

Updates to the ILRS Predictions and Data Formats

Randall L. Ricklefs, The University of Texas at Austin / Center for Space Research
Chris Moore, EOS Space Systems
for the ILRS Data Formats and Procedures Standing Committee and
the ILRS Central Bureau

Abstract

Since the adoption by the International Laser Ranging Service (ILRS) of the Consolidated Prediction Format (CPF) in 2004 and the Consolidated laser Ranging Data format (CRD) in 2007, there has been a slow influx of suggestions for additions and improvements to the formats, including changes for the European Laser Time Transfer (ELT) mission, additional configuration items, and better compatibility for those ranging to debris. These suggestions were winnowed, and additional suggestions were solicited and considered, with the CPF format version 2.00 being officially released in June, 2018 and the CRD version 2.00 being released in September 2018. At the same time, updated sample code and test files were released for ease of implementation by prediction providers, stations, operations and data centers, analysts, and other users. The Analysis Standing Committee, several stations and several prediction providers agreed to be early adopters and help test the new formats and software end-to-end before involving the rest of the ILRS. Discussed here is an overall view of the changes as well as the current status and anticipated schedule.

Introduction

Since the release of version 1 of the CPF and CRD formats, there have been a number of changes that have compelled the ILRS to create version 2 of the formats. These are listed below.

- A new mission, ELT, requires changes to the CPF format.
- Additional station configuration information was added to the CRD format.
- Additional calibration information has been added to better track the data used to create the system delay folded into the satellite ranges, both full rate and normal points.
- Correct a number of oversights in the original formats.
- Accommodate debris tracking and other non-SLR/LLR/TLR tracking data in the CRD format to avoid multiple format branches.
- Update and clarify the manuals.

Every attempt has been made to assist the users (prediction providers, tracking stations, data centers, and analysts, etc.) with the revised manuals, test data, sample code, and converters between versions.

Consolidated Prediction Format (CPF) changes

The ELT mission, a transponder on the International Space Station (ISS), requires an additional spacecraft time scale field in the transponder header, a field needed to help stations synchronize laser fire with the spacecraft. In addition, due to drag on the ISS, it is anticipated that there will be more than 9 prediction sets release for this mission per day. The current single digit sub-daily sequence number field in the CPF header and file name need to be expanded to accommodate this requirement.

The target type in a CPF header combined both target class (passive reflector, synchronous or asynchronous transponder) and location (earth orbit, lunar surface, etc) in one field. Since this is quite awkward, this field was split into two fields – target class and target location – in both the CPF and CRD formats.

To allow for more flexibility as header fields expand or contract in size (e.g., the sub-daily sequence number), the header records now permit free-format reads. Data records were always set up as free format.

The CPF manual was originally written with extensive references and comparisons to the Tuned IRV (TIV) format it replaced. Over a decade later, those references have now been downplayed, and the manual reorganized.

The dates and times on the CPF filename, the date headers, and prediction records have now been harmonized and clarified in the manual, permitting easier and more consistent storage of the data content in data bases.

Over the years, experience has been gained in handling leap seconds. The goal of coordinating a flag on the CPF data records and software at the stations to permit easy tracking through the time of a leap second has not been realized. Although the leap second flag has not been removed, it is currently no longer used, replaced instead by the “coffee break” (or maybe “tea time”) rule: stop tracking before the leap second, take a break, and start tracking with the new CPFs after the leap second.

The CPF format can be found at https://ilrs.cddis.eosdis.nasa.gov/data_and_products/formats/cpf.html.

Consolidated laser Ranging Data format (CRD) changes

As with the new CPF format, the CRD header files are now permit free-format reading, for more flexibility. Also like the CPF format, the target type has been split into target class and target location.

A new prediction header carries information on the prediction used for tracking a pass (date, time, provider, sequence number) that will permit locating the original tracking file (CPF or, for debris tracking, the Two-line Element (TLE)).

The philosophy of the CRD format is to carry enough of the critical station tracking instrument information to allow it to stand alone from external files, if necessary. This information has included the timing, laser, and detector sub-system as well as transponder details. To this has been added new record and fields. One of these includes the measurement path software, by name and version. Since every station has its own peculiarities, This record has been broken into tracking programs and their corresponding versions as well as analysis software and their corresponding versions. If these fields are augmented by the software along the path, the configuration information should be up-to-date.

The meteorological subsystem now has its own configuration record, permitting separate tracking of the pressure, temperature, and humidity instruments. The entry for each instrument (even if they are all the same) has fields for manufacturer, model, and serial number.

One item missing from the receiver configuration was the signal amplifier. This information is now included, including whether the amplifier is in the signal chain as well as its gain and bandwidth.

Another issue arising during some detailed data analysis was the lack of detailed calibration information. To remedy this, additional fields were added to the existing CRD calibration record, indicating whether this represents pre- or post-calibration or something else. A calibration detail record was added to capture the information on the pre- and post-calibration data. An addition change distinguishes internal calibration within the telescope from internal calibration within the dome, since these are distinct in philosophy and practice.

Transmit amplitude was added to the full-rate records to augment the already-existing receive amplitude. Although these fields are specified in arbitrary units, they do provide some trend information.

The pre-CRD SLR/LLR format shared a field, with SLR using it for return rate (%) and LLR using it

for signal to noise ratio. The sharing of this field was kept in the initial CRD format, but this field has been expanded into separate return rate and S:N fields in version 2. Both observation types can benefit from having both of these fields available.

The “precipitation type” field in version 1 have been renamed “weather conditions” in version 2. This allows the SYSOP/WMO fields, commonly available from many weather sensors, to also be used in this field in addition to the previous precipitation types.

Along with an explanation of all these updates in the manual, there is now an appendix dedicated to the a list of the permitted value ranges of all the fields in the CRD format. This has resulted from the efforts of the Operations Centers' (OC's) Quality Control (QC) harmonization effort. A new edition of this list which includes the new version 2 fields will be in the manual soon. This appendix is expected to be a “living document”, changing as the ILRS learns more about the nuances of the CRD fields.

The CRD format can be found at https://ilrs.cddis.eosdis.nasa.gov/data_and_products/formats/crd.html.

Non-ILRS targets using the CRD format

The CRD format can be used for distributing and archiving ranging data to non-ILRS targets, the primary example being debris tracking data. The goal was to “get ahead of the curve” of debris tracking from ranging stations and to incorporate the needs of the debris tracking community to avoid splitting and fragmenting of the CRD format into several user-specific versions.

One of the changes was to add a network name to a data header. This might be “ILRS” or “EUROLAS”, for instance, for ILRS targets and something else for debris tracking. That network name is to be included in the file name of the CRD file only for non-ILRS targets, allowing non-ILRS data to be easily culled in case it is mistakenly sent to the ILRS OCs.

In addition, “no retroreflector (including debris)” has been added to the target class in the target header record. The new prediction header record allows for TLE information, as TLEs are usually used for debris tracking. The target ID fields in the target header record are now explained to make sense to both ILRS and non-ILRS users. Finally, azimuth, elevation, and range rates have been added to appropriate data records.

Changes discussed but not included

There had been discussion for several years about allowing the seconds of day to exceed 86399 without rolling over. This idea was proposed to handle certain problems that arose when data users missed the fact that after a pass crossed the end of day the second of day pertained to the new day. This is an issue that can be avoided by using the already-existing start and stop date/time in the header records. There was an assurance by the Analysis Standing Committee (ASC) chair that this problem no longer exists. Therefore, the seconds of day will still roll back to zero after 86399

There was also discussion about including special data handling and statistical records for lunar data, especially the data from the APOLLO station. The consensus was that this information can continue to be transmitted in comment records, and that no new LLR records were needed.

Implementation details

Prediction providers will need to be able to produce version 1 and 2 CPFs until the end of 2021 to allow stations time to convert to the new version of the format.

OCs, DCs and ACs will need to be able to accept and process both versions 1 and 2 CRD files permanently, as there is no plan to convert archival version 1 data to version 2.

The CPF and CRD sample code contain converters to switch between version 1 and 2 files. These are useful for testing and as a stopgap measure, but do not provide fully populated version 2 files.

As with conversion to the original CRD format from the CSTG format, each station will need to submit data in both versions 1 and 2 of the format until the ASC has been able to validate their data.

Current status

The beta version of the CPF and CRD manuals, test data, and sample code were made available on the ILRS web site before the Canberra conference in November 2018. Several stations, a couple of predictions providers, and several analysis centers have been recruited to test the implementation of the new formats to clear the way for other ILRS members. The OCs and DCs are now (January 2019) able to handle CPF version 2 files and place them in their proper directories. Lunar predictions are already flowing, and one major prediction provider is expected to come on line shortly. It is expected that the CRD files can flow in the next couple of months. The MLRS data filtering and normal pointing has been modified to create and read the CRD version 2 files for testing. Processing LLR data is being worked.

Tentative conversion schedule

First quarter 2019:

- At least one major prediction provider should be producing version 2 CPF files and sending them to the data centers.
- OCs and DCs should be able to accept and distribute version 2 CRD files.
- One or two stations should be able to produce and distribute version 2 CRDs.

Second quarter 2019:

- At least two ACs should be able to ingest and analyze version 2 CRDs

First quarter 2020:

- Nearly all stations should be able to use version 2 CPF files.
- All stations involved in ELT tracking need to be able to handle version 2 CPFs.

Third quarter 2020:

- Nearly all stations should be producing CRD version 2 files.

Conclusion

The process of creating viable new versions of the CPF and CRD formats has taken several years, and has included input from numerous individuals and groups. As this point, all the materials needed to convert to the new format are available on the ILRS web site. Predictions providers, stations, and analysis groups are encouraged to begin the task of conversion.

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