Ball Aerospace’s Open Source Command and Control System

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“To enable small satellite developers to easily and cost effectively command and control their satellites”
WHAT IS COSMOS?

A command and control system made up of a set of 15 tools that let you send commands, visualize data (graphs, textual display), write automated scripts, analyze log files, and monitor telemetry.

A set of libraries that allow you to quickly create custom visualizations and applications for your project.
BRIEF HISTORY

• Development began in 2006

• Maintained and improved while growing to become the standard command and telemetry system used at Ball for instrument programs

• Open Sourced in January 2015

• Ball Aerospace COSMOS has been used for AI&T on over 35 flight programs at Ball
USE OUTSIDE OF BALL

Primarily for Cubesats!

EyasSat
Captech University
Various Defense Organizations
Sierra Nevada
And more
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
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<tbody>
<tr>
<td>Target</td>
<td>An embedded system that COSMOS can send commands to and receive telemetry from</td>
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<tr>
<td>Interface</td>
<td>A Ruby class that knows how to send commands to and receive telemetry from a target. COSMOS includes support for TCP/IP, UDP, and serial.</td>
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<tr>
<td>Ruby</td>
<td>Powerful dynamic programming language used to write COSMOS tools, scripts, and test procedures.</td>
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KEY ASPECTS

- Tools organized as:
  - Realtime Command and Scripting
  - Realtime Telemetry Visualization
  - Offline Analysis
  - Utilities

- Cross Platform: Windows, Linux, Mac OS X

- Built-in Support for: TCP/IP, UDP, and Serial

- Plaintext configuration
KEY BENEFITS

- Full Lifecycle – Board, Box, AI&T, and Ops
- Everything is logged
- Superb data visualization
- Powerful scripting
- Test Reporting and Organization
SUMMARY

- Ball Aerospace COSMOS is a freely available and highly functional command and control system for test and operations.
QUESTIONS?

- Try COSMOS Hands-on at the EyasSat Satellite Simulator Booth!

- Documentation at http://cosmosrb.com/

- Source code on Github at https://github.com/BallAerospace/COSMOS
- BACKUP SLIDES
LAUNCHER

Organize and launch all of the applications necessary to control your system

Key Features

- Displays an icon, name, and button to launch each application
- Launch multiple tools with one click
- The same config file works across all platforms (Windows, Mac, Linux)
COMMAND AND TELEMETRY SERVER

Connect to everything that makes up your system, log everything that happens, share the data with other tools

Key Features

- Provides the realtime hub for the system connecting to everything that needs to receive commands and send status
- Logs all commands sent and telemetry received
- Provides an API for other tools to send commands, receive telemetry, connect/disconnect interfaces, etc.
- Displays raw versions of commands/telemetry packets
- Performs limits monitoring on telemetry
REPLAY

Provides the same interfaces as the Command and Telemetry server but is used to replay telemetry log files. All other tools work as if they are receiving data in real time.

Key Features

- Play data sequentially or reverse.
- Quickly slide to specific points in time.
LIMITS MONITOR

Situational awareness of everything that is currently out of limits in your system and everything that has temporarily gone out of limits since it was started.

Key Features

- Limits bar widget used to show how badly out of limits you are.
- Known issues can be ignored.
COMMAND SENDER

Easily send individual commands

Key Features

- Select any command by target and command name and then fill out a form with the command parameters
- Command history can be used to resend the same or slightly modified commands
- Send raw data files to inject faults.
SCRIPT RUNNER
Develop and execute test procedures with code completion, line highlighting, syntax checking, and more

Key Features
• Simple API to send commands and check telemetry
• Query the user for information
• Currently executing line is highlighted.
• Full power of the Ruby programming language available
• Disconnect mode for offline testing
• Audit commands sent and telemetry checked
Break your test procedures into small easily repeatable test cases. Run all test cases or any test case individually. Automatic test report generated when you are done.

**Key Features**
- Develop system level tests much like unit tests.
- Automatic test report generation
- Test Selection to create custom test suites (great for regression tests)
- Meta data entry and data package creation
PACKET VIEWER

View any telemetry definition in the system with no extra configuration necessary

Key Features

• No extra configuration required. Just select the telemetry you want to view.

• Search bar allows you to quickly jump to the telemetry item you want
Easily create custom telemetry screens laying out your data how you want to see it.

Key Features:

- Advanced widgets available to display data.
- Search bar allows you to quickly bring up the screen containing the telemetry item you are looking for.
- Super easy auto configuration.
- Generate screens from within the tool.
- Audit that you have a screen for every telemetry point.
- Modular to allow for creating your own custom widgets.
TELEMETRY GRAPHER

Realtime or offline graphing of any telemetry point in the system

Key Features

• Line and x-y graphs
• One or more telemetry points per plot.
• Spread data across multiple plots and multiple tabs
• Easily save and restore configurations
• Search bar to quickly add points to graph
• Built in data analysis such as averaging available
DATA VIEWER

Great for text based data visualization of log files, memory dumps, and event messages

Key Features

• Display data that does not fit the telemetry screen paradigm well.
• Great for log file visualization and for display raw memory dumps
TELEMETRY EXTRACTOR

Quickly extract telemetry log files into CSV files with just the data you care about

Key Features

• Process any telemetry log file into CSV data for analysis in other tools.
• Add individual items, whole packets, and every packet from a given target using a search bar or drop downs
• Add text columns (great for adding excel equations)
COMMAND EXTRACTOR

Extract command log files into human readable text

Key Features

• Select any binary command log and a human readable text file is created
Create easy to read HTML and PDF command and telemetry definition reports

Key Features

• Takes the normal COSMOS config files and outputs them into beautifully formatted HTML and PDF documents
• Easily configure output using HTML template files
Edit binary files

Key Features

• Provides a simple GUI for editing binary configuration files
• Provides range checking and overall table validity checks
• Break any binary file into several internal tables
• Easily modified to provide table upload and download capabilities within the tool.