System Performance Assessment from NERC Simultaneous Arc Analysis

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Abstract: *Several years ago, the NERC Space Geodesy Facility in collaboration with the Department of Satellite Geodesy, Austrian Academy of Sciences, Graz developed an automatic LAGEOS Normal Point (NP) analysis service. This service enables quality checks of SLR network measurements on a very short timescale (i.e. within 24 hours). This technique includes both LAGEOS multi and short arc analyses. A short arc solution is generated on each LAGEOS pass that is tracked simultaneously by two or more EUROLAS stations. Simultaneous arc analysis, like collocation analysis, is primarily geometric. Geometric solutions are powerful, because the largest SLR error source, the orbit, is removed (i.e. cancels). Data aggregation of multiple pass results enables the delineation of coordinate errors from system problems at the sub-centimeter level. The NERC analysis has been instrumental in improving EUROLAS network performance.*

INTRODUCTION

In the mid 1990's, the NERC Space Geodesy Facility in collaboration with the Department of Satellite Geodesy, Austrian Academy of Sciences, Graz developed an automatic Normal Point (NP) analysis service. This service enables quality checks of SLR network measurements. The results of these analyses are based on multi and short arc orbital solutions. The key features of this service are as follows:

- Automatic
- Updated daily
- Graphical
- Web-based (http://nercslr.nmt.ac.uk/slrweb/auto_analysis.html)

The inputs used in this technique are LAGEOS NP, ITRF 1997 station positions and velocities, and IERS 1996 Modeling Conventions.

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EUROLAS network performance has been enhanced as a direct result of this service. The remainder of this paper compares analysis techniques, characterizes bias signatures, evaluates LAGEOS-1,-2 pass geometries, and reviews simultaneous arc Case Studies.

COMPARISON OF ANALYSIS TECHNIQUES

System performance assessment tools used by analysis centers are collocation, simultaneous arc, and multi arc. Each technique has strengths and weaknesses along with different bias detection capabilities (see Table 1 and 2 below).

Table 1. LAGEOS ***Range*** Bias Detection Capability
(all values are in millimeters)

Technique	Strength	Weakness	Single NP	Single Pass	Multi-Pass
Collocation	Detection capability	Station proximity <60m	5	3	1
Short Arc	Station proximity < 3000Km	Requires simultaneous ranging	10	6	3
Multi Arc	Simultaneous ranging not required	Detection capability	100	15	10

Table 2. LAGEOS ***Time*** Bias Detection Capability
(all values are in microseconds)

Technique	Single NP	Single Pass	Multi-Pass
Collocation	N.A.	1	<0.5
Short Arc	N.A.	2	1
Multi Arc	N.A.	5	3

Note: The values provided in the table above are best case conditions (i.e. systems with <3mm NP range precision and <2cm long term range bias stability).

BIAS SIGNATURES

Understanding biases signatures is critical for a system to diagnose the error source. The biases in SLR systems can be grouped into several broad categories. These categories are range bias, time bias, frequency error, barometric error, and range bias instability. These errors can appear in combination in poorly performing systems, however, as the SLR system components and operational procedures have improved, certain types of biases (i.e. time bias, barometric error, and frequency error) have been virtually eliminated. Station coordinate errors induce bias signatures that can be misleading in station performance assessment. Each of these bias sources has it's own time series signature (see Figure 1 below).

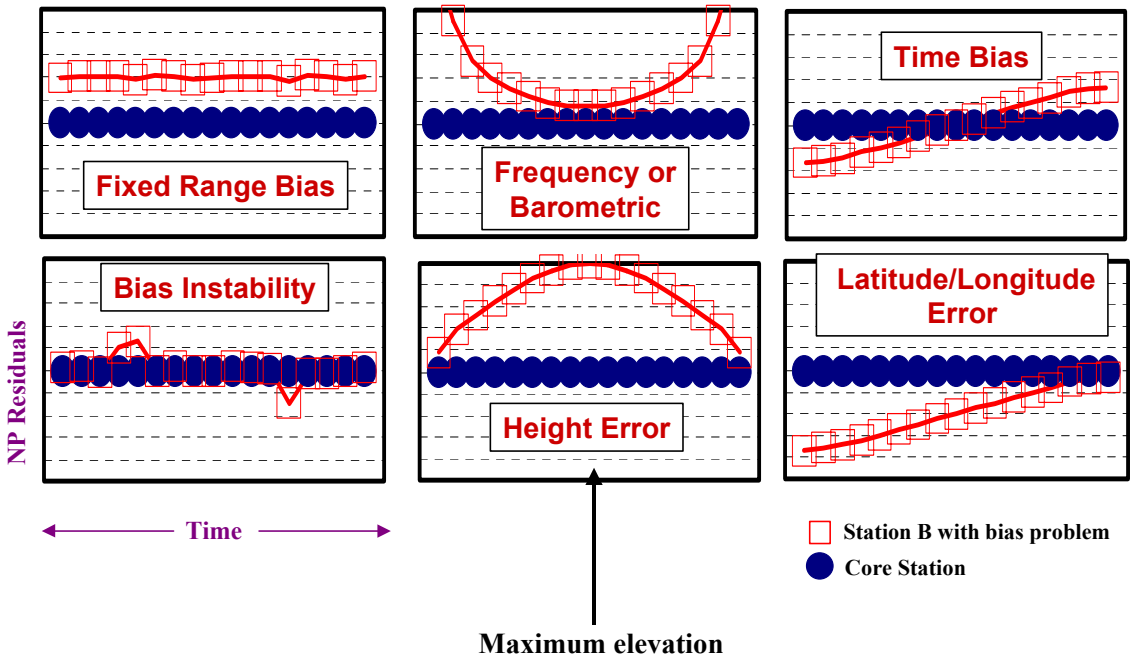

Figure 1: Bias Signatures Time Series

LAGEOS-1,-2 ORBITAL GEOMETRIES

The LAGEOS-1 and LAGEOS-2 orbits have inclinations of 110 and 53 degrees, respectively, which provide complimentary ground tracks (i.e. different geometries). LAGEOS-1,–2 orbits nearly repeat every 7 days, 23 hours, 40 minutes and 8 days, 23 hours, 0 minutes, respectively. Though aggregation of NERC short arc solutions coupled with the knowledge of LAGEOS pass geometries and bias signatures, stations can delineate system performance problems from analysis error. Now let's put this knowledge to work and examine two real case studies.

SHORT ARC CASE STUDIES

In the two Case Studies, depicted in Figures 2 and 3 below, normal point OMC's, from a short arc fit, are plotted in a time series. In Case Study 1, Graz residuals are flat, while residuals from Zimmerwald and Grasse have negative slopes. Also, notice the large fluctuations in the Zimmerwald residuals. These fluctuations were caused by performance problems of the Zimmerwald time interval unit. In Case Study 2, the station coordinates for Zimwmerwald and Grasse were updated and Zimmerwald replaced it's time interval unit. Now, the residuals from all three systems lie virtually on top of each other, indicating SLR systems can have bias agreement and short term bias stability at the few millimeter level.

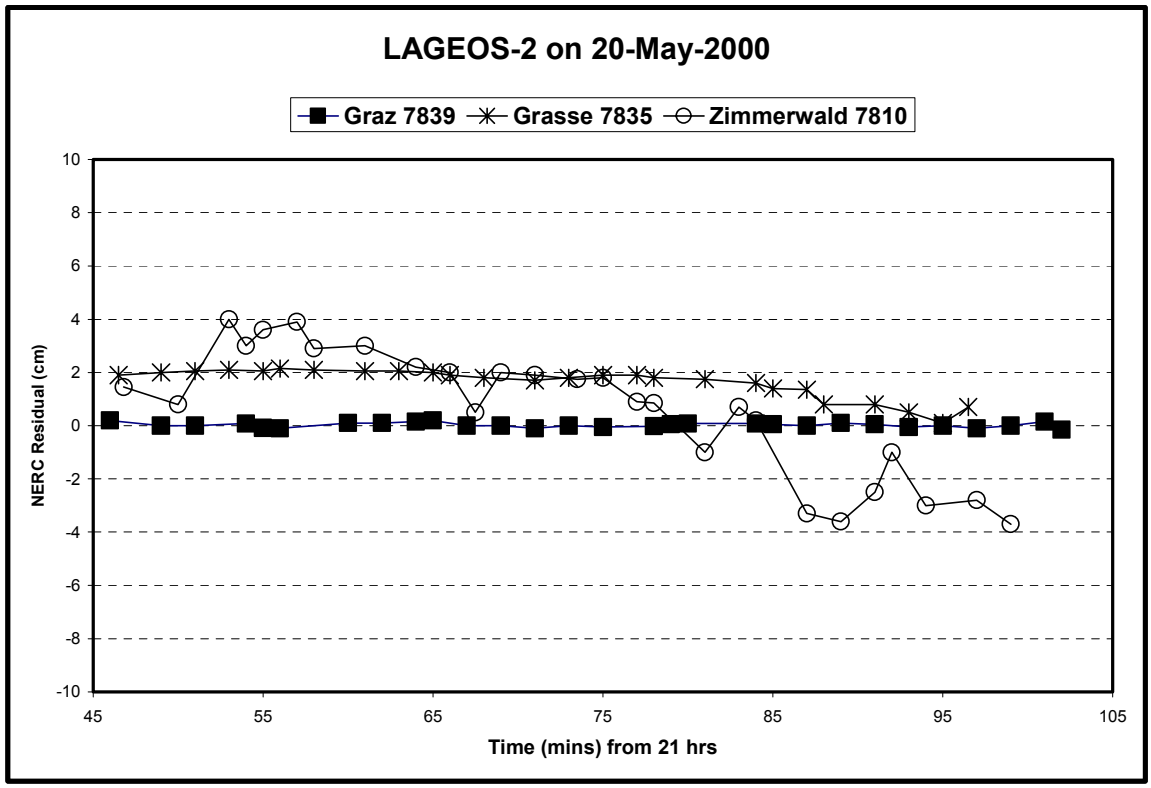

Figure 2: Case Study 1

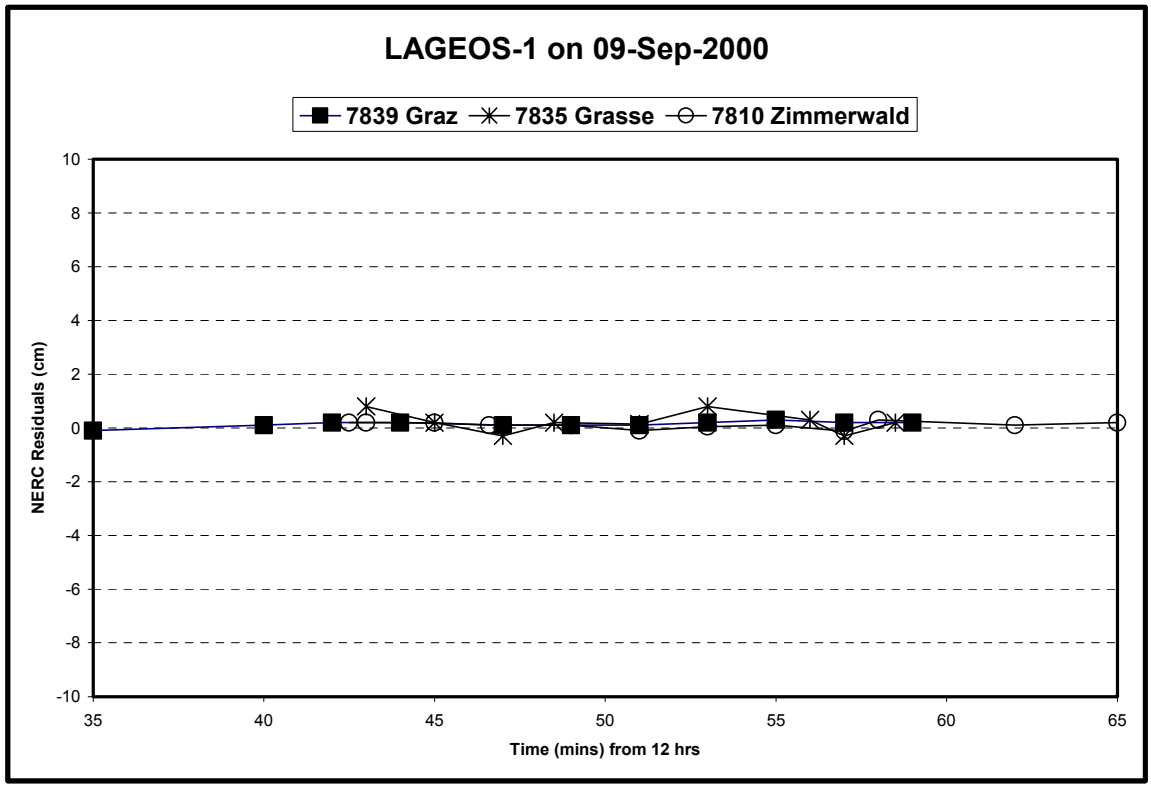

Figure 3: Case Study 2

CONCLUSIONS/RECOMMENDATIONS

The NERC short arc analysis technique is a powerful, automatic, graphical, web-based, system diagnostic tool. Systems are encouraged to print, file, and sort their results in a binder as a historical reference. Systems should annotate their charts with observations in each normal point bin and the pass system delay, plus make note of any system configuration changes.

NERC will pursue the incorporation of other ILRS sub-networks (e.g. China, United States, Australia) and LEO (e.g. Stella, Starlette, and ERS) and high satellites (e.g. Etalon) into it's short arc technique to expand it's service.