Field test campaign of Chandrayaan-3 radar altimeter

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Chandrayaan-3 is the third mission in the series of lunar exploration missions of the Indian Space Research Organisation. The mission demonstrates an end-to-end capability for safe landing and roving on the lunar surface. The lander was equipped with many sensors for a safe landing. One of the prime sensors for precise altitude estimation was the Ka-band radar altimeter (KaRA). The KaRA is designed to cover a large altitude range of 10 km to 10 m. To ensure its reliability, the KaRA go through an extensive verification and validation process, including a series of field tests designed to mimic the lander's expected descent trajectory. These tests used different platforms, such as a crane, a helicopter, and an aircraft, to simulate various flight profiles. In addition to field experiments, KaRA was subjected to hardware-in-loop simulations and laboratory testing. KaRA performed exceptionally well across all forms of evaluation. The present study discusses the comprehensive field test campaign, the challenges encountered, the outcomes achieved, and innovative strategies employed to enhance the robustness of the algorithms integral to KaRA operation.

Keywords: Aircraft test, crane test, field test, FMCW radar, helicopter test, KaRA.

and low-gain. These antennas were mounted at the specific orientation angle required for nadir viewing. It is essential for a radar altimeter with broad beams to validate its performance in field tests, for which various field tests were planned. The KaRA performance was verified and validated using laboratory tests, hardware-in-loop simulations[8] and field tests. Each type of test complements the others, with each having unique advantages and limitations. This paper does not cover the laboratory and simulation aspects. The primary objective of the field campaign was to confirm KaRA's performance across various flight profiles and terrains, simulating the lunar lander's descent. Testing incorporated three different tests: a standalone crane test, an integrated cold test (ICT) with a helicopter and an aircraft, and an integrated hot test (IHT) using a tower crane. The flight trajectory for these tests was designed similarly to a lander descent profile over artificially created test sites (artificial lunar craters). KaRA was tested from 8 km to 10 m height in a field with different pointing angles of the antenna.

Crane, helicopter, aircraft and balloons are widely used as test platforms for planetary navigation sensors[9–19]. A comparison of the landing missions field test is given in Table 1.

System overview