R²S: A TECHNOLOGY DEMONSTRATOR FOR NEO RECONNAISSANCE MISSION. P. F. Wren¹, R. A. Fevig¹, N. Kaabouch², M. E. Nelson³, F. Bourbour¹, J. W. Snarr⁴, D. Ghosh⁵, C. Church⁶. ¹Department of Space Studies, University of North Dakota, Clifford Hall Room 512, 4149 University Ave Stop 9008, Grand Forks, ND, 58202. ²Department of Electrical Engineering, University of North Dakota, Upson Hall II Room 160, 243 Centennial Drive Stop 7165, Grand Forks, ND, 58202 ³Department of Aerospace Engineering, Iowa State University, 0625 Howe Hall, Ames, IA, 50011.

Introduction: Of the 9000 known Near Earth Objects (NEO), many have the potential to collide with the Earth. Depending on its size, results could range from local effects to damage and casualties on a global scale. Some NEOs may be detected decades before their possible impact, as with 99942 Apophis [1], while others may be identified with little warning. The development and demonstration of technologies that can be quickly deployed to characterize NEOs is critical to ensure readiness to deal with these threats.

To assess and respond to a potential impacter, the object’s composition, internal structure, and mass must be determined. Constraints on the internal structure of a small asteroid may be derived from modeling the gravitational field during close proximity operations. Initial investigations into the feasibility of backing out the internal structure of such an NEO have been conducted [2]. A small spacecraft deployed in the vicinity of an NEO could use tracking data, and possibly images [3] to create a gravity model that would help to constrain the mass distribution of the object.

The University of North Dakota, in cooperation with Iowa State University, has been granted a NASA ELaNa program opportunity to launch a 1U CubeSat into low Earth orbit and demonstrate technologies capable of collecting data useful to gravitational modeling, as well as to general characterization of NEOs.

Mission: The mission objectives for the Rapid Response Spacecraft (R²S) are to demonstrate on-orbit image mosaicking and super-resolution processing to extend the capabilities of small imagers, and to demonstrate small spacecraft constellation operations.

R²S will capture images of the Earth along with certain metadata (time, location and orientation information), and then attempt to assemble them into a mosaic image. Super-resolution techniques will be used to enhance the images [4], and the final images will be downlinked to a ground station.

R²S will also communicate with multiple satellites in the Global Positioning System (GPS) to determine its location relative to these satellites, and report this information to the ground station.

Spacecraft: The 1U CubeSat spacecraft bus for R²S consists of commercial off-the-shelf (COTS) hardware: the structure, onboard computer (OBC), electrical power system (EPS), and transceiver. Only the command and data handling software will be developed internally. The use of space-proven components allows for greater focus on the development of the custom payload.

Payload: To meet the mission objectives, R²S incorporates two visible-light imagers, a GPS receiver, an inertial measurement unit, and a dedicated microprocessor to manage these instruments and process collected data. Each payload element is discussed here.

Visible Light Imagers. Two cameras will be mounted on adjacent faces of R²S (a separation angle of 90°) to increase the likelihood of capturing useful images of the Earth.

GPS Receiver. A GPS receiver and antenna will be used to determine the current position of R²S as part of constellation operations. The position information is also stored with captured images.

Inertial Measurement Unit (IMU). R²S will carry an IMU containing multi-axis gyroscope and accelerometer to measure the relative orientation of the spacecraft over time. This information will also be stored with captured images.

Payload Microprocessor. Distinct from the OBC, this high-performance microcomputer will be responsible for controlling cameras, selecting useful images, building image mosaics, performing super-resolution processing, and managing the GPS and IMU.

Conclusion: R²S is on the candidate list for an ISS launch in 2016. Operating R²S in low-Earth orbit will be the culmination of a multi-year effort involving UND and ISU students from across the country, fulfilling another primary mission objective to provide a unique educational experience.