MUST: Mission Utility and Support Tools

MUST was first developed in 2003 and helped revolutionise many of the workflows for managing spacecraft telemetry data. It was born out of the necessity to efficiently access and complement the packet based telemetry repositories available at the time with a high performance parameter archive. MUST is a suite of different tools, based on years of operational experience and user feedback, covering these areas:

- Efficient data storage
- Powerful data analysis, and
- Flexible, accessible data visualisation of data

Nowadays it is used actively by many spacecraft missions and has become an important set of tools to keep a grasp on time series data, particularly for spacecraft telemetry. At the core of MUST lies a relational database optimised for fast and efficient storage of spacecraft parameter data. While this data initially consisted of housekeeping telemetry in the form of calibrated numerical parameters, over time this data set has been greatly expanded to included ancillary data types such as telecommand history, flight dynamics data, mission planning data and ground station data. This data, while originating at many different external sources and systems, is converted to the common MUST storage format by data importers, each of which handles a specific source and/or data format. Over time, MUST has been enriched with a large suite of tools for visualisation, monitoring and analysis. This suite includes user friendly graphical applications for data visualisation such as WebMUST (and in the past Grains and JavaGrains), as well as diagnostics tools for automatic detection and analysis of anomalies, such as DrMUST and Novelty Detection. MUST has a flexible architecture that can be expanded and tailored to the needs of new users and spacecraft missions, and is constantly evolving through the implementation of new features based on user needs. Further data can be added to MUST by developing custom new data importers, and new clients can be developed based on the existing, fully featured, data access API. A separate branch of MUST, MUST 1.2, was developed by Solenix to introduce database independence in the system's architecture. MUST is used by most current spacecraft flight control teams (and many others in the past) at ESOC, DLR and CNES, and by spacecraft designers at ESTEC and scientists at ESAC. Since 2003, Solenix has been responsible for the maintenance and development of the MUST system and its client applications, under contract with the ESA Advanced Mission Concepts Office.

WebMUST and Grains

Over the years, several user interface applications have been developed for the MUST system, taking advantage of the latest available technologies. The first such application was Grains, a Matlab based client offering data plotting and exporting capabilities. It was developed in 2003 for the SMART-1 mission. In 2008, JavaGrains was developed, a rich client application based on the Eclipse Rich Client Platform. JavaGrains offered most of the functionality in Grains, with a more modern and user friendly interface. WebMUST is a web client application based on HTML5, CSS and JavaScript and allows for interactively plotting and exporting spacecraft data, using only a web browser. The fact that a rich client application is no longer required brings several advantages, such as easier distribution of updates and the ability to access spacecraft data remotely, including via smartphone or tablet. Through a technique called Viewpoint Resolution Aggregation, WebMUST is capable of plotting large amounts of data very efficiently. Visualising all available data for telemetry parameters since the beginning of a spacecraft mission first became possible for operators at ESOC with WebMUST. In addition to graphical plots, WebMUST supports other ways of visualising time series data. Numerical time series such as spacecraft parameters can be viewed in Alphanumerical Displays in a way similar to existing Mission Control Systems. More complex data types such as telecommand history and events can be viewed in tabular format. Several advanced features have been integrated in WebMUST based on user needs and advanced research and development outputs. A Reporting Tool capable of generating Microsoft Word with embedded time series data in the form of plots and tables is fully integrated in WebMUST. These reports can be generated on demand or scheduled for automatic generation. In addition, advanced monitoring and diagnosis tools such as DrMUST and Novelty Detection are fully integrated in WebMUST. DrMUST supports users in finding correlations between different telemetry parameters, while Novelty Detection automatically finds novel behaviour in the telemetry, which may lead to the diagnosis of anomalies. While the MUST system is the backend most often used with WebMUST for storing and accessing spacecraft data, WebMUST is extensible and can be used as a fronted to any system providing time series data. An example of such a system is ARES (Analysis and Reporting System), developed by ESOC infrastructure. WebMUST has been adapted to the ARES interfaces and currently serves as the web client for ESOC missions using this system for telemetry storage. WebMUST has been developed in close collaboration with the end users, spacecraft operators for multiple ESOC missions. User friendliness and ease of use have been guiding design principles since the very beginning. In recent years, WebMUST has become the main client application for the MUST system, and is currently used by most flight control teams at ESOC, Galileo teams at CNES and DLR, spacecraft design experts at ESTEC and spacecraft science operators at ESAC. WebMUST has been developed by Solenix under contract with the ESOC Advanced Mission Concepts Office.