Mount Stromlo Space Research Centre
Mt Stromlo SLR Station (7825)

- Operating since early 2004.
- Tracking automatically since mid 2006.
- Operates automatically and often unmanned for significant periods (over many days).
- Supporting staff levels are small (typically 2).
- Operates 24/7 irrespective of weather.
- One of the most productive stations in the world.
- Significant experience with automation.
What constitutes an Automated SLR Station?
Components of a Fully Automated SLR Station

Supporting Infrastructure
(Site/Building, Hardware, Computing Facilities)
Components of a Fully Automated SLR Station

Automated Scheduler

Supporting Infrastructure (Site/Building, Hardware, Computing Facilities)
Components of a Fully Automated SLR Station

Supporting Infrastructure
(Site/Building, Hardware, Computing Facilities)

Automated Scheduler

Automated Tracker
Components of a Fully Automated SLR Station

- Automated Scheduler
- Automated Tracker
- Automated File/Data Manager
- Supporting Infrastructure (Site/Building, Hardware, Computing Facilities)
Components of a Fully Automated SLR Station

- Automated Scheduler
- Automated Post processor
- Automated Tracker
- Automated File/Data Manager

Supporting Infrastructure
(Site/Building, Hardware, Computing Facilities)
Mt Stromlo Automation Infrastructure

- **Site & Building**
  - Secure building (24 hr monitoring)
  - Reliable power and communications
  - Aircraft safety (Lidar, ADS-B, IR Cameras)

- **Hardware Components**
  - 1m Telescope and sealed enclosure
  - Laser system (new, recently installed)
  - Mets (new, recently installed)
  - External calibration targets (cf previous workshops)
  - Stable, reliable, robust designs requiring minimal maintenance and manual intervention.

- **Computing Facilities**
Mt Stromlo Automation
Infrastructure

**1m Telescope**

- Excellent performance over 13 years
- Mount modelling every few months (>3)
- Original primary mirror coating
- Coude optics recoated ~3-4 years
- Good temperature stability
- No sun avoidance required
- Located in a sealed enclosure
Mt Stromlo Automation Infrastructure

Sealed Enclosure

- Provides telescope
  - sun avoidance
  - protection from rain, hail, snow, dust & stones
  - protection from wind loading
  - clean, isothermal & low humidity environment.

- Supports automated, unmanned operations any time of day and for any weather.
EOS Typhoon Enclosure
Mt Stromlo Automation Computing Facilities

- **Distributed Dedicated Computers (Win7)**
  - Local File Server to manager LAN
  - Hardware replacement ~4-5 years

- **Network supports remote control**
  - Via WAN to EOS staff offices
  - Via VPN clients elsewhere

- **Observatory Control System (OCS)**
  - Client-Server Architecture (see Canberra workshop, 2006)
  - C++ software components developed by EOSSS

- **System Control and Status Monitoring**
  - Client application to monitor and control servers
  - Fault identification and alerts (e-mail, SMS)
Mt Stromlo Automation Computing Facilities

Client Server Architecture.

Supports
- Incremental development
- Easy to add or remove functions & hardware.
- Minimize coupling between functions.
- Re-use.

Figure 2. Software architecture employed at Mt Stromlo (from M Pearson, Proc. of 15th International Workshop on Laser ranging, 2006)
Mt Stromlo Automation Computing Facilities

Schematic of automation servers –

- Data Distribution Server
- Scheduling Server
- Tracking Server
- Post Processing Server
Mt Stromlo Automation Computing Facilities

Client application supporting local and remote management of server operations and state.
Mt Stromlo Automation Computing Facilities

Client application supporting local and remote monitoring of servers and system components.
Mt Stromlo SLR System
Schematic of Primary Automation Servers

Prediction Suppliers
(CDDIS, EDC, Space Track...)

ILRS Data Centres
(CDDIS, EDC...)

Data Distribution Server

Elements Preprocessor

CPF, TLE files

XML files

Ranging System

Tracking Server

Scheduling Server

Schedule files

Post Processing Server

BRD files

Report Generator

NP and PR files
Mt Stromlo SLR System

Schematic of the Tracking Server

Ranging System (RangingServer, Telescope Server, LaserServer...)

Return Rate Calculator

Tracking Server

Search pattern script

Target Database

Ranging Data

bias (across, along)
window position, window width
ND

Averaging parameters
reset/clear

current return rate, current residual
current biases, current ND
current window width, current window position, target id
Auto Tracking

Search Pattern

Uses spiral search pattern until acquisition and then continuously looks for maximum signal using a delta azim/across & delta elev/along pattern.

Example shown obtained during initial tracking of cubesat “Biarri”
Auto Tracking

Progress

- Auto tracking functions developed and used at Mt Stromlo station (7849) in period 1998 – 2003.
- Auto tracking in continuous operation at Mt Stromlo station (7825) since 2006.
- Analysis of manual and automated tracking presented at Canberra (2006) workshop shows productivity was almost the same.
- Analysis of data from 10 years of tracking at Mt Stromlo indicates performance of auto-tracking has been maintained and is highly productive (up to 95% of possible passes tracked OK).
- More stations have adopted similar auto-tracking techniques.
Auto Tracking

Analysis of available passes successfully tracked. Includes all potentially trackable passes – ie good weather, no sun avoidance, predictions available, appropriate elevations etc.

There are many reasons for losses, eg equipment failure. But auto-tracking has been consistent. Data suggests >95% is achievable.
Summary

- Autonomous tracking has been successful over many years, but...
  - Consider additional search patterns.
  - Integrate script with tracking server to improve language capability.
  - Improve ND control responsiveness to keep return rates at single photon levels.
  - Simplify parameterization and integrate with target database.
Autonomous Data Management

Mt Stromlo SLR System Schematic of Primary Automation Servers

Prediction Suppliers (CDDIS, EDC, Space Track...)

ILRS Data Centres (CDDIS, EDC...)

Data Distribution Server

Everybody Preprocessor

Elements Preprocessor

Report Generator

CPF, TLE files

XML files

Ranging System

Scheduling Server

Tracking Server

Post Processing Server

Schedule files

BRD files

NP and PR files
Autonomous Data Management

- Download of prediction data, including
  - CPF files from CDDIS...
  - TLE file from Space Track...
  - EOP files from USNO...

- Upload of reports, including
  - Normal point, full rate data to EDC...
  - Operational report to clients...

- Intermediate processing including
  - Selecting the best CPFs
  - Extract TLE data and create files for each target
  - Creating reports from local data.

- Management of local files, including
  - Relocation of published files
  - Backup and archival of critical data.
Autonomous Data Management

- Autonomous Data Distribution Server
  - Define a script then set and forget.
  - Supports ftp, file and http(s) schemes.
  - Supports compression (libzip).
  - Proven robust to network problems, but...
  - Built on Qt4 networking library.

- Script of Transactions
  - Runs one transaction at a time.
  - Supports linked transactions (ie completing a transaction can start a new transaction).
  - Frequency of transactions is defined.
Autonomous Data Management

Processed files managed by the Data Distribution Server
Autonomous Data Management

Summary

- Currently in operation, replacing manual processes.
- Performs tedious/complex file management tasks.
- Supports timeliness of data transfers.
- Provides a log of all transactions.
- Provides alerts (e.g. email, SMS) of file transfer problems or failures.