Airborne Laser Systems Testing, Safety Analysis, Modelling and Simulation

Comprehensive Case Study of the Design and Development of Advanced Laser Test and Training Facilities for the Italian Air Force

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Recent developments in the field of electro-optics have led to innovative concepts in the mission management of current and next generation ground attack aircraft. Particularly, tactical laser systems including LIDAR, range finders (LRF) and target designators (LTD) are used today by most military forces in the world and new promising laser technologies are being explored. Most laser systems are active devices that operate in a manner very similar to microwave radars but at much higher frequency (e.g., LIDARS, LRF). Other devices (e.g., LTD, Beam-riders) are used to precisely direct laser guided weapons (LGW) against ground targets. A combination of both functions is often encountered in modern integrated airborne navigation-attack systems. Compared to similar microwave devices, the higher frequency of laser systems has the beneficial effect of smaller components and remarkable angular resolution values. On the other hand, laser systems performance are much more sensitive to the vagaries of the atmosphere and are thus generally restricted to shorter ranges in the lower atmosphere than microwave systems.

For aircraft experimental activities with laser systems, it is important to optimise test missions taking into account the tactics of employment of the systems in different operational scenarios and to verify the performance of the systems in realistic environments at the ranges. Also important for test/training purposes is the definition of laser safety criteria, since most systems currently in service operate in the near infrared with considerable risk for the naked human eye. Therefore, it is essential to define methods for predicting and evaluating the performance of laser systems operating in the infrared, with different operational and environmental conditions, taking into account laser safety issues.

This paper presents the main results of the PILASTER (**PI**SQ **LAS**er **T**est and **E**valuation **R**ange) research and development program, conducted by the Italian Air Force Flight Test Centre. Particularly, the paper describes state-of-the-art methods for evaluating the performance of laser systems operating in the infrared (including flight test, modelling and simulation), with different operational and environmental conditions. Present laser technology status and future technology trends are investigated, in order to determine the relative strengths and weaknesses of the most promising laser technologies when applied to airborne systems. Suitable mathematical models for laser beam propagation, geometric analysis, target reflectivity and detection are identified. Safety issues are deeply analysed in the light of the operational requirements for airborne systems (including guided weapons), and the technical characteristics of the PILASTER range instrumentation (designed for current and likely future laser systems test/training operations) are identified. Finally, the requirements associated with tactical and test/training mission planning are defined, together with the kernel algorithms of suitable simulation programs capable to assist aircrews and flight test engineers in the determination of optimal aircraft flight profiles for operations at the ranges.