The following abstracts are assigned to teams participating in the University Nanosatellite Program Mission Design Course. Each team of 3 or 4 students is assigned an abstract and spends two days developing a mission from it. Through the course, students learn how to take a broad idea and perform the necessary systems engineering and mission concepting exercises to develop a theoretical small satellite mission.

1. There is significant interest across the small satellite community in building mesh networks for satellite-to-satellite communication on a multi-node satellite platform. In this case, the objective is to design a multi-satellite system deployed from a single deployer that would demonstrate Bluetooth or a similar commercial standard that enables device to device or multi-devices communication. The objective is to capture distances when nodes begin to lose, and possibly reestablish, link depending on orbital dynamics. A launch of the ISS should be assumed to ensure nodes reenter quickly, minimizing space debris.
2. There is great benefit for a spacecraft to have knowledge of its surroundings. One technology that could prove fruitful in space is LIDAR (Light Detection and Ranging). With the increase self-driving vehicle research, low size, weight, and power (SWAP) LIDAR systems, including optical phased array LIDAR systems are becoming available. The objective of this mission is to demonstrate the ability of a LIDAR system to image a known space object and understand the physical limits for which the system can produce these images. For this mission, it is expected that the system continues to capture images of the rocket body from which it was deployed (the known object) until the rocket is no longer observable. The challenge of this mission will be the amount of data to be stored and sent to ground. Note that any imaging policy issues that this mission may or may not have should not be considered in the design of the space vehicle.
3. Astronaut freeze-dried foods lose most of their nutritional vitamin/mineral value within the first 6 months. Therefore, producing food in space in the form of edible crops for space exploration (e.g., Moon, Mars and beyond) is a necessity. The spaceflight environment (e.g., radiation and reduced/partial gravity) is stressful for humans and plants in space. The International Space Station (ISS) is in Low Earth Orbit (~250 miles up from Earth), which has a different microgravity and radiation exposure than that of natural satellites. The ability of seeds to germinate will be crucial for propagating crops for food on human bases on the surface of both the Moon and Mars. For this concept, design a seed storage method on a CubeSat, at the same elevation as the ISS, that will protect seeds from the harmful effects of space radiation. The mission objective is to prove through images that seeds still have the capability to germinate after exposure to space radiation-like levels.
4. With launch vehicles deploying more and more CubeSats there is a growing need to better understand the dynamics of CubeSats as they are deployed to ensure that they create no risk to the launch vehicle. Further understanding of the post-launch environment will provide confidence CubeSats can be deployed in various stages of the launch timeline for multi-satellite missions. The goal of this objective is to fly a 4k GoPro camera with a high frame rate (or similar low-cost camera) to capture the deployment. The remainder of the mission can be used to download the imagery. Compression of image or image editing of black space should be considered, but not required.
5. Clouds obscuring imagery products from large imaging satellites represent a significant optimization problem. When the data product is obscured, there is less value to this data. Downlink and analysis resources could be optimized if cloud detection data was available. For this concept, design a CubeSat mission that will provide a large visible/near infrared (VIS-NIR) imaging satellite with this valuable cloud data. Assume the CubeSat is placed into the same

orbital plane as the larger imager but with some separation to allow for the data to be utilized by the larger satellite. Note that any imaging policy issues that this mission may or may not have should not be considered in the design of the space vehicle.

6. Astronaut freeze-dried foods lose most of their nutritional vitamin/mineral value within the first 6 months. Therefore, producing food in space in the form of edible crops for space exploration (e.g., Moon, Mars and beyond) is a necessity. The spaceflight environment (e.g., radiation and reduced/partial gravity) is stressful for humans and plants in space. The International Space Station (ISS) is in Low Earth Orbit (~250 miles up from Earth), which has a different microgravity and radiation exposure than that of natural satellites. On Earth, pollination by birds, wind, and insects is critical for plant reproductive success, and for it to produce edible fruits/seeds. For this concept, design a CubeSat mission that will demonstrate successful pollination in microgravity or under radiation levels that mirror those levels on the Moon or Mars. The mission objective is to prove successful pollination or pollen tube emergence. Note: Pollination process occurs when pollen grains from the male part of one flower (anther) are transferred to the female part (stigma) of another flower. Once pollination occurs, the fertilized flowers produce seeds, which enable the associated plant to reproduce and/or form fruit.
7. Satellites continue to increase in data output, but at times may need to avoid using certain frequency bands due to environmental, legal, or other adverse effects. In this case, the goal is to demonstrate multiple paths to command and receive data from a CubeSat. The mission objective is to communicate on as many ground-to-space, and space-to-space networks as possible. Ground networks to consider are USN, Space Flight Services, ViaSat, MC3, and other commercial communications providers. Satellite-to-satellite links include Globalstar, Orbcomm, Iridium, and ViaSat. The “payload” for this mission should be a simple data generation payload such as a low-cost camera or GPS. The real objective is to send the data down through as many channels as possible as often as possible.
8. The commercial GEO market is increasingly competitive and protective of their GEO slot assignments. Recently there is an increased interest in allowing for more “shared” GEO slots to be made available and utilize shared launches to deliver multiple vehicles to GEO. To make this a reality, propose a LEO CubeSat mission that can assist in identification of GEO Transient Objects so that quiet/stable slots can be better identified. For this effort, assume that the CubeSat assesses a single GEO slot target at a time over multiple orbits to detect any changes. Some areas to consider/evaluate include change detection algorithms, data consolidation, on orbit processing vs ground processing, and other parameters considered important to the team.
9. Astronaut freeze-dried foods lose most of their nutritional vitamin/mineral value within the first 6 months. Therefore, producing food in space in the form of edible crops for space exploration (e.g., Moon, Mars and beyond) is a necessity. The spaceflight environment (e.g., radiation and reduced/partial gravity) is stressful for humans and plants in space. The International Space Station (ISS) is in Low Earth Orbit (~250 miles up from Earth), which has a different microgravity and radiation exposure than that of natural satellites. For this concept, design a CubeSat mission that will grow a plant in a CubeSat and expose it to partial gravity like that on the surface of the Moon and/or Mars. The goal is to use a multi/hyper spectral imaging sensor to capture the effects of partial gravity on the plant and communicate it back to Earth thru the relevant space networks for analysis.
10. This mission will explore low-cost approaches to space survivability in terrestrial electronics. The space environment is not friendly for low-cost, non-shielded hardware. Depending on the

orbit and radiation environment, parts intended for terrestrial use may have issues with bit-flips and anomaly events caused by radiation. Additionally, long-term radiation effects may produce performance issues and may eventually cause the hardware to no longer operate, particularly in CDH systems. This mission will demonstrate error handling for radiation events and will compare various approaches to error handling within the same spacecraft. There are many potential options for how this objective would be demonstrated. Any approach may be considered so long as the spacecraft explore radiation effects on terrestrial hardware and potential solutions. One option would be to have a single set of software fly on >5 different terrestrial embedded boards (i.e., Raspberry Pi, Beaglebone Black, Intel Edison, etc.) as well as various software "tricks" to recover from upsets that are regularly used. Examples of these tricks include rebooting regularly, triple modular redundancy (TMR), voting, watchdogs, etc.

11. It is very common for small satellites to have an on-board GPS, and the technology is necessary in many mission sets. While many GPS systems are available, is it possible to know which truly works best on an earth-based platform? In this case, the objective of this mission is to determine or compare GPS systems on orbit. At least three GPS systems should be compared on a SmallSat platform preferably of varied quality and price. The goal is to reduce the size, weight, and power (SWAP) of the GPS units (i.e., smart phone GPS units).
12. Affordable radios are needed for many cost-constrained small satellite missions, such as university missions. One possibility includes software defined radios (SDRs). The objective of this mission is to fly a SDR with at least two different waveform profiles that can be selected based on which ground station it is talking to. In principle, one of multiple ground stations sends a command to the satellite and, the SDR automatically switches to the correct waveform for that pass. The objective of this mission is to demonstrate this ground station-satellite combined system functionality on an SDR.
13. Lately there has been a growing concern of satellite collisions. One of the regions where this concern is the greatest is in GEO. High Area to mass ratio (HAMR) objects are highly susceptible to the primary perturbations in GEO. In this case, a small satellite should be designed to be a HAMR object, allowing the perturbations to be studied. The objective is to measure the perturbations and characterize them so that satellites in GEO have an accurate model. The satellite needs to be able to measure solar radiation pressure as well as confirm its attitude to accurately depict the perturbations. Keep in mind that the satellite should not contribute to the growing problem of orbital debris, hence it should not collide with any satellite that is currently in GEO. Assume that the satellite will be delivered to GEO by the launch vehicle and does not need propulsion to get there.
14. Astronaut freeze-dried foods lose most of their nutritional vitamin/mineral value within the first 6 months. Therefore, producing food in space in the form of edible crops for space exploration (e.g., Moon, Mars and beyond) is a necessity. The spaceflight environment (e.g., radiation and reduced/partial gravity) is stressful for humans and plants in space. The International Space Station (ISS) is in Low Earth Orbit (~250 miles up from Earth), which has a different microgravity and radiation exposure than that of natural satellites. The International Space Station (ISS) is in Low Earth Orbit (~250 miles up from Earth), which has a different microgravity and radiation exposure than that of other celestial bodies. For this concept, design a CubeSat mission that will grow a plant in a CubeSat that would be exposed to the radiation associated with the surface of the Moon (60 micro sieverts (mSv) of radiation every hour) or that of Mars (the average natural radiation level on Mars is 24-30 rads or 240-300 millisieverts (mSv) per year. This is about 40-50 times the average on Earth). The goal is to use a multi/hyper

spectral imaging sensor to capture the effect of radiation on the plant and communicate it back to Earth thru the relevant space networks for analysis.

15. As proliferated LEO becomes more of a reality, the volume of data generated and disseminated will quickly overcome our ability to push this data to the ground. For this mission concept propose a Laser Cross-Link demonstration in the CubeSat formfactor that can demonstrate the passing of information between nodes in a LEO constellation. Since this is intended to simply be a demonstration of the Cross-Link capability, focus on the ability of the systems to pass large volumes of data (GBs) between nodes rather than to the ground. The data passed to the ground operators should instead be focused on performance characterization data. Some areas to consider/evaluate: Orbit design trade space (in-plane, multi-plane), link ranges, attitude constraints, and additional parameters important to the team.