SPACE HAUC

Science Program Around Communications Engineering with High Achieving Undergraduate Cadres

Lowell Center for Space Science and Technology (LoCSST)

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BACKGROUND

SPACE HAUC is a multidisciplinary astronautical engineering research and development project that aims to launch UMass Lowell's first satellite: a CubeSat.

A CubeSat is a miniaturized satellite used for conducting space research. A 1U CubeSat is a 10 cm cube weighing no more than 1.33 kg. The use of CubeSats as an educational tool at the University level has grown exponentially over the past few years due to their small size, low cost, and short development time.

Many CubeSats settle for simple dipole antennas communicating in the S-band. While easy to implement, these simplistic satellite communications arrays limit the maximum data transfer to no more than 2 – 5 Mbps. For future CubeSat applications (formations of satellites, interplanetary missions), the communications system must be more advanced.

MISSION

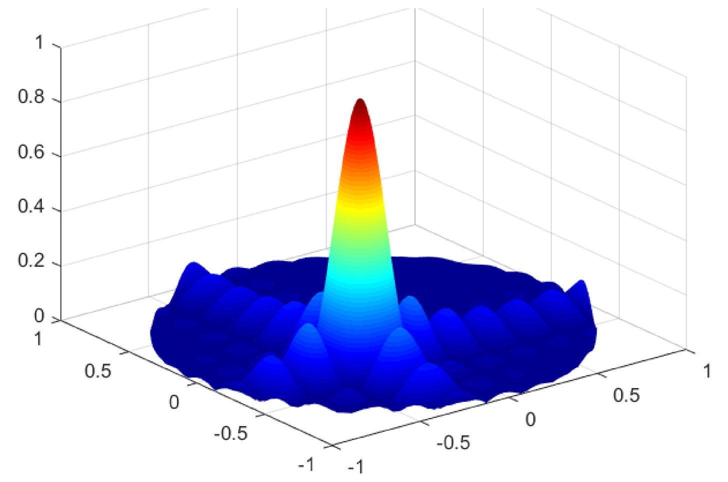
SPACE HAUC will demonstrate the practicality of high data rate X-band communications using a phased array of patch antennas to achieve dynamic beam steering on a CubeSat platform. This allows for the satellite to maximize gain and by extension achieve a very high data rate. SPACE HAUC plans to launch a 3U CubeSat (10 cm x 10 cm x 30 cm, 4 kg).

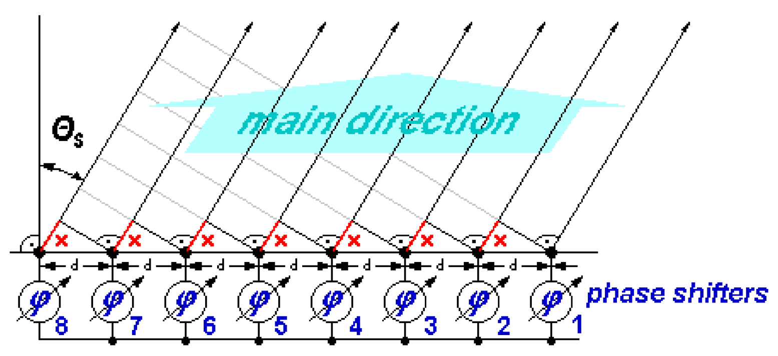
PHASED ARRAY ANTENNA

Beam steering will be achieved with a combination of patch antennas and phase shifters. The phase shifters act as a means to delay the delivery of voltage to each element, such that the output radiation pattern of each antenna element constructively and destructively interferes. As a result, the main lobe, which contains the maximum power, is dynamically steered toward the ground station below. When the CubeSat's camera and deployable solar panels are nominally pointed towards the sun, the current plan is to mount the antennas on the opposite satellite face.

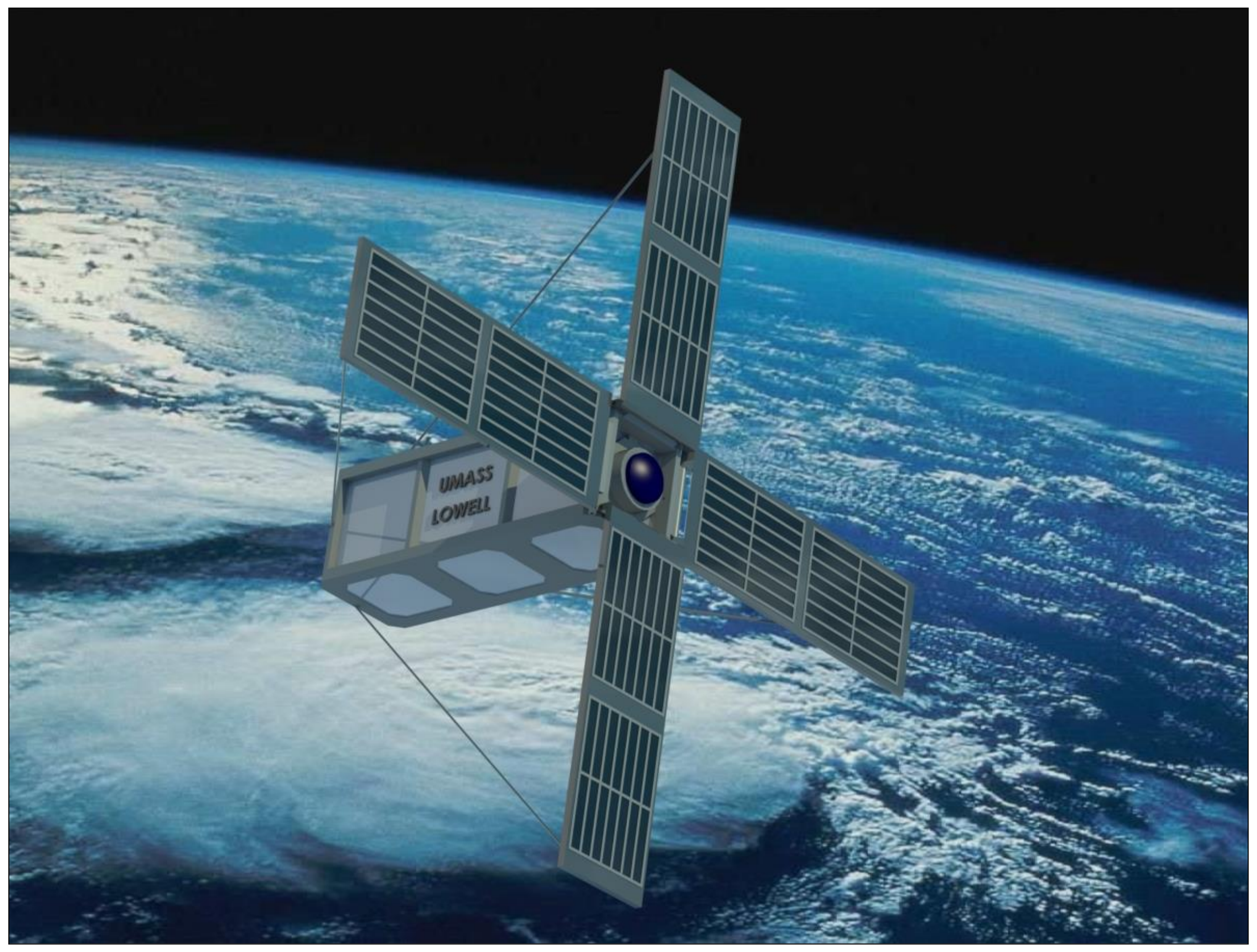
PROPOSED ANTENNA PARAMETERS

- Frequency Range: 8.0 to 8.4 GHz
- Polarization: Circular
- Number of elements: 16 (4 x 4)
- Array size: Square, within area of 8.1 cm x 8.1 cm
- Beam width: 27° (approximation)
- Range: 450 km, consistent with low-Earth orbit (LEO)
- Data Rate: Goal of 50 – 100 Mbps



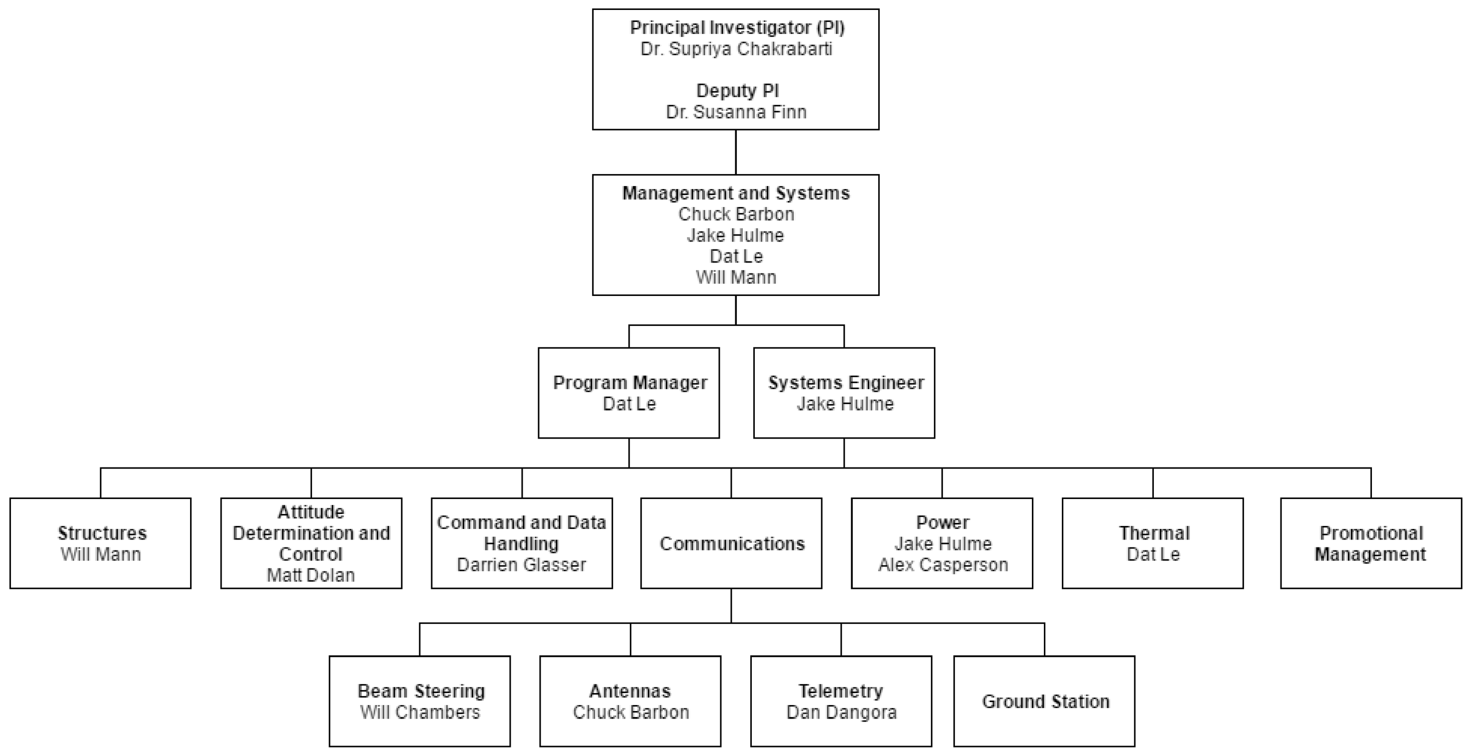


Visualization of the antenna lobe containing maximum power created in MATLAB by the beam steering team (left) and a schematic detailing the main direction of the wavefront after phase shifting (right)

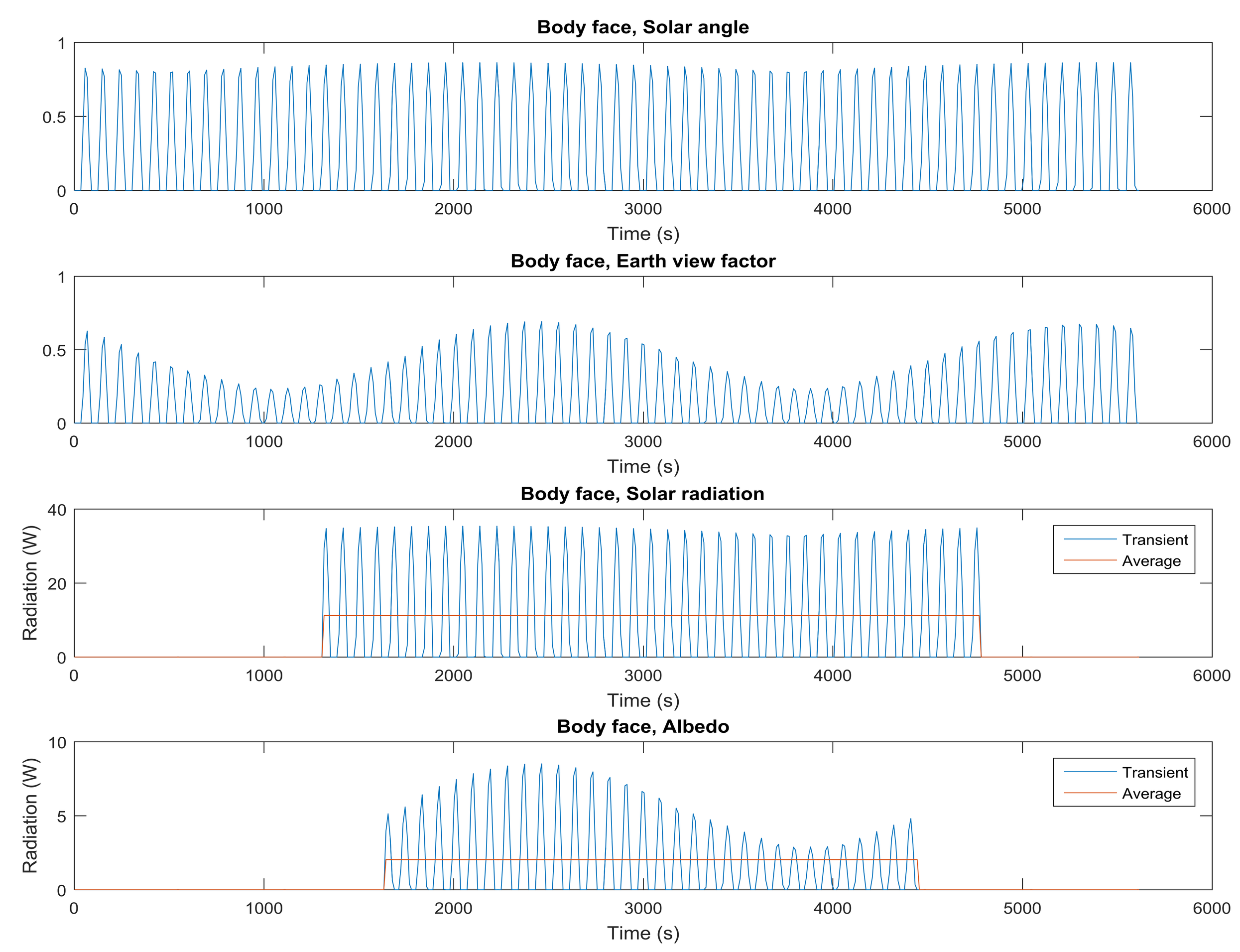


First conceptual rendering of the SPACE HAUC 3U CubeSat – solar panels are depicted in the deployed position with a high-resolution camera taking images of the sun

50+ STUDENTS ACROSS SEVERAL SUBSYSTEM TEAMS



SPACE HAUC Organizational Chart; SPACE HAUC currently has 50+ students involved in the ongoing design and development of the CubeSat



In one example of a low-inclination (28°) orbit analysis, our team can analyze the amount of incident radiation on surfaces of interest during the detumble stage when the spacecraft is spinning wildly. These results will help inform our placement and sizing of required solar panels

DESIGN CHALLENGES and SOLUTION / APPROACH

- Selection of low-outgassing materials
- Strict mass, power, and link budgets with margins
- Survive induced stress and shock/vibration due to launch vehicle
- Minimum power required by magnetorquers and on-board computer during tumbling period
- Protection against harsh thermal radiation environment
- Ensure radiation tolerance to long-term dosage and single-event upsets (SEU)
- Patch antenna and phase shifter integrated PCB
- Telemetry of mission data to be sent back to Earth via X-band transmitter
- Distribution of power to all subsystems collectively requiring 15 W
- … and many more!

Our approach to overcoming these challenges begins with extensive review of published literature and existing CubeSat documentation. Then design solutions are generated by the team to be explored, characterized, and applied to the challenges specific to SPACE HAUC. Through an iterative process, the final design is chosen and testing and validation begins. As our models are verified, the satellite shall take form and in time be ready for launch.

NEXT STEPS

News Flash! Less than 2 weeks ago, the National Aeronautics and Space Administration (NASA) selected SPACE HAUC for Undergraduate Student Instrument Project (USIP) funding!

The preliminary conceptual design of the satellite shall continue into Summer 2016 and beyond. As the design is reviewed and improved upon, SPACE HAUC shall transition into the test and development phase where the team shall begin validating the design and constructing the physical satellite.

ACKNOWLEDGEMENTS

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And a big thank you to Professor Supriya Chakrabarti and Professor Tim Cook of the Lowell Center for Space Science and Technology (LoCSST) for creating this project and allowing for UMass Lowell students to become involved in space research and development.

The Lowell Center for Space Science and Technology (LoCSST) provides a home for space science and technology research activities on the UMass Lowell campus. Our goal is to involve industry partners in curriculum, research, projects and proposals/business development while training the next generation of space scientists, technologists, teachers, business leaders, and policy makers.

www.uml.edu/research/LoCSST

BAE SYSTEMS DRAPER

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