2020-2021 MN Space Grant Consortium (MnSGC) Exploration-Flying Quadcopter Challenge (updated 11/30/2020)

The Minnesota Space Grant Consortium (MnSGC), led from the Aerospace Engineering and Mechanics (AEM) Department at the University of Minnesota - Twin Cities (UMTC) (Director, Professor Demoz Gebre, and Associate Director, Professor James Flaten) is funding the 2020-2021 MnSGC Quadcopter Exploration-Flying Challenge. This program is designed to enhance student and faculty capability at colleges and universities in Minnesota in STEM areas of interest to NASA - in this particular case, for un-crewed RC multi-rotor drones (AKA quadcopters). Oversight of this challenge is being organized by Professor Thelma Berquó and Ben Bogart (on right in photo below), an undergraduate teaching assistant at Concordia College, Moorhead.

Quadcopters are being used for this challenge because pre-built quadcopter and quadcopter kits are readily available. Compared to fixed-wing, radio-controlled airplanes, students can quickly learn to pilot quadcopters and they can be operated in small spaces (including indoors) with limited infrastructure (which is not the case with fixed-wing, radio-controlled airplanes). Each student team will start by learning to fly a commercially-available "toy" quadcopter. (No kit-built quadcopters in 2020-2021.) Students will then design, test, and eventually mount sensors, actuator(s), and the electronics necessary for the "exploration-flying challenge." Students will have to learn to program a microcontroller and integrate their electronics, sensors, and actuator(s). The sample-return mechanism may involve some mechanical design and fabrication, giving the students experience with computer-aided design (CAD) software for design, documentation, and (potentially) fabrication with 3-D printing and laser cutting.

Challenge website:
https://dept.aem.umn.edu/msgc/MN_Space_Grant_Quadcopter_Challenge_2020_2021/

List of participating schools and deadlines for 2020-2021:
https://dept.aem.umn.edu/msgc/MN_Space_Grant_Quadcopter_Challenge_2020_2021/Quadcopter_Kickoff_Slides_2020-2021.pdf

A 7-minute video showing a team (from a past class at the U of MN) trying this challenge:
http://www.aem.umn.edu/people/faculty/flate001/MnSGC_Quadcopter_Challenge_2020-2021/

Photo showing the (toy) drone we will use (right) and a larger kit drone (used last year) (left).

Synopsis of the 2020-2021 MnSGC Quadcopter Exploration-Flying Challenge.

In this challenge (AKA "competition", though without prizes) student teams will do the following:

1. Possibly attend the "Kick-off (mostly for advisers)" on Oct. 14, 2020. Then have student representatives attend a technical training on Oct. 28, 2020, then do update check-ins with the TA about every second week from November through March.
2. Learn to fly a toy "Blue Heron" drone (at right in photo above), first bare then carrying its video camera (and learn to use that for both on-board recording and live streaming) then carrying more and more weight (to establish how heavy the electronics package for the exploration flying can possibly be).
3. Learn to program a provided microcontroller and use it to read data from "basic" sensors and to control a servo. Possibly test other sensors (and maybe a radio telemetry system). Figure out how to mount electronics so that they are light enough to fly. This will probably entail switching from solderless breadboards to soldering parts onto a soldered breadboard (so learn how to solder too) or perhaps even a designing and using custom printed circuit board (pcb). Note: teams may elect to swap what the drone carries during the fly-off – e.g. fly the camera first, replace that with sensor set A, replace that with sample return device, replace that with…
4. Plan for "exploration" flying, preferably set up in an indoor area to minimize wind and weather considerations. The team won't know in advance exactly what this will look like, but the photo below shows one possibility: an area with (a) various horizontal, vertical, and hidden surfaces (such as items on a table or even behind a column) plus (b) various "targets" including things to take photos of for close-up examination and also mapping (with units) plus (c) things to characterize (might be hot, might be magnetic, etc.) plus (d) things like sand (a granular material) and/or water (a fluid) to try to retrieve at least 1 cm cubed samples. Teams will be allowed to fly their drone in and out of the exploration area and swap what it carries for various flights, but team members will not be allowed to enter the exploration area themselves nor stray from their "home base" (i.e. team

members cannot walk around the back side of the area to look at surfaces not-visible from the home base.

5. Outfit the drone with camera(s) (live video telemetry optional), a sample return device, and microcontroller-logged sensors (use a Teensy microcontroller (or something even better); measure at least ambient temperature (and find any odd-temperature targets), ambient pressure, ambient relative humidity, ambient magnetic field (and find any magnetic targets); plus additional sensors (optional – no guarantee that the basic sensors will be able to characterize all the oddities of the environment – the list above is not an exhaustive list of what might be "odd" about the area); live data telemetry also optional)
6. Write one mid-project Preliminary Design Review (PDR) talking about progress as of January 22, 2021, as well as plans for the remainder of the project. A PDR template and rubric will be posted
7. Practice flying, data collection (including sample return), and data processing
8. Do a ~15-minute live (but remote) oral presentation before a panel of judges talking about what they have built and how they plan to use it for exploration flying.
9. Do a (blindfolded) walk-through (with one team member carrying the drone and the pilot "controlling" them orally) of a sample exploration area to at least collect some data from a stable platform that could be analyzed if actual flying doesn't go well.
10. Do a 30-minute (running time) fly-off on a different exploration course, monitored (via recording) by judges. See "Overall distribution of points" document – to be posted. Note that 5 out of the 25 points for fly-off performance are "supplementary" – basically, "impress the judges by doing things particularly well and/or above and beyond the required elements."
11. Make a 2-3 minute educational/promotional video about their experience in the project (due after the fly-off but before the final video is due).
12. Submit a 10-minute-max final video report talking about technical results – especially discussing graphs of sensor data, maps, photos/videos taken, etc. The materials discussed in this report will also be submitted electronically, if judges want to take a closer look.

Key dates:

- October 14, 2020 – kick-off with faculty advisers
- Oct. 28, 2020 – technical training with students
- TAs hold videocons with teams every 2 weeks to discuss progress and handle questions.
- January 22, 2021 – PDR (written report) due
- March 10 (or 11 or 15 or 16), 2021 – live (remote) oral presentations before judge panel
- Instructions for building the two mystery areas will be provided to the team adviser after their team has completed the oral presentation
- No later than March 21 – walk-through Area #1 (no time limit) then fly-off in Area #2 (30 minute running time limit) – this can be done any time up through March 21 but the later you do it the less time you will have for data analysis before the final report is due
- March 24, 2021 – promotional video due
- March 31, 2021 – final video (with supplementary materials) due

Photo showing a possible exploration area. Note the “mountain” (two covered tables), column, bucket (of water), pile of sand (on a table), photography targets on top and back side of column (which are not directly visible to the team from their “home base”), plus two other “interesting” targets (white cylinders on the right side).

Instructions for assembling an exploration Area #1 (to walk through) and a different exploration Area #2 (to fly through) will be provided to the faculty adviser (and not shared with the team) after the team has completed their oral presentation before the panel of judges. The adviser needs to set up the two mystery areas one after the other (not necessarily on the same date) in an indoor space that measures at least 20 ft by 20 ft with preferably more than 8 ft of vertical clearance. A gymnasium is preferred, but other spaces could work too as long as they can be cleared so that all the mystery items (all basic or provided items) can be placed according to the plan.

The team will establish a “home base” (a table (with power) for computer(s) plus a landing zone measuring 2 ft by 2 ft) outside one edge of each mystery area. Team members must all stay in the “home base” (separated appropriately, as need be) during the entire fly-off – only the drone may enter the mystery area. The team may make video recording(s) of their operations and the drone in flight, but only from the “home base” (so they might not be able to see all details of the mystery area directly). The team will have 30 minutes running time to explore Area #2 by flying.

Here is a map of that sample exploration area pictured earlier. Notice that details <u>with units</u> are given including “how hot/cold” and “how large/tall” etc. Ambient conditions are reported, as are values taken in particularly-interesting locations (all of which will be well-marked so you can directly explore potentially-odd locations in the area – you don’t have to “find” them first).