Remote operations tools, infrastructure and logistics used during the LITA 2004 expedition and development priorities for 2005

Peter Coppin
EventScope Project/Remote Experience and Learning Lab, Carnegie Mellon University
[Karl Fischer, Melissa Ludowise, Luisa Lu, Eben Myers, Mike Wagner, Ron McCloskey,
with help from Dan Cuellar, Trey Smith, Dave Thompson and Kristen Stubbs]
Carnegie Mellon University
January 6, 2005
[Far away places]

[EventScope lab, team and tools]

[Museums, homes and schools]
Presentation overview

• Topics
  – Teleoperations center
  – Interfaces
    • Uplink
    • Downlink [via web and the ops interface]
  – E/PO [tomorrow]

• Presentation format for each topic
  – Review initial concepts that guided our 2004 development
  – Review concepts that were implemented
  – Review what worked & what needs to be improved
  – Development priorities for 2005
04 ops concepts were based on 03 shakedown [and MER]
Teleoperations center
Science Activity Areas:
Two science activity areas for two theme groups. Consists of:
- Computers
- Projectors

Instrument Teams:
- Other computing areas for instrument specialists
- Wireless internet for scientist laptops
- Support and EventScope staff

Observations and ethnography
- Cameras and recording devices
- Observers: Stubbs, Thomas, Glasgow, Hinds

K. Stubbs, 7/28/04  Updated: E. Myers, 9/27/04
Science Ops
Room Layout v.3.1a

Figure is drawn to scale.
1/8” in figure = 1’ in room

Key:
Scientists
ES
ES EPO
General

Behind curtain is same as v.2
(see slide 4)

K. Stubbs, 7/28/04  Updated: E. Myers, 9/27/04
Science Ops
Room Layout v.3.1b

Figure is drawn to scale.
1/8" in figure = 1’ in room

Key:
Scientists
ES
ES EPO
General

Behind curtain is same as v.2 (see slide 4)

K. Stubbs, 7/28/04  Updated: E. Myers, 9/27/04
Science Ops
Room Layout v.3

*Figure is drawn to scale.*
*1/8” in figure = 1’ in room*

**Key:**
- Scientists
- ES
- ES EPO
- General

Behind curtain is same as v.2 (see slide 4)

---

Work Areas
Desks and chairs for individual work

Wall available for use of sketchpads and whiteboard

Food/Coffee Table

Projector screen

Secondary Meeting Area
Includes one ops workstation (with a projector) possibly for FI work.

Central Meeting Table
Includes two ops workstations (each with a projector)

Printers

Projector screens

curtain
Logistical considerations

Teleoperation center housed with ES staff for extra support [ref. 03]

Near Craig St. Amenities
   Hotels
   Mass transit
   Food
   Coffee
Data presentation through ops workstations, individual laptops and paper

Mapping and brainstorming on pin walls
Science activity stations
Science activity station [cont.]
Science activity station [detail]
What worked/ what needs improvement

- **What worked**
  - Overall room layout and it’s reconfigurability [we went through 2 iterations].
    - Map areas/pin walls
  - Location near hotels, transit, food, coffee shop
  - Surveillance and ethnography support
  - VNC [a form of remote desktop] worked great for distributed ops

- **Areas that need improvement**
  - Wireless internet was flaky
  - Need kitchen area/breakroom [we have one as of Jan05]
  - Need better conference phone
  - Need more light
  - More tables and chairs
Interfaces
Interface types

- Uplink interface
- Downlink interfaces
  - EventScope
  - Web [with Dan Cuellar, David Seneker and Trey Smith]
- Triangulation tool
- E/PO interfaces [to be presented tomorrow]
Uplink interface / downlink interface
Uplink interface pin concept
Specifying actions with the action palette

1. Click
2. Select
3. Tune parameters
Switching between actions
Switching between actions through the use of pins or toggle buttons
“Cutting and pasting” previous actions to save time and reduce effort
Specifying a “via point” [a location with no actions]
Running a sample plan by using the “quicklook” feature to get feedback from local planning software
Uplinking the plan
What happens when we uplink a plan:

- Human/machine readable .xml uploads to the Remote Download Directory [RDL]
- A visualization of the plan uploads to the RDL for later reference
Various ops screenshots
Uplinking: Next steps

- **What worked**
  - Science team operated tools on their own [contrast to initial expectations]
  - CVS version installed on ops workstations enabled us to improve interface during expedition. Example:
    - Added the ability to copy previous actions
    - Changed the .xml file to make it human readable

- **Areas that need improvement**
  - Work with rover team to integrate ops tests with rover tests
  - Quicker integration of orbital data enables scientists to know when they are in an unplannable area [requires orbital visible data prior to expedition]
  - Fix overlapping text on pins through better scaling during DEM navigation
  - Minor interface change: Put actions in chronological order
  - Include rational from the rover or field team that explains why locals were skipped
  - Include common actions in interface. This is partially achieved through cut and paste feature.

- **Questions**
  - Quicklook plan simulator
  - Could we replace request ID’s with local names?
Downlinking techniques

- **Method 1: via science website**
  - **Pros:**
    - Familiar Mozilla/ IE interface
    - Easy for scientists to bring data into other tools
  - **Cons:**
    - Data is not *visually* correlated to the DEM or pins

- **Method 2: via ops interface**
  - **Pros:**
    - Data is hyperlinked to the pins on the DEM
    - Path of the rover is visualized in interface
  - **Cons:**
    - Greater dependence on rover systems [dangerous during the rover debugging phase]
Downlinking through the Remote Download Directory [RDL]
Downlink: Rover path visualization
Pins are linked to data
Downlink: other data
Other downlink screenshot Friday [note data from localization system]
Dowlink via the Atacama Science website
[Dan Cuellar, David Seneker, Trey Smith]
Atacama science web site contains:

– View Data Folder [this was the primary resource during the mission]
– The ability for team members to upload files
– Documents [science command dictionary, Zoë camera layout, data size chart [rough sizes]]
– Orbital data
– Tools [search, etc.]
Welcome to the Atacama Science Site. There will be a front page here eventually. This is the section of the website which will contain tools for scientific analysis that can be used in parallel with eventscope.

- New
  - Science Command Dictionary
  - Zoe Camera Layout
  - CRUDE APPROXIMATE ROUGH data sizes

- Tools
- Data Search
- DEMs
  - Site B
  - Site C
- Satellite Images
  - Site B
  - Site C

- Other
  - Resourcesat 1 data
  - Upload File
  - View Files
  - View Data Folder

© 2003-2005 Carnegie Mellon University
## Directory listing of /data04

<table>
<thead>
<tr>
<th>Name</th>
<th>Last Modified</th>
<th>Size</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parent Directory</td>
<td></td>
<td></td>
<td>directory</td>
</tr>
<tr>
<td>backups</td>
<td>00:22:51 2004/10/06</td>
<td>-----</td>
<td>directory</td>
</tr>
<tr>
<td>example_composite</td>
<td>15:36:02 2004/10/29</td>
<td>-----</td>
<td>directory</td>
</tr>
<tr>
<td>siteB</td>
<td>08:54:22 2004/09/22</td>
<td>-----</td>
<td>directory</td>
</tr>
<tr>
<td>siteC</td>
<td>20:23:41 2004/10/09</td>
<td>-----</td>
<td>directory</td>
</tr>
<tr>
<td>sol01</td>
<td>13:21:19 2004/09/17</td>
<td>-----</td>
<td>directory</td>
</tr>
<tr>
<td>sol02</td>
<td>13:21:19 2004/09/17</td>
<td>-----</td>
<td>directory</td>
</tr>
<tr>
<td>sol03</td>
<td>13:21:19 2004/09/17</td>
<td>-----</td>
<td>directory</td>
</tr>
<tr>
<td>sol04</td>
<td>13:21:19 2004/09/17</td>
<td>-----</td>
<td>directory</td>
</tr>
<tr>
<td>sol05</td>
<td>16:10:17 2004/09/17</td>
<td>-----</td>
<td>directory</td>
</tr>
<tr>
<td>sol06</td>
<td>23:46:40 2004/09/17</td>
<td>-----</td>
<td>directory</td>
</tr>
<tr>
<td>sol07</td>
<td>18:59:17 2004/09/18</td>
<td>-----</td>
<td>directory</td>
</tr>
<tr>
<td>sol08</td>
<td>17:46:24 2004/10/04</td>
<td>-----</td>
<td>directory</td>
</tr>
<tr>
<td>sol09</td>
<td>19:25:42 2004/10/05</td>
<td>-----</td>
<td>directory</td>
</tr>
<tr>
<td>sol10</td>
<td>00:41:15 2004/10/06</td>
<td>-----</td>
<td>directory</td>
</tr>
<tr>
<td>sol11</td>
<td>22:32:48 2004/10/06</td>
<td>-----</td>
<td>directory</td>
</tr>
<tr>
<td>test fi fov</td>
<td>15:59:34 2004/10/29</td>
<td>-----</td>
<td>directory</td>
</tr>
</tbody>
</table>
### Directory listing of /data04/siteB

<table>
<thead>
<tr>
<th>Name</th>
<th>Last Modified</th>
<th>Size</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>sol1</td>
<td>13:21:19 2004/09/17</td>
<td>------</td>
<td>directory</td>
</tr>
<tr>
<td>sol3</td>
<td>13:21:19 2004/09/17</td>
<td>------</td>
<td>directory</td>
</tr>
<tr>
<td>sol4</td>
<td>13:21:19 2004/09/17</td>
<td>------</td>
<td>directory</td>
</tr>
<tr>
<td>sol5</td>
<td>16:10:17 2004/09/17</td>
<td>------</td>
<td>directory</td>
</tr>
<tr>
<td>sol6</td>
<td>23:46:40 2004/09/17</td>
<td>------</td>
<td>directory</td>
</tr>
<tr>
<td>sol7</td>
<td>18:59:17 2004/09/18</td>
<td>------</td>
<td>directory</td>
</tr>
<tr>
<td>weather</td>
<td>17:58:35 2004/09/18</td>
<td>------</td>
<td>directory</td>
</tr>
<tr>
<td>weather.test</td>
<td>16:54:42 2004/09/22</td>
<td>------</td>
<td>directory</td>
</tr>
</tbody>
</table>
## Directory listing of /data04/siteB/sol4

<table>
<thead>
<tr>
<th>Name</th>
<th>Last Modified</th>
<th>Size</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parent Directory</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TIR locales7-11</td>
<td>19:26:15 2004/09/15</td>
<td>------</td>
<td>directory</td>
</tr>
<tr>
<td>locale08</td>
<td>00:28 2004/09/15</td>
<td>------</td>
<td>directory</td>
</tr>
<tr>
<td>locale10</td>
<td>20:15:03 2004/09/15</td>
<td>------</td>
<td>directory</td>
</tr>
<tr>
<td>telemetry</td>
<td>20:01:53 2004/09/15</td>
<td>------</td>
<td>directory</td>
</tr>
<tr>
<td>weather</td>
<td>17:58:35 2004/09/18</td>
<td>------</td>
<td>directory</td>
</tr>
</tbody>
</table>
Directory listing of /data04/siteB/sol4/locale08

<table>
<thead>
<tr>
<th>Name</th>
<th>Last Modified</th>
<th>Size</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parent Directory</td>
<td></td>
<td></td>
<td>directory</td>
</tr>
<tr>
<td>4 25 SPI</td>
<td>08:00 2004/09/16</td>
<td></td>
<td>directory</td>
</tr>
<tr>
<td>4 29 VNIR</td>
<td>18:52:42 2004/09/15</td>
<td></td>
<td>directory</td>
</tr>
<tr>
<td>4 30 FI</td>
<td>15:56:45 2004/10/29</td>
<td></td>
<td>directory</td>
</tr>
<tr>
<td>4 30 WKS</td>
<td>15:57:17 2004/10/29</td>
<td></td>
<td>directory</td>
</tr>
<tr>
<td>TIR locales7-11</td>
<td>19:26:15 2004/09/15</td>
<td></td>
<td>directory</td>
</tr>
</tbody>
</table>
### Directory listing of `/data04/siteB/sol4/locale08/4_25_SPI`

<table>
<thead>
<tr>
<th>Name</th>
<th>Last Modified</th>
<th>Size</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parent Directory</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>00 raw data</td>
<td>15:57:16 2004/10/29</td>
<td>-----</td>
<td>directory</td>
</tr>
<tr>
<td>00 stereo</td>
<td>22:13:53 2004/09/15</td>
<td>-----</td>
<td>directory</td>
</tr>
<tr>
<td>00 panorama.html</td>
<td>22:13:53 2004/09/16</td>
<td>10.4 kB</td>
<td>text/html</td>
</tr>
<tr>
<td>script.txt</td>
<td>12:05:11 2004/09/16</td>
<td>3.6 kB</td>
<td>text/plain</td>
</tr>
<tr>
<td>tile -104 -12.html</td>
<td>14:06:09 2004/09/16</td>
<td>698 bytes</td>
<td>text/html</td>
</tr>
<tr>
<td>tile -104 -40.html</td>
<td>14:06:09 2004/09/16</td>
<td>698 bytes</td>
<td>text/html</td>
</tr>
<tr>
<td>tile -104 15.html</td>
<td>14:06:09 2004/09/16</td>
<td>695 bytes</td>
<td>text/html</td>
</tr>
<tr>
<td>tile -104 2.html</td>
<td>14:06:09 2004/09/16</td>
<td>692 bytes</td>
<td>text/html</td>
</tr>
<tr>
<td>tile -123 15.html</td>
<td>14:06:09 2004/09/16</td>
<td>695 bytes</td>
<td>text/html</td>
</tr>
<tr>
<td>tile -123 2.html</td>
<td>14:06:09 2004/09/16</td>
<td>692 bytes</td>
<td>text/html</td>
</tr>
<tr>
<td>tile -142 -40.html</td>
<td>14:06:09 2004/09/16</td>
<td>698 bytes</td>
<td>text/html</td>
</tr>
<tr>
<td>tile -142 15.html</td>
<td>14:06:09 2004/09/16</td>
<td>695 bytes</td>
<td>text/html</td>
</tr>
</tbody>
</table>
locale08/4_25_SPI] pano tile: az=68 el=-12

```json
{
  rover => "Z",
  reason => "S",
  azimuth => "68.296571",
  elevation => "-12.370159",
  request_id => "4_25",
  time_utc => "GMT 2004 Sep 15 17:39:11.990815",
  instrument => "spi",
  width => 320,
  height => 240,
  file_bytes => 230400,
  color_data => "rgb",
  which_camera => "M",
  exposure_time_seconds => 0,
  aperture_f_number => 0,
  file_name => "U040915_1739_155SPIM_____raw3.ppm"
}```
**Directory listing of /data04/siteB/sol4/locale08**

<table>
<thead>
<tr>
<th>Name</th>
<th>Last Modified</th>
<th>Size</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Parent Directory</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 29 VNIR</td>
<td>18:52:42 2004/09/15</td>
<td>-----</td>
<td>directory</td>
</tr>
<tr>
<td>4 30 FI</td>
<td>6:45 2004/10/29</td>
<td>-----</td>
<td>directory</td>
</tr>
<tr>
<td>4 30 WKS</td>
<td>15:57:17 2004/10/29</td>
<td>-----</td>
<td>directory</td>
</tr>
<tr>
<td>TIR locales7-11</td>
<td>19:26:15 2004/09/15</td>
<td>-----</td>
<td>directory</td>
</tr>
</tbody>
</table>

© 2003-2005 Carnegie Mellon University
## Directory listing of `/data04/siteB/sol4/locale08/4_30_FI`

<table>
<thead>
<tr>
<th>Name</th>
<th>Last Modified</th>
<th>Size</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parent Directory</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2040915 1808 005FIPN1RGBF rawS.jpg</td>
<td>08:18 2004/09/15</td>
<td>1.1 MB</td>
<td>image/jpeg</td>
</tr>
<tr>
<td>2040915 1808 005FIPN1RGBF rawS.jpg.thumb</td>
<td>15:56:44 2004/10/29</td>
<td>5.6 kB</td>
<td>application/octet-stream</td>
</tr>
<tr>
<td>2040915 1808 005FIPN1RGBF rawS.ppm.meta.old</td>
<td>23:01:55 2004/09/15</td>
<td>406 bytes</td>
<td>text/plain</td>
</tr>
<tr>
<td>2040915 1810 006FIP54X74MS rawS.jpg</td>
<td>18:33:49 2004/09/15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2040915 1810 006FIP54X74MS rawS.jpg.meta</td>
<td>13:43:20 2004/09/15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2040915 1810 006FIP54X74MS rawS.jpg.thumb</td>
<td>15:56:43 2004/09/15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2040915 1810 010FIP54X74MS rawS.jpg</td>
<td>18:35:30 2004/09/15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2040915 1810 010FIP54X74MS rawS.jpg.meta</td>
<td>13:43:20 2004/09/15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2040915 1810 010FIP54X74MS rawS.jpg.thumb</td>
<td>15:56:45 2004/09/15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2040915 1814 014FIB45X74MS rawS.jpg</td>
<td>18:37:14 2004/09/15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2040915 1814 014FIB45X74MS rawS.jpg.meta</td>
<td>13:43:20 2004/09/15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2040915 1814 014FIB45X74MS rawS.jpg.thumb</td>
<td>15:56:44 2004/09/15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2040915 1815 018FIP54X74MS rawS.jpg</td>
<td>18:38:45 2004/09/15</td>
<td>945.5 kB</td>
<td>image/jpeg</td>
</tr>
<tr>
<td>2040915 1815 018FIP54X74MS rawS.jpg.meta</td>
<td>10:40:22 2004/09/21</td>
<td>521 bytes</td>
<td>text/plain</td>
</tr>
</tbody>
</table>
Welcome to the Atacama Science Site. There will be a front page here eventually. This is the section of the website which will contain tools for scientific analysis that can be used in parallel with eventscope.

- New
  - Science Command Dictionary
  - Zoe Camera Layout
  - CRUDE APPROXIMATE ROUGH data sizes

- Tools
- Data Search
- DEMs
  - Site B
  - Site C
- Satellite Images
  - Site B
  - Site C
- Other
  - Resourcesat 1 data
  - Upload File
  - View Files
  - View Data Folder

© 2003-2005 Carnegie Mellon University. All rights reserved. Webmaster.
Local File System at /science/files

You may upload a file using the form below. Choose an existing file from your local computer by clicking the Browse button.

File: [Browse]

You can also create new directories relative to the base:

Path: [Create Directory]

StreamingFile used: 1
Downlink interface

• What worked
  – Request ID system, though hard at first was a huge improvement over 03
  – Web
  – Data access through pins [on prototype level]
  – Visualization that represented the path of the rover

• What needs improvement
  – Data access through pins either needs to be improved or scrapped. Depends on rover localization and other factors
  – Improve 3D pan data if we want to navigate within the pan
  – Focus on usability of web, but keep it simple
    • Take a look at science reports [Lucia example, Trey example, Geb ideas]
Take a look at science reports for data representation ideas [Lucia example, Trey examples, Geb ideas]
Triangulation tool
Triangulation tool
Triangulation tool
Triangulation tool
Triangulation tool: Next

- Good concept and potentially very valuable for operations [note rover localization issues]
- Needs more testing with real datasets [prioritize in relation to competing priorities]
- Needs better focus on usability
- Address texture and DEM registration
Remote experiences at museums
Remote Experiences for the public

• 3D Virtual Environment updates each day for public and museum downloads
EventScope remote experience .pse files
Conclusions from 2nd ops briefing

- Round trip data tracking
  - Great progress with request ID and database system
  - Perhaps make it more visual

- Improve testing schedule through integration with rover team

- Thumbnails for science website
  - Lucia ideas, Geb ideas, Trey ideas, include other ethnographic feedback

- Distributed ops
  - VNC worked great, but need better speaker phone system

- Better integration of orbital data
  - Suggest conducting orbital pre-mission using distributed operations prior to on site live expedition
    - Enables us to familiarize ourselves with orbital data, align coordinate frames, etc.
    - Enables us to refine distributed operations prior to live mission

- Expand mission templates: Nathalie’s standard package idea

- Bore site the spectrometer

- Room: Create more individual work areas [now possible]
Overall conclusions

- Most findings from 03 shakedown test incorporated into 04 ops...[but need testing-integration time to reap full benefits]

- Uplink vs. downlink interfaces
  - Use ops interface
    - For uplinking
    - To visualize the path of the rover
  - Use web for downlinking

- Improve map registration

- Finish triangulation tool

- Keep ops room the same, utilizing benefits of new amenities
  - Improve printing

- Question: In 2005 will we be targeting rover’s within the pan? Role of 3D pan data

- Quick look plan simulator: clarify next steps [prioritize]

- Get feedback from ethnographers

- Base ops interface on E/PO interface to reduce the number of buttons?

- Camera positions/ context images: Chong slides and context images for rover?
Remote ops discussion
Contact

Peter Coppin
coppin@cmu.edu