Implementing the Consolidated laser Ranging Data (CRD) Format throughout the ILRS Network

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Abstract

Technological changes in recent years and new missions such as LRO and T2L2 with novel use of laser signals mandated the revision and consolidation of the various ILRS data formats. The new laser data format is required to accommodate higher precision laser data and include additional data fields with ancillary information. After several years of development, the Consolidated laser Ranging Data (CRD) format, which accommodates full-rate, sampled engineering, and normal point data in a unified, expanded, flexible format, is ready to be implemented throughout the ILRS network. The first step in implementation requires the Operations Centers (OCs) and Data Centers (DCs) to be able to accept and distribute data in the CRD format. Next, a number of analysis centers (ACs) must be able to ingest data in the new format for testing and validating each station's transition from old to new format. Finally, the stations need to produce the CRD format. Owing to the changes in precision and total restructuring of the data format, it has been decided to require validation step for each station's normal points in the new format prior to their being made generally available. The timetable, details, and status of implementation of this plan are presented here.

Introduction

The CRD format [1] was the result of a multi-year effort to create a flexible, expandable format to support current needs and those of future generations of ranging activities. Technology changes such as kHz ranging and multi-channel detectors required rethinking the data format structure and required new data fields. New missions carrying one-way transponders, such as LRO and T2L2, require higher precision timing and additional data fields not present in the old format. Lunar laser ranging (LLR), especially the APOLLO system, also benefits from having a full rate and normal point data format capable of including all the fields needed by analysts.

Current Status

Version 1.00 of the CRD documentation and sample code was released on the ILRS website (http://ilrs.gsfc.nasa.gov/products_formats_procedures/crd.html) on 30 June 2008. Sometime later an "errata page" was published on this website to keep track of minor changes or errors found between releases. An announcement from the ILRS Central Bureau with a call for implementation of the CRD format by stations, analysts, and operations and data centers was emailed on 13 August 2008.

MLRS CRD data, which has been available in various earlier versions, began to be deposited in v1.00 on 7 July, and is currently being validated. Several other stations have recently begun to produce CRD-formatted data. Operations Centers (OCs), Date Centers (DCs), and several Analysis Centers (ACs) are either ready to accept CRD data or will be by the end of 2008. The main thrusts at this time are finalizing the production data flow and procedures for data validation at the OCs and ACs, as well as encouraging the stations and analysts to implement the new format.

Official Timetable

The official timetable included in the ILRS CB announcement contained the following elements. These are already dated as explained below.

1. BY NOW – Stations and ACs should begin conversion to the CRD format.
2. October 15 – NASA OC, operated by HTSI, is ready to accept data in CRD format, to QC old/new format and to perform Validation "Step 2".
3. Dec 1 – Analysis Centers (ACs) will be able to compare data in the old and new formats.
4. April 15, 2009 – All stations must submit data in the CRD format.
5. Dec 31, 2009 – Only CRD data will be accepted and archived.

Normal Point Validation

The CRD format represents a major change in format with increased flexibility and expandability. Due to changes in precision and sequence of records, the addition of new fields, and the variety of ways in which the format can be implemented, CRD normal point content can differ from the old. This means that having different results between old and new format data does not necessarily mean wrong results - see figures 1 and 2. In fact one should expect to see differences when using the CRD format for the same tracking data. Therefore, a formal and thorough validation process is required before CRD-formatted data submission is accepted from a station as the final data product. A flowchart of the validation process is shown in figure 3.

Although full rate and sampled engineering data will also be written in the CRD format, the ILRS will not have a formal procedure to validate these data products. Validating these data types is left as a cooperative project between the stations and the users of those products.

Validation Process Step 1 - Stations

Stations need to implement the CRD format, producing at least normal points in the new format. CRD full rate files are needed for LRO, T2L2 and other investigations. The initial validation will naturally be at the stations. The ILRS CRD sample code will help the stations get started with this task. First, the CRD files must be tested for compliance with the format, which can be accomplished with the ***crd_chk*** program. Next the content of the old and new format files must be compared. Normal points and sampled engineering data can be compared with ***crd_cstg_np_cmp***, while full rate files can be compared with ***crd_merit_fr_cmp***.

When the station is satisfied with its validation results, it may proceed to Step 2

Validation Process Step 2 – Stations contact their OC

At this point the station contacts its OC (HTSI or EDC) with the starting date of CRD-formatted file delivery. The stations are expected to continue sending CRD and old format files in parallel until notified by their OC. As usual, the OC will immediately distribute data in the old format. Meanwhile, CRD normal points will undergo 3 phases of testing before they become publicly available.

Validation Process Step 3 – OCs and ACs

OCs will begin receiving CRD normal points (and possibly full rate and sampled engineering data) from the station. Phase 1 of the validation plan requires the responsible OC, EDC or HTSI, to confirm format compliance and content agreement for the station's normal points using version 1.0 of the CRD sample code. In addition, the OC will flow the normal points through its quality assessment algorithms to insure the validity of meteorological and other data, as described on the ILRS web page. As mentioned above, the content checks may show differences which are not significant to end results of data analysis. This fact prompted the establishment of the next phases of testing.

Phase 2 follows, in which HTSI passes the CRD normal point files through its daily automated prediction generation software package for short-arc comparisons. The short-arc analysis uses NASA Goddard's Geodyn, a well known orbital analysis and modeling package. This step compares the normal points at a higher level, insuring that differences due to precision and filtering do not significantly affect the outcome. Figures 1 and 2 show a pass that fails the content check while passing the more important short-arc analysis.
Once HTSI is satisfied with 2 weeks of CRD deposits from the station, the data is transferred to a hidden directory on the CDDIS ftp site, and the Analysis Working Group (AWG) and designated ACs are notified for the validation process.

A number of the ACs have agreed to test the CRD data by comparing long arcs from the old and new format normal points. Each of the ACs uses a different software suite, so that when all analysts agree that the station has passed its tests, the result will be robust. When the data has passed these tests, the responsible OC is notified.

During this validation process the OC and ACs may find problems with the data, which will be communicated to the station. The station may have to answer questions, resubmit corrected data, and insure that the corrections are in all subsequent data.

The goal is for the OCs to pass the data to the AC after at least 2 weeks of data has passed the validation tests. The ACs should finish their tests in another 2 weeks, limiting the validation period for a station to about 30 days. In reality, this time span will be longer, especially for the first few stations.

Post-validation

Once the responsible OC is notified by the analysts that the data has passed their tests, the OC officially notifies the station with the good news, and the station ceases sending data in the old format. The OC then notifies the DCs, and the DCs store CRD data from the validation period and thereafter in the ILRS archives in CRD-specific directories. Until

January 31, 2010 the OCs will convert CRD normal points for validated stations into the old format and store them in the ILRS archives. This will allow analysis centers to use data from validated stations before they are able to accept CRD files.

A web page showing station validation status and progress is maintained on the ILRS website at http://ilrs.gsfc.nasa.gov/products_formats_procedures/crd_station_status.html. See Figure 4 for an example.

Conclusion

The ILRS community will immediately begin converting its processes to produce and use laser ranging data in the CRD format. To minimize the chance that converting to a more complex and demanding format will adversely affects analysis results, a formal data validation procedure has been put into place. With an ambitious plan to complete conversion **by early 2010, starting this process early is essential.**

Acknowledgments

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References

[1] Ricklefs, R. L., and Moore, C. J. , "Consolidated Laser Ranging Data Format (CRD) Version 1.00", http://ilrs.gsfc.nasa.gov/docs/crd_v1.00.pdf.

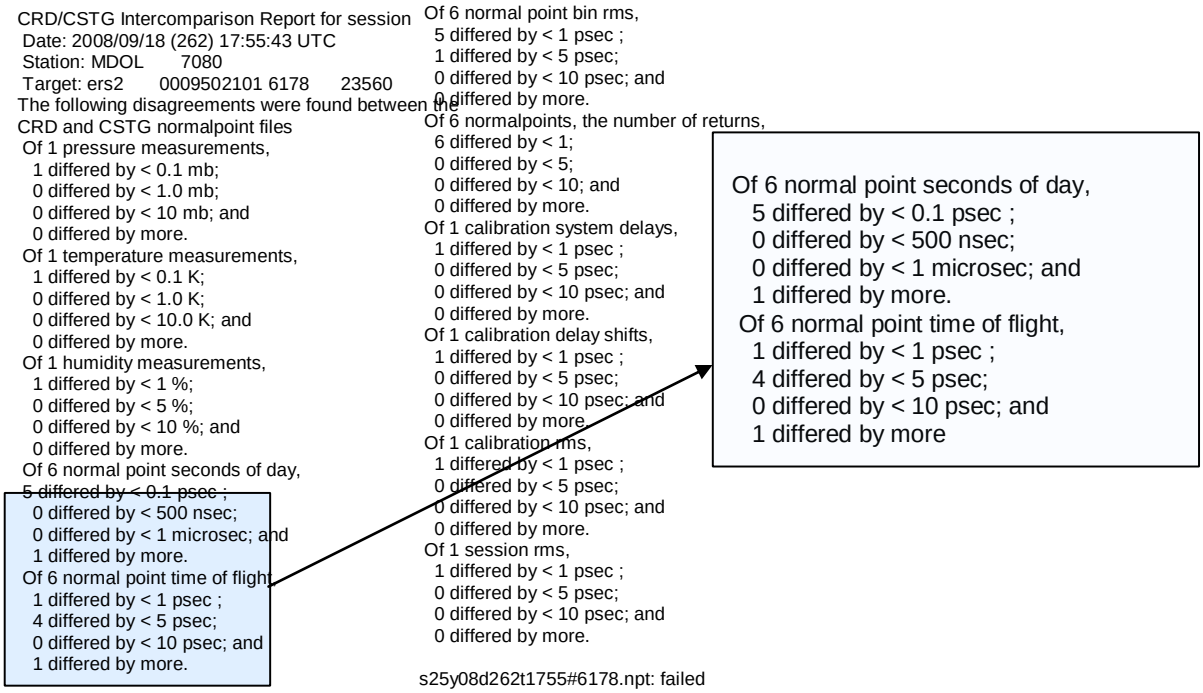


Figure 1. Pass fails content test

RESIDUAL SUMMARY BY STATION

NUMBER	MEAN	RMS	NO.-WTD	WTD-MEAN	WTD-RMS	TYPE	CONFIGURATION	
6	-0.9333	1.0324	6	**-0.9333**	**1.0324**	2W RANGE	MLRS1CRD	9502101
6	-0.9412	1.0403	6	**-0.9412**	**1.0403**	2W RANGE	MLRS1 NP	9502101

Figure 2. Same pass successfully passes short arc test

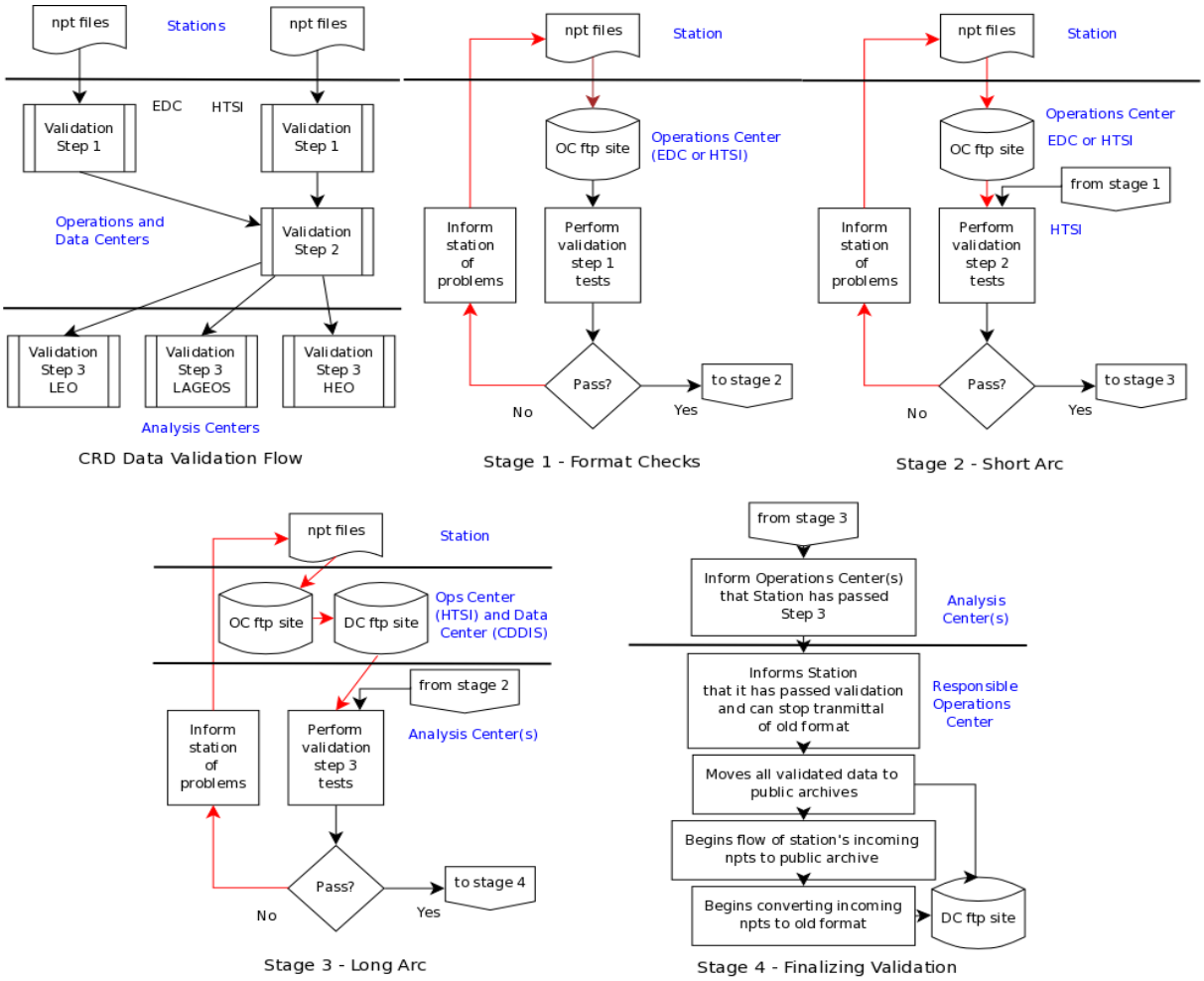
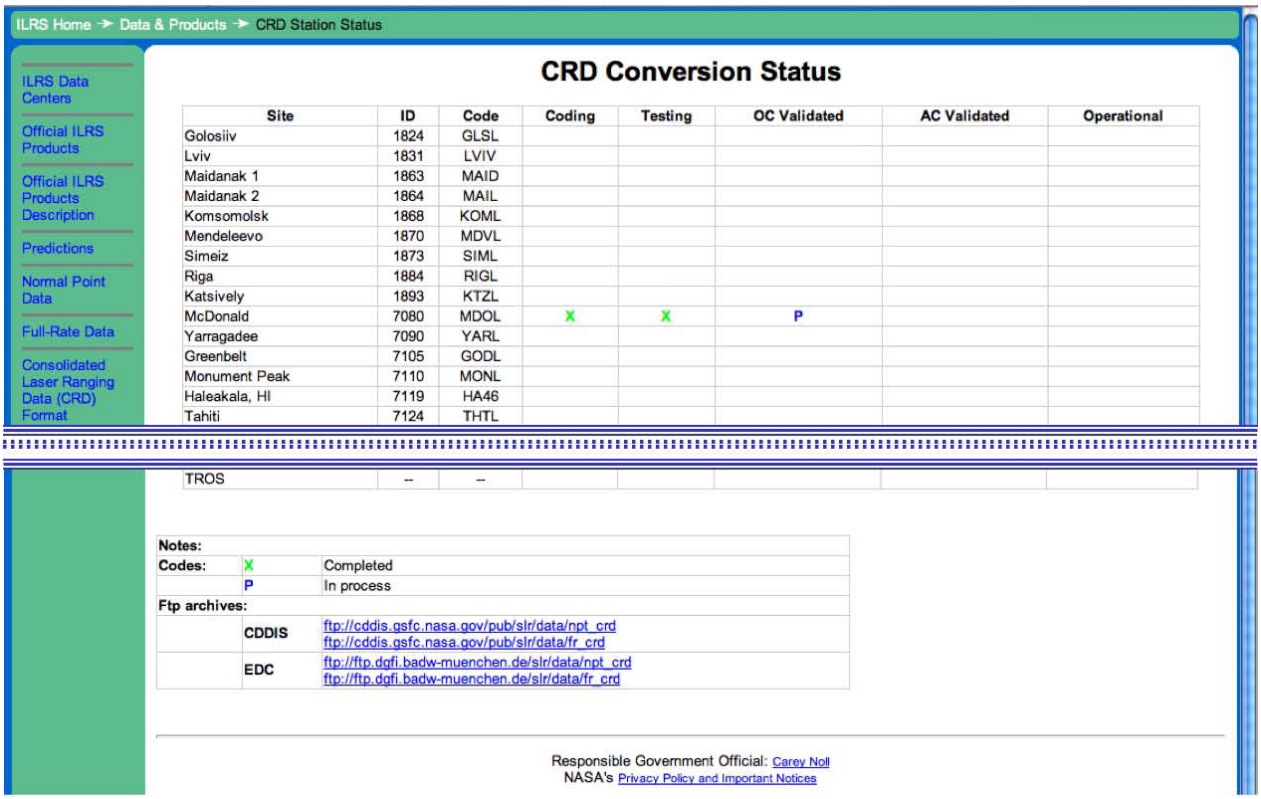


Figure 3. Validation Process Flowchart



ILRS Home → Data & Products → CRD Station Status

ILRS Data Centers
Official ILRS Products
Official ILRS Products Description
Predictions
Normal Point Data
Full-Rate Data
Consolidated Laser Ranging Data (CRD) Format

CRD Conversion Status

Site	ID	Code	Coding	Testing	OC Validated	AC Validated	Operational
Golosiiv	1824	GLSL					
Lviv	1831	LVIV					
Maidanak 1	1863	MAID					
Maidanak 2	1864	MAIL					
Komsomolsk	1868	KOML					
Mendeleevo	1870	MDVL					
Simeiz	1873	SIML					
Riga	1884	RIGL					
Katsively	1893	KTZL					
McDonald	7080	MDOL	X	X	P		
Yarragadee	7090	YARL					
Greenbelt	7105	GODL					
Monument Peak	7110	MONL					
Haleakala, HI	7119	HA46					
Tahiti	7124	THTL					
TROS	--	--					

Notes:		
Codes:	X	Completed
	P	In process
Ftp archives:		
	CDDIS	ftp://cddis.gsfc.nasa.gov/pub/slr/data/npt_crd ftp://cddis.gsfc.nasa.gov/pub/slr/data/fr_crd
	EDC	ftp://ftp.dgfi.badw-muenchen.de/slr/data/npt_crd ftp://ftp.dgfi.badw-muenchen.de/slr/data/fr_crd

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Figure 4. ILRS website CRD Conversion Status