2017-2018 Midwest Space Grant Rocketry Competition:
The Active Roll/Orientation Challenge (with a BONUS Communications Challenge)
Additional Notes – re-released March 27, 2018; one typo fixed (in green), one change (in blue)
Questions? Write to James Flaten <flate001@umn.edu> and Gary Stroick <president@OffWeGoRocketry.com>

Mentor questions (the same for both the PDR and the FRR written reports – due when those two reports are due – to be submitted by the mentor directly, not as part of the student reports) "*Mentors are, in part, responsible for safety. They should, minimally, conduct a review of the design (before construction begins) and a review of the rocket once constructed (before any test flights), with an eye toward safety.*"

- Briefly describe your interactions with the team to date – how many meetings, in person or remotely, how much time spent, topics discussed
- How familiar are you with the team's rocket design (which might still be evolving) and what safety concerns do you have about it, if any?
- How familiar are you with the team's rocket build – in particular, did you see it (or at least photos of it) as it progressed before it was flown for the first time – and what safety concerns do you have about it, if any?
- Do you have any suggestions about how to improve your interaction with the team going forward? (This feedback will be shared with your team, and possibly with other teams and their mentors too.)

Flight #1 details – submit video from flight to the judges immediate after the first flight (before flying again) – single LED (or bank of LEDs) should be in view of the down-looking camera and bright enough to be read even in full sunlight

- NEW – Turn on down-looking camera before launch. Use LED(s) (need to be in camera view) to indicate status even before activating roll control. Have LED(s) flash 0.2 sec ON then 0.2 sec off repeatedly once rocket is armed but before launch is sensed. Once launch is sensed, have LED(s) be steady ON through full burn plus 3 (three) additional seconds. (Aside: You may either sense motor burn-out or else use a timer that is based on the manufacturer's stated value for burn time. Either way, you will need to sense the launch itself.)
- For the remainder of the ascent, all the way to apogee, have LED(s) indicate the system's attempt to quash roll (here orientations are "as viewed looking down from the rocket" (i.e. orientations as seen by the down-looking camera)) – be sure LED(s) can indicate "trying to roll the rocket clockwise (presumably to undo sensed counter-clockwise roll)" and "trying to roll the rocket counter-clockwise (presumably to undo sensed clockwise roll)" and "trying to maintain orientation with zero roll rate (hopefully this will be the LED message for much of the time during Flight #1)".
- Once apogee is reached (sense that), turn off roll control and put LED(s) into a 0.5 sec ON then 0.5 sec off flashing pattern for the duration of the flight – descent, landing, recovery.

Flight #2 default commands – again, submit video from flight to the judges immediately after the flight (before leaving the competition site) (Note: **Mount the rocket** on the south side of the rail **so that the camera-side**, which is by definition opposite the rail-side, also **faces south**.)

- NEW – Turn on down-looking camera before launch. Use LED(s) (need to be in camera view) to indicate status even before activating roll control. Have LED(s) flash 0.2 sec ON then 0.2 sec off repeatedly once rocket is armed but before launch is sensed. Once launch is sensed, have LED(s) be steady ON through full burn plus 2 (two) additional seconds. (Aside: You may either sense motor burn-out or else use a timer that is based on the manufacturer's stated value for burn time. Either way, you will need to sense the launch itself.)
- Accomplish as many of the following roll commands as possible prior to apogee. Once apogee is reached (sense that), skip immediately to the last step in this section.
- Command 1: After the burn is complete and 2 additional seconds of flight are also over, activate the roll control mechanism then **roll the rocket clockwise until the camera-side is pointing north**. (Here orientations are "as viewed looking down from the rocket" (i.e. orientations as seen by the down-looking camera.) Note: If the rocket does not roll at all on its own (unlikely), the camera will still be pointing south so this command will require rotating 180 degrees clockwise (so the video view will appear to rotate counter-clockwise by 180 degrees). **Hold that orientation for 1 full second**. This should be accompanied by the "trying to roll the rocket clockwise" LED message, followed by the "trying to maintain orientation with zero roll rate" LED message.
- Command 2: **Roll the rocket counter-clockwise until the camera-side is pointing west** (so the video view will appear to rotate clockwise by 90 degrees). **Hold that orientation for 1 full second**. This should be accompanied by the "counter-clockwise" LED message then the "hold" LED message.
- Command 3: **Roll the rocket counter-clockwise until the camera-side is pointing east** (so the video view will appear to rotate clockwise by 180 degrees). **Hold that orientation for 1 full second**. This should be accompanied by the "counter-clockwise" LED message then the "hold" LED message.
- Command 4: **Roll the rocket clockwise until the camera-side is pointing south** (so the video view will appear to rotate counter-clockwise by 90 degrees). **Hold that orientation for 1 full second**. This should be accompanied by the "clockwise" LED message then the "hold" LED message.
- If not yet at apogee, **repeat all 4 commands, holding each orientation for 0.75 seconds**. Illuminate appropriate LED(s).
- If not yet at apogee, **repeat all 4 commands, holding each orientation for 0.50 seconds**. Illuminate appropriate LED(s).
- If not yet at apogee, **repeat all 4 commands, holding each orientation for 0.25 seconds**. Illuminate appropriate LED(s).
- Once apogee is reached (sense that), turn off roll control and put LED(s) into a 0.5 sec ON then 0.5 sec off flashing pattern for the duration of the flight – descent, landing, recovery.

Bonus details. The 3 bonus challenges will be judged independently from one another, so you don't necessarily need to try them all. If you decide to try any of the bonus challenges, you will be given extra space in your written reports and extra time in your oral presentation to discuss it.

- Remember to precede every radio transmission made from the ground to your rocket and also every radio transmission from the rocket to the ground with your team's unique two-character "security code" chosen from the ASCII character set. Don't duplicate characters

and use at least one letter. E.g. “1G” and “Rr” and “a%” all are fine, but not “AA” nor “47”. Although only one rocket will typically be in flight at a time, ground testing may result in multiple XBEE radio systems being on at the same time. Radio pairing will limit interference but also be sure your system ignores messages with the wrong code.

- Bonus Challenge A is to “reprogram” your rocket at a distance to follow an alternative set of roll instructions. Assume the alternative instructions will be provided (in text form) much like the instructions above. Be ready to tell the rocket which way to roll (CW or CCW), what orientation to roll to (in compass increments of 90 degrees), how long to hold the orientation (in seconds or fractions of seconds), etc. The alternative instructions will be comparable in format and complexity to the default roll instructions given above. The post-burnout wait time will remain at 2 seconds.
- Bonus Challenge B is to transmit real sensor data, including (though not limited to) roll orientation data, to a ground station while the rocket is in flight. Be sure data values from different sensors in a single transmission can be distinguished from one another, possibly by sending them separated by a comma (though that might not be the most efficient solution). Include a “count” with each transmission. This system may be started pre-launch, but only in-flight data will be judged. Thus, be sure to reset the count variable to zero when launch is detected. For example, if a rocket with a security code of “F2” transmits roll orientation (in degrees as measured CW from the south-facing orientation), temperature (in degrees Fahrenheit), and altitude (in feet above the ground), the ground station record while the rocket is still ascending might include lines like:
  F2,4,-52,78,2026
  F2,5,-65,78,4789
  F2,6,-65,77,3314
  F2,7,-66,75,3794 etc.
  Notice that the altitude in the second line appears to contain an error, perhaps just in the first digit. Log all sensor data on-board the rocket, for post-flight comparison to the data received by the ground station. Stop logging transmissions (honor system here) as soon as the rocket lands, even if you still are in radio contact with it. Note that if you transmit data on a regular basis, the “count” value can double as a time stamp. Or you can transmit an actual time stamp. You are not required to transmit all the roll orientation data you collect (at a rate of 10+ Hz) but again, you should keep an on-board log all sensor data. Immediately after the flight submit to the judges (and keep a copy yourself) a text file containing a complete list of data strings received. Judges will rate this bonus challenge (somewhat subjectively) as to “How much sensor data you got to the ground, how error free it was, and how valuable it was.” Roll orientation data is required – you can choose what other sensor data to transmit, if any. If the transmission frequency and data quality are similar, a rocket that sends down data from more sensors will receive a higher score. Use sensors whose output actually changes during the course of a rocket flight, of course.
- Bonus Challenge C is for the rocket to receive “commands” from the ground and to reply appropriately. Each command will consist of five characters, three of which are digits and two of which are math operations (chosen from “+”, “-”, and “*”). The appropriate reply will be to evaluate the math expression on-board the rocket, from left to right (notice no order of operations), and then to respond with the (always-positive) two-digit numerical answer. For example (with “2d” as the security code):
  Command transmission: 2d2*7+7 Response: 2d21

Command transmission: 2d5-2*3 Response: 2d09
Command transmission: 2d4*5*4 Response: 2d80

A text file with a list of commands will be provided to the team's ground station just prior to launch. The ground station should be able to read the list and then relay the commands to the rocket, one after another, starting after launch, and adding your rocket's security code before every transmission. (Test transmissions can also be sent, prior to launch, to ensure radio contact.) In between transmissions the ground station needs to receive and log the response. Take just one shot at every transmission – no repeating a command if the response is incorrect. Stop sending commands (honor system here) as soon as the rocket lands, even if you still are in radio contact with it. The most bonus points will be given for the largest number of error-free up/down transmission cycles completed, from ignition to touch-down. Immediately after the flight submit to the judges (and keep a copy yourself) a text file containing the complete list of in-flight responses. Notice that if you are also doing Bonus Challenge B the values in this file might become interspersed with the sensor data. But this won't cause any confusion because the data involved is identifiably different. Sample text file provided – you add the security code:

2*7+7
5-2*3
4*5*4
etc.

- Note – teams that want to implement a radio system but use it in other ways than these, such as to command the rocket to do something specific from the ground, may present their ideas to the judges in their pre-competition written reports. Feedback will be given as to whether or not bonus points will be awarded and, if so, in which of the categories above (quite possibly in category B, since that is already open to the most creativity). For example, a team might decide to have their rocket only send down sensor data when requested to do so from the ground, and perhaps even have different requests to ask for data from different sensors (rather than having all data sent down on an automatically-repeated basis). This alternative proposal for bonus points would probably be accepted and would be incorporated into the judging of Bonus Challenge B.