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Author: Mr. Vishesh Vatsal
India, vishesh.vatsal@teamindus.in

Mr. Barath C
Team Indus, Axiom Research Labs Pvt. Ltd., India, barath.c@teamindus.in
Mr. Yogeshwaran Jayaraman
Team Indus, Axiom Research Labs Pvt. Ltd., India, yogeshwaran.j@teamindus.in
Ms. Deepana Gandhi
Team Indus, Axiom Research Labs Pvt. Ltd., India, deepana.gandhi@teamindus.in
Ms. Chhavilata Sahu
Team Indus, Axiom Research Labs Pvt. Ltd., India, chhavilata.sahu@teamindus.in
Mr. Shyam Mohan
Team Indus, Axiom Research Labs Pvt. Ltd., India, shyam.mohan@teamindus.in
Mr. Karthic Balasubramanian
Team Indus, Axiom Research Labs Pvt. Ltd., India, karthic.balasubramanian@teamindus.in
Dr. Midhun S Menon
Team Indus, Axiom Research Labs Pvt. Ltd., India, midhun.sreekumar@gmail.com
Mr. Natarajan P
Team Indus, Axiom Research Labs Pvt. Ltd., India, pn@teamindus.in

DESIGN OF THE GUIDANCE, NAVIGATION AND CONTROL SYSTEM OF THE TEAMINDUS LUNAR LANDER

Abstract

TeamIndus' Lunar Logistics vision includes multiple lunar missions over the coming years to meet requirements of science, commercial and efforts towards building readiness for crewed missions to Mars in the global exploration roadmap. TeamIndus is the only Indian team that participated in the Google Lunar X Prize. The challenge called for privately funded spaceflight teams to be the first to land a robotic spacecraft on the Moon, travel 500 meters, and transmit back high-definition video and images. The first mission is slated for launch in 2019, with a net landed payload capacity of 50 kg. The prime objective is to demonstrate autonomous precision lunar landing, and a Surface Exploration Rover - to collect data on the vicinity of the landing site. The landing site selected (29.52 deg N, 25.68 deg W) is in the Mare Imbrium basin, near Annegrit Crater, which is a regolith plain, with average surface slopes less than 3 degrees and clear regions devoid of craters greater than 500 m diameter. TeamIndus has developed various technologies towards lowering the access barrier to the lunar surface. This paper shall provide an overview of the design of the Guidance, Navigation and Control (GNC) system of the TeamIndus lunar lander.

The GNC design went through various iterations due to evolving commercial requirements. This led to the documentation of the GNC requirements and design philosophy for the mission. The design of the GNC system has been described after concluding studies on sensor and actuator configurations. One of the major criteria for system design was to minimize the cost of GNC hardware, hence a reliable but cost effective suite of sensors required to safely land an unmanned spacecraft was chosen. The hardware elements of the GNC system including sensor and actuator placement studies and redundancy are discussed. The GNC software description focuses on the system architecture, modes of operation, and core elements of the GNC software. Various aspects of the GNC design of the autonomous lunar descent maneuver: timeline of events, guidance algorithms, inertial and optical terrain relative navigation schemes are reviewed. Software verification, Monte-Carlo simulations and processor-in-loop testing schemes are summarized. The paper is concluded with a descriptions of the key risk mitigation studies by the GNC team over the past five years in conceptualizing, designing, testing and operating a relatively complex GNC.