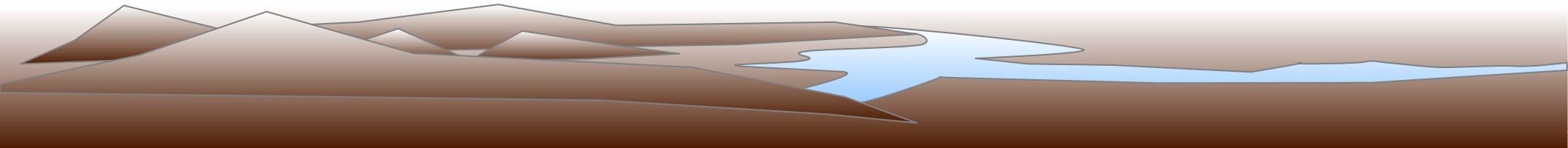
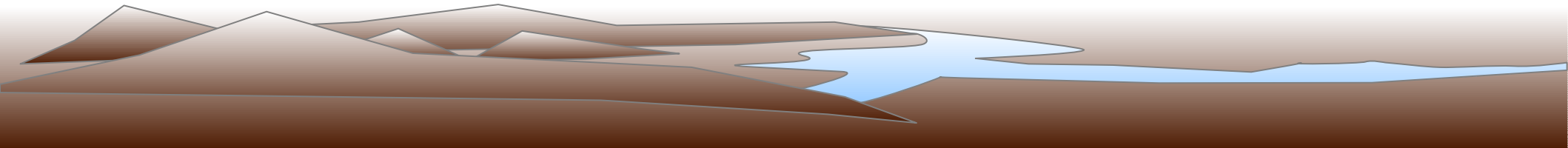
# Conversion from Classical to Robotic Astronomy: The Lowell Observatory 0.8-m Telescope

Marc W. Buie
Southwest Research Institute
Boulder, CO



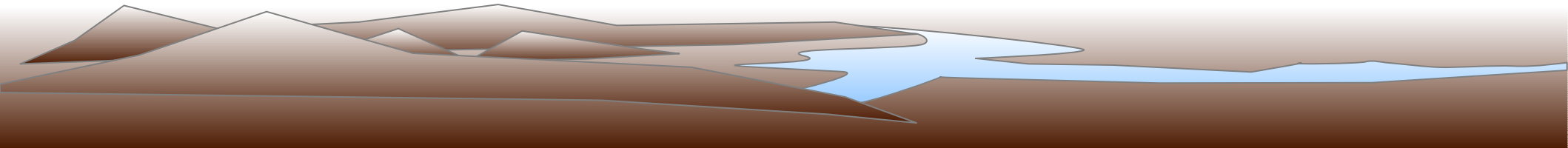
# Philosophical Approach

- Robotic mode is a new option, not a conversion
- Observing with no oversight during the night
  - No image display
  - Log files are only source of feedback
- Foundation of system is an automaton
- Modular and layered design
- Linux/Solaris platform
- No off-site network connectivity required



# Ground Rules and Other Constraints

- Zero impact allowed on classical observing
- Continue to support instrument changes
- Essentially no funding or institutional support
- Do no harm to people or equipment
- Minimal effort required for operational support



# System Overview

- One process per system
  - `move` – telescope interface layer
  - `roboccd` – camera operation
  - `cmdr` – observing queue
- Communication via IPC messages
  - Fast and tight communication
  - Simple program design
- Everything is modular and separate

# Telescope

- 0.8-m aperture, Anderson Mesa Station
- English-yoke equatorial mount
  - 60°N pointing limit, very stable
- Closed-tube made of aluminum
  - Very strong temperature/focus relationship
- Digital stepper motors, RA/DEC and focus
- Ash dome
  - upper/lower shutter with narrow power pad
  - Bar code reader for absolute position knowledge

# Camera(s)

- PCCD (2001-2005)
  - Photometrics TH7883 CCD (384x576), 1.3"/pix
  - Thermoelectrically cooled: –43°C
  - 10-position filter wheel
- NASAcam (2007-present)
  - EEV 2k CCD, 0.45"/pixel
  - Leach Gen3 readout electronics
  - Cryotiger cooling: –112ºC
  - Two 10-position filter wheels

# Environmental Data

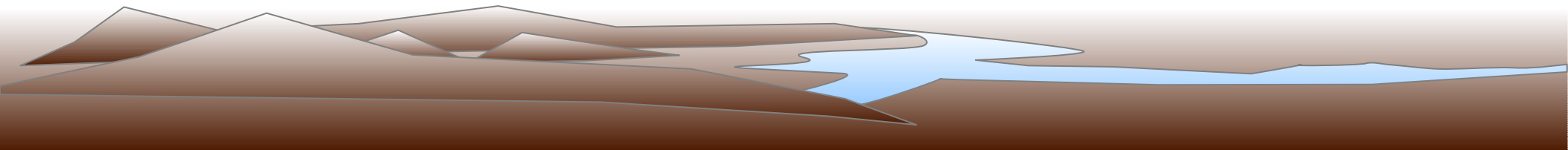
- Davis weather station with server/logger
- Color day-time webcam (90° FOV)
- B/W high-sensitivity night camera (90° FOV)
- Dome CCTV monitoring camera
- Boresight high-sensitivity camera (10x14° FOV)
- Tube, mirror, and dome air temperature

# Interesting Lessons Learned

- How much real-time analysis?
  - Peak pixel: x, y, DN, FWHM, aperture flux
  - Sky background: mean, standard deviation
- How to focus?
  - Focus sweep, 1 second exposures work
  - No fitting, find best figure-of-merit (peak/flux)
- Timing control – LST is your friend
- No automated error recovery
  - Supervised recovery, only one failure allowed

# Interesting Lessons Learned, cont'd

- Good log files are critically important
  - Balance required between too much and too little
  - Use good search string markers for use with grep
  - Time-tag *everything*
  - *All* machines involved need good time, use ntp
- Standard star scheduling
  - Magic time when standard field at X=2.5
  - Work science data around standards



# Interesting Lessons Learned, cont'd

- Demand for this system was limited at Lowell
  - Inertia, mysterious but consistent with most professional observatories
  - Non full-time mode excluded some projects
- Maintenance (non-observing) costs independent of classical/robotic usage

# Come see the poster for more details