

Paratoi - Python-Based Flight Control Procedures for Mission Control Systems

The Challenge

Flight-control procedures for spacecraft are often written using domain-specific languages designed specifically for space operations. Although these languages provide concepts and functionality tailored to the domain, they can be difficult and time-consuming for flight-control teams and software developers to learn and use. At the same time, many engineers are already familiar with Python, a widely used and flexible programming language with a large ecosystem of development, testing, and automation tools.

Creating and executing procedures can also involve several different tools and interfaces. Procedures need to access spacecraft-specific telecommands, telemetry parameters, and their associated arguments and values. The way these operations are represented and executed may vary between mission control systems, making procedures more difficult to create, validate, and maintain.

A user-friendly approach based on Python could simplify procedure development while still providing access to the spacecraft operations defined in the mission database. The challenge is to create a user-friendly interface that hides the technical details of the underlying mission control system specific data model without limiting the functionality available to procedure authors.

Goal of the Project

The goal of this project is to develop an application called Paratoi that enables users to create, validate, manage, and submit Python-based flight-control procedures.

The application shall provide a generic Python interface for accessing spacecraft database information and executing database-defined operations. Procedure authors should be able to work with spacecraft-specific telecommands, telemetry parameters, and their associated arguments without needing to understand how these operations are implemented internally.

Paratoi shall be designed to work with different mission control systems through a dedicated adaptor layer, with each adaptor implementing the scheduling and execution logic for one specific system; a first adaptor shall be developed for Telespazio's cloud-based EASE-Rise mission control system.

The project will be demonstrated using a ground-based CubeSat testbed, providing a realistic environment for testing the complete workflow.

The Project

In this project, you will design and implement an environment for developing Python-based flight-control procedures. The application should offer a user-friendly editor with features such as syntax highlighting,

browsing available telecommands and telemetry parameters, basic validation, and clear feedback about errors.

A central part of the project will be the development of a Python interface for accessing the spacecraft database and executing spacecraft operations. Users should be able to refer to spacecraft-specific commands and telemetry using a consistent Python interface, while an adaptor layer handles the communication with the underlying mission control system in the background.

The minimum viable product should support an end-to-end workflow in which a user can:

- Create a Python procedure in the application
- Use telecommands and telemetry parameters from the spacecraft database within the python procedure,
- Validate the procedure and its parameters
- **Submit the procedure for scheduling and execution through the mission control system**
- Monitor its execution status

The workflow will be demonstrated with a meaningful procedure executed against the CubeSat testbed via the EASE-Rise adaptor. For example, a procedure could send a command to change the mode of a subsystem, wait for the corresponding telemetry value, request operator confirmation, and then send a follow-up command. The procedure should include suitable timeout and error-handling behavior.

Depending on the progress of the project and the interests of the student team, additional features could include code completion, validation of parameter ranges, procedure versioning, or AI-assisted procedure documentation.

The focus of the project is to deliver a complete and usable prototype rather than a replacement for a full mission-control system. The developed architecture should nevertheless be extensible so that additional spacecraft operations and future mission-control integrations can be supported.

Technologies / Frameworks

As this project focuses on developing Python-based flight-control procedures and integrating them with a mission control system, you will encounter and work with technologies such as:

- **Python** for implementing flight-control procedures and the spacecraft operations interface
- **Editor and tooling frameworks** for developing the procedure editor and user interface, including syntax highlighting, validation, and potentially code completion
- **REST APIs** for communication between the application, procedure services, and the mission control system
- **Spacecraft database interfaces** for accessing telecommands, telemetry parameters, arguments, and metadata

- EASE-Rise, as the first mission control system integrated via an adaptor, for scheduling and executing procedures
- **A ground-based CubeSat** for testing and demonstrating the complete workflow
- **Database and persistence technologies** for storing procedures, execution results, and logs

The specific frontend and backend technologies will be selected at the beginning of the project based on the project requirements and the experience of the student team. We encourage the use of open-source libraries with permissive licenses wherever possible, allowing the team to build on existing solutions rather than reimplementing established functionality.

Methodologies

We are looking forward to working with you on this activity in an agile way (think SCRUM). You can always reach out to our Product Owner who will initialise and prioritise the product backlog. We welcome you to our office in Darmstadt for CubeSat activities and meetings, if necessary (e.g. Sprint reviews), but otherwise work can be done remotely/off-site using our instance of GitLab. We hope to get in regular touch with you using emails and MS Teams. The whole activity is expected to be performed in English.

About Telespazio Germany

Telespazio Germany GmbH is a well-established consulting, technology and engineering services business. Over the past 40 years, we have built up a first-class reputation in high-technology markets, where quality and reliability are essential. Our roots are in the Space market and the experience we have developed there now brings benefits to our other core markets of Aviation and Defence. Our more than 400 staff are experts in a full range of systems & operations engineering and ICT disciplines and develop ground-based, software-intensive systems for control, planning and data processing as well as for simulations and training. After development of such complex systems, we are able to provide operations services at highest quality standards, up to fully outsourced services or our clients.

Our knowledge and experience enable us to provide support through the entire programme lifecycle, ensuring that all quality standards, customer-specific standards and country specific regulations are met.

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