I. T-38A ADV GENERAL FEATURES

Physics Model:

- **Custom Flight Dynamics Engine (FDE)**
  The T-38A ADV uses a 100% custom physics engine. Aside of a new level of accuracy in terms of flight dynamics modeling, it lacks the traditional and well-known MSFS / P3D FDE limitations.

- **Custom ground dynamics and structural model**
  This allows structural characteristics and limitations being realistically modeled for the T-38 airframe, engines, landing gear struts and tires.

- **Accurate T-38 aerodynamic model based on Northrop and NASA data**
  The ADV model is built only around wind tunnel and Flight Test data obtained from the aircraft manufacturer, NASA and other research agencies. The resulting model has been corrected and validated by real T-38 pilots.

- **Realistic GE- J85-5A engine model**
  The engine dynamics and performance characteristics are accurately modeled. This also involves real engine operating limitations (compressor stall, afterburner flameout, etc…) and realistic engine start procedures, including in-flight windmilling restarts.

- **Accurate aircraft performance numbers vs real thing**
  As result of the highly accurate model, the T38 ADV matches the real jet figures in terms of flight envelope, fuel consumption (range/endurance), energy manoeuvre diagrams, etc…

Flight Control System:

The T-38 ADV flight control system model features:

- **Stability Augmentation System (SAS)**
  - Yaw SAS
  - Pitch SAS (T-38A Block20)

- **Control stick bob-weight**
  While a 100% realistic recreation of the aircraft control stick effects due to its "bob-weight" system would need from a ForceFeedback joystick device, some algorithms have been included in this version in order to partially model it. This results in an overall more realistic flight experience.

- **Flap-Slab system**
  T-38 aircraft flap-horizontal tail interconnect system is implemented in this version.

- **Flight Control System limitations depending on Flaps configuration**
  The maximum control surfaces deflection for ailerons and rudder are accurately limited depending on aircraft flaps position.

- **Realistic control surfaces response curves to pilot inputs**
  The control surfaces (ailerons, horizontal tails and rudder) are realistically deflected according to stick and pedal displacements since the actual flight controls gearing is implemented.

- **Hydraulic/electric actuators model**
  The dynamics of the hydraulic (ailerons, h. tails, and rudder) and electric (flaps) actuators is implemented.

Other systems:

- **Nose Wheel Steering**
  Accurate model recreation based on actual T38´s NWS characteristics and limitations.

- **Hydraulic Systems**
  Flight Controls and Utility Hydraulic Systems realistically implemented including separated sub-system feed lines.

Failures/damage model:

- **Custom failures model affecting**:
  - Airframe
  - Engines
  - Landing gear
  - Hydraulic Systems (FLT CTRLS + UTILITY)
  - Flight Controls (control surfaces, flap-slab, etc…)
  - SAS

- **Forced and random failures system**
  Possibility to create time dependant events or randomly created failures on different systems with scalability in damage. In case of random failures selection, the probabilities can be adjusted to realistic values based on actual T-38 fleet maintenance data.

- **Operating limitations damage**
  Exceeding real aircraft operating limitations will cause damage depending on the system affected: i.e. flaps jamming, tires blowout, etc…

- **Bird strikes**
  Based on real data for military aircraft, bird strikes could happen if flying at low altitudes. Damage severity and systems affected is based on a probabilistic system.

- **Icing effects on engine and airframe**
  The engines can be damaged when flying in icing conditions without ANTI-ICE system activated. This damage is due to ice accrued on engine intake that is detached and ingested by the compressor causing a FOD.
  Due to the lack of wing anti-ice devices, the aircraft could see a degradation of its handling qualities and its performance due to ice accrued on its airframe.

II. T-38A ADV Failures description

Realism bar:

This setting bar enables and simultaneously modifies the probability of failure for all aircraft systems. The "realistic" position sets the failure probabilities according to values taken from real T-38 fleet maintenance data (USAF source). Moving the realism selector to the right or to the left, will increase or decrease the mentioned probabilities above or below a realistic value. So, moving the selector all the way to the right will increase the probabilities to meet those of a poorly maintained aircraft and doing the opposite (to the left) will reflect an over reliable aircraft.

Birds:

This option enables the possibility of aircraft mid-air (or on ground!) collisions with birds. The probability of a bird strike will increase with increasing aircraft airspeed and decreasing altitude. So, the best way to have an undesired "encounter" is flying low & fast.

The effects of an impact will depend on the impact zone: fuselage or engines and the strike energy (bird weight / relative speed). The effects will range from a slight engine or fuselage damage to a complete engine loss or severe airframe damage affecting the aircraft handling qualities.

Icing:

Flying in icing conditions with the engine Anti-Ice in OFF position will cause ice being accrued in the inlet guide vanes and bullet nose of the engine. This will increase the probability of getting an engine FOD (Foreign Object Damage) due to ice being detached from these parts and ingested by the compressor.

Aside, the T-38 is not provided with any wing DE-ICE / ANTI-ICE device. Flying in icing conditions will also cause ice being accrued on wings. This will have negative impact on the aircraft handling qualities and performance.

As a tip, avoid flying under icing conditions as much as possible!.

Realistic Landing gear:

This option enables landing gear mechanical characteristics and limitations. With this option enabled, the maximum energy the landing gear can absorb in an impact (a touchdown) is limited to realistic values. Very high sink rates could cause a partial or a total landing gear collapse.

Aside, the landing gear tires limitations are modeled. Exceeding the maximum ground speed (≥190kts) could and will damage the nose and/or main gear wheels causing a blowout. Applying full brake action beyond 100kcas is not recommended either, as it could overheat the breaks and wheels and could block the main gear wheels causing tires skidding and a possible blowout due to an excessive tires wear.

Taxing the aircraft off the runway on unprepared terrains may damage the landing gear.

Realistic Engine:

This option enables realistic GE-J85-5A engine characteristics. Flying at high angles of attack, applying aggressive engine throttle inputs or flying outside the engine operational envelope could (and will) lead to engine compressor stalls or engine flameouts.

Failures explained:

- The below table explains the causes and/or the effects and behaviours that should be expected with each failure. As can be seen, they range from a minor or negligible degradation of aircraft system functionalities… to the total loss of aircraft control.

FAILURE GROUP	DESCRIPTION
Airframe	This failure is mainly caused due to the delamination in the wing tip resulting in roll and/or yaw control deficiencies. Depending on the level of damage a more or less pronounced aircraft roll and/or yaw tendency will be noticed.
Horizontal Tail	Most of the horizontal tail problems are due to improper rigging. This failure could partially or totally affect the flap to horizontal tail interconnect function. In the most critical situation a horizontal tail jamming can occur. In this case, no pitch axis control from stick or trim inputs will be possible after the failure…and aircraft ejection will be more than a recommended option.
Ailerons	A large percentage of the aileron problems are due to improper adjustments of the rigging. In the most critical case, an aileron jamming can occur. The aircraft roll capability will be affected accordingly.
Rudder	The principal causes of rudder subsystem failures are: improper rigging, hydraulic leaks and access door screw fastenings improperly secured that project sufficiently to hinder rudder movement. In the most critical case a rudder jamming can occur. In this case, yaw axis control will be lost and a residual yaw movement will be found depending on the rudder jamming position.
Flaps	The trailing edge flaps can partially or totally fail to extend or retract (if previously extended) if a flaps system failure occurs. Aside, the flaps can result damaged if extended beyond its maximum extension speed (≈240kcas @ Flaps>46%). In this case, a single or dual flap jamming can occur. A residual roll motion could result due to the flaps asymmetry after the jamming.
Airbrakes	The airbrakes can partially or totally fail to extend or retract (if previously extended) if an airbrakes system failure occurs.
Hydraulic systems	A failure in the Hydraulic System will suppose the total loss of one or both (if a system leakage exists) of the Hyd Sub-Systems: - Flight Controls Hyd - Utility Hyd.
Landing gear	The landing gear failures range from a failure to obtain a positive indication of gear up or down to an actual landing gear leg extraction or retraction failure. In the first case, the failure is due to an improperly adjusted landing gear door and can be solved by recycling the landing gear up and down after the initial extension or retraction in order to obtain the proper indication.
Engine / Power	This failure reflects damage occurred in the engine core (compressor/turbine), the Variable Exhaust Nozzle (VEN) actuation system or the engine power gearbox. Damage will range from unnoticeable effects by the pilot to a complete engine or power gearbox loss, depending on damage severity. If the gearbox is failed, the engine associated generator and hydraulic systems (FLT CTLS or UTILITY) will be lost.
Stability Aug. Sys.(SAS)	A SAS failure will involve different possibilities ranging from an erratic/oscillatory SAS behaviour in the affected axis (either pitch or yaw) to a non responding system (no stability augmentation). If any undamped oscillation is found in either pitch or yaw with the system ON, the corresponding SAS switch should be immediately turned OFF.

III. T-38A ADV FAQs

- **The Nose wheel steering is not working:**

  - The NWS is toggled with the "Tailhook" command. Like in the real aircraft, the NWS is automatically disabled if afterburner operation is selected. Also, once the aircraft weight is off wheels, the NWS is automatically disengaged. It must be manually activated (tailhook) after each landing.

- **Sudden loss of aircraft control after brakes application (realistic landing gear):**

  - The T-38 aircraft is not provided with anti-skid brakes system. This means, the faster you go and the harder the brakes are applied, the higher the heat generated in both, the brakes and the wheels. In extreme cases the wheels could result blocked and a wheel blowout will follow almost inmediately.

- **Wheels blowout at high speeds (realistic landing gear):**

  - If the aircraft ground speed limitation is exceeded (>190kts approx.) landing gear wheels will result damaged and a wheel blowout could happen.

- **When I start the left engine first I can hear the engine sound but I don’t see RPM increasing :**

  - That´s because the engine instruments need AC current to work. Only the right engine instruments are supplied with AC from a battery operated static inverter. In absence of any external ground power, the right engine should be started first. If both generators are offline (and the battery is ON), only the right engine instruments will work.

- **Engines go "BANG!" and flameout (realistic engine):**

  - The J85-GE-5 engine is an old and tricky engine. If engine operational limitations are not observed, it is relatively easy to enter in the compressor instability zone. This can be caused by several factors:

  > Rapid engine throttle movements
  > Selecting afterburner outside its operational envelope
  > Flying at high AoA or Sideslip angles

- Once the instability be noticed (loud "bangs" heard) the affected engine throttle must be inmediately retarded to idle to recover the compressor and to avoid engine damage. If no corrective action is taken an engine flame-out will follow.

- **Low engine RPMs and engine not responding to throttle commands (realistic engine):**

  - This low rpm condition is caused by a compressor stall ("RPM drop"). In this situation, the FADEC limits the amount of fuel injected to avoid a flameout and/or engine damage. To exit this condition the throttle needs to be retarded to idle and "pumped" starting from this position. Also, the airspeed needs to be increased above 300KIAs to help nominal compressor airflow conditions be restored.

- **Oscillating engine RPMs (realistic engine):**

  - The best indication that the engine has been damaged :)

  - In this ADV version different sources of engine damage are implemented: compressor/turbine blade mechanical failures, ground collisions, birds ingestion, ice ingestion (see below), etc...Also, engine damage level can range from mild damage (small vibrations) to a complete engine loss, in some cases accompained by fire!.

  - Once any engine damage be noticed or suspected, the emergency procedures should be inmediately applied. Usually, retarding to idle or completely shutting off the affected engine is the safest option. On the other hand, if the engine keeps running while damaged, specially at high RPM regimes, it becomes more and more probable a damage increment and a fire risk with it.

- **Anti-ice...just only cosmetic? (realistic engine):**

  - Not at all!

  - Flying in icing conditions with the anti-ice system OFF will cause ice being accrued on the inlet guides vanes and engine bullet nose. If the ice results detached (i.e during high-g manoeuvring) and hence ingested by the compressor, an engine FOD damage will happen.

  - The anti-ice device will have a realistic impact on engine performance and operation.

- **Engine over-temperature (realistic engine):**

  - EGT values well above 650ºC is the best evidence that something is going wrong in the engine. High engine temperature is caused by engine damage either in its core (compressor/combustion chamber/turbine) or its VEN (Variable Exhaust Nozzle). It could be also a good evidence of an engine fire, of course.

  - If a VEN failure happens (VEN not changing with RPM or Afterburner) an increased EGT values will be obtained if the exhaust flow is not correctly expanded. This will happen when the exhaust area is smaller than the required one. Flying in an over temperature condition should be always avoided.

- **Engine under-temperature (realistic engine):**

  - This condition is only obtained when a VEN failure occurrs and the exhaust area is bigger than the required one. In this case, the exhaust gas is over expanded. In this case, the most remarkable effect will be a more or less noticeable loss of thrust in the affected engine.

- **I have an engine flame out…how/where can I re-start it?:**

  - The J85-GE-5 restart envelope is depicted below. Having a successful engine restart outside the shaded area is very unlikely. Even in the heart of the envelope it can take several attempts before the engine comes to life again.

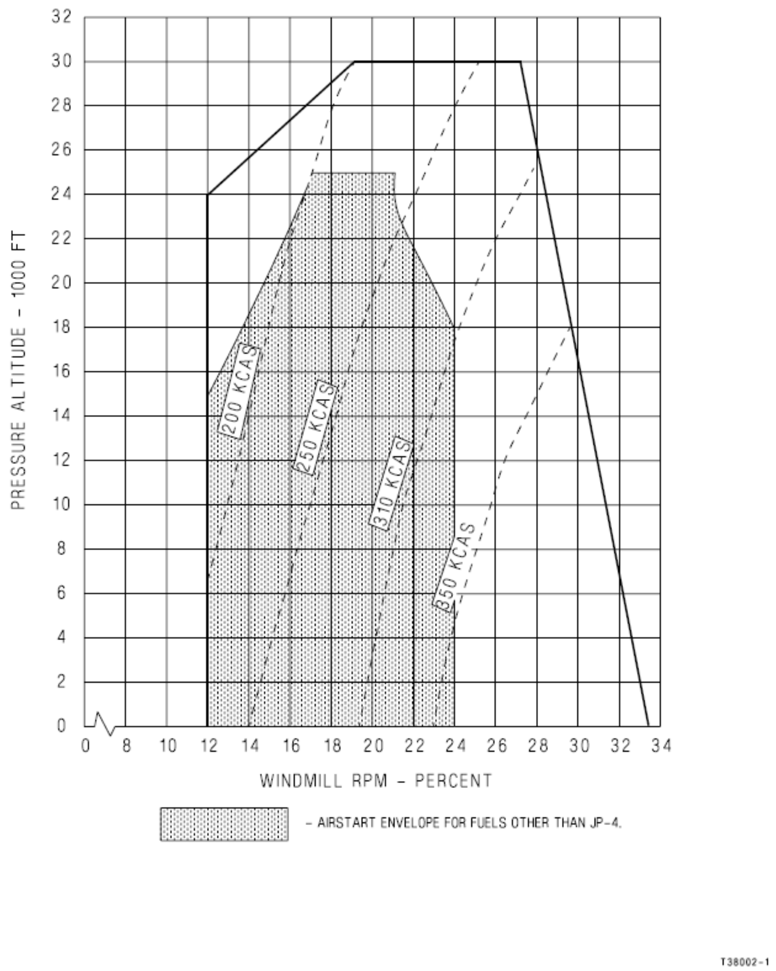

Figure 3-5. Airstart Envelope (Sheet 1 of 2)

- **IMPORTANT! - External Weather modules (Active Sky Next):**

  - It has been observed some interferences with the T-38A ADV Flight Dynamics and engine models when using external weather modules like ASN. Without entering to discuss about their realism...issues are caused by the injection of abrupt changes in the atmospheric variables. So, aside of wind, ambient temperature or pressure are abruptly modified and hence the inputs the T38A ADV model is using. Sudden engine parameter or aircraft attitude changes will be the result.

  - In order to minimize these unrealistic and unwanted effects, it is recommended to use the following settings with ASN:

  Turbulence effect scale = 50% (max value)
  Enhance Turbulence = OFF

- **Flaps stopped moving & roll-out tendency (realism enabled - Failures interface):**

  - If flaps are operated beyond their structural limits (280 to 350 kias depending on deflection), a flaps system jamming will occurr. If this happens while the system is moving, an asymmetric jam (left/right flap) is very likely to occur and a residual roll tendency will result. The higher the flap asymmetry, the higher the roll tendency that simple.

- **I can't spin this aircraft!!:**

  - The T-38 is a very spin resistant airframe, but this does not mean it is impossible...with the correct technique. During the T-38 development it was found very difficult to force the aircraft into a spin. After several failed attempts, it was found that the pilot needed to perform a PIO like manoeuvre in pitch at very low speed, high pitch attitude and AoA conditions in order to force the spin. Adding some lateral stick will help in some occasions (no rudder needed). With that very unnatural pilot commands the resulting inertial coupling in combination with a reduced stability will do the rest. However, it was finally concluded that even when applying such abnormal control combinations (no "operational" at all) the spin was very difficult to get.

  - A good proof of the T-38 trainer spin resistance is that not a single T-38 aircraft has been lost in a spin related incident.

- **Ok, I´m in a spin...now, how to exit?!!:**

  - The T-38 has two spin modes. The first one is a pitch and roll oscillatory mode, usually happening at the first stages of the spin development. The second mode (fully developed spin) is characterized by a quite flat spin with very steady yaw rotation (about 90-120 deg/s) with the nose slightly below the horizon and with no roll oscillations.

  - Once the spin confirmed, the recovery actions MUST be IMMEDIATELY applied: full aileron in direction of spin, full opposite rudder and full after stick (erect spin)

  - If no positive recovery is obtained after 4 or 5 gyrations from the spin start it is very likely that the spin start transitioning to its flat-steady mode which has been demonstrated unrecoverable. In this case, EJECT!! ☺

- **EJECT EJECT!!!...I try to raise the handgrip but:**

  - Sorry, no ejection sequence implemented ☹

- **Electrical failures not modeled…why??!:**

  - Simply, because there are no records of a dual electrical system failure (dual generator loss) nor AC crossover system failure in this aircraft. Electrical system redundancy will make transparent for the pilot any single system failure.