
Publishable Summary for 14SIP07 Digital Standard Standard for Digital Data Format for Nuclear Instrumentation

Overview

The field of radionuclide metrology provides safety and security for a range of economic, environmental and societal needs. The applications span anything from nuclear medicine, to radioactive waste management and nuclear forensics. As the world becomes increasingly computerised, the use of digital acquisition systems in radionuclide metrology is rapidly increasing. However, there are presently no suitable standards for formatting the list-mode data presented by such systems. With the input from equipment manufacturers and experts appointed by the IEC/TC 45 National Committees, the DigitalStandard consortium successfully produced the International Standard IEC 63047 "Nuclear instrumentation – Data format for list mode digital data acquisition used in radiation detection and measurement". The International Standard has been published in October 2018, six months ahead of schedule.

Need

Modern data acquisition systems sample the signal directly from the radiation detector at a high rate and present digital data to computer systems for further processing and analysis. These digital systems offer several advantages over conventional analog modular electronics. However, the lack of a standard for the format of the data presented by such systems hinders the interoperability between hardware for data acquisition and software for data analysis.

The need for such a standard was recognised by the European Standardisation Organisation CEN, Technical Committee 391 "Societal and Citizen Security" in the frame of mandate M/487, and earlier by the European Metrology Research Programme "MetroFission". The European Commission Directorate General for Migration and Home Affairs responded to the gap analysis by CEN by defining new priorities and standardisation activities, by means of:

- A new request to CEN proposing 9 European Standards related to Crisis Management and CBRNE (Chemical, Biological, Radiological, Nuclear and Explosives);
- An administrative arrangement under Horizon2020 with the European Reference Network for Critical Infrastructure Protection (ERNICIP), coordinated by the Joint Research Centre (JRC). The administrative arrangement addresses four threats in the CBRNE area, including RN threats to critical infrastructure.

The ERNICIP RN Thematic Group was specifically mandated to perform the pre-normative research related to the standardisation of the list-mode data format and to propose the basic elements of such a standard to the appropriate standardisation organisation. Several members of the RN Thematic Group continued with the actual development of the standard through this EMPIR DigitalStandard project.

Objectives

The project objectives were to stimulate the development and use of accurate and effective digital instrumentation in the nuclear industry by:

1. The development of an accepted committee draft IEC standard for a digital list-mode data format to be used in nuclear instrumentation;
2. The development of web-based software tools for users of the standard (i.e. equipment manufacturers and developers of software for data analysis). The software tools will allow compliance verification, generation of test data sets, basic analysis and conversion to common spectral formats.

Results

1. The development of an accepted committee draft IEC standard for a digital list-mode data format to be used in nuclear instrumentation:

The consortium exceeded expectation when the committee draft IEC standard was accepted for publication six months ahead of schedule, with a release date of October 2018. On 27 April 2018, the IEC published the results of the voting on the CDV (JRC112149). As only a few national comments were received, the TC 45 Chair, in cooperation with the IEC 63047 Project Leader and the TC 45 Secretary and after consultation with the CEO of the IEC office, took the decision to proceed directly to the publication of standard.

The publication of the standard was both enabled and expedited because of the work of the project Consortium. In October 2016 the JRC submitted a New Work Item Proposal to the International Electrotechnical Commission (IEC), Technical Committee 45 "Nuclear Instrumentation". The scope of IEC/TC 45 is to prepare international standards relating to electrical and electronic equipment and systems for instrumentation specific to nuclear applications. The proposal was accompanied by a preliminary draft standard, developed by members of the consortium. The IEC/TC 45 National Committee members accepted the proposal and appointed twelve experts, two of which are participating in the EMPIR DigitalStandard project (NPL and the JRC). The work was assigned project number IEC 63047 and allocated to IEC/TC 45/WG 9 "Detectors and systems". In March 2016, the JRC established a liaison category A with IEC/TC 45. The JRC liaison officer (also participating in the DigitalStandard project) was appointed as project leader for the development of the standard. At the WG 9 meeting on 9 March 2016, the comments received after the three month voting period were discussed and solutions agreed upon. Further details are available in report EUR 27811 and presentation JRC100689.

A workshop "IEC 63047 – A new international standard for the data format of list-mode digital data acquisition used in radiation detection and measurement" was held at the JRC in Geel, Belgium from 15 to 17 June 2016. The workshop brought together stakeholders involved in the development of the standard IEC 63047: Experts appointed by the IEC/TC 45 National Committees; members of IEC/TC 45 Working Group 9; EMPIR DigitalStandard Consortium Partners; and representatives of equipment manufacturers who expressed their interest and are admitted to the list established after the publication of the call for testing procedure, published in the Supplement to the Official Journal of the EU, ref. 2015/S 222-403785 and 2016/S 042-068536. The workshop discussed technical aspects in the development of the standard and its implementation in hardware/software. Because the standard relies on the internationally standardised ASN.1 notation, a tailor-made training in ASN.1 was provided during the workshop.

The outcome of the workshop was used by the EMPIR DigitalStandard consortium partners for the development of the first Committee Draft standard (1CD), submitted to IEC/TC 45 and circulated to their members on 28 October 2016. The 1CD was translated to German by the German National Committee. The 1CD was approved by IEC/TC 45 in January 2017. Comments were addressed in the preparation of the second Committee Draft (2CD, JRC107306).

An interim meeting of the IEC/TC 45/WG 9 was held in Brussels in April 2017, where the comments on the 2CD were analysed and acted upon (JRC106688). The consortium prepared the Committee Draft for Vote (CDV, JRC109443), which was presented at the main IEC/TC 45 meeting in Shanghai in October 2017, translated by AFNOR to French and circulated for voting and commenting to the National Committees on 19 January 2018.

2. Development of web-based software tools for users of the standard (i.e equipment manufacturers and developers of software for data analysis). The software tools will allow compliance verification, generation of test data sets, basic analysis and conversion to common spectral formats:

Work has continued at NPL on the development of the software tools and algorithms for simulating data sets for IEC 63047 compliance verification in the C/C++ programming language. Discussions have been held with JRC, STUK, CEA and ENEA on the scope and operation of these software tools. The "shell" has been developed allowing the simulation of data sets with known parameters, such as Poisson counting rates, dead-times, simple spectral shapes, jitter between channels, etc. This shell has been integrated with encoding and decoding (codec) software, developed by the JRC and the consortium, which enables writing IEC 63047 CDV formatted data, sampled from real or simulated gamma-ray spectra. The other features of the shell currently store data in an interim (simpler) data format developed by NPL. Integration of these features with the codec is ongoing.

The codec relies on the open-source software "ASN1C". A JRC technical report (JRC109013) has been prepared that provides guidance on how to obtain "ASN1C" and readily produce their own codec. The codec supports the format specified in the CDV draft of IEC 63047 and remains to be verified and updated where necessary to ensure compliance with the final published version of the standard. The decoding routines of the software automatically verify compliance with the standard. To continue the development and to avoid duplication of efforts, the JRC included this work in its 2018-2019 work programme in the work package 6261 "STANDER". JRC will publish the software as an open-source software tool on a collaborative platform.

Impact

This project has effectively led to a new International Standard for digital list-mode data format. Uptake of the use standard has been discussed with the International Committee for Radionuclide Metrology (ICRM) (via the primary supporter) and the CIPM Consultative Committee for Ionising Radiation, and all bodies agreed that the IEC 63047 data format will form the basis for enabling improved international harmonisation of nuclear instrumentation and traceability to the derived SI unit of the becquerel for a multitude of radionuclides. It will also provide greater confidence in, and harmonisation of, radioactivity measurements by end-users in a variety of fields, including nuclear physics, environmental monitoring, nuclear energy, decommissioning, radiation protection, nuclear security and safeguards.

Dissemination and engagement activities

The information relating to the development of the International Standard has been shared within the nuclear industry sector through various channels. This included presentations at international conferences and to standardisation organisations, a dedicated IEC 63047 Workshop, and two written communications in the form of a technical paper and a newsletter. Collaboration agreements with five equipment manufacturers and one university were set up, to allow maximum involvement of the primary stakeholders. A total of 11 conference presentations and posters have been presented, predominantly to the scientific community (higher education, public research organisations). JRC Technical Reports have been published documenting the acceptance of the New Work Item Proposal (JRC100968) and the submission of the various drafts (2CD JRC107306, CDV JRC109443).

The IEC 63047 workshop was attended by academic and industrial stakeholders. It pooled together experts in radioactivity measurements to develop the standard. Furthermore, it facilitated engagement with the equipment manufacturers, enabling beneficiaries of the work developed in this project to disseminate the standards work and software requirements.

The standard at its advantages in nuclear security was also presented at the Technical Reachback Workshop, co-organised by the JRC and the Global Initiative to Combat Nuclear Terrorism (GICNT) in March 2017, and at a Technical Meeting on Radiation Detection Instrumentation for Nuclear Security, held at the IAEA in April 2016.

Impact on relevant standards

The EMPIR DigitalStandard project successfully produced a new International Standard, IEC 63047. The standard complements and does not conflict with IEC 62755 (identical to ANSI N42.42), a standard format for nuclear security equipment. IEC 63047 data may include IEC 62755 data and vice-versa. At the CENELEC/TC 45B meetings, status updates were provided with the aim to facilitate the endorsement as European Standard, should there be a need.

Impact on industrial and other user communities

Through calls for expression of interests, equipment manufacturers were invited to participate from an early stage in the development process. Five manufacturers and one university actively contributed to the development of the standard. Three manufacturers successfully implemented the IEC 63047 2CD draft format in their data acquisition software with the aid of a dynamic link library (DLL). One of them supplied a fully compliant IEC 63047 2CD data file one day after receiving the DLL and the 2CD draft (JRC103417). This demonstrates that it is not complicated to implement the standard, providing that the right tools are available.

The participating manufacturers have a competitive advantage on a global scale when the International Standard is published.

Successful interoperability of radiation detection and measurement systems will enable improved technology for safeguards and nuclear safety. European and/or international standards devised for a digitised data format will enable a combination of measurements to be compared within, and between, remote data analysis centres, which will be a significant advance in the capability of emergency response.

Impact on the metrological and scientific communities

The project developed a new International Standard for digital list-mode data format. This has brought together 40 NMIs, working towards providing greater confidence in, and harmonisation of, radioactivity measurements by end-users in a variety of fields, including nuclear physics, environmental monitoring, nuclear energy, decommissioning, radiation protection, nuclear security and safeguards. By linking the work to the requirements of CEN/TC 391, and the work of the ERNCIP Thematic Group on Radiological and Nuclear Threats to Critical Infrastructure, the new standard is helping to meet the high-priority requirements for societal and citizen security. The development of standard has been repeatedly reported to the International Committee for Ionising Radiation and the CIPM Consultative Committee for Ionising Radiation, Section II.

List of Publications

PAEPEN J., KEIGHTLEY J., BOBIN C., CAPOGNI M., ILANDER T., Acceptance of the proposal for a new international standard for list-mode data used in nuclear instrumentation - EMPIR 14SIP07 "DigitalStandard", Deliverable D1; JRC work package 3883 "DiSNU", Deliverable 1, Report EUR 27811, 2016

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1. NPL, UK 2. CEA, France 3. ENEA, Italy 4. STUK, Finland		5. JRC, European Commission