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INSTANTANEOUS IMPACT POINT PREDICTION FOR SOUNDING ROCKET LAUNCH SAFETY

Abstract

Safety will always be a concern in sounding rocket launch operations. The potential to cause harm to people and infrastructure creates a need for numerous technical and operational safety measures. One of these is the on-board Flight Termination System (FTS), capable of neutralising the rocket in case of a malfunction or non-nominal behaviour. Operations with an FTS require predefined criteria, upon detection of which the flight is terminated. Apart from monitoring major subsystems for failures, communication loss , trajectory deviation and loss of control, an important tool is real-time estimation of the impact point of the rocket in case of a complete thrust cut-off, usually referred to as the Instantaneous Impact Point (IIP). The following paper describes the approach to sounding rocket IIP prediction developed by the Łukasiewicz Research Network — Institute of Aviation.

The first part of the paper describes the IIP estimation algorithm itself. Presented are its assumptions, input and output parameters, 3-DOF physical model, Kalman filter for state estimation and methodology of impact point determination. The accuracy and performance of the algorithm are demonstrated using data from both 6-DOF simulations as well as real flight tests of the ILR-33 AMBER 2K rocket. The process of tuning of the algorithm parameters for application to specific rockets, including the use of Monte Carlo optimization methods, is also showcased using simulation data.

The second part focuses on the practical application of the algorithm, including possible formulations of IIP-based flight termination criteria. Relevant implementation details are introduced. The importance of extensibility and flexibility in the program architecture is discussed, as well as how the specific use-case impacts other factors, such as the choice of the programming language. Furthermore, possible avenues for improvement are explored, along with the role the IIP prediction plays in the entire launch facility infrastructure.