"THE LVC ENABLER FOR FIGHTER AIRCRAFT"

REAL FLIGHT, SYNTHETIC TARGETS

EMBEDDED COMBAT AIRCRAFT TRAINING SYSTEM

EMBEDDED TRAINING (ET)

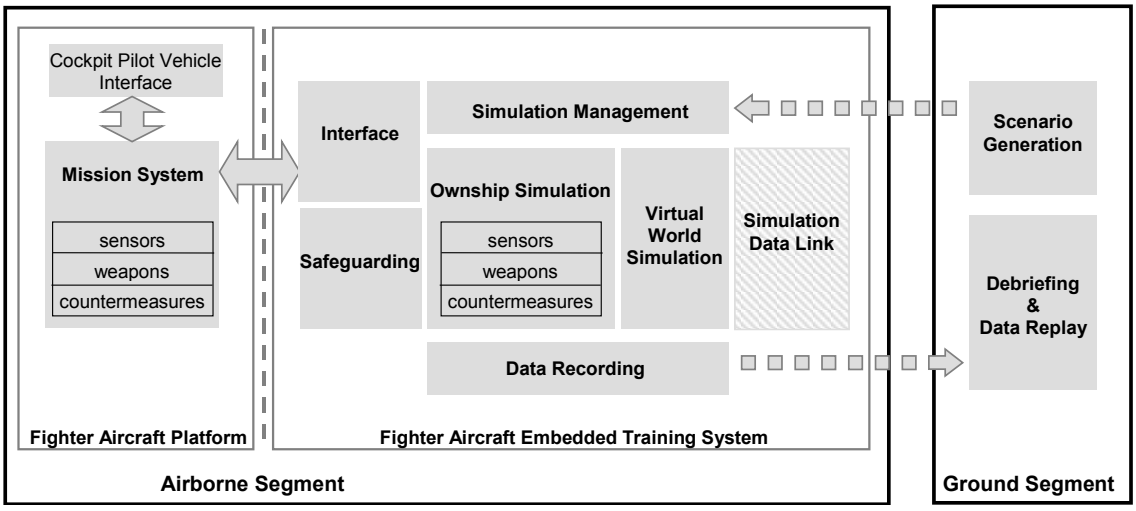
Embedded Training (ET) can be defined in general as a training capability built into an operational system that enables the operator to use the system in a situation that it was designed for while that situation is not actually available. More specifically for fighter aircraft, ET allows pilots to train intensively and realistically by immersing them into a mission scenario augmented with synthetic entities with which they can interact. As a result, the pilot is able to utilize his aircraft ("ownship") to its full capability and to engage large numbers of air and ground threats in challenging scenarios.

EMBEDDED TRAINING IN A FIGHTER AIRCRAFT

The pilot interacts with the synthetic threats by using his unmodified cockpit controls and displays. For example, he or she performs identification, fires weapons, and applies countermeasures. Effectiveness of countermeasures is also realistically simulated. Synthetic threats will show a realistic intelligent behavior. For example, they fire missiles at the real aircraft and apply countermeasures when they are attacked. So ECATS provides the **L** and the **C** of ***L**ive **V**irtual **C**onstructive* training for fighter aircraft, and is prepared for the integration of *Virtual* components. Therefore, for fighter aircraft it is THE enabler for participation in LVC training configurations.

Dutch Space and NLR have jointly developed an Embedded Combat Aircraft Training System (ECATS). This system interfaces with the mission system of the aircraft in order to exchange data. Inputs to ECATS are the flight parameters, weapon selections and other pilot actions. Outputs of ECATS that are injected into the mission system are the virtual target locations and sensor settings. The mission system processes the virtual targets as if they are being acquired by the aircraft ownship sensors. As such ECATS has been integrated on an operational F-16 MLU fighter aicraft from the RNLAF and will be integrated in the mission system of Lockheed Martin's F-35 Lightning II aircraft.

ECATS consists of several modules, which are shown in the figure below.



System architecture

Simulation management module

During flight in ETS-mode, the simulation management module performs functions such as selecting training scenarios, starting and stopping training exercises.

Ownship simulation module

The ownship simulation includes models of the aircraft systems that are relevant for ET, such as fire control radar, missiles, chaff, and the radar-warning receiver. Another function of the ownship simulation is to realistically assess hostile weapon effectiveness, including hit calculation and probability of kill.

Virtual world simulation module

The virtual world simulation includes the virtual ground and air threats, their weapons, and dynamic behavior, involving strategies, tactics, maneuvers, and countermeasures including elements of surprise to avoid predictability. A simulated Ground Control Intercept (GCI) is included as part of the virtual world. It verbally provides the pilot with an air picture.

Safeguarding module

In case of severe safety risks the safeguarding module automatically shuts down the execution of the training scenario to allow the pilot to regain situational awareness of the real world. Safety risks covered by that module include the inadvertent crossing of the boundaries of the reserved airspace by pilots immersed in ET or inadvertent arming by the pilot of the missile weapon system with the risk of firing a real missile at a virtual threat.

Scenario generation module

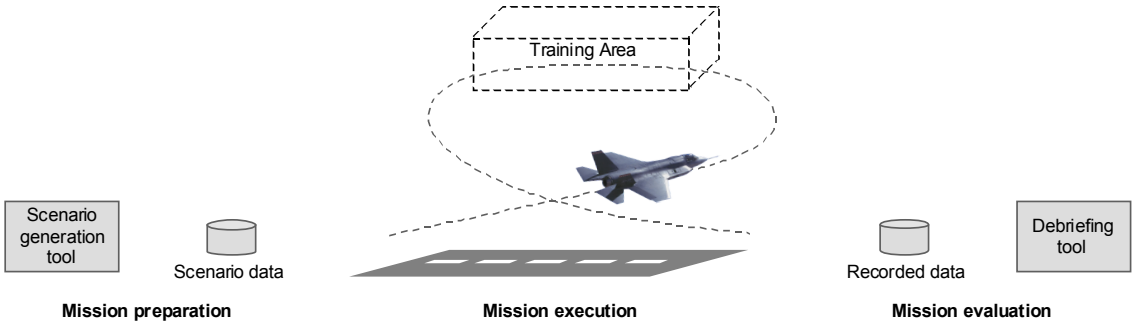
By means of the scenario generation module scenarios can be tailored to specific training needs. After verification of the scenarios, the digital representation of the set of scenarios is loaded in the aircraft.

Debriefing module

The debriefing module is used for replay for post-flight debriefing and training evaluation purposes. It provides the pilot and his instructor with an interactive tool for replay of in-flight recorded data that generates a synchronized representation of the cockpit displays, the aircraft flight tracks and an event list.

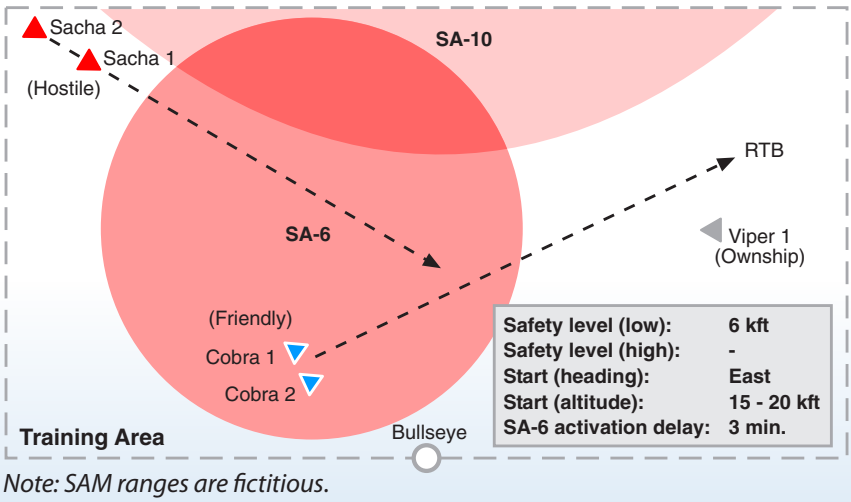
ECATS TRAINING MISSION

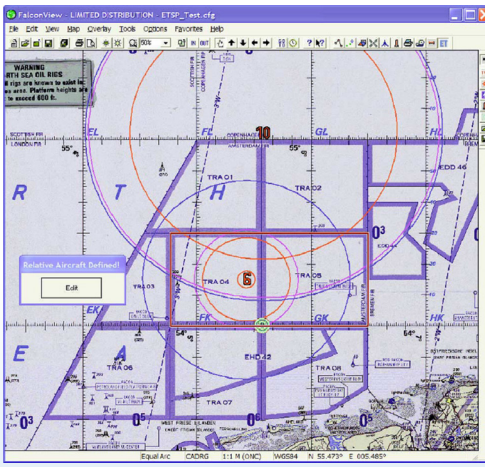
A training mission with ECATS consists of three phases. Each phase is described below.



Mission preparation

From the pilot point of view, preparation for an ECATS training mission will be the same as for any normal mission. Using existing mission planning systems, input data like target data, intelligence data, and meteorological data are analyzed and transformed into data for use on-board. ECATS training missions require one additional step, i.e. the selection of type, routes and tactics of the virtual aircraft and SAM-sites.





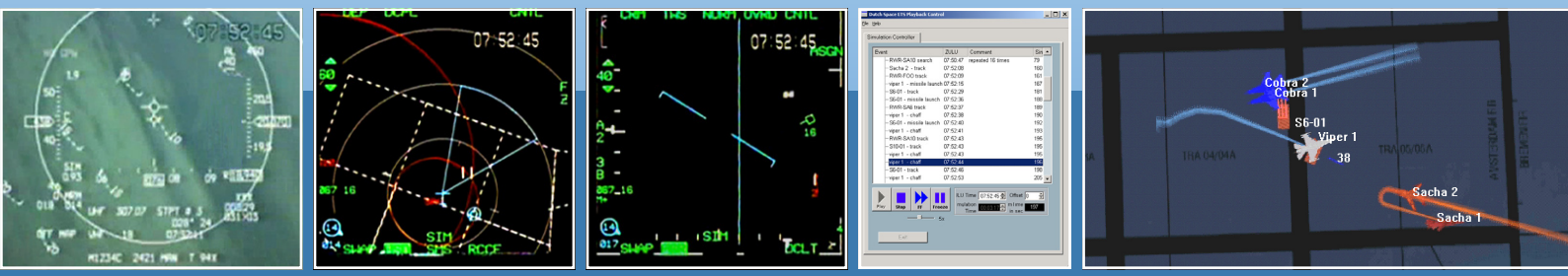
Note: SAM ranges are fictitious.

Mission execution

Upon arrival at the designated training area, the pilot selects one of the available scenarios. After starting the scenario, the pilot will be confronted with the virtual threats. While a scenario is running, the ECATS records all the necessary data to enable mission replay on the ground. The pilot can stop the scenario at any point in time.

Mission evaluation

For mission evaluation the ECATS debriefing tool enables the pilot or instructor to playback all the maneuvers and events as have happened during mission execution. E.g.: start and stop of simulation runs, launches of missiles, break-lock maneuvering, deployment of countermeasures, etc. The information will be presented in the form of 3D and 2D graphics and in association with recorded video when available. The mission playback will be displayed as synchronized multiple output channels(/windows) and will also contain the planned training scenario data. Playback control can be done interactively or in scripted form, both at various speeds. Additional facilities are available for assessment of the course of activities.



HUD and MFD displays, 3D (top) view of aircraft tracks

ECATS OPERATIONAL BENEFITS

SAM training anywhere, anytime
- Many air forces do not have SAM training resources
- Over water ranges prevent SAM training

Adversary air anywhere, anytime
- Operational deployments
- Night flying
- Multi-ship capable

Save money: higher quality flight hours
- Red air replacement / augmentation
- Fallout impact minimization
- Example: adversaries no-show due to tanker fallout, or weather

C4ISR anywhere, anytime
- Off-board cueing cornerstone of stealth employment
- C4ISR assets stretched too thin to support daily training

Reduces impact of training airspace limitations
- Virtual threats can fly outside the airspace
- Current BVR training requires ~ 80 miles separation at the 'fights on'
- Future weapons advances will only require greater distances

Virtual expendables
- Dangerous / limited / unauthorized expendables
- Countermeasure dispensers often kept off
- Causes pilots to forget - major factor to today's air forces
- ET: can still use 'switches' and get feedback

Security
- Conceals full capabilities while still training to them
- LO / Stealth / Special combat mode

Overall, the training interaction possibilities with the virtual SAMs and virtual aircraft result in a boost of training intensity. Analysis has shown that this results in an increase of training effectiveness by 30% at existing flying budgets.

Embedded Training – a decade of development

Since the late 1990s, NLR and Dutch Space have cooperated in transforming embedded training from a concept to reality for the Joint Strike Fighter. Single-ship capability was demonstrated in 2004 on an operational Royal Netherlands Air Force F-16. In 2007, the multi-ship demonstration for the JSF Program Office provided further insight into the technical maturity and the additional advantages of multi-ship embedded training. Using multi-ship embedded training, fighter pilots can train in-flight within one shared tactical environment. To implement this capability, each aircraft is fitted with a computer system with embedded training software. The software uses an existing data link to ensure each aircraft has the same tactical picture. Early 2009 Dutch Space and NLR received the go-ahead from Lockheed Martin to develop embedded training for integration in the F-35 Lightning II (Joint Strike Fighter). The contract was signed on October 7th, 2009.

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F261-NLR-DutchSpace-02