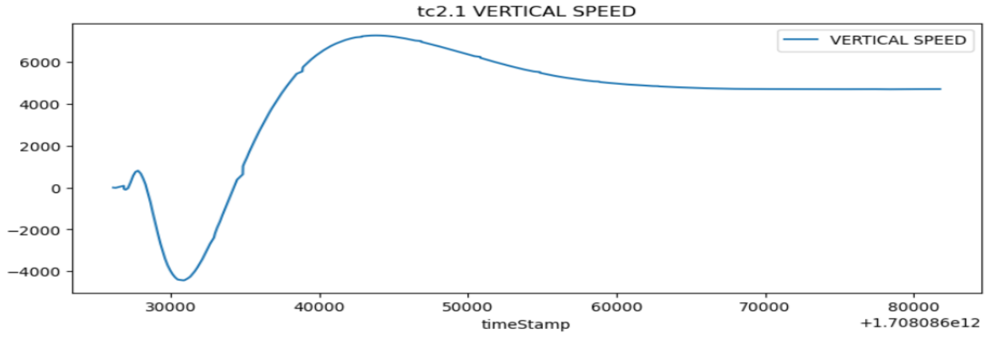
* Only average value throughout the whole climb, test case will be tuned to time to climb target

** Assuming a drag index of 80

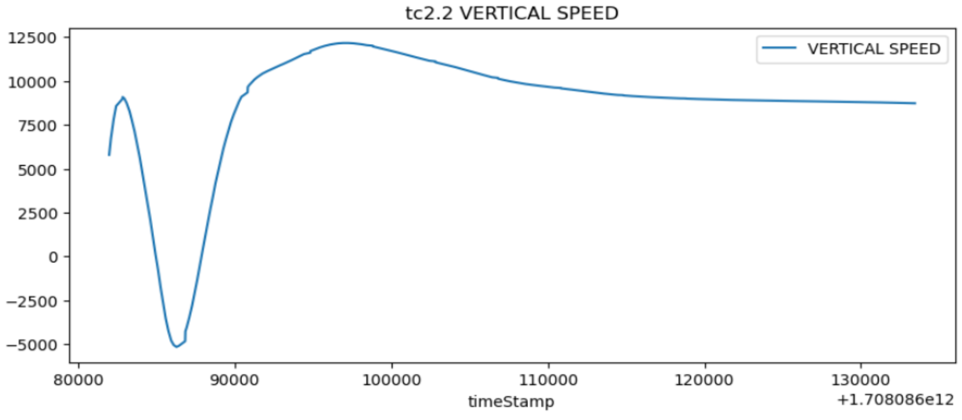
Additional parameters: QNH 1013, 15C. Initial altitude 1000' ISA

Results

```
tc2.1 (23, 415) static  |  330 Climb - MIL
     VERTICAL SPEED [4697.9006195]  min/max:  [4693.653717] / [4702.510071]
```




```
tc2.2 (415, 777) static  |  515 Climb - MAX
     VERTICAL SPEED [8815.54109198]  min/max:  [8729.962463] / [8888.008118]
```



Acceleration

Definition

Testing the acceleration according to the Flight Manual.

Parameters:

	Input						Output
Name	**Thrust**	**Weight [lb]**	**Pres.Alt. [ft]**	**Configuration**	**Initial M**	**Terminal M**	**Time [s]**
3.1 Level at low altitude	MAX	20.000	1.000	Clean	0.5	0.9	48
3.2 Level at high altitude	MAX	15.000	36.000	Clean	0.8	1.5	396

Results

…

Level flight combat speed

Definition

This scenario is testing the speed, power, and pitch parameters of the aircraft at a given configuration.

Parameters are the following:

- Input parameters: …, Altitude (+-50 ft), configuration.
- Output variables: TAS (1 kts tolerance), Pitch (1° tolerance)

	Input				Output	
Name	**Thrust**	**Weight [lb]**	**Pres.Alt. [ft]**	**Configuration**	**Speed [M]**	**FF total [lb/h]**
4.1 Combat sea level	MAX	13.300	500	Clean	0.95***	30.000**
4.2 Combat 37.000’	MAX	13.300	37.000	Clean	1.63*	15.900**
4.3 Combat 33.000’	MIL	13.300	33.000	Clean	0.99*	3.840**

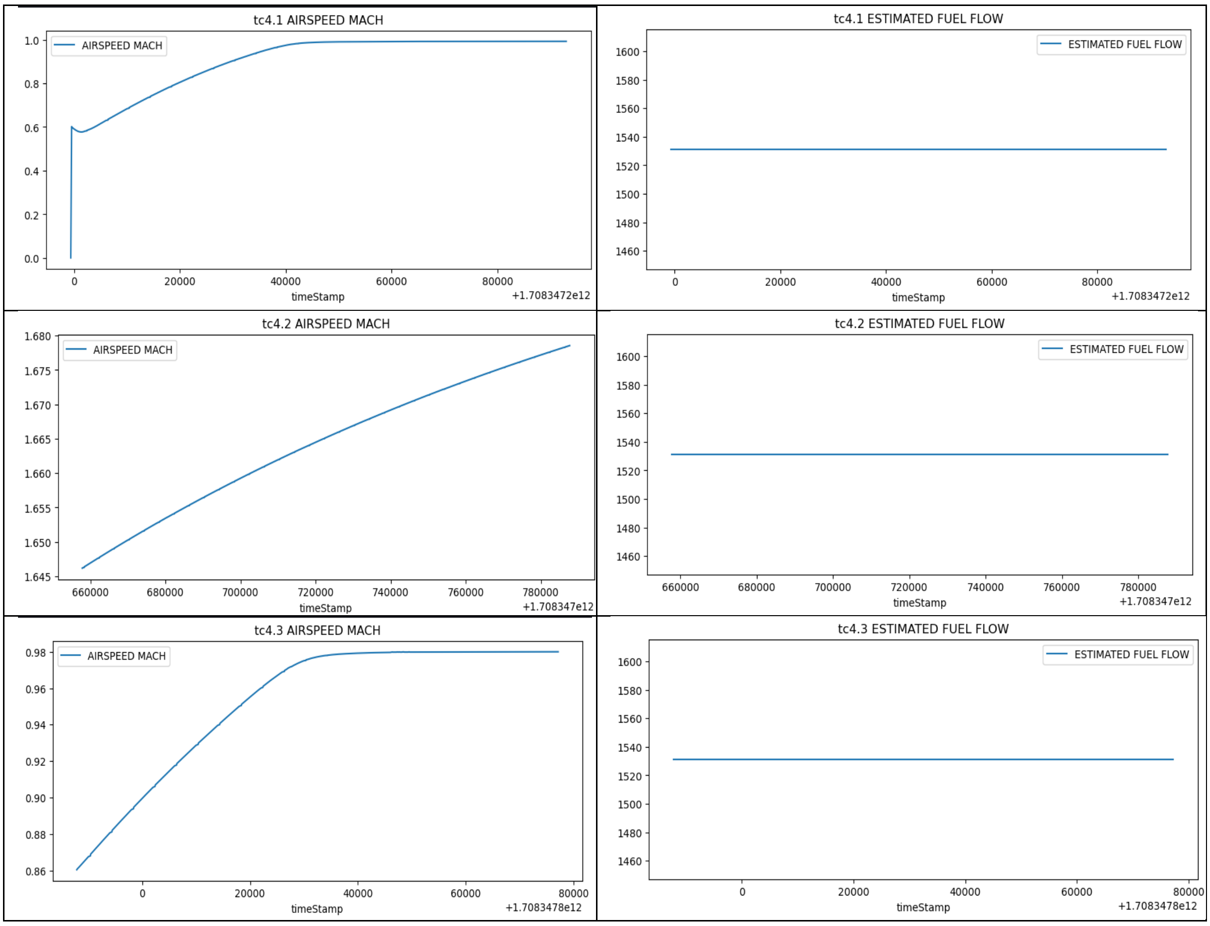
*Reference tables: F5E Flight Manual, * p405 FA8-10 (Sheet 1), ** p390 FA8-1*

*** Aircraft does not reach Mach 1, reference p390 FA8-1

Additional parameters: ISA

```
tc4.1 (7, 664) static  |  Combat SL MAX Thrust
     ESTIMATED FUEL FLOW [1531.320528]  min/max:  [1531.320528] / [1531.320528]
     AIRSPEED MACH [0.99224842]  min/max:  [0.992158] / [0.99235]
tc4.2 (665, 4128) static  |  Combat 37k ft MAX Thrust
     ESTIMATED FUEL FLOW [1531.320528]  min/max:  [1531.320528] / [1531.320528]
     AIRSPEED MACH [1.67768515]  min/max:  [1.6768] / [1.678553]
tc4.3 (4128, 4756) static  |  Combat 33k ft MIL Thrust
     ESTIMATED FUEL FLOW [1531.320528]  min/max:  [1531.320528] / [1531.320528]
     AIRSPEED MACH [0.98002287]  min/max:  [0.980012] / [0.980031]
```

Results


tc4.1 AIRSPEED MACH
AIRSPEED MACH
timeStamp
+1.7083472e12
tc4.1 ESTIMATED FUEL FLOW
ESTIMATED FUEL FLOW
timeStamp
+1.7083472e12
tc4.2 AIRSPEED MACH
AIRSPEED MACH
timeStamp
+1.708347e12
tc4.2 ESTIMATED FUEL FLOW
ESTIMATED FUEL FLOW
timeStamp
+1.708347e12
tc4.3 AIRSPEED MACH
AIRSPEED MACH
timeStamp
+1.7083478e12
tc4.3 ESTIMATED FUEL FLOW
ESTIMATED FUEL FLOW
timeStamp
+1.7083478e12

Glide

Definition

This scenario is testing the glide performance with parameters following:

- Input parameters: Throttle IDLE, configuration, IAS (+-2 kts).
- Output variables: V/S (20 ft/min bandwidth), Pitch (1˚ bandwidth)

	Input			Output	
Name	**Power [%]**	**Configuration**	**IAS [kt]**	**V/S [ft/min]**	**Pitch [˚]**
5.1 Glide – clean	Idle	Clean	250	3500*	

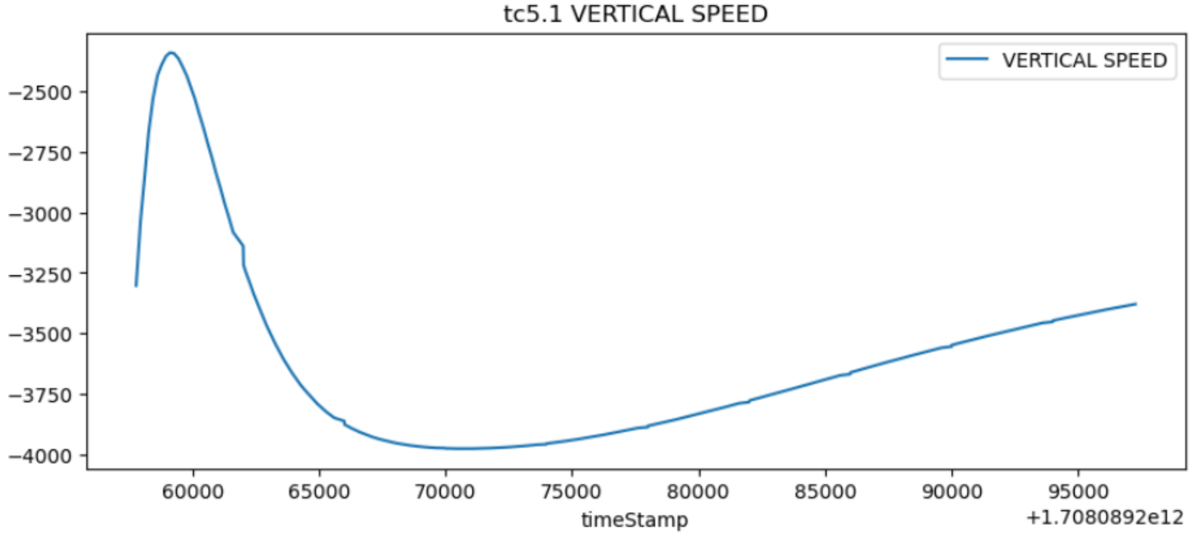
Reference table: F5E Flight Manual, p183 Figure 3-11

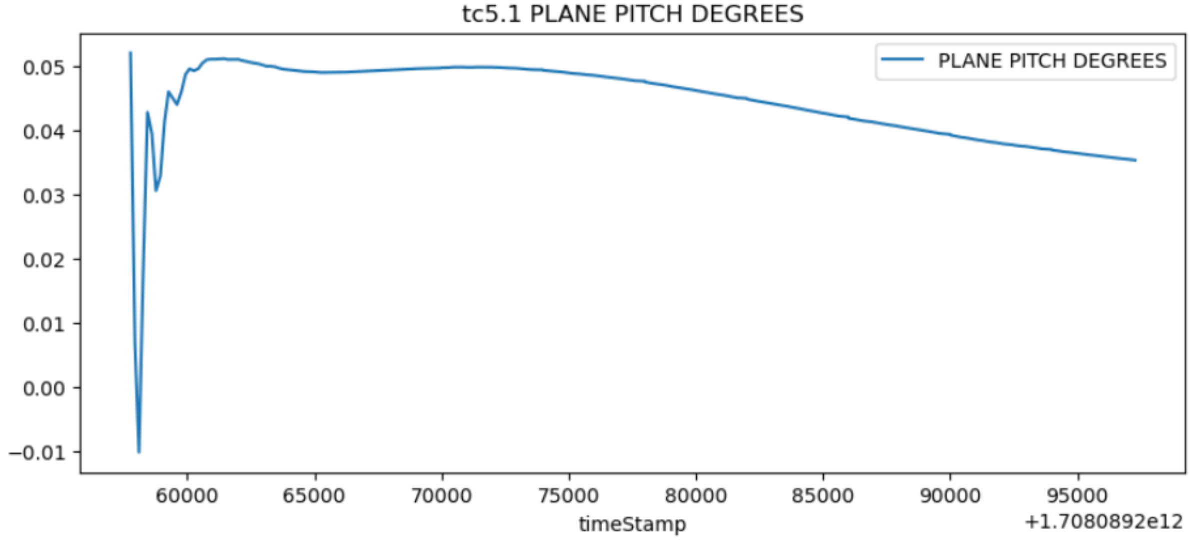
Glide is from 5000' ISA.

* Glide ratio 7:1 is calculated from Flight Manual – 1.1 NM travelled by 1000' loss of altitude. Best glide speed is 250 kt according to FM.

Results

```
tc5.1 (0, 279) static  |  Glide 250 Clean
     PLANE PITCH DEGREES [0.03783955]  min/max:  [0.035264] / [0.040852]
     VERTICAL SPEED [-3491.89749528]  min/max:  [-3619.999695] / [-3379.631424]
```





Stall

Definition

Conditions: From cruise, power is set to idle, and the aircraft slows down to stall speed and below. IAS specified speeds apply for all altitudes.

- Input parameters: throttle minimum, configuration
- Output variables: no output variable to stabilize (due to dynamic nature of the test case).

	Input			Output	
Name	**Weight**	**Power [%]**	**Configuration**	**IAS [kt]**	**Pitch [˚]**
6.1 Clean stall (V_{S1g})	22.000 lb	Idle	Clean	175	
6.2 Stall in landing configuration (V_{S0})	22.000 lb	Idle	Flaps 24°/20° gear down	158	

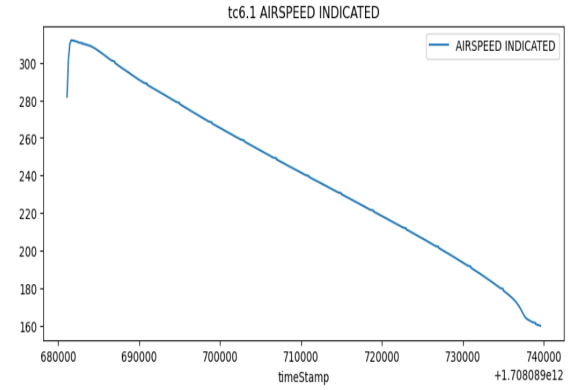
Reference table:

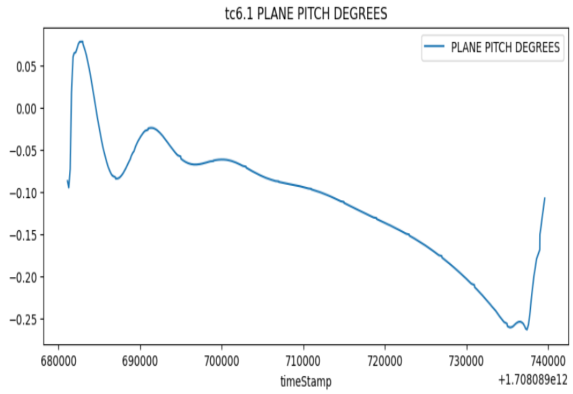
Environmental parameters: QNH 1013, 15C, (21.824 lbs), Altitude 5000 ft.

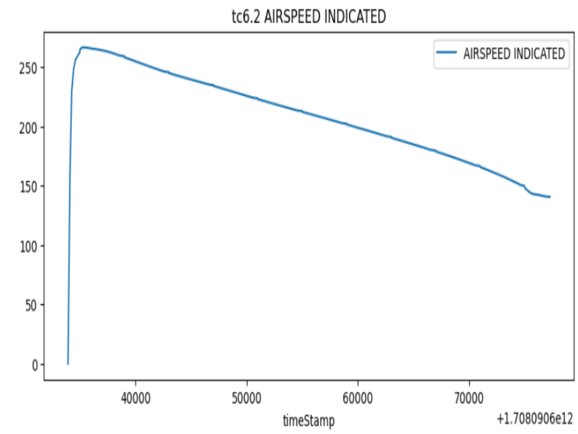
Results

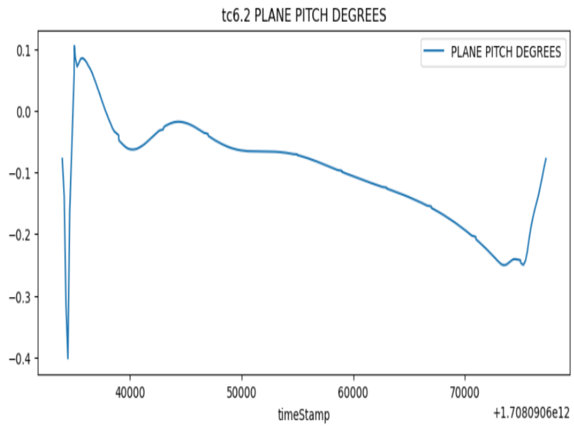
```
tc6.1 (12, 423) stall  |  clean stall
     PLANE PITCH DEGREES [-0.22531407]  min/max:  [-0.263543] / [-0.107946]
     AIRSPEED INDICATED [178.23930077]  min/max:  [160.093216] / [194.294357]

tc6.2 (106, 411) stall  |  stall landing config
     PLANE PITCH DEGREES [-0.2012814]  min/max:  [-0.250318] / [-0.078262]
     AIRSPEED INDICATED [159.3242093]  min/max:  [140.590897] / [177.483627]
```









Landing (TO-DO)

Definition

	Input				Output		
Name	**Weight [lb]**	**Thrust**	**Pres.Alt. [ft]**	**Configuration**	**Landing distance (from 50') [m]**	**Landing roll distance [m]**	
7.1 Landing full flaps	22.000	Idle	Sea level	Full flaps			

Reference tables:

Additional parameters: ISA, sea level.

Results

Manual tests

Manual tests require the flight model developer to fly and evaluate the scenarios in the simulated aircraft. The characteristics of behaviour must be assessed and documented in detail. Manual tests are last in the development sequence and the aircraft handling should be close to the real behaviour at this time.

Flight characteristics are described from page 245, Section 6-1 in the Flight Manual.

GENERAL FLIGHT CHARACTERISTICS

The aircraft is a high-performance, multipurpose tactical fighter with a primary mission of air superiority in the aerial combat maneuvering (ACM) environment. Maneuvering flaps are used to increase wing lift, delay buffet onset and generally improve the maneuver capability of the aircraft. Maneuvering flaps should be selected when initiating a maneuver above 1 g flight and the flaps retracted in less than 1 g flight. Flaps should be retracted when accelerating because of the reduced drag.

The two-axis (pitch and yaw) stability augmenter system provides improved flight characteristics. The aircraft can be maneuvered through-out the flight envelope with the augmenters disengaged with minimal degradation of flying qualities.

The aircraft can maneuver to the structural limiting g-load above 360 KIAS. Below 360 KIAS, the aircraft is aerodynamically lift-limited rather than structurally limited, and maximum lift capability is attained near stall AOA. Stall occurs at approximately 24 units AOA and is characterized primarily by the onset of wing rock and/or yaw oscillations (see STALLS). In most cases, full aft stick will produce AOAs above stall with a resultant increase in drag. In general, buffet onset (13 to 14 units AOA without flaps, 15 to 17 units AOA with flaps) can be used as a guide to indicate when maximum sustained level turn performance is attained.

Manuevering and handling qualities are degraded at lower airspeeds; therefore, a minimum of 300 KIAS should be maintained except for instrument approaches, maximum range descents, landings, and tactical maneuvering. The objective for establishing a minimum airspeed is to maintain a satisfactory energy state (i.e., "G" available) that will provide desired recovery response if an undesirable flight parameter is encountered below 15,000 ft. AGL.

+6.5g / -3.0g (p241)

Name	Description
8.1 Take-off	Acceleration, lift-off speed, airborne acceleration
8.2 Traffic patterns	Speed 300kt, height 1500’ AGL, fuel flow 1000lb/h/engine
8.3 Approach	Approach with full landing configuration and with assumed weight.
8.4 Flare and landing	Flary stability and controllability.
8.5 Stall behaviour	Stall characteristics of the aircraft.
8.6 Zoom & boom profile	Going over Mcrit and over LSS
8.7 Roll (aileron and rudder)	Roll rate and opposite yaw and other tendencies.

Traffic patterns

I flew several overhead traffic patterns, and they seemed mostly very realistic. Overheads in the T-38 are typically flown down initial at 300 kts and 1500' AGL with about 1000 lbs/hr fuel flow per engine. That worked fine with the F-5 model. The pitch-out is usually flown at 60 degrees of bank and 2 Gs back pressure--with the throttles still set at 1000 lbs/hr/engine that should bleed-off airspeed to under 240 kts on inside downwind, which is below gear-lowering airspeed.

This pattern has been flown with the parameters above and deceleration below 240 kt happens with the 2G-turn at 1000 lb/h FF on the engines.

Stall

I tried what we called a "full aft stick stall" by going to idle and allowing the airspeed to bleed-off. In the T-38, you could keep the nose up with full aft stick and maintain roll control during the post-stall descent, but I couldn't keep the nose of the F-5 model from pitching down like more conventional aircraft. The F-5E has a slightly more cambered wing, so that may be accurate. Surprisingly, the airspeed stayed between 130-140 kts forward flight during the stall, which I think is fairly realistic.

Take-off, Zoom&boom profile

- I flew the F-5 on a "Zoom and Boom" profile similar to the initial student sortie (what we called the "dollar ride"). On that profile, you go to full afterburner on takeoff (as we were required to do), rotate at about 155 knots, lift-off at about 165 kts (with a full fuel load), clean-up, stay in afterburner, and accelerate to about 300 knots. Typically, you'd reach 300 before the end of an 8000' runway.

Then climb at 300 kts in afterburner (that'd give you about 10,000 fpm climb) to 10,000', lower the nose accelerate to 400 kts, then climb at 400 until crosover at .9 mach, level at 30,000' and go supersonic. I did all that, and the F-5 model seemed mostly accurate to my experience.

Roll, ailerons and rudder

At speed and 1 G load, the T-38 is VERY roll sensitive--it would take very little stick pressure or trim to roll in either direction. In fact, if you unloaded the aircraft to 0 G and gave it full deflection stick, the T-38 would roll 720 degree/sec (BTW, that was a prohibitive maneuver because it's pretty violent and disorienting). On the other hand, if you G the aircraft up to high alpha, the ailerons become relatively ineffective while the rudders become very effective. As a demonstration to my students, I'd slow and configure at altitude and apply moderate rudder. That would induce an immediate "rudder roll" --a warning to the student not to do that on an approach.