

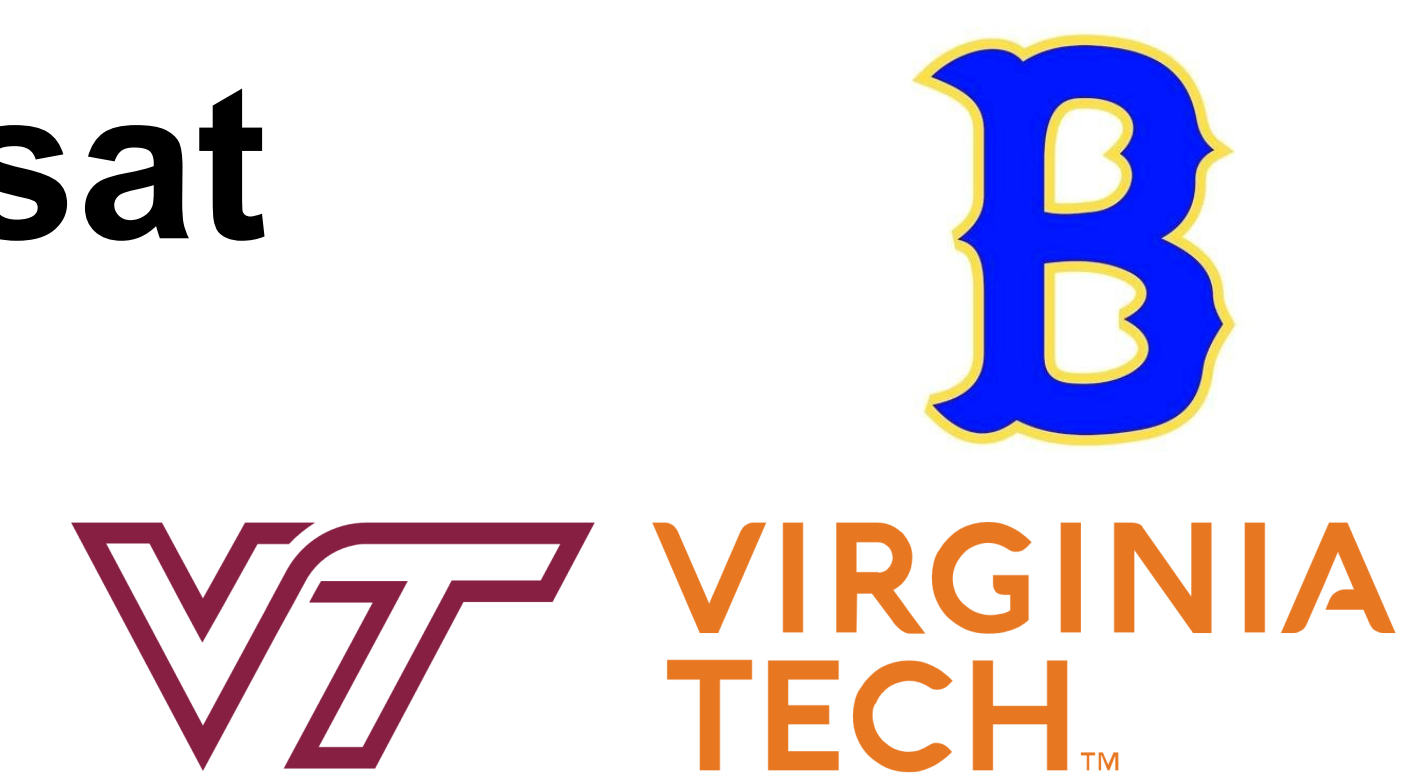


DATA01: Scheduling and Analysis Software for the LAICE Cubesat

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Introduction

The Lower Atmosphere/Ionosphere Coupling Experiment (LAICE) is a 6U Cubesat that will launch in 2020 into a circular mid-inclination orbit. It carries four instruments to detect gravity waves in the lower thermosphere and upper mesosphere, as shown in Table 1. Figure 1 shows a photograph of the assembled system. This poster describes the software used to schedule command modes for the satellite and to visualize and analyze the downlinked data.

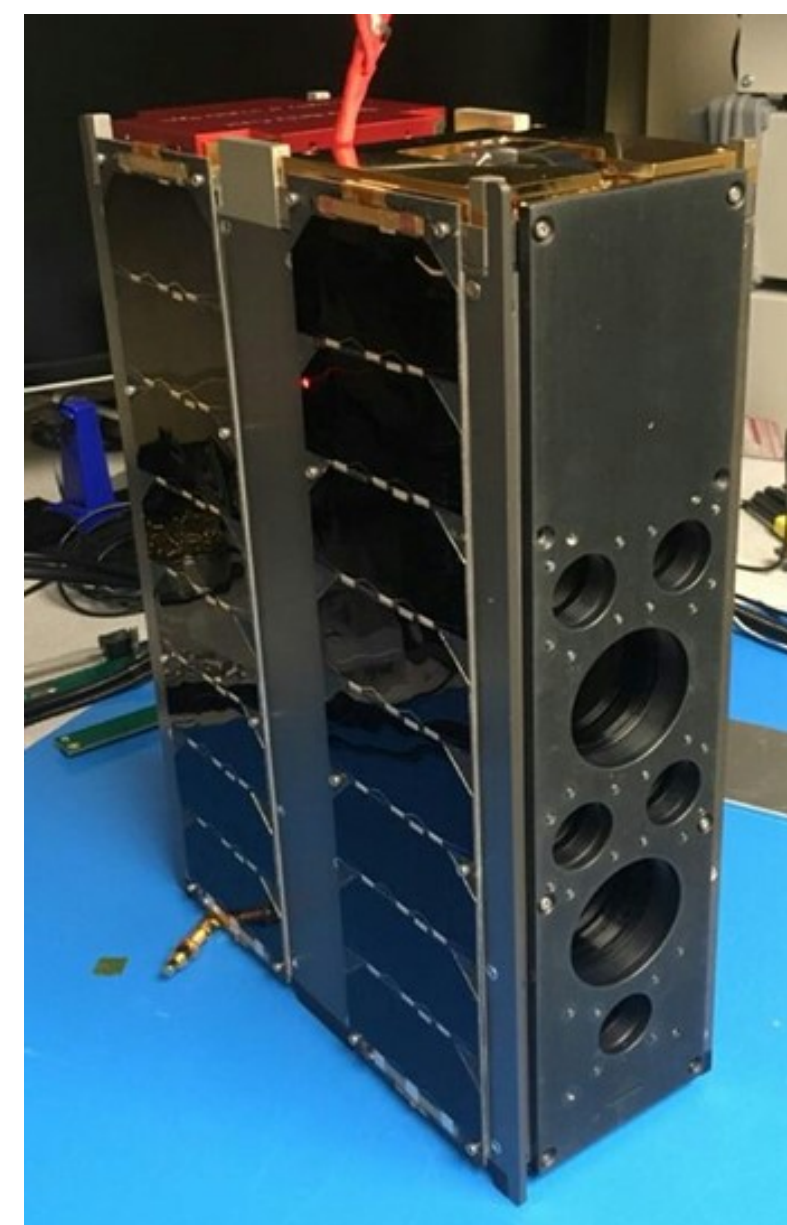


Figure 1 - Assembled LAICE spacecraft. The photometer apertures are at the right, while the CuRPA, LINAS, and SNeuPI apertures are at the top of the image.

Table 1 - LAICE Instrumentation

Instrument	Measurements	Institution
LINAS	Neutral density	The Aerospace Corp.
SNeuPI	Neutral density fluctuations	Virginia Tech
CuRPA (Cubesat RPA)	Ion density, ion temperature, and ram ion velocity	Virginia Tech
Photometers	Mesospheric airglow	Univ. of Illinois

Current Status

The satellite instrumentation and systems were integrated in late 2017, but shortly thereafter the FCC suspended LAICE's radio licenses due to concerns about orbital debris. The spacecraft easily satisfies NASA's orbital debris specifications, but the FCC has more stringent requirements. NASA and Virginia Tech are working together to mitigate these issues and get the licenses re-instated to enable a 2020 launch.

As shown in Figure 2, the LAICE satellite will downlink all science data to the Mission Operations Center (MOC) at UIUC through the Wallops Flight Facility. Custom software running in the Science Operations Center (SOC) at Virginia Tech will clone the UIUC database on a dedicated server for subsequent analysis.

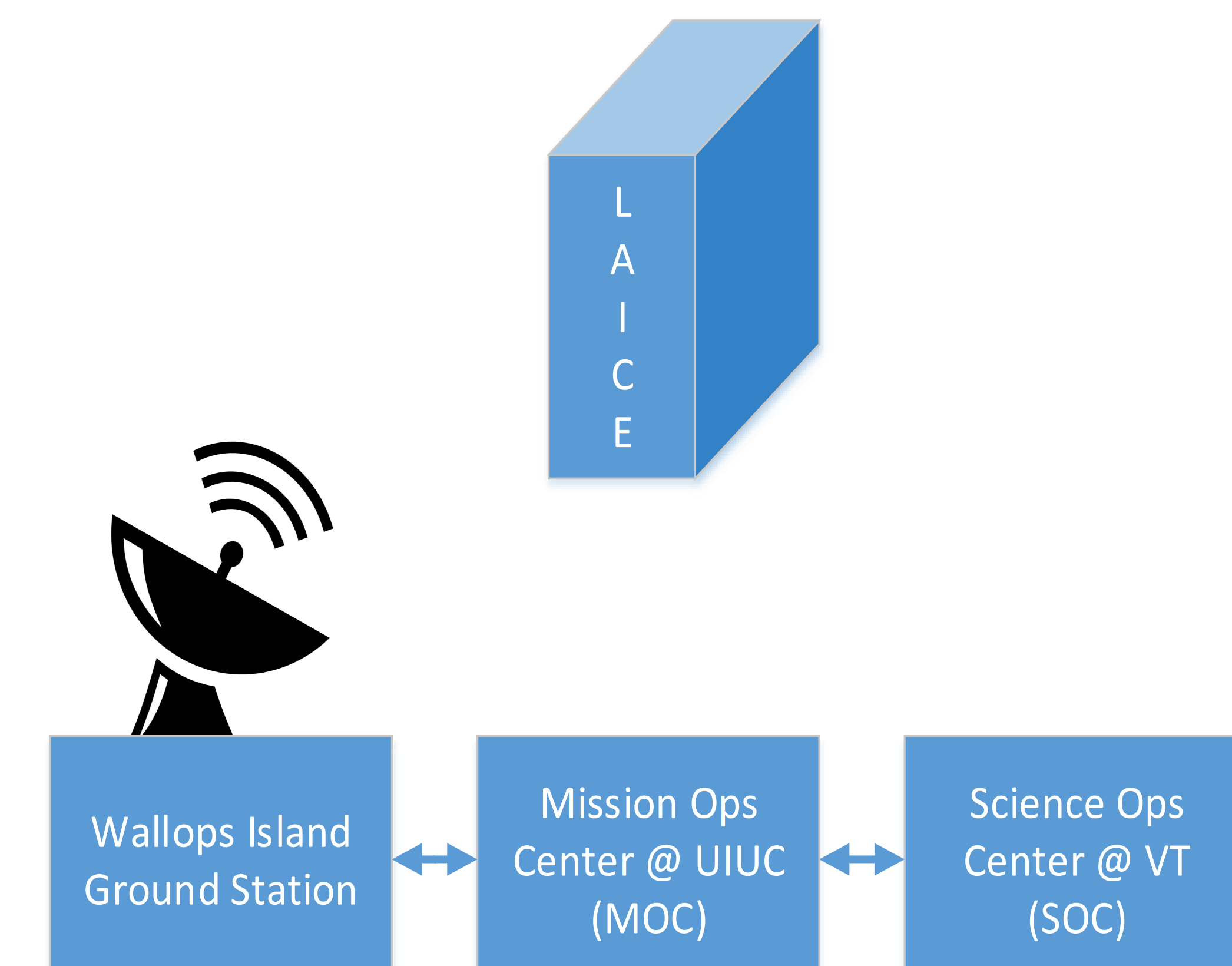


Figure 2 - Data flow diagram

Uplink Software

The uplink software allows the user to generate, schedule, and export commands to UIUC in a compressed form that is suitable for uplinking to the satellite¹. Figure 3 shows the typical flow when using the software, which creates an intuitive web interface so that the application is accessible from any computer infrastructure in place at the SOC. The interface contains 3 major components: the calendar view, the command generator, and the export dialog.

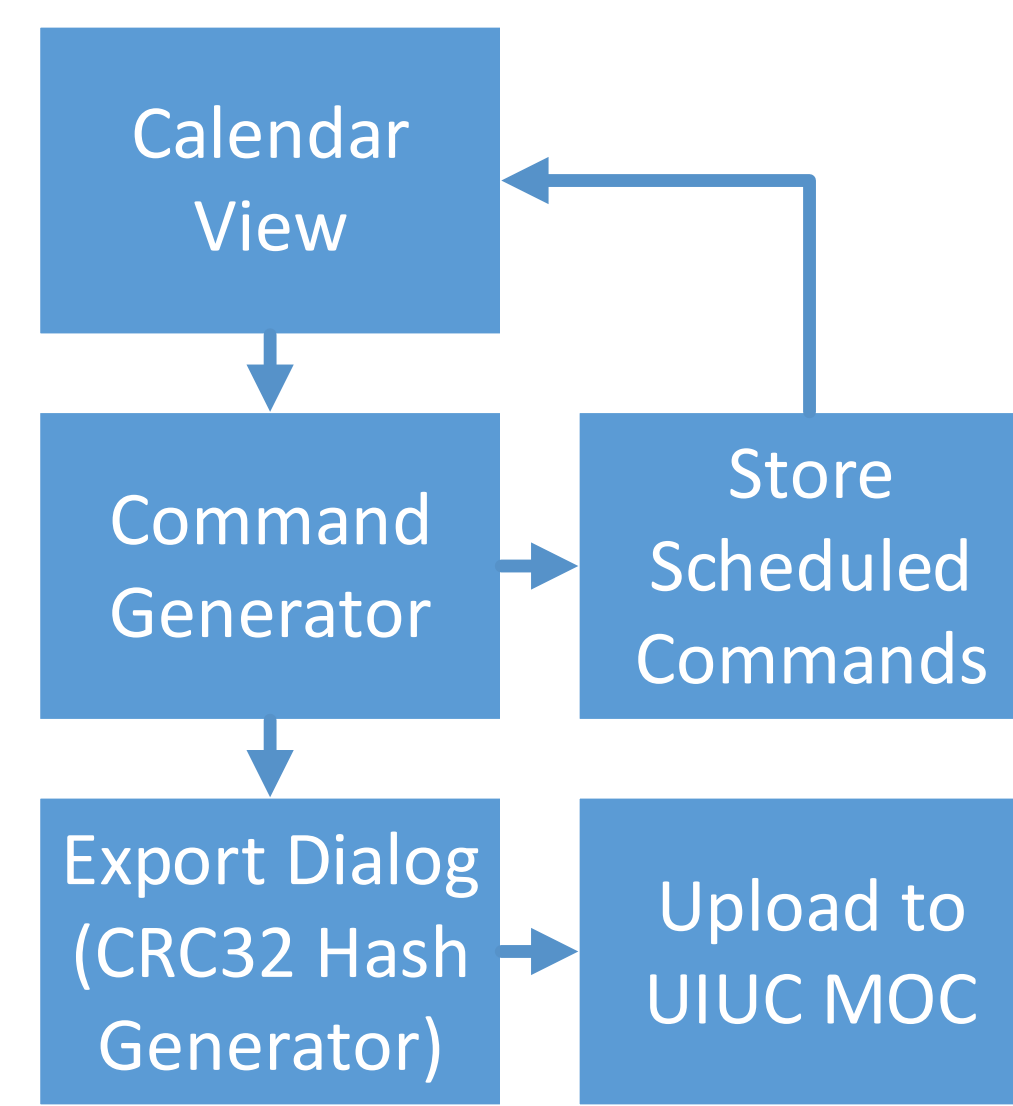


Figure 3 - Overview of the uplink software components.

Figure 4 shows the calendar view that displays all scheduled satellite commands. From here, the user can click a command to modify, export, or delete it. Each command is displayed on the calendar using a special "shorthand" name corresponding to the instruments and modes for that command.

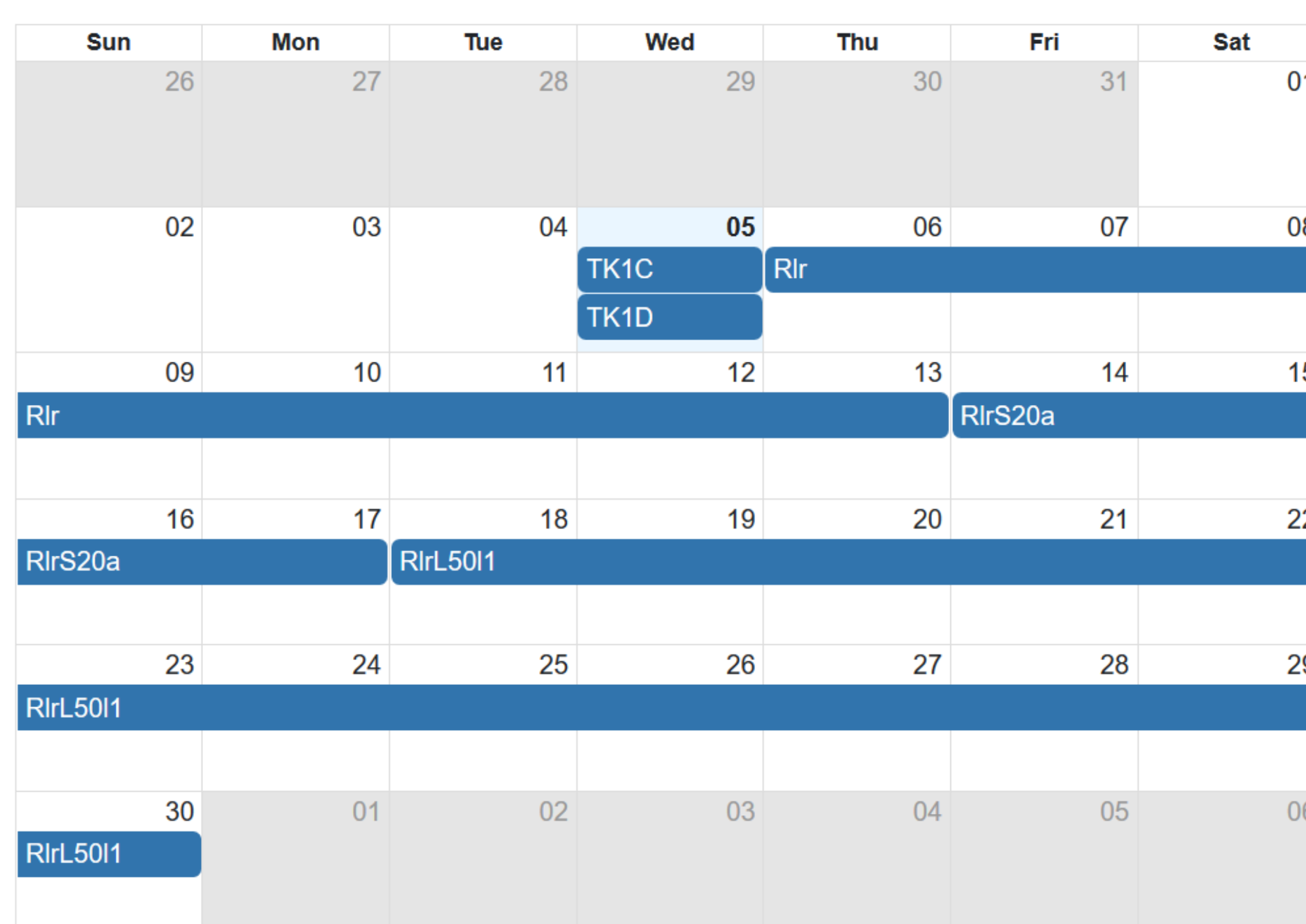


Figure 4 - Screenshot of the calendar view with some sample commands inserted.

Figure 5 shows the command builder interface, which is used to select the instruments that are enabled, as well as the modes and duty cycles for each. After creating the command, the next screen (not pictured) allows the user to choose the date interval for which the command should be scheduled. Error handling is in place at each step to prevent invalid conditions from occurring.

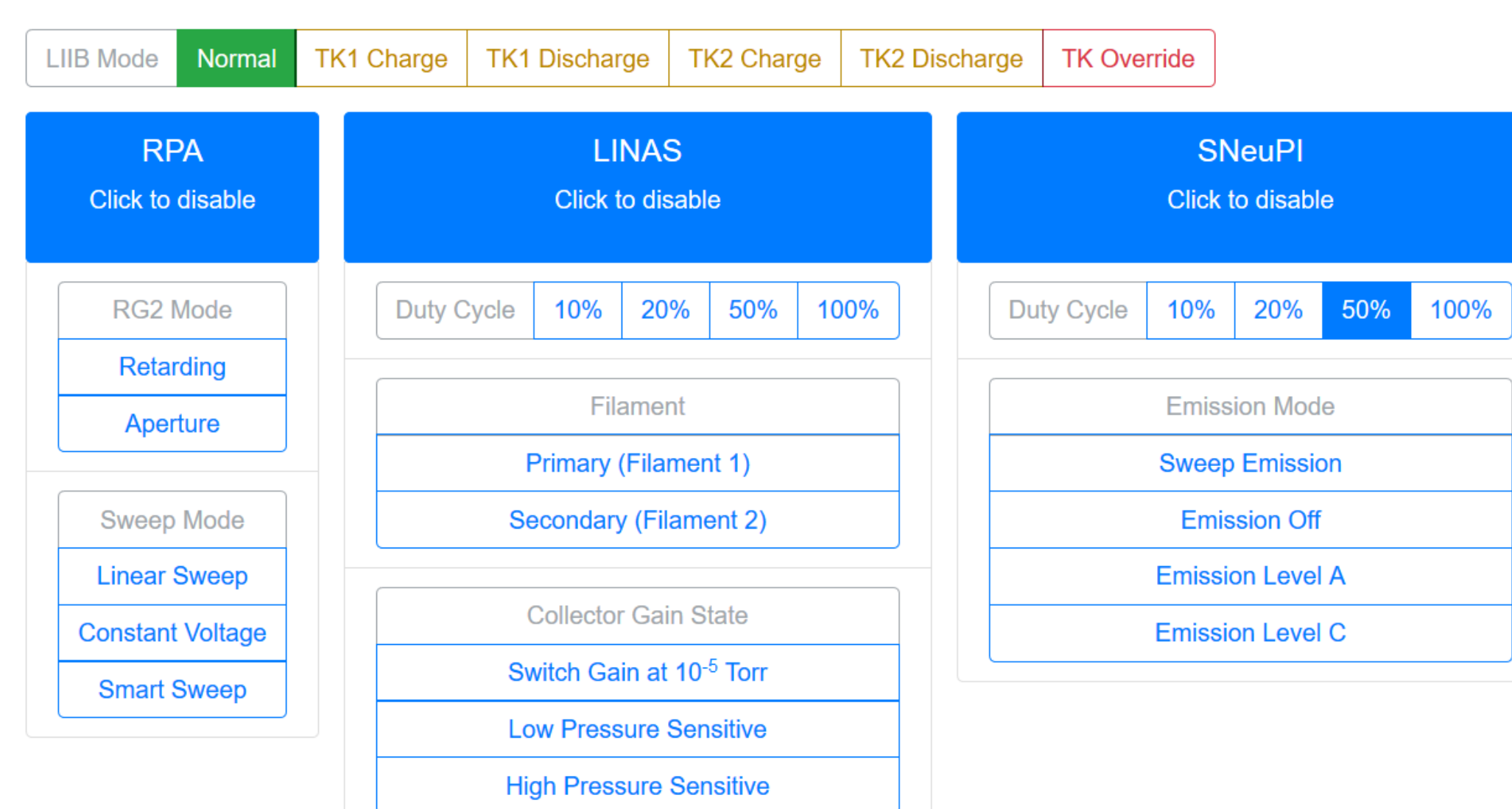


Figure 5 - Screenshot of the command builder with all instruments enabled to show all available modes.

Data Visualization Software

The downlink software connects to the VT MOC database, which is a clone of the database at UIUC that contains data downlinked from the satellite. The database contains both level 0 data (binary) and processed level 1 data (engineering units). The software allows the user to plot level 1 data from any of the four onboard VT instruments against several independent variables, including UT, satellite time, latitude, and longitude. The user can choose to examine data over a set of intervals ranging from multiple orbits down to approximately one minute. For the RPA², it is also possible to graphically visualize the 64 points of an IV sweep corresponding to a single second of data. The main function of these visualization tools is to allow analysts to identify large scale features and interesting intervals that require more detailed investigation.

Figure 6 shows a part of the selector interface used to choose dependent variables to be plotted. Not pictured is the search function, which allows the user to quickly find the desired variables.

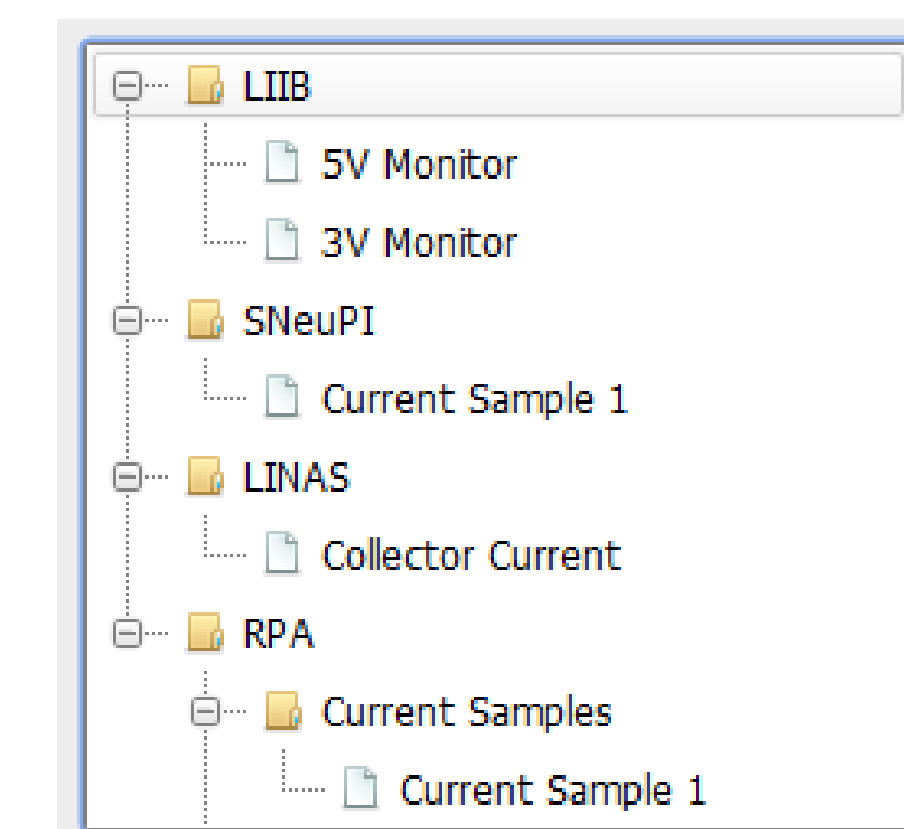


Figure 6 - Selector tree for dependent variables.

Figure 7 shows an example of four parameters plotted vs Packet ID over a period of two hours, which is slightly more than a single orbit. The sample data were generated along an STK simulated mid-inclination orbit using the MSIS and IRI empirical models.

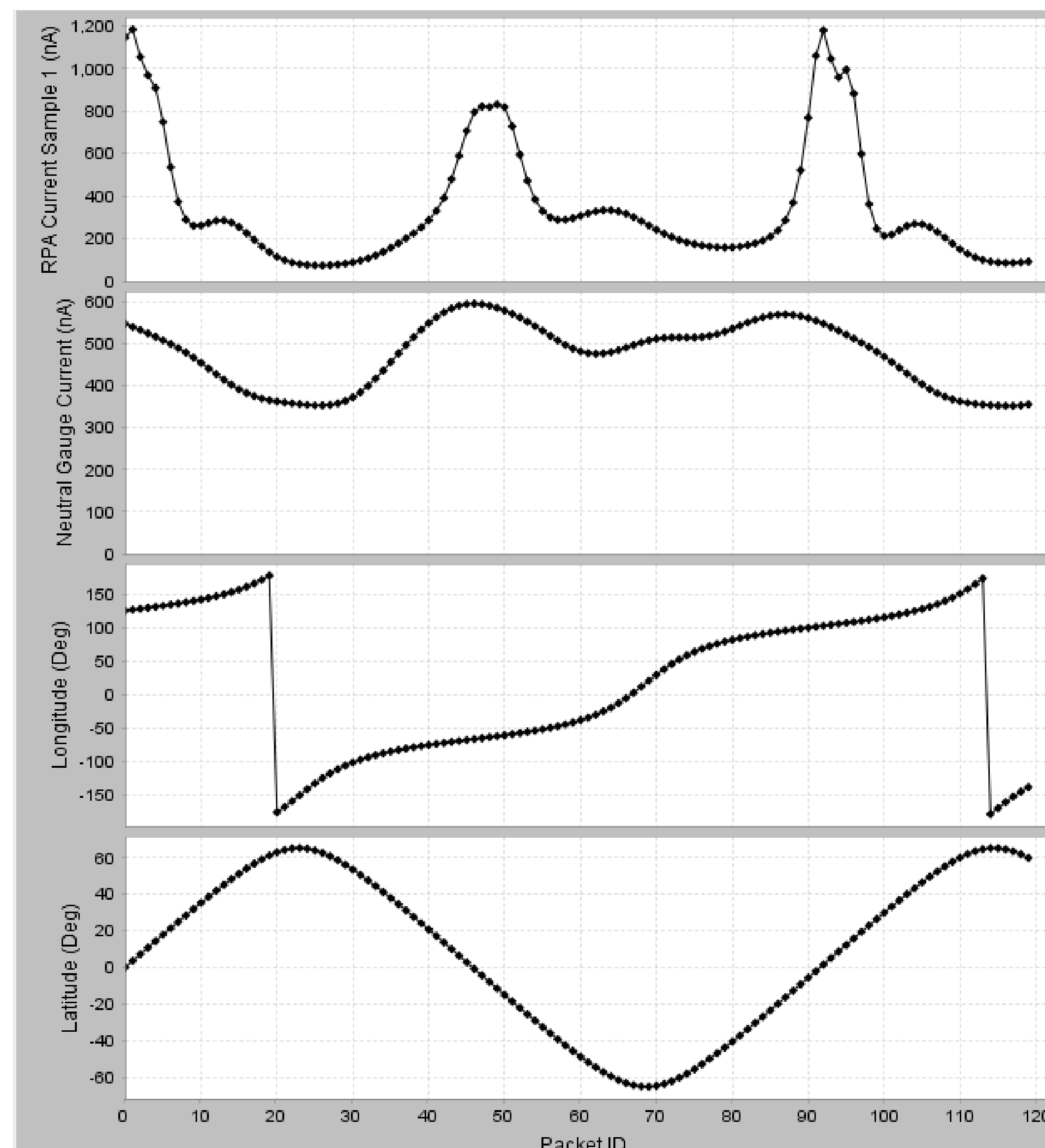


Figure 7 - Screenshot of simulated level 1 data from the SNeuPI and RPA instruments, including position data, plotted by the program.

Figure 8 shows an example of a simulated IV characteristic from the RPA instrument³. This feature is included in the software because it is sometimes useful to examine RPA data in its raw form to identify questionable data points that may have been produced by interference from other spacecraft systems (e.g., attitude control adjustments) or spacecraft charging.

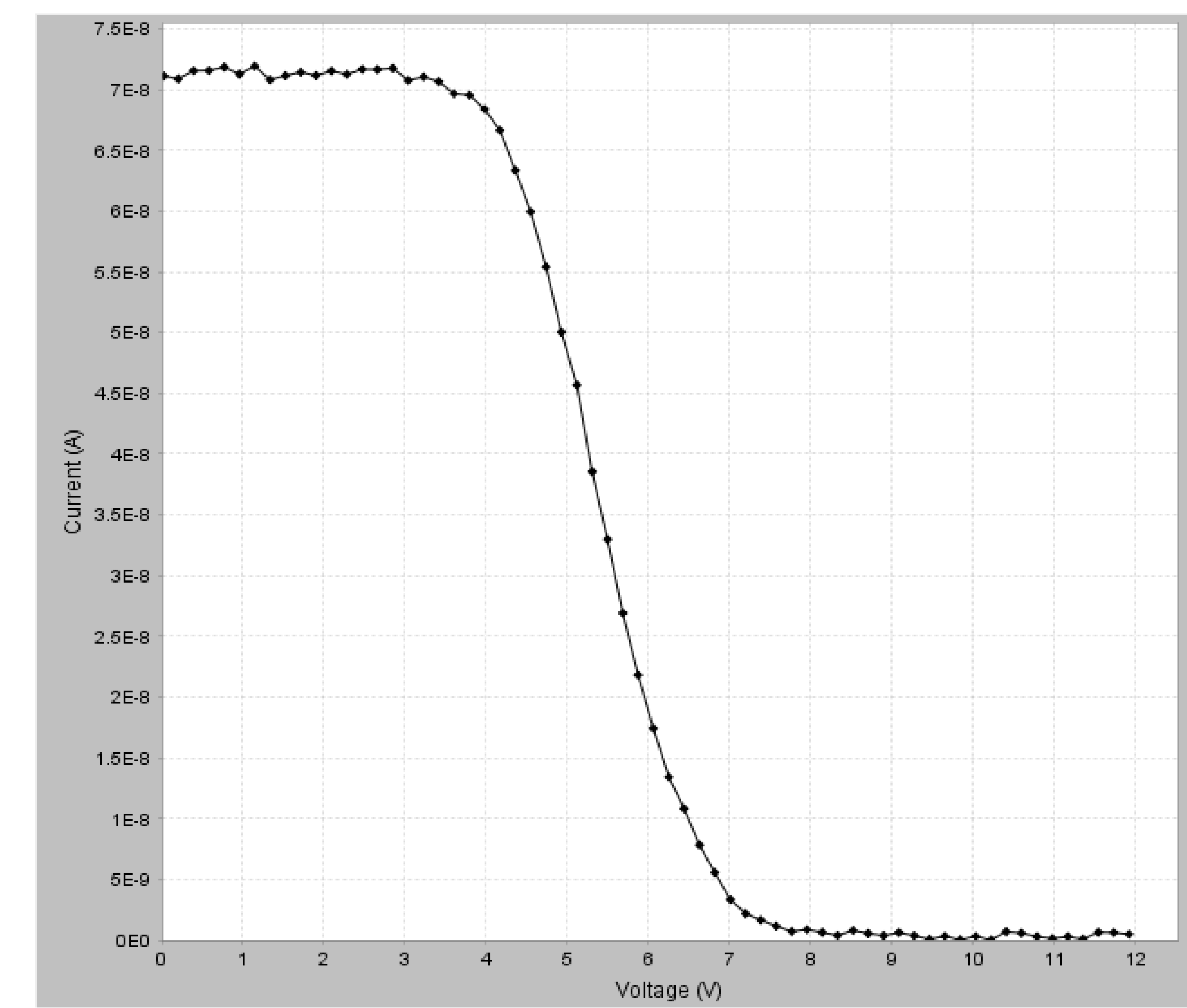


Figure 8 - Screenshot of a simulated IV characteristic from the RPA instrument plotted by the program.

Implementation Details

The uplink software is implemented as a web application using Spring Boot as the web backend (server) with business logic implemented in Kotlin. The React JavaScript framework is used for the frontend (user interface). The data visualization software is a desktop application written entirely in Kotlin. Kotlin is a language similar to Java, and runs in the same way any Java application would.

Summary and Conclusions

The software described here runs in the VT Science Operations Center, and will be used by a team of students and faculty to achieve full command scheduling and data analysis capabilities during the LAICE mission. The main features are:

- Intuitive calendar-based scheduler
- Fast binary command generation algorithm
- Data redundancy between VT and UIUC
- Flexible visualization capability

References

1. Kedia, Namrata, Ground station up-link software for the LAICE cube-sat, Virginia Tech MS Thesis, ECE Dept., August 2016.
2. Fanelli, Lucy - Electronics for a Versatile and Robust Retarding Potential Analyzer for Nano-Satellite Platforms, Virginia Tech MS Thesis, ECE Dept., July 2014.
3. Debchoudhury, Shantanab - Parameter estimation from retarding potential analyzers in the presence of realistic noise, Virginia Tech Doctoral Dissertation, ECE Dept., February 2019.

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