Single Engine Turbine Multirole Aircraft supporting Air-Force-Training TACTICAL ENGAGEMENT SIMULATION

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This bulletin is part of an article series published in ActaAvionika, discussing the author's idea of supporting adequate air-force training while having in use only a single engine turbine multirole aircraft. There are a handful different manufactures in the market today with comparable performance of theirs airplanes which might fulfill the operational demands discussed here in the paper.
This abstract covers TES Tactical Engagement Simulation+Operations for air-force in-flight training.

K e y w o r d s: EMB 314 Super Tucano, TES, Tactical Engagement Simulation

INTRODUCTION

In modern, quick turning markets and their demands the initial situation can be changed even in the time between writing and publishing these series of articles. So the author did not lay claim to a detailed operational or performance matrix, neither privileging companies nor any of their products.

Any of the described aircrafts have in common to be a single-engine, low-wing tandem-seat turboprop airplane with reasonable operational costs and expenses. Many of those can be already found in operation by different air-forces worldwide for pilot flight-training , but now the author's idea is to expand the envelope of operations to fields in which turbo-fan driven jets were used today. [1]
The economically point of view might supporting the use of a single-engine turboprop aircraft versus jet-engine single- or dual seated fighters. Regardless of speed questions needed sometime, there are different applications and in-flight training sections which could be handled with the here presented airframes.

The selected airframes are widely flown worldwide and are unveiled here in that documentation with different training and application purposes.

The EMB 314 Super Tucano of Brazil will continue the series with "TES – Tactical Engagement Simulation" considerations.

EMBRAER EMB 314 AIRCRAFT

Figure 1: Embraer EMB 314 [2]

The Embraer EMB 314 Super Tucano, also named ALX or A-29 is a turboprop aircraft designed for light attack, counter insurgency (COIN) and pilot training missions, incorporating modern avionics and weapons systems. It is currently in service with the air forces of Brazil, and Colombia, and has been ordered by Chile and the Dominican Republic. Embraer has plans to sell it to other countries in Asia and the Middle East. Besides pilot training, it is heavily employed in monitoring operations in the Amazon region. [3]
The request for a light attack aircraft was part of the Brazilian government's SIVAM (Amazon Monitoring System) Project.
This aircraft would fly with the R-99A and R-99B aircraft currently in service and would be respon-

sible for intercepting illegal aircraft flights and patrolling Brazil's borders.
The ALX Project was then created by the Brazilian Air Force, which was also in need of a military trainer to replace the Embraer EMB 326GB Xavante. The project of the new aircraft was suited to the Amazon region (high temperature, moisture, and precipitation; low threat).
The ALX was then specified as a turboprop engine aircraft with a long range and autonomy, able to operate in night and day, in any meteorological conditions, and able to land on short airfields lacking infrastructure.

The first flight of a single-seat Super Tucano production aircraft occurred on 2 June 1999. The first flight of the two-seat version occurred on 22 October 1999.

On 11 January 2006 Embraer had a potential sale of 24 units to Venezuela fall through.

Twenty-four Super Tucano (variant AT-29) were purchased by the Colombian Air Force in a 234 million USD deal, purchased directly from the Brazilian company Embraer.
The first three planes arrived in the morning of 14 December 2006 to the military airfield of CATAM in Bogotá. Two more planes were delivered on the week of December 16, 2006, ten more in the first semester of 2007 and the rest in June 2008.
One Super Tucano has also been purchased by a subsidiary of Blackwater Worldwide, an American private military contracting firm. The plane did not include the machine guns normally attached to the wings.

Different EMB314 or A29 variants can be found:

- A-29A
  Single-seater for attack and armed reconnaissance (on interdiction tasks), attack and cover (on close air support tasks), able to intercept and destroy low performance aircraft.

- A-29B
  Twin-seater for the same tasks as the single seat version, also used in training and advanced aerial control (on monitoring tasks).

EMBRAER EMB 314 AIRCRAFT PERFORMANCES

General characteristics [3]
Crew: One pilot on single seat version, one pilot plus one navigator/student on double seat version

Length: 11.33 m (37.17 ft)
Wingspan: 11.14 m (36.55 ft)
Height: 3.97 m (13.02 ft)
Wing area: 19.4 m² (208.82 sq ft)
Empty weight: 3,020 kg (6,658 lb)
Loaded weight: 4,520 kg (9,965 lb)
Max takeoff weight: 5,200 kg (11,464 lb)

Powerplant: 1× Pratt & Whitney Canada PT6A-68C, 1,600 hp (1,193 kW)

Performance
Maximum speed: 593 km/h (320 knots, 368 mph)
Range: 4,820 km (2,995 mi)
Service ceiling 10,670 m (35,008 ft)
Rate of climb: 24 m/s (79 ft/s)

Armament
(This section is different from the above ones, because here armament issues are explicitly named in the performance section by the manufacturer. The author will print it undiscussed; to what extend also the other aircrafts underwing-stores might be used in armament ways, is not in focus.)

2x 12.7 mm FN Herstal M3P machine guns
1x 20 mm cannon pod below the fuselage
4x 70 mm rocket launcher pods
Conventional ('Iron') and Guided ('Smart') bombs
2x AIM-9 Sidewinder or MAA-1 Piranha or Python 3/4 air-to-air missiles
External stores on 5 hardpoints

EMBRAER EMB 314 COCKPIT & AVIONICS

The Super Tucano provides a latest generation Human-Machine Interface designed to minimize pilot workload through the optimization of all tasks (tracking, interception, surveillance, support, etc.). [3]
Featuring a state-of-the-art avionics system structured around a MIL-STD-1533 Databus Architec-

ture, the Super Tucano also incorporates the following systems:

- Full Hands on Throttle and Stick (HOTAS) concept
- Laser INS with GPS Navigation System
- Computerized Attack Modes (CCIP, CCRP, CCIL, etc.)
- HUD (Head Up Display) with UFCP (Up Front Control Panel)
- Two 6” x 8” Liquid crystal, active matrix Color Multi-Function Displays (CMFD) per pilot station
- Tactical V/UHF with provisions for datalinks
  Tactical communications take place through a digital anti-interception and jamming V/UHF radio, which through a datalink modem is capable of transmitting frozen FLIR (Forward Looking Infrared) images or positioning fixes to other aircraft. In the silent receiver mode, the system can pick up data from ground stations or AEW&C aircraft without revealing its position.
- Integrated Radio Communication and Navigation
- Video Camera/Recorder
- NVG Gen III-compatible internal/external lighting system
- Automatic Pilot with embedded mission planning capability
  A two-axes military automatic pilot helps reduce pilot workload on long-endurance missions.
- FLIR (Forward Looking Infrared) supplies digitized thermal imaging in two crew-selectable display modes, fully compatible with third-generation NVGs or better.
- All-glass, low workload cockpit for situational awareness
- Helmet Mounted Display System (optional)
- Crew survivability is ensured through armor protection and state-of-the-art provisions such as MAWS (Missile Approach Warning System) and RWR (Radar Warning Receiver) in addition to chaff and flare dispensers. The communication and navigation system is similar to that of training applications, but features such as PR (Positioning Reporting) and ALE (Automatic Link Establishment) allow automatic transmission of aircraft position and flight data to ground bases. The aircraft is also equipped with an EGIR (Embedded GPS/INS & Radar Altimeter).

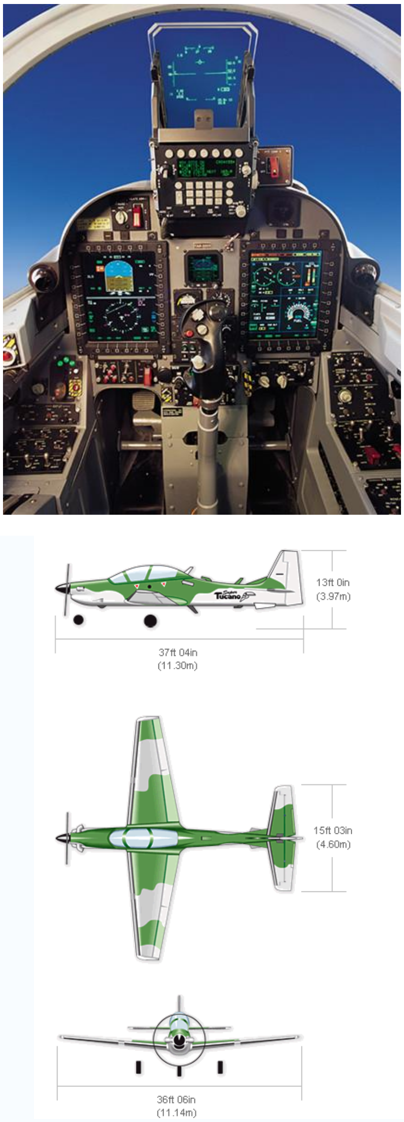

Figure 2: Embraer tableaus of a EMB 314 [3]

TACTICAL ENGAGEMENT SIMULATION

A Tactical Engagement Simulation (TES) is a training system for using weapons. Laser transmitters are used instead of bullets, larger rounds, or shorter-range guided weapons such as anti-tank missiles.
A laser transmitter is mounted on the weapon and aligned with the weapon's barrel. [4]

Gallium arsenide (GaAs) is often used as the stimulated medium and this produces a wavelength of 904 nanometres (nm), in the near infrared band outside the sensitivity of the human eye which is from about 400 nm to 700 nm (0.4 to 0.7 micrometres).

In modern TES systems the laser transmission is coded so that in a field exercise, individual weapons can be identified by exercise control (EXCOM) and appropriate calculations made of gravity drop, warhead damage radius and so forth.

Weapons as small as hand guns can be part of a TES system as can larger weapons including tanks and large caliber guns.

In field exercises, the laser transmitters can trigger cartridge-based Weapon effects simulation (WES) devices mounted on potential targets such as tanks and other vehicles. WES systems could include pyrotechnic flash/bang and smoke devices that add realism to a field exercise.

All these events are recorded on the exercise computer. After-Action Review (AAR) can include comprehensive analysis of weapon firing, accuracy and warhead effects on the targets.

Such techniques have taken much speculation out of the assessment of field exercises and have resulted in more realistic training than formerly was available other than by using (dangerous) live firing.

STANDART COMPONENTS OF A “TES” SYSTEM

The tactical engagement simulators are meant to permit training under combat conditions for all branches of service by means of simulating the effects (representation of hits and effects) of direct fire weapons. [5]

Figure 3: Components of an AGDUS variant BT46 used by the German Military [5]

To reach this goal the TES (in Germany called “AGDUS” = ***A***usbildungs***G***erät ***DU***ell***S***imulator) simulators have been designed in such a way that they can be used to simulate combined arms combat.

This concept includes the following essential military requirements:

- All tactical engagement simulators must be interoperable (family concept). The correct behavior of the soldier in terms of tactics and shooting technique during a fire fight against targets must lead to realistic success respectively failure.

- The original operational procedures and courses of action during a fire fight must be maintained ("the weapon is operated, not the simulator").

ISSN 1335-9479

- Range and hit probability must reflect reality.

Each TES simulator has an active component (laser transmitter) and a passive component (receiver) to simulate weapons effects. The active component scores hits against the passive component of the opponent by means of eye safe laser.

In principle, there are three different systems:

- One-way systems (one transmitter irradiates one receiver)
- Two-way systems (following a distance measurement an adapted pulse is transmitted (power, beam expand))
- Real-time systems (the trajectory is searched for potential targets with a laser scanner during the simulated flight time of the projectile)

The projectile trajectory is simulated in case of TES tube weapons (main battle tanks, armored cavalry assault vehicles, etc.) and in case of antiarmor weapons (MILAN, TOW, etc.) the trajectory of the guided missile.

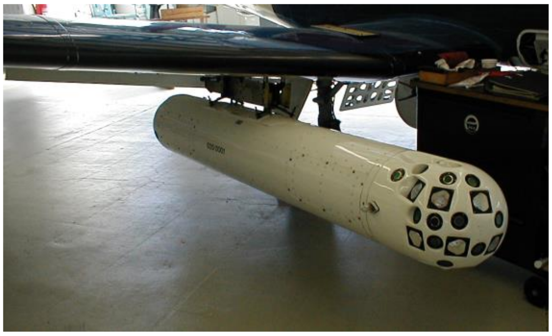

Figure 4: TES installed under wing [5]

Now the idea is to replace the winch-pod-system underwing at a hardport by an AGDUS compatible system and its components. [6]
So German forces could exercise their common AGDUS / TES also with aircraft usage!

Two pods are filled up with electronics, weighing each 65kg with a total lenght of 2.70 m. and a diameter of ca. 40 cm.

Additional a Black-Box “steering and computing” is needed, installed somewhere in the aircraft, and in the cockpit a handheld-control display is added.

INSTALLED AGDUS EQUIPMENT & OPERATION

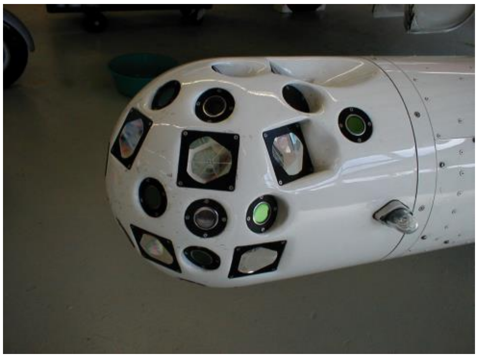

Figure 5: TES Receiver head under wing [5]

Each underwing pod has the same optics and electronics installed regardless left or right pod. Besides triple-prisms, laser-detectors and laser-reflectors, evaluation-electronics a strobe-light is added.

The Black-Box is stored within the Co-Pilots right arm rest because the handheld-control cables run directly into its computing box, therefore the cables can be kept quite short. The handheld control is also operated by the Co-Pilot.
This control fulfils different demands, besides tactical hit data’s to be shown instantly, a PC-computer-readable data-card for later on-ground-evaluation is installed, also system-parameter can be called by the flight crew.

The underwing installed receiver-head detects any emitted laser fired towards the aircraft.
In accordance to the point where the first detection was encountered the fire-hit is calculated. Even more details can be answered due to the pulsed and coded laser; the ammunition, the used weapon, the identity of the emitter and ammunition course track are determined.

14 detectors and 8 reflectors (triple-prisms) cover the whole aircraft. The detectors are active components in receiving and for the calculations needed. The reflectors as the name reveals reflect the laser-light exactly to its source and are passive components. So for example the anti-aircraft tank unit use the own emitted and by the reflector returned laser-beam for internal fire-sequence computing.

The aircraft could be splitted by software into different sections;

Figure 6: Calculated zone of impact [7]

Light blue shows the tail and power-plant exhaust area, red stands for the wing-section, green for the fuselage of the aircraft and forward yellow for the nose and cockpit zone.
With the utilised coded ammunition, direct statements about the strength of the impact can be given.

Each section is overlapping the other in short range so multiple hits can be diverted into single fatal ones or into a fusillade with their damage grade.

All datas are stored and directly displayed at the handheld control. The mentioned strobe-light can be flashed to let ground forces also know if the firing was successfully placed of not.

Reprogramming of its software might enable every aircraft-silhouette to be used with that TES under-wing pod system.

This part of the Tactical Engagement Simulation (TES) is a very efficient one. With minor changes to the airframe, demounting of the winch system and installation of the TES/AGDUS pots, a huge benefit is achieved.
From gunned infantry to high-tech fire-and forget anti-aircraft missile, all kinds of tanks and troop detachments can be duels simulated within a maneuver. Up to 23 different weapons and ammunition can be simultaneously appraised. [7]

CONCLUSION

The above mentioned and in detailed discussed aircrafts ware sold with a price tag inbetween
4 Mio. Euros [6 in 1990] up to nearly 8 Mio. Euros [3 in 2008] per aircraft.
Surely it is a big price tag, but on the other hand with this multi-role platform in its operation every penny was obviously the investment worth right.

All of them were reliable aircrafts, easy to operate, quick to adapt onto different customer's demands and fulfilling its performance envelope over a wide application range

Regardsless if any aircraft-type is a gladly seen attendent at an airshow, figure 7 Polish Airforce PZL130s; or a work horse outward appearance in a fighting force training environment, as figure 8 shows a fully equipped EMB314. Those aircrafts are adequate to the task.

Figure 7: Polish PZL 130 Aerobatics [8]

Figure 8: EMB 314 for airforce training suited [3]

Comparable turbo-jet aircraft for training like the T-38 Talon [9], the T-45 Goshawk [10] or the T-50 Golden Eagle [11] came with a price of 15+Mio. Euros, so at least 2 times more, conservatively calculated. Operational costs considered not at all!

As explained in the intro, if no speed related usage is supposed, all single-engine low-wing turbo-prop aircrafts could honor the demands.
Perhaps one of the readers will find him-/herself in a position to consider airframe and/or avionics modification or upgrades on aircrafts sitting on his/her ramp, so go ahead and use what is there!
Economy will thanks it and saved money -if unawared left- can be speed useful elsewhere.

The author is happy to discuss questions about his achieved conclusions in that topic or to share ideas about the described modifications.

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