Development of Automated SLR Data Processing at Mt Stromlo SLR Station

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Automated Post Processing

- **What?**

  Automatically...
  - input files containing CSPAD timing event epochs from ranging targets.
  - separate ranging measurements (signal) from noise.
  - extract/apply system calibration data.
  - generate output files including full rate and normal points.

- **Why?**

  To…
  - reduce (eliminate?) manpower requirements
  - improve responsiveness
  - improve quality and consistency of results
  - improve productivity

Challenges

- Manage system (pre- and post-) calibration data and apply them to SLR data in a reliable and consistent way.
- Identification of satellite returns in low S/N conditions and elimination of noise without
  - Significant signal data loss
  - Including noise (false positives)
- Developing a complex system consisting of many system components.

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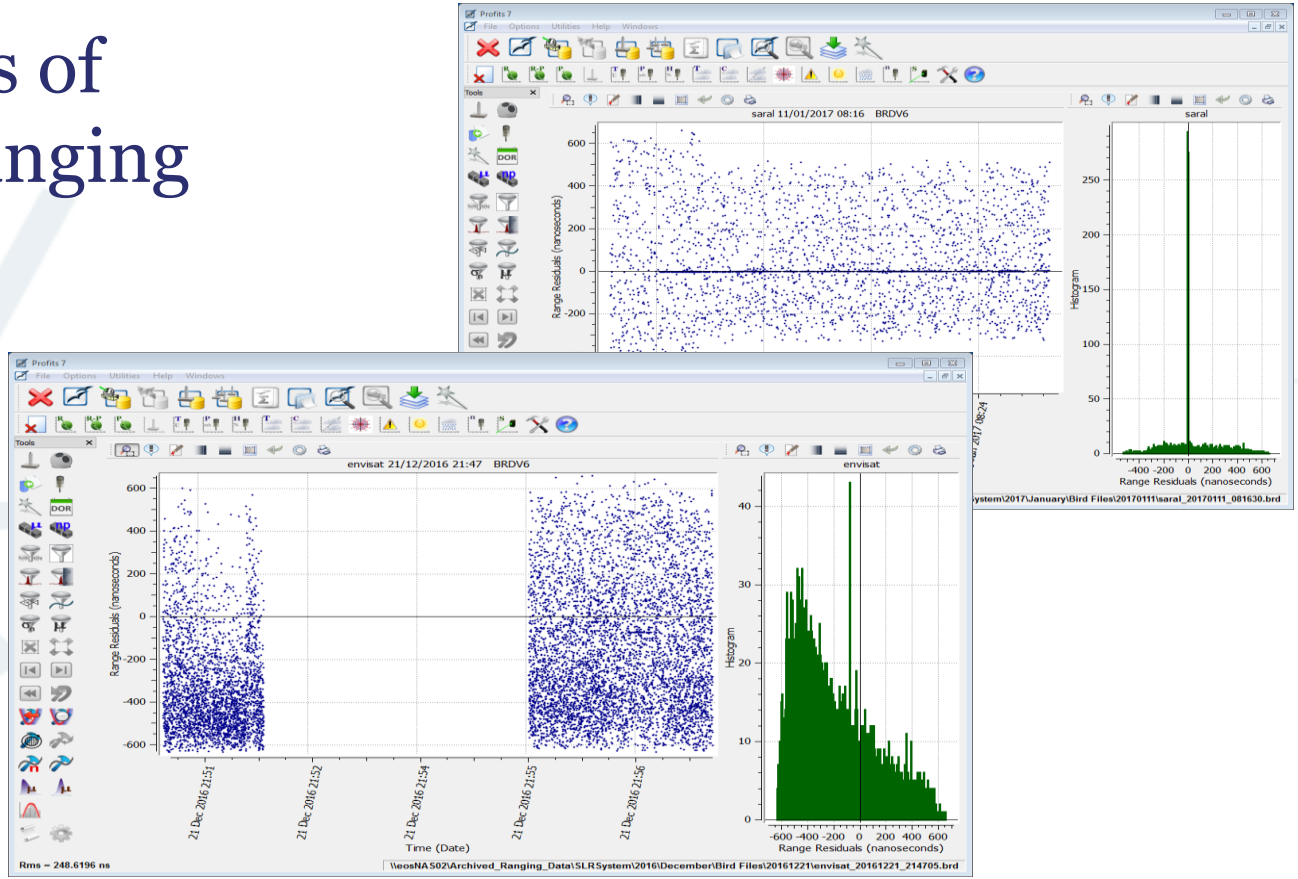
Examples of typical ranging data.



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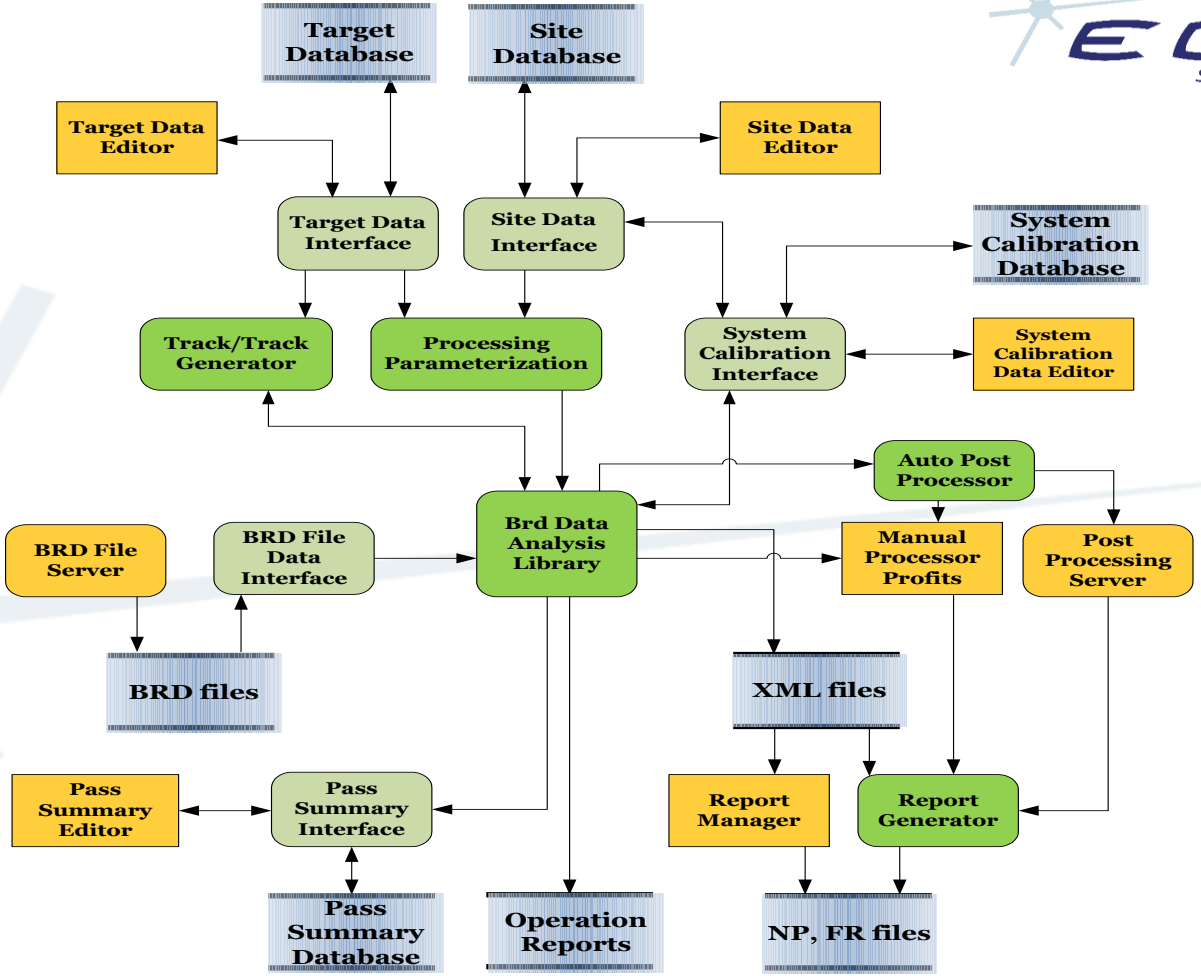
Mt Stromlo SLR System

Software modules supporting autonomous range data processing



Post Processor Characteristics

- Supports manual and automated processing.
- Input is binary range data (BRD) files generated by the system ranging server.
- Treats calibration target data similar to SLR data and applies the necessary system calibrations.
- Uses a configurable recipe of various data filtering and curve fitting procedures.
- Uses configurable normalized parameters.
- Output is an XML file of meta-data, full rate, normal point, mets and pointing data.
- Independent generation/publication of reports (CRD etc).

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Binary Range Data files (*.BRD)

- **Captures raw data from the ranging server, including;**
  - Pass metadata (System , Target, Track data)
  - Shot Events
  - Mets, Cloud data
  - Telescope Pointing
  - Prediction Element(s)
  - System State/Interlocks

- **Stored as serialized files using Google's Protocol Buffers.**
  - Compact (<50% of binary files.)
  - Efficient (Supports fast processing.)
  - Schema based(Supports backward compatibility.)

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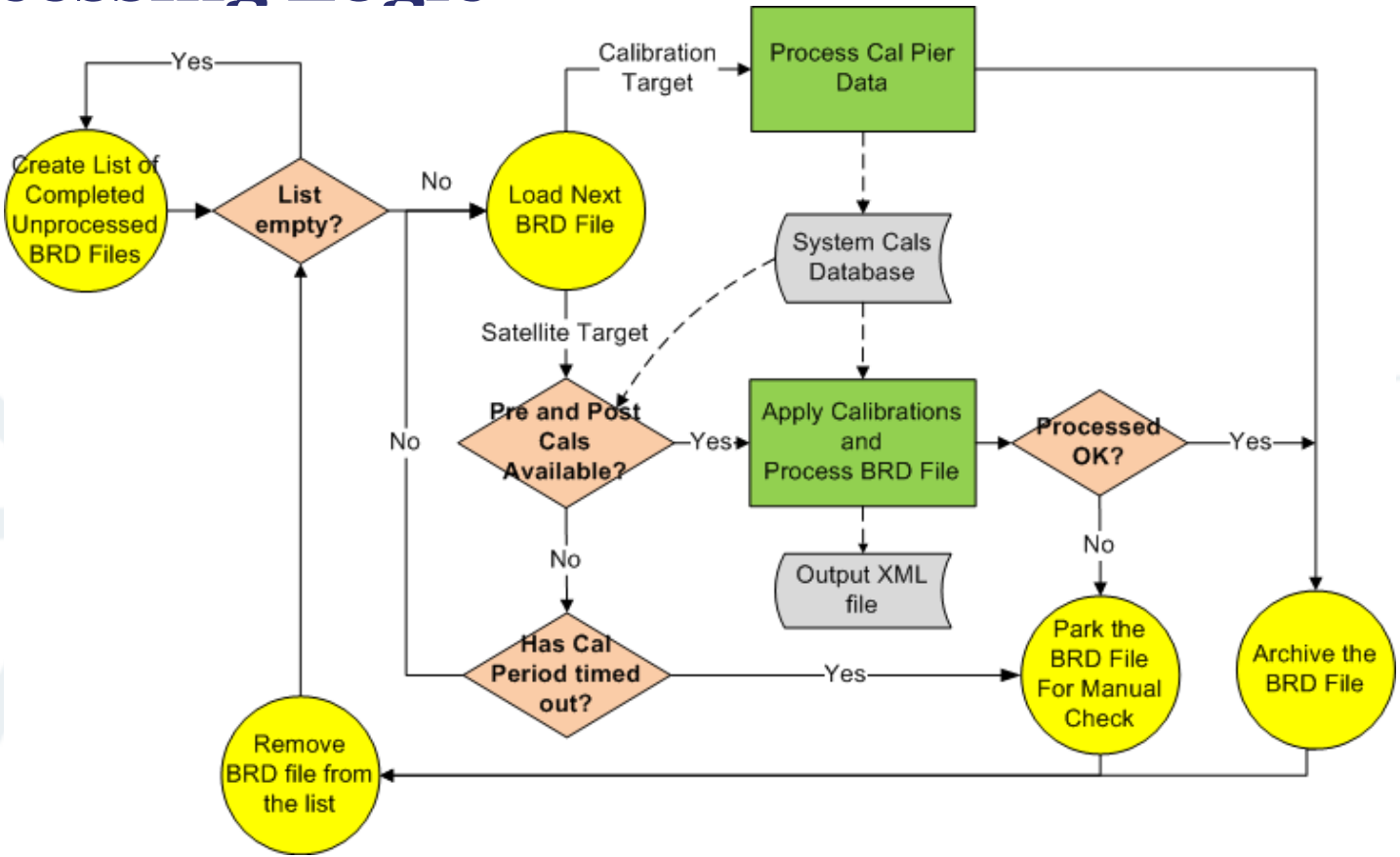
Processing Logic



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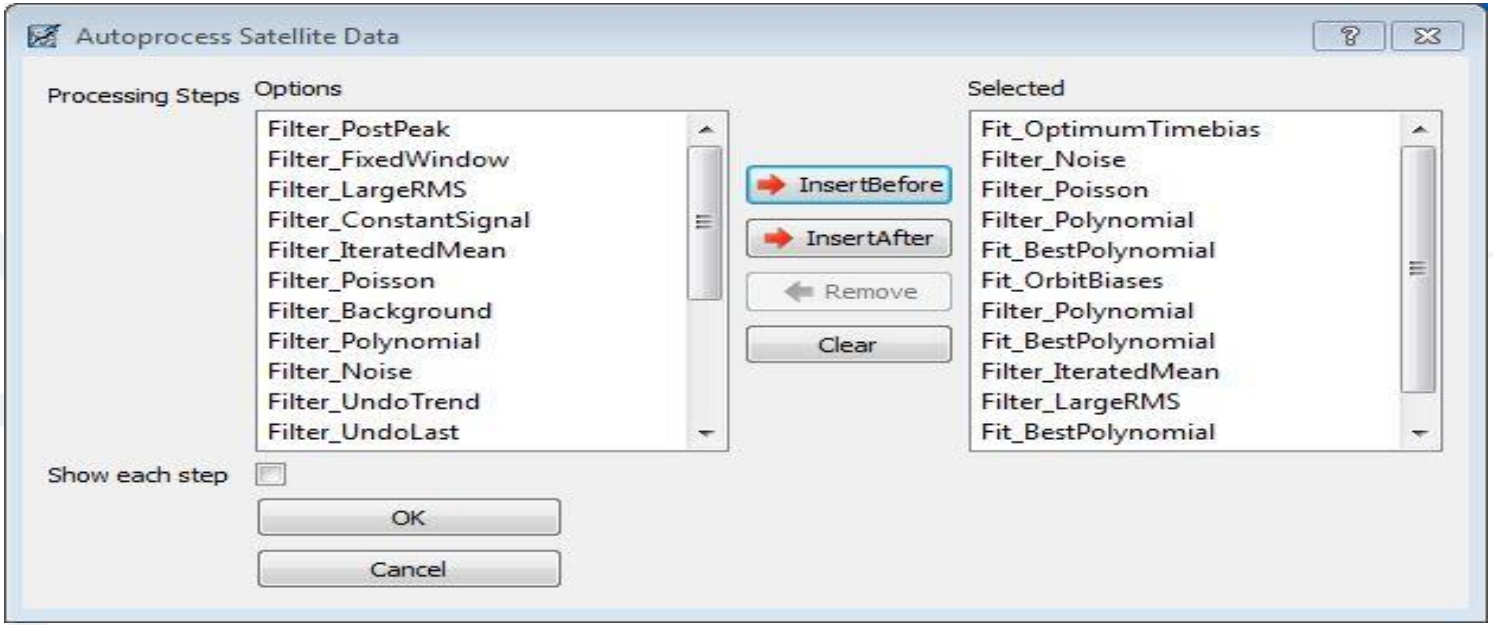
Processing Recipe



Processing Methods

Optimized Time Bias	Performs a recursive time bias scan to maximize the histogram peak. Identifies possible signal.
Noise Filter	Uses rectangular histogram bins (2 at a time) in time slices to remove as much sparse data as possible.
Poisson Filter	Uses rotated trapezoidal histogram bins (2 at a time) in time slices to identify probable signal and remove remaining noise. Based on Ricklefs and Shelus (1993), 8th International workshop on Laser Ranging Instrumentation.
Polynomial Filter	Uses polynomials of increasing degree to filter points outside a band around the fitted curve. This technique works well if sparse noise has been removed and the signal dominates the remaining data points.
Polynomial Fit	This selects the best polynomial to fit to the accepted data such that the polynomial degree does not exceed the maximum allowed, determined using the Akaike Information Criteria to avoid over-fitting. See Akaike H., 1974, IEEE Transactions on Automatic Control 19 (6): 716–723.
Orbital LS Fit	Undertakes a least squares fit to all the accepted data to minimize range bias and time bias. It is most effective when signal dominates noise. This method is applied once noise is removed to estimate range and time bias and to reset any fitting function.
Iterated Mean Filter	Used when the residual data is expected to be constant and distribution is probably non-Gaussian. During iteration, data on the wings of the distribution may be filtered. See Sinclair (1995) Proceedings of Annual Eurolas Meeting, Munich.
RMS Filter	Used as a final check for excessive spread of data within time bins.
Normal Point Generator	Generates normal point data according to the ILRS normal point algorithm (Sinclair, 1997).

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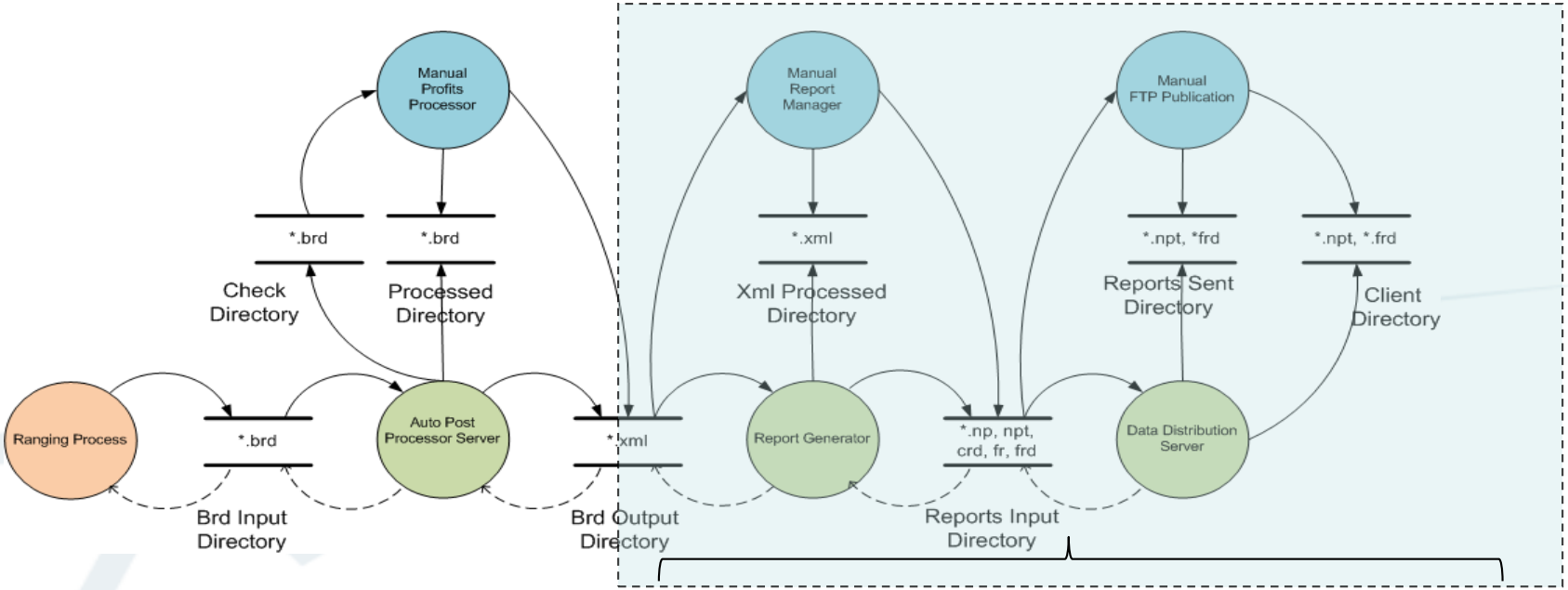
Autonomous Report Generation and Data Management



Processed files managed by the Data Distribution Server

Current Status

- **On-going analysis and regression testing, including**
  - Differential analysis of 20000+ manually and automatically processed BRD files.
  - Identification and focus on outliers, especially false positives.
  - Minimization of data loss.
  - External independent analysis.

Current Status

- Productivity 90-95% vs manual.
- False positives approaching acceptable level.
- Manual processing hand-off for special targets or inconclusive results.
- Supports evolutionary improvement.
- Adoption at Mt Stromlo imminent.