École Polytechnique de Montréal

AER8300: Lab #2

STK, MATLAB, Mission Requirements

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1 Practical Information

Deliverables	A single PDF document in English. An archive (.zip, .tar, .tar.gz) with your MATLAB scripts and a README.txt instruction file.
Deadline	March 10, 2020 at 11:59pm.
How to submit	By e-mail at yanjun.cao@polymtl.ca.
Teamwork	The 2-people groups are the same as for Lab #1.
Evaluation	Up to 35% (of 40%). All the members of a group will receive the same evaluation.

2 Tasks

In the first laboratory session, you learned how to get around STK and one of its module, SEET. Now, you will be exposed to a few additional features, then you will sketch your how satellite mission.

AGI STK interfaces with MATLAB using its proprietary connector. Take the time to review the how this module works: `http://help.agi.com/stk/LinkedDocuments/UsingMATLABForSTKAutomation.pdf`. If you are working on your own computer, you can find the connector installation and update procedure, for troubleshoot, at `http://help.agi.com/stk/index.htm#install/MATLABsetup.htm`

> **Task 1 (2 points):** MATLAB is a powerful tool to automate any task you would perform in STK. Follow the tutorial you can find at `http://help.agi.com/stk/LinkedDocuments/UsingMATLABForSTKAutomation.pdf` to create a scenario with a moving Predator drone observing randomly disposed targets. Briefly discuss any challenge you encountered in performing the tutorial and provide a screen capture with a 2D visual of the drone, the targets, the access lines, etc. (Missing any file? Did it affect the tutorial outcome? If yes, how? If no, why?)

Similarly to what you did in Task 1, use MATLAB to automate your mission scenario.

> **Task 2 (4 points):** Use MATLAB to automate the creation of a scenario with a small satellite (any model) <u>spin-stabilized at a rate of your choice</u> on a Sun-synchronous, low Earth orbit to observe Montréal for <u>1 year</u>. Choose up to 3 possible orbits. (2 points) Briefly compare them with respect to their viability, access times, etc. (use a table if you find it appropriate). (2 points)

If necessary, you can find more STK-MATLAB snippets at `http://help.agi.com/stkdevkit/index.htm`, browsing to "Using Core Libraries > STK Object Model > MATLAB Code Snippets". Another useful resource is at "STK Programming Interface > Library Reference > Connect Command Library > Alphabetical Listing".

Recall what you did in the first laboratory to study the effects of space radiation on a spacecraft using the SEET module: `http://help.agi.com/stk/index.htm#training/SEET_RadiationEnvironment.htm`. SEET can also models the South Atlantic Anomaly.

> **Task 3 (2 points):** Follow the tutorial about the South Atlantic Anomaly: `http://help.agi.com/stk/index.htm#training/SEET_SAA.htm`. In your report, include screen captures of the crossing times and of the 3D view showing your satellite passing through the South Atlantic Anomaly.

If you are interest, check out how SEET allows you to also model particle impact: `http://help.agi.com/stk/index.htm#training/SEET_ParticleImpact.htm`.

Now, go back to your orbit proposals, how are they affected by space radiation?

Task 4 (4 points): Study the electron, proton, and total dose radiation of the orbits you proposed, over the 1 year period of your mission. As your mission shall be performed with a small satellite, consider having only little shielding. Report results relative to the crossing of the SAA crossing the relative ion flux. Briefly discuss the results and how your orbits proposal compare one another.

You did choose Sun-synchronous orbits but how do you compute the sun exposure of your satellite?

Task 5 (2 points): Follow the tutorial on Aqua's sun exposure: `http://help.agi.com/stk/index.htm#training/SeasonalPower.htm`. Include in your report the screen capture the power graph report. Did you encounter any issue (again, e.g. missing files) during this tutorial? If yes, is there a naive way of circumventing it (suggestion: are other satellite models available)? How does it affect the tutorial?

Again, what about the sun exposure of the orbits you proposed for your mission?

Task 6 (3 points): Study the sun exposure of your obit proposals using the default satellite model in STK. Include your (approximate, but numerical) considerations on how much (less) actual power you would get in a smaller satellite (e.g. a 3U CubeSat whose major axis is directed towards the centre of the Earth). Think of the area of the solar panels actually directed towards the sun.

Indeed, an imaging satellite without and Attitude Determination and Control System is pretty useless.

Task 7 (12 points): Review the octave script (or you can run it in MATLAB, if you prefer) `01.MATLAB-ADCS-testbench.m`. It includes a model of the dynamics of yaw, pitch, and roll of your satellite (see function `satupdate`). Imagine your satellite initially sitting aligned with an absolute reference system W and a target moving on a circular trajectory (on a plane with any inclination w.r.t. W, extra points for a non-null value) around it. (1) Implement he function `toTarget` that computes the motion of the target and return the yaw, pitch, and roll separation w.r.t your satellite. (2) implement a controller (PID, manually or automatically tuned, or else) that applies torque to the 3 axes of your satellite in order to follow the target (i.e. align the satellite's reference system S to the target's T).

Have a look at commercial, off-the-shelf, components for CubeSats and choose some for your mission.

Task 8 (4 points): Go to `http://www.cubesatshop.com` and/or `http://www.clyde-space.com` and choose the components you would buy for a CubeSat bus: motherboard, micro-controller EPS, batteries, solar panels, radio, etc. (1 point) Using the information you have on sun exposure (and the considerations you made), sketch a power budget for one of your orbits. (1.5 points) Use the information on operating voltages, currents, etc. from the data sheets of the components you chose to show that you can fit within this budget. Do you have to periodically turn of the system? (1 point) How much does your system cost in CA$? (0.5 points)

Finally, is it even that much of a good idea to send your satellite to space?

Task 9 (2 points): Read the guidelines of the Inter-agency Space Debris Coordination Committee on debris mitigation: `02.IADC-Space-Debris-Guidelines.pdf`. Frame your orbits with respect to these guidelines. (0.5 points) What could you do to improve compliance? Look for post-mission disposal technologies. List and describe at least three. (0.5 points) Which ones are the most suitable for a nano-satellite and which ones are the least advisable? Why? (1 point)

3 Hints

- A report that is anywhere between 10 and 20 pages will do the work.
- Approach the attitude control coding task as small puzzle to help you think about moving reference systems (W, S, and T), trigonometry, and control, not as a hyperrealistic physical simulation. Refer to the figure below, if necessary.