



The Design and Architecture of the Rover Sequencing and Visualization Program (RSVP)

SpaceOps 2004 Presentation

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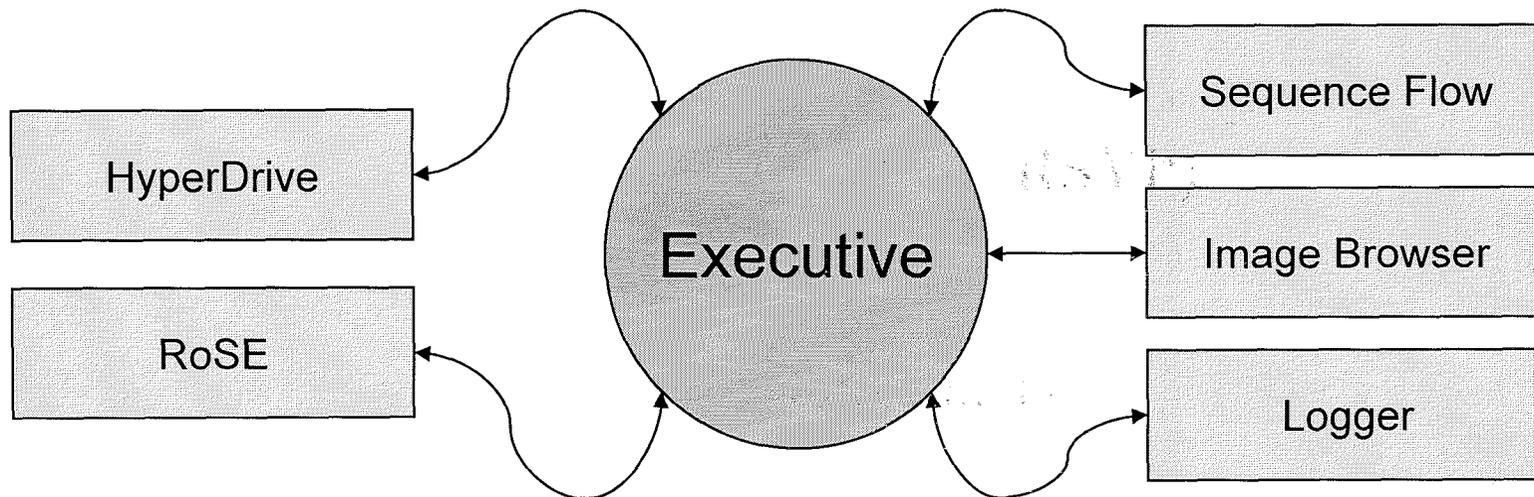
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Software Design Overview



- **RSVP is the MER project's command-level editor**
 - Textual command editing
 - Graphical command editing
 - Simulation, resource modeling, error checking, etc.
- **Central system design feature is a message-passing hub (the Executive)**
- **RSVP component applications run independently, plug into the Executive, and coordinate work by passing messages**
- **Message-passing library based on PVM (thanks, Oak Ridge National Laboratory!)**



RoSE component



- Rover Sequence Editor
- Textual command editor
- Aggressively data-driven
 - Spacecraft command dictionary is just another config file
 - Dynamically constructs command-editing GUIs from command dictionary read at startup time
- “First among equals”
 - Command ID assignment
 - Provides interface to launch other RSVP apps
- Save/load sequence in XML-based RML format (native format) and legacy formats for use with other JPL tools
- Display resource modeling info

The screenshot displays the Rover Sequence Editor (RoSE) interface. The main window shows a table of sequence commands:

CM	Time	Sequence	Command	Arguments	Comment
55		(no such command)	white_boat		
56		(no such command)	white_boat		
57	2004-042T17:33:50.718	white_boat		14 0/rtr 0/steas 0/images	penultimate: col
58	2004-042T17:33:51.718	white_boat		53 1 0 15 1 0008-000-00	penultimate: sav
59	2004-042T17:34:11.718	white_boat		PHAZ	penultimate: ma
60	2004-042T17:35:11.718	white_boat		OK_TO_DRIVE EQ 1 0	penultimate: pe
61		(not executed)	white_boat		
62	2004-042T17:35:12.718	white_boat		0 3/m 0/rad ENABLE 0/sec	penultimate:
63	2004-042T17:35:12.718	white_boat		PHAZ	penultimate:
64	2004-042T18:35:12.718	white_boat		0.2/m 0/rad ENABLE 0/sec	penultimate:
65	2004-042T18:35:12.718	white_boat		DRV_GOAL	penultimate: w
66	2004-042T18:36:12.718	white_boat		1/rad -1.0/rad 1/rad -1.0/	penultimate: ste
67	2004-042T18:36:12.718	white_boat		0/rad 0/rad 0 0.1/rad -0.01	penultimate: pre
68	2004-042T18:36:22.718	white_boat		DRV_GOAL	penultimate: IM
69	2004-042T18:36:32.718	white_boat		53 1 0 31 1 0008-000-00	penultimate: ret
70		(no such command)	white_boat		
71	2004-042T18:36:32.718	white_boat		5/sec	end: pause need.
72	2004-042T18:36:37.718	white_boat		OFF	end:
73	2004-042T18:37:02.718	white_boat		e2455 NOABORT	end: GET_FINE_A...
74	2004-042T18:37:02.718	white_boat			end:
75	2004-042T18:37:02.718	white_boat		SUMMARY	end:
76	2004-042T18:37:02.718	white_boat		PHAZ	end: updates p.o.
77	2004-042T18:37:02.718	white_boat		PHAZ	end:

The 'Detailed Editor' window shows the following command details:

EXAMPLE_CMD

EXAMPLE_CMD is restricted in some modes, so use it with caution. See Restricted Modes

The [] command is used to modify or add a fixed inertial vector in the IVP table. Refer to JPL D-12532 before using this command.

A fixed vector is intended to be attached to one of the spacecraft objects (such as SC_Earth, SC_Sun, or SC_Mars) using a place holder source of these argument values: left-to-command dictionary defaults

vec_base: PHOBOS
 vec_base: DEIMOS
 start: 2000-001T12:00:00 SCET (2000-001T12:00:00 to 2010-001T12:00:00 SCET)
 xcomp: 0 (-3.0E+10 to 3.0E+10)
 ycomp: 0 (-3.0E+10 to 3.0E+10)
 zcomp: 0 (-3.0E+10 to 3.0E+10)

Description of "xcomp" Argument
 X component of head body position vector.

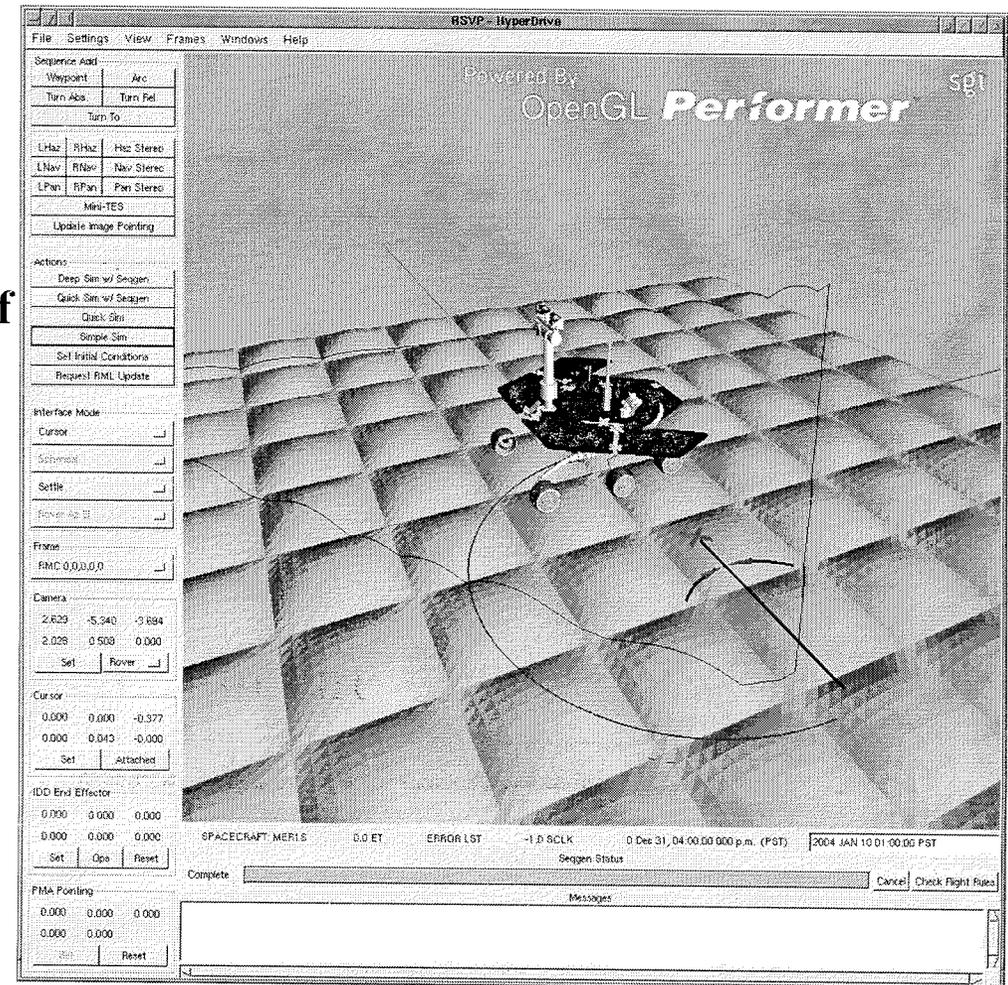
Argument State Errors
 The argument "xcomp" has an invalid value: real out of range



HyperDrive component



- 3-D command editor
- Displays terrain
- Move rover within terrain
- Specialized for editing a subset of MER commands:
 - Driving
 - Arm motion
 - Imaging
- Simulate rover's behavior
- Store and play back simulation results as a "movie"
 - Valuable review product
 - Valuable outreach product





Other RSVP components



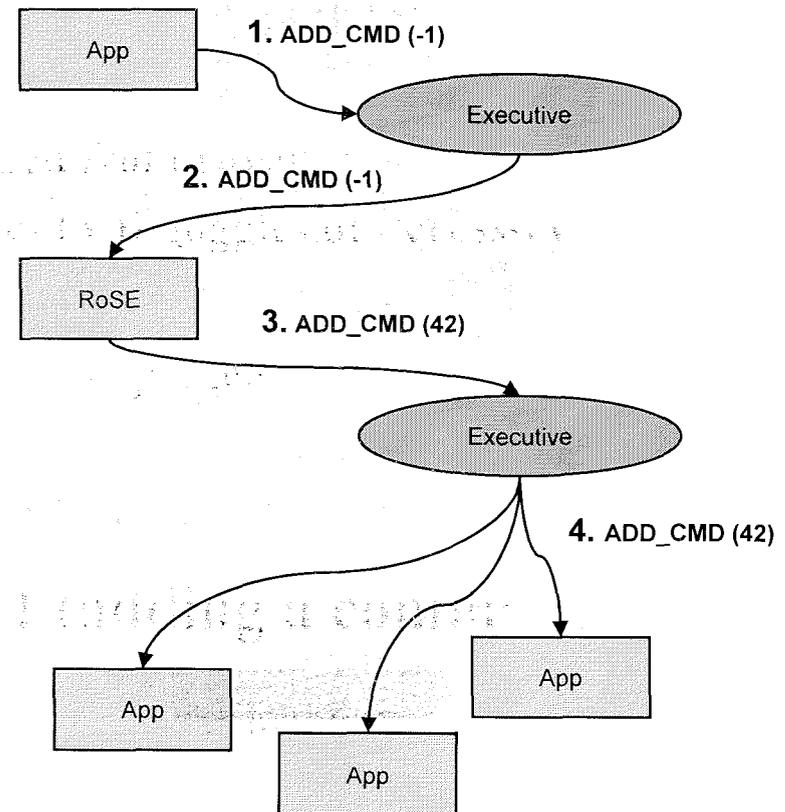
- **Logger**
 - Simple ASCII dump of messages flowing through the system
- **Image Browser**
 - Show mono/stereo images downlinked from rover
 - Stereo images shown in stereo modes (3-D goggles or “cross-eyed”)
- **Sequence Flow Browser**
 - Graphically displays timeline for each sequence
 - Commands appear on the timeline where they execute
 - Overlays comm windows when info available
- **Other applications as needed**
 - Modular design: add new functionality by writing a new component app; plug it in by adding it to a configuration file



Message-passing example #1 (adding a command) **JPL**

1. Component app sends ADD_CMD to Executive with special -1 command ID
2. Executive notices -1 ID, sends to RoSE
3. RoSE assigns ID (here, 42), adds command internally, passes resulting message back to Executive
4. Executive broadcasts message to all apps

When RoSE itself adds a command, process starts at step #3.





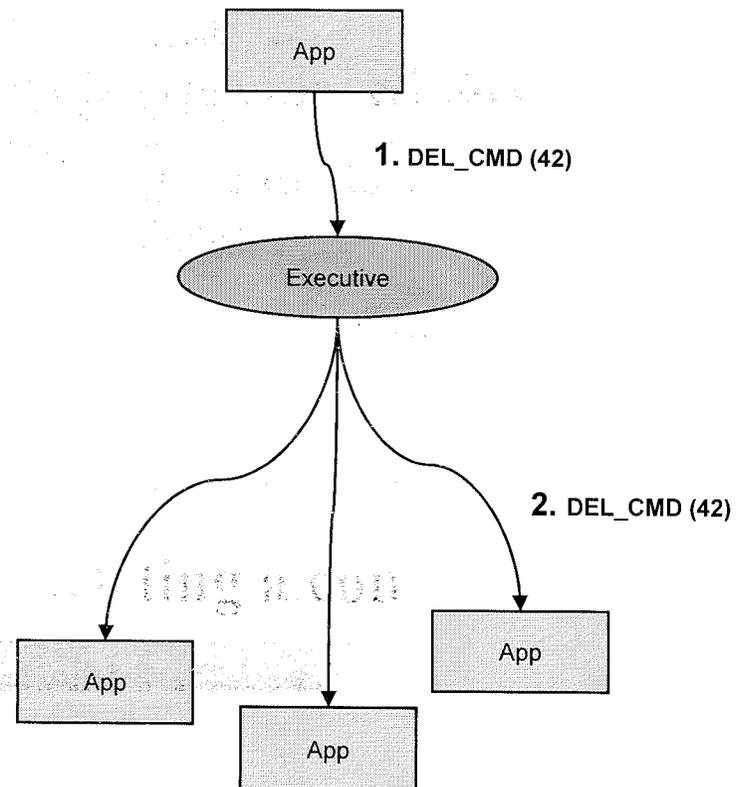
Message-passing example #2 (deleting a command) **JPL**

1. Component app sends
DEL_CMD message with ID of
command to delete

- XML text for command is also included for the benefit of human readers; not needed by tools

2. Executive broadcasts **DEL_CMD** message to all other tools

Most cases are as simple as this one;
the **ADD_CMD** case is unusual





All message types



<u>Message</u>	<u>Description</u>	<u>Message</u>	<u>Description</u>
ADD_CMD	Add a command	MOD_REGION	Modify a no-go region
DEL_CMD	Delete command	SET_REFERENCE_POINT	Set a reference point
MOD_CMD	Modify command	SET_XFM	We don't remember what this was supposed to be for!
CMD_CONTROL	Random extensions (save RML, kill one component app, etc.)	SEQGEN_DURATIONS	HyperDrive-modeled command durations to send to SEQGEN
NEW_RML	New RML file	SEQGEN_TIMES	Command start times received from SEQGEN
ADD_RML	Add RML text to file	EXPLORE_FUTURE	Explore a "future" (in which a set of conditional commands is assumed to work out in a specified way)
3D_CURSOR	Place 3-D cursor	SELECT_FUTURE	Select a previously explored future
SET_INSERT_PT	Set insertion point for next added command	SET_STATE	Set state data (a name/value pair)
LAUNCH_SUBTOOL	Launch named RSVP component app	IMAGE_DATA	New image data from Image Browser
KILL_SUBTOOLS	Kill all non-RoSE component apps	SEL_CMD	Set of commands to select in tools
ADD_REGION	Add a no-go region	SEL_ADD	Add to set of selected commands
DEL_REGION	Delete a no-go region	SC_ID	Spacecraft ID and related info



Conclusion: message passing is good



- **Facilitates multi-language development**
 - **RoSE, Executive, Logger in Java**
 - **HyperDrive, Image Viewer, Sequence Flow Browser in C++**
 - **Other apps could be written in any language that can connect to PVM (Perl, Python, etc.)**
- **Can develop components independently**
 - **All inter-application interfaces “forced” to be clean**
- **Easily add/remove functionality**
- **Send messages across network instead of machine-local to get load-balancing/collaboration “for free”**