Chapter 4 – PILASTER GENERAL REQUIREMENTS

4.1 INTRODUCTION

This chapter describes the requirements for upgrading the PISQ (Poligono Interforze del Salto di Quirra – Sardinia, Italy), adding new facilities for carrying out safe training and experimental activities using the ground and airborne laser systems already in service or under test with the Italian Air Force (ItAF), and installed on its tactical aircraft (TORNADO-IDS, AM-X, Eurofighter TYPHOON, etc.) and helicopters (AB-212, AB-412, NH-90, etc.). Other national or international customers will be allowed to use the new facilities on case-by-case basis and according to agreements, memorandums of understanding or international co-operation agreements in force at the time concerned. The ItAF research and development program aiming to the PISQ facilities upgrade for laser test and training activities, is herein identified as PISQ LASer Test and Tactical Evaluation Range program (PILASTER program). According to the program requirements, the PILASTER facilities have grown modularly in two different phases. The aim of the first phase of the program (1999 – 2002) was to provide an initial operational capability for carrying out, in fully safe conditions, ground tests and flight experimental activities (with related measurements and data analysis), required for performance evaluation of military laser systems. The successive phase of the program (still ongoing) is aimed to implementing the PILASTER full operational capability, required for performing all required laser test and training activities (2002 – 2004).

In this chapter, the laser range concept of operation is described and the general requirements set in 1998 for the PILASTER program are presented. More information about the PILASTER range design and technical characteristics, progressively refined during the various implementation stages of the program, are given in Chapter 5.

4.2 PILASTER CONCEPT OF OPERATION

The PILASTER concept of operation is depicted in Figure 4-1. The on-board operator of a training/ experimental aircraft aims the Airborne Laser Target Designator (ALTD) system at the centre of a co-operating target. A Laser Safety Officer (LSO), located in the PISQ Control Centre (PCC) building, verifies that the laser Armament is aimed at the proper target and (for laser designators) the target lock-on status has been achieved. For this purpose, a real-time video link (video telemetry ground unit) is available between the aircraft and the PCC for safe operations. The LSO then authorises activation of the laser system. Should the video link be unavailable, as in the case of a Ground Laser Target Designator (GLTD) system operated from a ground Forward Air Controller (FAC) or a training aircraft not equipped with the video telemetry unit, the LSO may authorise the laser activation upon receiving confirmation (via voice link) that the planned target has been unambiguously recognised and aimed to by the aircraft Pilot/Weapon Systems Operator (WSO) or by the ground FAC.

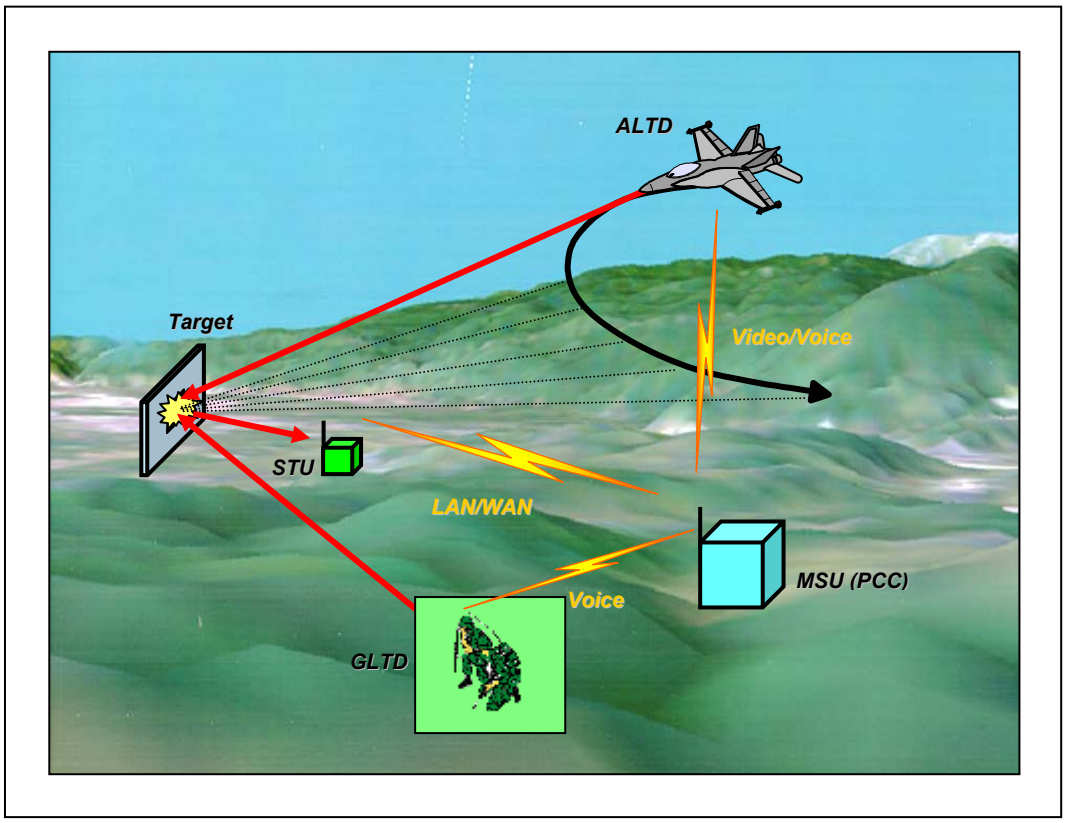

Figure 4-1: PILASTER Concept of Operation.

The Sensor Tracking and Measurement Unit (STU) detects the laser spot spatial energy distribution, calculating the spot centroid as well as its position with respect to the target centre (global pointing error). The captured laser spots, as well as the others applicable measurements, are recorded on a magnetic support.

During laser activation, the STU sends to the PILASTER Monitoring and Control Station Unit (MSU), located at the PCC, the laser spot parameters (dimension and position with respect to the target centre). These parameters are represented on the MSU display to allow the Safety Officer to supervise the operations. When the laser spot approaches the target peripheral zones and the LSO believes there is a possibility for the laser spot to fall outside the target itself, he might order the WSO/FAC to deactivate the laser (through the voice link).

4.2.1 PILASTER Training Activities

Training with both self-designation and co-operative attacks shall be possible, both by laser guided inert bomb releasing and by simulated attack. These types of missions are described in the following sub-paragraphs.

4.2.1.1 Training by Real LGB Releasing

In self-designation attacks, the aircraft follows the flight plans up to the optimal estimated release point, and then releases the inert Laser Guided Bomb (LGB). Then, it performs the escape manoeuvre, activating the airborne laser designator at a proper time. In co-operative attacks (two aircraft with a “spiker” and a “bomber”), the bomber releases the weapon and the spiker aircraft performs illumination as required for an effective guidance on the designated target. During this type of attack, both aircraft manoeuvre as required by the planned training tactics. In both self-designation and co-operative attacks with inert bomb

delivery, the STU starts measuring and recording the laser spot applicable parameters (e.g., spot centroid, time of laser activation, time of laser deactivation).

Measurement of the attack radial error is done by detecting the target/ground impact point of the laser-guided bomb. Consequently, one (or more) high-speed digital TV camera(s) shall be used at the STU to collect images of a relevant volume around the target. TV camera(s) frames shall be recorded as well for analysis purposes.

4.2.1.2 Training by Simulated Attack

In simulated self-designation attacks, the aircrew follows the flight plans up to the optimal estimated release point, and then simulates the release itself, manoeuvring as if it had occurred. At the required time, the pilot/WSO performs target illumination. In co-operative simulated attacks ("spiker" and "bomber" aircraft), the spiker aircraft performs illumination as required and both bomber and spiker aircraft manoeuvre following the planned training tactics. For both self-designation and co-operative attacks, the following information shall be supplied to the MSU (in the PCC).

1) During the entire attack, the aircraft (self-designation) or the bomber/spiker (co-operative) flight parameters up to the instant of release, from an available Data-link, the PISQ Radars/ Cinetheodolites (filtered or automated) or other TSPI systems (e.g., GPS/INS or DGPS/INS).

2) At the instant of simulated release, with a Synchronous Signal (SRTOA), from an available Data-link or manually from a PCC operator (using the Voice-link with the aircrew).

3) After the simulated release, with the Laser Activation Time Signal (LATOA), marking the beginning of the laser designation, and the detected laser spot parameters until designation is completed (planned designation time). The LATOA signal will be supplied either by the available Data-link or by means of the Voice-link with the aircrew/FAC. Should the laser spot on the target be undetected by the STU sensors (when expected to be on the target), a warning signal shall be sent to the PCC, allowing the LSO to order the immediate laser deactivation (emergency procedure). In both normal and emergency procedures, the time of laser deactivation (LDTOA) shall be supplied, with similar modalities (Data-link/Voice-Link), and confirmed as well by the STU sensors.

4) Before mission is initiated, with the relevant atmospheric parameters in the area of operations (visibility, relative humidity, air temperature, wind speed/direction, etc.) and target parameters (reflectivity, geometry, etc.).

The MSU then calculates the optimal "Bomb Release Corridor" (BRC) taking into account the bomber flight parameters and gives an output of the computed errors in quasi-real-time (i.e., before the beginning of a new releasing exercise, within 1 minute) if Data-link is available, or in deferred time (i.e., post-mission analysis performed using the data of all releasing exercises done) if Data-link is unavailable.

The training crew(s) will be supplied, in quasi-real or deferred time (according to the previous statement), with the information listed below.

- **Self Designation Attacks**

  a) The calculated optimal time of release (and the difference with the real one), keeping fixed all flight parameters, taking into account the designation time and STU detected laser spot characteristics (on target).

  b) The calculated optimal aircraft speed (ground speed) at the simulated time of release (and the difference with the real one), keeping fixed all the other flight and designation parameters.

c) The calculated optimal aircraft designation time and range envelope (distances from the target outside the simulated target lethal-range but within the maximum range for an effective designation) and the differences with the real designation time and profile.

- **Co-operative Attacks (Bomber-Spiker Aircraft)**

a) The calculated optimal time of release (and the difference with the real one), taking into account the spiker designation time and STU detected laser spot characteristics (on target), keeping fixed all flight parameters of both spiker and bomber aircraft.

b) The calculated optimal bomber aircraft speed (ground speed) at the simulated time of release (and the difference with the real one), keeping fixed all the other (spiker/bomber) flight parameters and designation parameters.

c) The calculated optimal spiker aircraft designation time and range envelope (distances from the target outside the simulated target lethal-range but within the maximum range for an effective designation) and the differences with the real designation time and profile.

- **Co-operative Attacks (Bomber-FAC)**

a) The calculated optimal time of release (and the difference with the real one), taking into account the GLTD designation time and STU detected laser spot characteristics (on target), keeping fixed all bomber flight parameters.

b) The calculated optimal bomber aircraft speed (ground speed) at the simulated time of release (and the difference with the real one), keeping fixed all the other flight parameters and GLTD designation parameters.

c) The calculated optimal designation time and the difference with the real designation time, using the aircraft flight parameters during the simulated release.

4.2.2 Experimental Activities

The PILASTER shall allow measurement of the applicable laser spot parameters, such as the laser spot dimensions, energy distribution and centroid position, laser spot quality, atmospheric extinction measurements, and code-signal measurements (on target).

4.3 PILASTER COMPOSITION

Unless otherwise specified, all the components of PILASTER will comply with all applicable systems and laser safety standards approved by the ItAF [1]-[26]. The PILASTER shall be fully operational with the present generation laser systems and armaments. Furthermore, its design shall be modular and expandable in order to allow future upgrades which may become necessary for test/training operations with next generation laser systems and armaments.

According to the general description and concept of operation previously illustrated, the PILASTER will be composed by the following main systems:

- Modular Target(s) for Real Attacks (Weapon Deliveries);
- Permanent Target(s) for Simulated Attacks (No Weapon Deliveries);
- Standing/Mobile Laser Sensor and Tracking Unit(s) (STU);
- Monitoring Control and Display Station Unit (MSU);
- LAN/WAN (between MSU and STU);

- Video Link (Aircraft to MSU); and
- Voice Link (V/UHF radio communications).

Furthermore, the use of a Bi-directional Data-link (MSU-Aircraft), and Encryption/Description of the Video Link, are considered as growth options for future PILASTER upgrade programs.

4.3.1 Targets

In order to fulfil the various test/training mission requirements, the following different kinds of targets are envisaged:

- ***Fast-Recoverable Target(s):*** This type of target (FRCT) shall be used for the effective laser-guided inert bomb releasing, and shall have a goal Mean Time To Repair (MTTR) of 1 hour.
- ***Fixed Target(s):*** This type of target (FXDT) shall be used for simulated laser-guided bomb releasing.
- ***Destroyable Target(s):*** This target (DEST) shall simulate a tactical target, and shall be used for releasing laser-guided weapons with their normal (or reduced) warhead explosive charges.
- ***IR Reference Target(s):*** Using this target (IREF), the Minimum Resolvable Temperature Differences (MRTD) and Spatial Frequencies (corresponding to various 2-D discrimination levels), can be determined for the FLIR systems integrated with airborne laser systems.
- ***Acquisition Training Target(s):*** This kind of target (ATGT) shall simulate a tactical target for acquisition training (shelter, tank, bridge, etc.).

The FRCT and FXDT targets are considered **essential**, and will be implemented since the first phases of the PILASTER program. The DEST, IREF and ATGT targets are considered as **growth options**. Both the FRCT and FXDT will have a dimension of approximately 10×10 m^2 in order to be extended for the majority of laser systems (ground and airborne) currently in service, at most ranges and grazing angles of practical interest. Furthermore, they will be painted with a highly diffusive paint of known reflection properties (i.e., reflectance and BRDF), in order to allow STU spot energy measurements. The DEST and ATGT targets shall have dimensions and shapes appropriate to simulate real targets and to perform real-time (in flight) and post-mission damage-assessment (DEST). The IREF target shall be a standard IR multiple bars target, whose bars shall be heated at precisely tuneable temperature differences (ΔT) with respect to the background.

4.3.2 Sensor Tracking and Measurement Unit

The STU shall be positioned nearby the targets. A hardened location (e.g., a little bunker) will be constructed nearby the FRCT and DEST targets. The STU shall be composed by the following elements:

- IR and TV Cameras;
- Detector Arrays and Processing Units (to be placed on the FXDT target only);
- Recording Systems;
- Computer System(s) with Windows NT or other operating system; and
- Data Acquisition and Processing Application Software.

The STU shall calculate the position of the laser spot energy centroid with respect to the target centre. A representation of this position within the target shall be supplied in real-time to the MSU. The STU will also determine and record the laser spot geometric dimensions on the target.

Using the FXDT detectors array, the STU shall also provide laser energy measurements (on the target) and therefore allow, in post-processing, atmospheric extinction determination (by comparison with the known aircraft/system co-ordinates). Furthermore, the FXDT detectors will allow PRF measurements for pulsed laser systems. All these measurements will allow to verify the impact of atmospheric and operational mission parameters on systems effectiveness.

The STU shall be capable of analysing, in the first development phases, 1.064 μm wavelength lasers (NIR) and shall be extensible, in successive phases, to analyse additional laser systems, such as the Near Infrared (NIR) 1.54 – 1.55 μm eye-safe lasers, Mid-Infrared (MIR) and Far-Infrared (FIR) lasers.

4.3.3 Monitoring and Control Station Unit

The MSU shall be installed in the PCC building. The MSU receives the data from the STU and shows, on dedicated displays, the laser spot on the target and the video signal received from the aircraft (Video-link). Particularly, the MSU shall be capable of:

- Showing, simultaneously on the same display, the data output coming from at least two different STU positions;
- Providing aural/visual warnings to the LSO when the expected laser signal is not detected by the STU; and
- Showing in real-time the video signal received from the aircraft (Video-link), on a dedicated display.

The MSU shall be designed to add, in successive development phases, the possibility of automatically deactivating the on board laser armament, when critical safety conditions are detected. The MSU shall be basically composed of:

- A computer based workstation with a powerful CPU, high-speed graphic and recording capabilities (adequate RAM and internal/external mass memory devices), analogue and digital I/O and LAN/WAN interfaces;
- A Video-link ground unit;
- A Voice-link (V/UHF radio); and
- A Data-link ground unit (growth option).

4.3.4 LAN/WAN Networks

The PISQ shall be provided with local or wireless area networks (LAN/WAN) for interconnecting the STU and the MSU. The choice and combination of LAN/WAN networks shall be suitable for a correct operability of the PILASTER systems from the available STU/MSU locations.

4.3.5 Meteorological Sensors

In order to perform measurements of the relevant meteorological parameters, the PILASTER range must employ two meteorological stations, both equipped with the sensors necessary for accurate measurements, during test/training missions, of temperature (T), pressure (QHN), wind speed (W_s), relative humidity (RH), rainfall rate ($\Delta x/\Delta t$), and turbulence structure constant (C_n). Each of the two groups of sensors will be mounted on a tower with height adjustable between 0 and 8 metres. For trials/training activities with ground laser systems, the sensors towers will be placed at the target and laser system locations, and all data relative to the two locations will be gathered and recorded at the meteorological stations. During trials/ training missions with airborne laser systems, only the data relative to the relevant target(s) location(s) will be recorded. All collected meteorological data will be used for post-mission analysis of laser beam atmospheric propagation performance.

4.3.6 Video Link

The PILASTER will be provided with a Real-time Video Link from the aircraft to the MSU, to allow Safety and Trial Officers (in the PCC) to monitor and control the whole laser test/training operations. Particularly, the laser system video signal (also available to the on-board operator) must be sent to the ground MSU.

Two functional blocks shall be considered: an On-board Unit, to be installed on the training/experimental aircraft, and a Ground Unit, to be installed in the PCC and interfacing with the MSU. Provision for additional encryption/decryption modules for the video signals should be also incorporated in the system.

4.3.7 Voice Link

The Voice Link between the aircraft and the MSU will be provided by installing a V/UHF radio communication system (including the relevant antenna and control panel) at the PCC. The system shall be fully compatible with radio-communication systems currently installed or expected to be installed on-board aircraft.

4.3.8 Data Link

The Data Link is only considered as an option (growth potential) for the PILASTER. If implemented, it can be used to perform the following functions:

a) To maximise laser safety, the MSU may have the capability of controlling the laser armament's key-data signals, such as the *Laser ON*, *Track Mode*, *Lock-On* or *Track Lost* signals. For this purpose, the MSU shall be capable of integrating additional HW/SW modules for analysing in real time the 1553/1760 or other Data Bus messages exchanged between the laser system and the on-board mission computer via Data Link (LINK-16 or other).

b) To perform a real-time attack simulation (self-designation or co-operative), the MSU shall have the capability of acquiring in real-time the significant flight parameters, by reading the applicable bus messages (MIL-STD-1553 or other avionic bus). In order to provide the crew(s) with quasi real-time feedback during simulated attacks, the relevant MSU outputs can be also sent to the aircraft.

4.4 OTHER REQUIREMENTS

A feasibility study has to be carried out in order to investigate the possibility of using the cinetheodolite (CITE) systems presently available at PISQ (non-automatic systems), by filtering the operator-telescopes from the laser radiation that might reach the eyes of the systems operators, or by using automatic systems and/or visible cameras applied at the current CITE systems oculars (to avoid any operator injury risk). Analysis will be carried out to specify the optimal solution (e.g., determination of the optical density for the protective filters, or modification of the CITE systems optics design using visible cameras).

As an alternative to the current CITE, automatic CITE systems, Differential GPS (DGPS), Analog/Digital Translators, or Integrated (D)GPS/INS systems may be used (for both aircraft and weapon tracking). The final solution shall be selected balancing cost-effectiveness and minimising the related requirements in terms of aircraft/weapon and ground installations.

4.5 GROWTH POTENTIALS

As already mentioned in the previous paragraphs, the PILASTER systems shall be designed to respond, at successive stages, to the following additional needs:

- ***Video Link Encryption*** (On-board Module) and ***Video Link Decryption*** (Ground Module).

- ***Use of a DATA LINK***, to allow the real-time availability of the status words of the laser systems. This will allow ***Real-time Simulation*** of bomb releasing and ***Improved Laser Safety*** by monitoring at the MSU the Laser Armed, Target Lock-on (active or lost) and other significant signal status, in connection with the laser spot parameters measured by the STU (and transmitted to the MSU). Particularly, using a Data-link, Automatic deactivation of the laser firing is foreseen as a feasible growth option. The MSU may in fact be capable of automatically deactivating the laser firing, according to the tracking status (active or lost) when the STU detects a possibility for the laser beam to fall outside the target. For this purpose, a Laser De-Activation (LDAC) signal may be generated. This signal, sent to the aircraft by means of the bi-directional link, will set off the Laser Arm signal by means of an encoded-remote-controlled relay circuitry.
- ***Upgrades for New Laser Systems:*** The STU shall have the possibility of extending the measurement capability to wavelengths other than 1.064 μm, such as the 1.54 – 1.55 μm lasers, and MIR/FIR lasers.
- ***Construction of Additional Targets,*** such as Destroyable Targets (DEST), IR Reference Targets (IREF) and Acquisition Training Targets (ATGT).

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