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Experimental and Numerical Investigations on the Vulnerability of Flying Structures to High-Energy Laser Irradiations

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Abstract : Inflight devices are nowadays major actors in both military and civilian landscapes. Among others, missiles, mortars, rockets or even drones this last decade are increasingly sophisticated, and it is today of prior manner to develop always more efficient defensive systems from all these potential threats. In this frame, recent High Energy Laser weapon prototypes (HEL) have demonstrated some extremely good operational abilities to shot down within seconds flying targets several kilometers off. Whereas test outcomes are promising from both experimental and cost-related perspectives, the deterioration process still needs to be explored to be able to closely predict the effects of a high-energy laser irradiation on typical structures, heading finally to an effective design of laser sources and protective countermeasures. Laser matter interaction researches have a long history of more than 40 years at the French-German Research Institute (ISL). Those studies were tied with laser sources development in the mid-60s, mainly for specific metrology of fast phenomena. Nowadays, laser matter interaction can be viewed as the terminal ballistics of conventional weapons, with the unique capability of laser beams to carry energy at light velocity over large ranges. In the last years, a strong focus was made at ISL on the interaction process of laser radiation with metal targets such as artillery shells. Due to the absorbed laser radiation and the resulting heating process, an encased explosive charge can be initiated resulting in deflagration or even detonation of the projectile in flight. Drones and Unmanned Air Vehicles (UAVs) are of outmost interests in modern warfare. Those aerial systems are usually made up of polymer-based composite materials, whose complexity involves new scientific challenges. Aside this main laser-matter interaction activity, a lot of experimental and numerical knowledge has been gathered at ISL within domains like spectrometry, thermodynamics or mechanics. Techniques and devices were developed to study separately each aspect concerned by this topic; optical characterization, thermal investigations, chemical reactions analysis or mechanical examinations are beyond carried out to neatly estimate essential key values. Results from these diverse tasks are then incorporated into analytic or FE numerical models that were elaborated, for example, to predict thermal repercussion on explosive charges or mechanical failures of structures. These simulations highlight the influence of each phenomenon during the laser irradiation and forecast experimental observations with good accuracy.

Keywords : composite materials, countermeasure, experimental work, high-energy laser, laser-matter interaction, modeling
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