ION Software-Defined Radio Metadata Standard Report: September 2018

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BIOGRAPHIES

Thomas Pany is with the Universität der Bundeswehr München at the faculty of aerospace engineering. He has been involved with software-defined radio (SDR) research and development since 2002. He contributes to the Institute of Navigation (ION) SDR metadata standard with this technical expertise. As part of the standard development effort, he conducts testing with numerous existing data sets from various SDR devices to ensure that the standard supports these various formats. He has also successfully incorporated the standard into both commercial and research GNSS software receivers that he has developed.

Markel Arizabaleta is a research associate at the Universität der Bundeswehr München since 2017 and has a Master's Degree in Telecommunication Engineering. He has been working with the ION SDR metadata standard since 2017. His contributions to this effort includes updates to the standard document, normative software C++ code debugging and optimization, and performing consistency checks between the standard document and source code.

James Curran has worked on the ION SDR metadata standard development for several years and programmed important parts of the normative software C++ source code. This includes the core sample decoder libraries as well as the platform-independent test environment. He also contributed with his invaluable technical expertise and also managed the Working Group's GitHub repository.

Sanjeev Gunawardena is with the US Air Force of Technology and designed the XML-based scheme of the ION SDR metadata standard as well as early prototype software. He further coordinates the formal standard development process with ION staff and also manages Working Group activities.

Alexander Rügamer is with the Fraunhofer IIS and manages the research and development group that has integrated the ION SDR metadata standard into several research projects and commercialized products. As a member of the Working Group, he has provided technical expertise to the standard development process since its inception.

ABSTRACT

The Institute of Navigation's GNSS SDR Metadata Standard and the associated open-source normative software project simplifies the exchange of sampled datasets between producers and consumers of these datasets. Further details can be found at http://sdr.ion.org. This paper describes the activities of the Working Group since the ION GNSS+ 2017 conference. This includes: details and outcomes of the initial public Request for Comments (RFC1), revisions and updates to the standards document and normative software that were made as a result of RFC1, details of the follow-on public comment process RFC2, and current applications and use of the draft standard and associated normative software. The paper is based on meeting minutes, emails, and materials exchanged by the various Working Group members from the period Sept. 2017 to Sept. 2018. Contributions made by members of the Working Group during this period are highly appreciated and acknowledged.

INTRODUCTION AND USE CASES OF THE STANDARD

Proliferation of GNSS SDR technology during the last several years has caused the appearance of various SDR data collection systems that output data in various formats. As this does neither promote interoperability, nor data/resource sharing, nor re-use, a solution for unambiguous transfer of all essential SDR metadata and the digital intermediate frequency (IF) samples has been sought by the satellite navigation and timing (SatNav) community.

Several researchers assembled in 2013 to further develop an initial idea presented in [1], with the goal to eventually create an officially and widely accepted standard to describe essential SDR metadata, provide reference software source code to access this metadata, and provide representative IF sample datasets and metadata files to demonstrate the seamless handling of datasets using this standard. The Working Group, comprised of recognized experts from the SatNav SDR community, working purely on a voluntary basis has made slow but steady progress over these past five years since the effort was formally sanctioned by ION [2]. Many key contributions have been made by multiple researchers over this period. All of the Working Group's contributions are contained in an online public archive at http://sdr.ion.org. This web portal contains an introduction, the draft standard document, an archive of all reports and presentations given by the Working Group, representative test datasets, and links to the GitHub repository containing the normative software project.

With regards to the normative software source code, it should be noted that the main purpose is to provide a functional and standard-compliant metadata interpreter and sample decoder that can serve as an initial starting point for further development. The normative software is neither considered to be efficient or optimized in terms of memory usage and execution time. Based on the experience of several researchers, especially the conversion (casting) from the IF sample format used in the file to the target format (e.g. int8) is a bottleneck (mostly on embedded systems) as this casting involves a number of bit-wise operations that are applied sequentially.

The standard is widely known in the SatNav SDR research community and has been adopted by a number of SatNav software radio projects. For example the Multi Sensor Navigation Analysis Tool (MuSNAT) from the Universität der Bundeswehr München fully supports the standard [3]. A commercial software supports a slightly older version of the standard [4]. The standard has been applied in remote processing SDRs [5]. For the open source Global Navigation Satellite Systems software-defined receiver, GNSS-SDR, full support of the standard is anticipated in the near future [6]. Packaging of the C++ code for the major Linux distribution is also on the roadmap of the GNSS-SDR developer group. At the Fraunhofer IIS in Nürnberg Germany, extensive adoption of the standard has been made in the following projects:

- Flexiband / GTEC USB3.0 Front-end: Recording multiplexed IF data [7]
- Multi-GNSS Simulation & Test Environment, MGSE: Record/Replay-System: Replay multiplexed IF data [8]
- Interference Monitoring and Detection Station: Recorded IF files with events tagged using the Metadata Standard [9]
- InterferenceAnalyzer-Tool: Visualization of raw data files that are decoded using the Metadata Standard
- PROOF/PRISMA#2 PRS Rx: raw data snapshots with the Metadata info according to the standard
- Server-Based "Sample & Processing" PRS-Receiver: Raw data snapshots tagged with standard-compliant metadata for PRS processing [10]

Also, the European Space Agency (ESA) has included a requirement for standard compliance in a recent Invitation to Tender (ITT) [11]:

[REQ-CD-072]	The signal gathered by the **receiver platforms** and stored in the **Database** shall be compliant with the ION GNSS SDR Metadata standard ([AD-01], [RD-02], [RD-03]).

SUMMARY OF RFC1 AND WORKING GROUP ACTIVITIES

RFC1 was conducted during the period September 15, 2017 – December 31, 2017. A total of 33 comments were received. The Working Group responded to each individual commenter via email. The comments and the Working Group's responses are available for review at http://sdr.ion.org/RFC1_Comments_Responses.html. A majority of the comments were editorial nature, referring to the draft standard document. Some comments pertained to the inclusion of additional data formats or fields. Other comments referred to the C++ normative reference software.

At the conclusion of RFC1, all 33 comments were evaluated by the Working Group. Based on the evaluated comments, revisions to the normative software was performed and tested, and the standard document was also revised. All revisions were then checked for consistency. As part of the post-RFC1 revision process, the GitHub repository was also cleaned up where redundancies were removed and outdated code was moved to an archive folder. The new metadata features that were added to the standard as a result of RFC1 include support for magnitude-sign (MS) and magnitude-sign adjusted (MSA) encoding schemes as well as support for floating point sample representation.

During this reporting period, the Working Group also added several new example datasets to the data archive at http://sdr.ion.org/api-sample-data.html. At this point, datasets from 12 different SDR data collection systems are included. This includes both commercial as well as research systems. These datasets contain live-sky signals from GPS, GLONASS, Galileo, and BeiDou. Between these datasets, the various schemes of data collection topology, sampled data representation and encoding, and their metadata descriptions according to the standard are well represented. Decoding of these datasets by the normative software has also been tested. As stated previously, the goal of the dataset repository is to provide working examples that will simplify the integration of the standard. The community is encouraged to contact the Working Group to submit additional datasets to be included in this archive – especially if their system topologies or data formats are significantly different to those that are already represented.

SECOND REQUEST FOR COMMENTS (RFC2)

The second request for public comments (RFC2) is open from September 1, 2018 – November 30, 2018. At the time of this writing several comments have been received. The Working Group encourages the community to submit their comments at http://sdr.ion.org/. Commenters can submit new comments, or refer their comments to those from RFC1.

REMAINING STEPS

This section summarizes the steps remaining for the conclusion of these standard development activities and the formal ratification of Version 1.0 of the standard. These steps are in accordance with the standard's formal Terms of Reference [12].

- Revisions based on RFC2
  At the conclusion of RFC2, all comments will be evaluated by the Working Group and appropriate revisions will be made to the standard document as well as the normative software through consensus. These changes will result in the final version of the draft standard and normative software.
- Approval of the final draft standard by all members of the Working Group will be sought through formal vote. The final draft standard shall be deemed approved by the Working Group through majority vote of those members who participate in the voting process.
- The draft standard will then be submitted to ION Council for review.
- After ION Council review, council approves submission of the draft standard as well as all archival records for legal review.
- Following legal review, ION Council formally approves ratification as a formal ION Standard
- Announcement of standard at ION GNSS+ conference and presentation of final report by Working Group
- Termination of Working Group activities

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