



IEEE Standard Data Format for Real-Time Streaming from Radiation Detection Instruments

IEEE Instruments and Measurements Society

Developed by the
Radiation and Nuclear Instrumentation and Systems Standards Committee

IEEE Std N42.61™-2025

STANDARDS

IEEE Standard Data Format for Real-Time Streaming from Radiation Detection Instruments

Developed by the

Radiation and Nuclear Instrumentation and Systems Standards Committee
of the
IEEE Instruments and Measurements Society

Approved 19 June 2025

IEEE SA Standards Board

Recognized as an American National Standard

Abstract: The notation of radiation data and some non-radiation data that is streamed in real-time from a radiation detection instrument to a receiving device is specified in this standard. The data is intended to be streamed wirelessly but can be also transmitted by cable. The transmission protocol is not part of the standard, although some general transmission rules recommendations are provided. The subsequent display, processing, and analysis of the radiation data on the receiving device are outside the scope of this standard. The radiation data consist mainly of raw or unprocessed data, and include dosimetric data, and non-radiation data such as the status of the instrument and its sensors and detectors (e.g., temperature, remaining battery charge, voltage).

Keywords: ASN.1, encoding rules, IEEE N42.61™, radiation data, radiation data format, real-time streaming, streamed packet specification

The Institute of Electrical and Electronics Engineers, Inc.
3 Park Avenue, New York, NY 10016-5997, USA

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Participants

At the time this IEEE standard was completed, the Radiation Data Format Working Group had the following membership:

Radoslav Radev, *Chair*
Michael Bondin, *Vice Chair*

Leticia Pibida
Nathaniel Bass

James Christian
Martin Smith

Scott MacEwan
Andrey Gueorguiev

The following members of the individual Standards Association balloting group voted on this standard. Balloters may have voted for approval, disapproval, or abstention.

Michael Bondin
Pin Chang
Christina Forrester

Akram Hakiri
Piotr Karocki
Richard Kouzes
Leticia Pibida

Donivan Porterfield
Don Potter
Radoslav Radev

When the IEEE SA Standards Board approved this standard on 19 June 2025, it had the following membership:

Lei Wang, *Chair*
Jon Walter Rosdahl, *Vice Chair*
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Edward Au
Ted Burse
Xiaofeng (Alfred) Chen
Doug Edwards
Nehad El-Sherif
J. Travis Griffith
Deborah R. Hagar

Guido R. Hiertz
Ronald W. Hotchkiss
Tyler L. Jaynes
Thomas Koshy
Howard Li
Xiaohui Liu
Kevin W. Lu
Hiroshi Mano

Daleep C. Mohla
Annette D. Reilly
Robby Robson
Daniel Sabin
F. Keith Waters
Sha Wei
Luyang (Eric) Zhang

Introduction

This introduction is not part of IEEE Std N42.61-2025, IEEE Standard for Data Format for Real-Time Streaming from Radiation Detection Instruments.

This is a new standard describing the data format of the radiation data and other associated parameters for real-time streaming. This standard is the responsibility of the IEEE Technical Committee 45 Radiation and Nuclear Instrumentation and Systems. The standard was approved on TC45 letter ballot.

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IEEE Standard Data Format for Real-Time Streaming from Radiation Detection Instruments

1. Overview

1.1 Scope

This standard specifies the notation of radiation data and some non-radiation data that is streamed digitally in real-time from a radiation detection instrument to a receiving device (e.g., smartphone or tablet). ISO/IEC 8824-1 Abstract Syntax Notation One (ASN.1) is used for specifying the data to be streamed.⁶ The complementary ISO/IEC 8825-1 ASN.1 encoding rules are recommended for converting the data into digital binary code for streaming. The standard is intended for both lower-bandwidth transmission, corresponding to instruments that generate data on the order of kilobits per second (kbit/s), and higher-bandwidth transmission. The radiation data consist mainly of raw or unprocessed data, but other data such as precise time, dosimetric data, device parameters, and settings applicable to the further display, processing, or analysis of the data can be streamed as well. The data can be streamed wirelessly but can also be transmitted by cable. Data format for commands from the receiving device to the measurement instrument is not part of this standard. This standard does not address data format for visual data (e.g., photos, videos), for radiation imagers, or for lidar distance data. The transmission protocol is not part of the standard, although some general transmission rules recommendations are provided. The subsequent display, processing, and analysis of the radiation data on the receiving device are outside the scope of this standard. The standard does not address the transmission media, receipt, and later transmission of data to a larger and distant network or how the data will be used and processed on the receiving device.

1.2 Purpose

This standard is intended for use in applications where real-time radiation data is needed. It can be applied for standardized streaming of radiation data from simple gross counts detectors up to complex thermal and fast neutron multiplicity systems used for international arms control verification and nuclear safeguards. The standard is designed to be efficient and versatile for a wide variety of radiation detector types, to be programming-language independent, and to be simple to implement.

⁶ Information on references can be found in Clause 2.

1.3 Word usage

The word *shall* indicates mandatory requirements strictly to be followed in order to conform to the standard and from which no deviation is permitted (*shall* equals *is required to*).^{7,8}

The word *should* indicates that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required (*should* equals *is recommended that*).

The word *may* is used to indicate a course of action permissible within the limits of the standard (*may* equals *is permitted to*).

The word *can* is used for statements of possibility and capability, whether material, physical, or causal (*can* equals *is able to*).

1.4 Structure of this standard

This standard specifies a notation for the presentation of data acquired by radiation detection instruments using ASN.1 variable definitions. The ASN.1 data representation format is applied for the digital streaming of information from a radiation-detecting instrument to a receiving device through a standardized encoding/decoding protocol (Encoding Rules). ASN.1 is specified in the international standard ISO/IEC 8824 series/ ITU-T X.680 series. The encoding and decoding rules are specified in the International Standard ISO/IEC 8825 series/ ITU-T X.690 series.

The basic terminology, notation, and basic ASN.1 types used in this standard are contained in Clause 4. Clause 5 contains the design principles and the basic structure of the streamed data. The expanded definitions and full specifications of the individual variables are contained in Clause 6 through Clause 9. Annex A provides an example of the order of the list elements for the temperature-dependent energy calibration files. Annex B through Annex F contain coding examples of streamed packets in ASN.1 notation for various detector configurations. Annex G contains the complete coded schema in ASN.1 notation for the packets defined in the standard.

2. Normative references

The following referenced documents are indispensable for the application of this document (i.e., they must be understood and used, so each referenced document is cited in text and its relationship to this document is explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

ISO/IEC 8824-1: Information technology – Abstract Syntax Notation One (ASN.1) – Part 1: Specification of basic notation.^{9, 10}

ISO/IEC 8825-1: Information technology – ASN.1 encoding rules – Part 1: Specification of Basic Encoding Rules (BER), Canonical Encoding Rules (CER) and Distinguished Encoding Rules (DER).

⁷ The use of the word *must* is deprecated and cannot be used when stating mandatory requirements; *must* is used only to describe unavoidable situations.

⁸ The use of *will* is deprecated and cannot be used when stating mandatory requirements; *will* is only used in statements of fact.

⁹ ISO publications are available from the International Organization for Standardization (<https://www.iso.org/>) and the American National Standards Institute (<https://www.ansi.org/>).

¹⁰ IEC publications are available from the International Electrotechnical Commission (<https://www.iec.ch>) and the American National Standards Institute (<https://www.ansi.org/>).

ISO 8601-1: Date and time – Representations for information interchange – Part 1: Basic rules.

ISO 8601-2: Date and time – Representations for information interchange – Part 2: Extensions.

ISO/IEC 10646: Information technology – Universal Coded Character Set (UCS).

3. Definitions, acronyms and abbreviations, and quantities and units

3.1 Definitions

For the purposes of this document, the following terms and definitions apply. The *IEEE Standards Dictionary Online* should be consulted for terms not defined in this clause.¹¹

ISO and IEC maintain technological databases for use in standardization at the following Internet addresses:

- IEC Electropedia: available at <http://www.electropedia.org>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

For the purposes of this document, the following terms are explicitly defined. The *IEEE Standards Dictionary Online* should be referenced for terms not defined in this clause.

accumulation time: The duration of the radiation packet, that is, the time the data has been measured and recorded in a single radiation packet.

NOTE 1—Radiation data is streamed (transmitted) in `RadiationData` packets from all the instrument's detectors to the receiving device.¹²

NOTE 2—The radiation data from each detector of the instrument is accumulated (summed) in the instrument memory for a very short period (`accumulationTime`), for example, 1 second. At the end of this `accumulationTime` the accumulated radiation data from all detectors is streamed to the receiving device (e.g., smartphone) in one packet (`RadiationData` packet).

alarm: An audible, visual, or other user-perceptible signal activated when the instrument reading exceeds a preset value or falls outside a preset range.

ambient dose equivalent $H^*(10)$: Dose equivalent at a point in a radiation field, produced by the corresponding aligned and expanded field, in the ICRU sphere at a depth of 10 mm, on the radius opposing the direction of the aligned field.

NOTE 1—The ICRU sphere (see ICRU Report 33 [B3]) is a 30-cm diameter, tissue-equivalent sphere with a density of 1 g•cm⁻³ and a mass composition of tissue equivalent material (see IEC 60050-393-14-78 [B6]).¹³

NOTE 2—The depth for ambient dose equivalent for $H^*(10)$ is 10 mm.

NOTE 3—Modified from ICRU Report 39 [B4] and ICRU Report 47 [B5] (see IEC 60050-395-05-43 [B7]).

¹¹*IEEE Standards Dictionary Online* is available at: <http://dictionary.ieee.org>. An IEEE account is required for access to the dictionary, and one can be created at no charge on the dictionary sign-in page.

¹²Notes in text, tables, and figures of a standard are given for information only and do not contain requirements needed to implement this standard.

¹³The numbers in brackets correspond to those of the bibliography in Annex H.

ASN.1 (Abstract Syntax Notation One): notation that describes rules and structures for representing, encoding, transmitting, and decoding data in computer networking.

NOTE—ASN.1 is a joint ISO/IEC international standard.

ASN.1 component type: The constituent type, or one of multiple constituent types, of a defined CHOICE, SEQUENCE, or SEQUENCE OF type.

ASN.1 schema: Collection of one or more specifications in ASN.1 notation.

ASN.1 simple basic type: Basic types as defined by ISO/IEC 8824-1.

NOTE—Examples include BOOLEAN, BIT STRING, CHOICE, ENUMERATED, INTEGER, REAL, SEQUENCE, SEQUENCE OF, OCTET STRING, UTF8String

ASN.1 specification: The ASN.1 notation of types defined in this document using ASN.1 notation.

canonical encoding: An encoding procedure resulting in a unique binary representation for all encoded data.

NOTE—Most of the ASN.1 encoding rules leave some freedom for variability of the final encoded message. Encoding rules that leave no degrees of freedom during the encoding are called canonical.

confidence level (indication): An indication provided by the instrument of the reliability assigned to the determined identification.

Coordinated Universal Time (UTC): The time scale maintained by the Bureau International de l'Heure (International Time Bureau) that forms the basis of a coordinated dissemination of standard frequencies and time signals.

NOTE 1—The source of this definition is Rec. ITU-R TF.460-5 [B8]. ITU-R has also defined the acronym for Coordinated Universal Time as UTC.

NOTE 2—UTC and Greenwich Mean Time (GMT) are two alternative time standards which for most practical purposes determine the same time.

dead time: The time that the detection system is not able to process or record events properly from its detectors or sensors.

NOTE—Dead time could be caused by the detection process, the data acquisition device, or be imposed on the data after the acquisition.

detector: Any single radiation detector that responds to radiation. A detector can be further specified as a basic gamma, neutron, alpha, or beta count (rate) detector, or as a more sophisticated detector providing gamma exposure, gamma or neutron dose (rate), gamma spectroscopy, and/or radionuclide identification information.

distinguished encoding rules (DER): A set of encoding rules established by ISO/IEC 8825-1, which restricts the basic encoding rules (BER) to a canonical encoding of a particular packet.

encoding rule (ASN.1): Rules specifying the binary representation of transmitted ASN.1 packets according to a provided ASN.1 specification. Encoding rules additionally describe decoding of binary packets into ASN.1 representation, given knowledge of the ASN.1 specification.

encoding: The bit pattern resulting from the application of a set of encoding rules to a value or collection of values.

end of measurement data transmission (end of measurement): Measurement data transmission ends when the link between the instrument and the receiving device is terminated or, if available, when a measurement end signal is received by the measuring instrument.

event: A single recorded interaction by the detector (e.g., a single count).

exposure: The measure of ionization produced in air by x-ray or gamma-ray radiation.

NOTE—The special unit of exposure is the Roentgen, abbreviated in this standard as R. The exposure rate is Roentgen per hour, abbreviated in this standard as R/h.

instrument: Includes a minimum of one detector or incorporates several sensors and/or detectors (e.g., a gamma detector, neutron detector, HV sensor, battery charge sensor, SPRD, RID) and associated electronics with storing, processing, and streaming/transmitting capabilities in one assembly. The collected processed data can be stored internally in the instrument, can be displayed on the instrument's own display, or can be transferred outside the instrument via removable storage media, cable, or wirelessly. *Syn:* **measuring instrument, measuring device, data acquisition device.**

keyword: Terms possessing a reserved associated meaning in ASN.1 and understood by compilers. Examples include BEGIN, DEFINITIONS, DEFAULT, END, and OPTIONAL. Additional keywords not automatically supported by compilers can be defined by the user. ASN.1 KEYWORDS (including built-in types) are written exclusively in uppercase.

lexical item: A named sequence of characters from the ASN.1 character set, specified in clause 12 of ISO/IEC 8824-1, which is used in forming the ASN.1 notation.

live time: Time that a data acquisition device is able to completely and properly record events from a radiation detector. Live time is alternatively defined as the measurement time between periods of dead time.

measurement: Process of collecting radiation data.

packet: An encoded specification of data containing information in ASN.1 structures, organized as a transmittable unit to a receiving device.

NOTE—Packets are encoded prior to transmission according to the ASN.1 encoding rules (ITU Standard X.690 [B9], ITU Standard X.691 [B10], ITU Standard X.692 [B11], ITU Standard X.693 [B12], ITU Standard X.694 [B13], ITU Standard X.695 [B14], and ITU Standard X.696 [B15]).

receiving device (alternative: smartphone): Smartphone, tablet, or similar device with sufficient computing and receiving/transmitting capabilities to communicate with a transmitting instrument.

sensor: A basic unit that responds to a physical non-radiation stimulus such as heat, voltage, pressure, battery charge, etc.

NOTE—Examples: HV sensor, battery charge sensor, temperature sensor.

sequence of type: Each value in the sequence of type is a fixed and ordered list of zero, one or more values of the same ASN.1 type

sequence type: A fixed, ordered list that contains variables of more than one distinct ASN.1 component type.

start of measurement data transmission (beginning or start of measurement): Measurement data transmission starts when a link (pairing) between the instrument and the receiving device is established.

type (ASN.1): A named set of values.

variable: An assigned name for data stored in an ASN.1 type. The variable name precedes the TYPE designation during assignment.

NOTE—As an example, a counts value of 10 can be stored in an ASN.1 under the variable name “counts” of type INTEGER, for example, “counts 10”.

3.2 Acronyms and abbreviations

The following acronyms and abbreviations are used in this standard:

ASN.1	Abstract Syntax Notation One
BER	Basic Encoding Rules (ASN.1)
CER	Canonical Encoding Rules (ASN.1)
C-OER	Canonical Octet Encoding Rules
DER	Distinguished Encoding Rules (ASN.1)
ICRP	International Commission on Radiological Protection
ICRU	International Committee for Radiological Units
MCA	multichannel analyzer
PER	Packed Encoding Rules
PRD	personal radiation detector
RID	radioisotope identification device
SiPM	silicon photomultiplier
SPRD	spectrometric personal radiation detector
UTC	Coordinated Universal Time

3.3 Quantities and units

This standard uses the International System of Units (SI). Multiples and submultiples of SI units will be used, when practicable, according to the SI system.

This standard also uses the following units and their multiples and submultiples:

- For energy: electron-volt (eV), $1 \text{ eV} = 1.602 \times 10^{-19} \text{ J}$
- For ambient dose equivalent: Sievert (Sv)
- For exposure: Roentgen (R), $1 \text{ R/h} = 2.58 \times 10^{-4} \text{ C/kg/h}$
- For encoded radiation data packet size: bytes (B)

4. General

4.1 ASN.1 notation

This standard relies on Abstract Syntax Notation One (ASN.1) notation [ISO/IEC 8824]. ASN.1 is a joint international standard of the ISO¹⁴, IEC¹⁵, and ITU-T¹⁶. The ASN.1 syntax is specified in ISO/IEC 8824/ITU-T X680 series of standards [ISO/IEC 8824-1]. Using available commercial or free ASN.1 compilers, source code can be generated in a user's programming language of choice from the ASN.1 syntax specification. The use of such compilers is not a requirement.

The ASN.1 notation standard is complemented by standardized encoding rules (e.g., BER [Basic Encoding Rules], DER [Distinguished Encoding Rules], PER [Packed Encoding Rules], C-OER [Canonical Octet Encoding Rules]), which are independent of notation, and are platform- and language-independent. The ASN.1 encoding and decoding rules are specified in ISO/IEC 8825/ITU-T X690 series of standards [ISO/IEC 8825-1]. The encoding rules determine the precise bit-patterns in which values of the ASN.1 structures are represented when they are streamed to the receiving device.

The ASN.1 notation consists of a sequence of characters from the ASN.1 character set specified in clause 11 of IEC/ISO 8824-1:2021. Each use of the ASN.1 notation contains characters from the ASN.1 character set grouped into lexical items. The IEC/ISO 8824-1 specifies all the sequences of characters forming lexical items. All lexical items are named, and the permitted sequences of lexical items are also named. A new (more complex) permitted sequence of lexical items is defined by means of production. A production uses the names of lexical items and of permitted sequences of lexical items and forms a new named permitted sequence of lexical items. Additionally, there are types that were defined or constructed for use specifically in this standard. They are referred to as IEEE N42.61 standard-defined types.

The ASN.1 format was chosen for its information compression, speed (binary information), stability, and lack of ambiguity. The ASN.1 standardization and decades of use in a variety of applications shaped ASN.1 to be reliable data representation convention utilized across many industries.

4.2 Notation in this standard

The basic notation of ASN.1 is specified in ISO/IEC 8824-1. This subclause briefly summarizes the notation and stylistic conventions used in this standard:

- ASN.1 type names start with an upper-case letter and use `Courier New` font.
- ASN.1 KEYWORDS (including built-in types) are written exclusively in uppercase.
- Each element of a SEQUENCE, SEQUENCE OF, or CHOICE type is named by an identifier, which begins with a lower-case letter and uses `Courier New` font.
- One-line comments in ASN.1 notation begin and end with a pair of adjacent hyphens, "--".
- Multiple-line comments begin with "/*" and end with a corresponding "*/".

¹⁴ <https://www.iso.org/home.html>

¹⁵ <https://www.iec.ch/>

¹⁶ <https://www.itu.int/home/>

- Three dots (...) indicate instances where the ASN.1 definitions are extensible. Specifically, the three dots (...) at the end of CHOICE, SEQUENCE, SEQUENCE OF, etc. indicate where new elements can be added in future revisions of the standard.

IEEE N42.61 standard-defined ASN.1 variables are defined in the following convention:

<ASN.1 Variable Name>

Format:

<ASN.1 Type>

Requirement:

<Mandatory or OPTIONAL>

Unit:

<Unit convention established by the standard, for example, degrees Celsius, counts per second, decimal degrees, unitless. Unit designation is not transmitted by the instrument>

Default value:

<Default value established by the standard, for example, FALSE for BOOLEAN, “N/A” for UTF8-STRING>

Description:

<Description of data included and its structure>

4.3 ASN.1 types used in this standard

The ASN.1 types used in this standard include simple built-in types (those defined in ISO/IEC 8824-1), as well as user-defined types specific to this standard. The IEEE N42.61 standard-defined types and variables are defined in Clause 6 through Clause 10 of this document. The simple built-in ASN.1 types used in this standard are described below.

BIT STRING

A simple type whose distinguished values are an ordered sequence of zero, one, or more bits.

BOOLEAN

A simple type with two distinguished values: TRUE or FALSE.

INTEGER

A simple type with distinguished values, which are the positive and negative whole numbers including zero (as a single digit).

OCTET STRING

A simple type whose distinguished values are an ordered sequence of zero, one, or more octets, each octet being an ordered sequence of eight bits.

REAL

A simple type whose distinguished values include the set of real numbers.

UTF8String

A restricted character string. UTF8String can have any of the characters from the ISO/IEC 10646 Standard.

CHOICE

Types defined by referencing a list of distinct specified types. The type and value of a CHOICE type variable is derived from the type and value of one of its listed component types specified in the variable definition. The parent CHOICE type shall be designated as Mandatory or OPTIONAL, with its component types bearing no Mandatory/OPTIONAL designation.

The CHOICE type is structured as follows:

```
identifier ::= CHOICE
{
    identifier1 TYPE1,
    identifier2 TYPE2,
    identifier3 TYPE3,
    ...
}
```

ENUMERATED

Simple type whose values are given distinct identifiers as part of the type notation. The ENUMERATED type is a list of variables of the same type with an associated numerical value for each. The list is ordered ascending numerically. The value for an ENUMERATED-type variable is an integer denoting one of the specified variables in the list. The ENUMERATED type is designated as Mandatory or OPTIONAL, with its components bearing no Mandatory/OPTIONAL designation.

The ENUMERATED type is structured as,

```
Identifier ::= ENUMERATED
{
    identifier1 (INTEGER1),
    identifier2 (INTEGER2),
    identifier3 (INTEGER3),
    ...
}
```

DATE-TIME

DATE-TIME is a default ASN.1 type for representing date and time in accordance with ISO 8601-1 and ISO 8601-2. It is used to represent local time, UTC time, and local time with time difference between local and UTC time.

Local time: The representation of DATE-TIME local time is YYYY-MM-DDTHH:MM:SS.

UTC time: The representation of DATE-TIME UTC time is YYYY-MM-DDTHH:MM:SSZ.

Local time with time difference between local and UTC time: The representation of DATE-TIME with time difference between local and UTC time is YYYY-MM-DDTHH:MM:SS±HH:MM.

SEQUENCE

Type defined as an ordered list of variables permitting the use of multiple types. Included types can be default ASN.1 types such as INTEGER, REAL, or BOOLEAN, as well as user-defined types and other SEQUENCES or SEQUENCES OF. The identifier for the SEQUENCE is capitalized.

The SEQUENCE type is structured as follows:

```
Identifier ::= SEQUENCE
{
    identifier1 <TYPE1>,
    identifier2 <TYPE2>,
    ...
}
```

```
        identifier3 <TYPE3>,  
        ...  
    }
```

SEQUENCE OF

Defined by referencing a single component type; each value in the SEQUENCE OF type is an ordered list of zero, one, or more values of a single component type. The component type can be a default ASN.1 type, such as BOOLEAN, INTEGER, or REAL, as well as a user-defined type or another SEQUENCE or SEQUENCE OF. The variable type is specified following SEQUENCE OF. The identifier for the SEQUENCE OF is capitalized.

The SEQUENCE OF type is structured as,

```
Identifier ::= SEQUENCE OF <TYPE>  
  
{  
    identifier1,  
    identifier2,  
    identifier3,  
    ...  
}
```

4.4 Encoding rules

The ASN.1 encoding rules for the application of this standard shall be the Distinguished Encoding Rules (DER) as specified in ISO/IEC 8825-1.

ISO/IEC 8825-1 specifies a set of encoding rules that are used to derive the specification of a transfer syntax for values of types defined using the ASN.1 notation. These encoding rules are also to be applied for decoding such a transfer syntax to identify the data values transmitted.

4.5 Extensibility

Extensibility ensures backward and forward compatibility between different editions of this standard. The ASN.1 specifications in this standard permit this extensibility. This ensures future revisions of this standard including new features remain compatible with applications developed according to previous standard editions and will continue to work on data encoded using the revised edition of the standard (but will ignore the new features). Applications developed using the revised standard will be able to read data generated by applications developed for previous editions.

NOTE—Backward and forward compatibility between different editions of this standard is conditional on compatibility of existing default ASN.1 definitions and syntax in future editions. Deprecation of ASN.1 definitions used in this standard will require modification of schema structures to accommodate evolution in ASN.1.

5. Design principles

5.1 Basic assumptions

The basic assumptions for this standard are:

- The instrument is capable of streaming four distinct encoded ASN.1 packet types: `Header`, `InstrumentStatus`, `RadiationData`, and `Footer`.
- The instrument sends information about the instrument parameters and its detectors in the `Header` packet and about its sensors and detectors' status in the `InstrumentStatus` packet.
- Radiation data is streamed (transmitted) in `RadiationData` packets from all the instrument's detectors to the receiving device (e.g., smartphone).
- The radiation data from each detector of the instrument is accumulated (summed) in the instrument memory for a very short period (`accumulationTime`), e.g., 1 second. At the end of this `accumulationTime` the accumulated radiation data from all detectors is streamed to the receiving device (e.g., smartphone) in one packet (`RadiationData` packet).
- Each packet has mandatory data (data that have to be streamed in each packet transmission instance) and `OPTIONAL` data. The instrument manufacturer/developer determines which `OPTIONAL` data the instrument will stream; however, the mandatory/`OPTIONAL` field designations are determined by the standard.
- The receiving device actively monitors for the receipt of packets.
- The timing of each `RadiationData` and `InstrumentStatus` packet is indicated by the `relativeTime`: the time elapsed (in milliseconds) from the beginning of streaming session (`timeStampZero`) until the end of `accumulationTime` for the `RadiationData` packet, and until the time of packet transmission for the `InstrumentStatus` packet. There is an option to stream the absolute date and time.
- The `InstrumentStatus` packet can be streamed once, at regular intervals, or upon a change in instrument conditions. The frequency and the criteria by which an updated `InstrumentStatus` packet is transmitted is left to the manufacturer/developer of the instrument.
- At the end of the streaming session, the instrument sends a single packet (`Footer`) indicating the end of the measurement. This packet can contain only a stop signal or include summarized information about the measurement session.

Some detectors can be operated in several modes with different parameter settings or produce two or more types of radiation. IEEE N42.61 format structure allows a single physical detector to be presented as two or more virtual detectors. For example, a single neutron detector can stream thermal and fast neutrons and be represented in IEEE N42.61 as two virtual detectors: one streaming only thermal neutrons and the second one streaming only fast neutrons. The same concept of virtual detectors can be applied for a single alpha/beta detector represented as two virtual detectors, one for alphas and one for betas. Another example

for IEEE N42.61 virtual detectors is for a single detection instrument with several modes of operation, for example, search mode, find mode, localization mode.

5.2 Basic packet structure of the streamed data

All data is streamed in encoded ASN.1 packets, and this standard defines the following four ASN.1 packet types: `Header`, `InstrumentStatus`, `RadiationData`, and `Footer`. The `StreamedPacket` type contains the data streamed and shall be a choice of one of the four standard-defined packet types:

<code>Header</code>	Contains the description and the parameters of the instrument and all of its radiation detectors. This information typically does not change during the transmission, but it can change, for example, when the calibration information changes during the streaming time.
<code>InstrumentStatus</code>	Contains information about the status of the instrument and its sensors and detectors (e.g., temperature, remaining battery charge, voltage). This information can change during the measurement.
<code>RadiationData</code>	Contains the radiation data from all instrument detectors that is collected for the <code>accumulationTime</code> . It is streamed typically at regular intervals (e.g., every second) for the duration of the measurement.
<code>Footer</code>	Signifies the end of the streaming session.

The high-level packet structure containing all data to be streamed/transmitted is named `StreamedPacket`. The data contained in `StreamedPacket` must be one of the four designated packet types: `Header`, `InstrumentStatus`, `RadiationData`, or `Footer`. Its structure is provided below:

<code>StreamedPacket</code>	CHOICE
<code>headerPacket</code>	<code>Header</code>
<code>instrumentStatusPacket</code>	<code>InstrumentStatus</code>
<code>radiationDataPacket</code>	<code>RadiationData</code>
<code>footerPacket</code>	<code>Footer</code>

The high-level structure of the four main packets is provided below. Each packet contains a time information `SEQUENCE` with mandatory and `OPTIONAL` elements. The `Header`, the `InstrumentStatus`, and the `RadiationData` packets all contain respective data `SEQUENCES` for the instrument, and `SEQUENCES` for a list of the instrument's detectors ordered by assigned detector ID numbers (i.e., 0, 1, 2, ...).

Header	ASN.1 Type	Requirement
MeasurementType	ENUMERATED	Mandatory
timeInformationHeader	SEQUENCE	Mandatory
instrumentInformationHeader	SEQUENCE	Mandatory
detectorsListHeader	SEQUENCE OF	Mandatory
detectorInformationHeader	SEQUENCE	Mandatory
InstrumentStatus	ASN.1 Type	Requirement
instrumentStatusPacketNumber	INTEGER	OPTIONAL
timeInformationInstrumentStatus	SEQUENCE	Mandatory
instrumentStatusInformation	SEQUENCE	Mandatory
detectorsListInformationStatus	SEQUENCE OF	Mandatory
detectorStatusInformation	SEQUENCE	Mandatory
RadiationData	ASN.1 Type	Requirement
radiationDataPacketNumber	INTEGER	OPTIONAL
timeInformationRadiationData	SEQUENCE	Mandatory
instrumentLocation	SEQUENCE	OPTIONAL
detectorsListRadiationData	SEQUENCE OF	Mandatory
detectorRadiationData	SEQUENCE	Mandatory
Footer	ASN.1 Type	Requirement
timeInformationFooter	SEQUENCE	Mandatory
lastInstrumentStatusPacketNumber	INTEGER	OPTIONAL
lastRadiationDataPacketNumber	INTEGER	OPTIONAL

The streamed RadiationData packets consist of mandatory data (i.e., basic radiation data that must be streamed) and OPTIONAL data. The manufacturer or developer determines which OPTIONAL data their instrument will stream. Examples of mandatory data are gross gamma counts from a gamma detector, gross neutron counts from a neutron detector, and accumulation and relative times. Examples of OPTIONAL data are derived quantities (e.g., gamma exposure, neutron dose, exposure rate, neutron dose rate, identified radionuclides), which can be calculated by the instrument but can alternatively be calculated by the receiving device using the basic mandatory streamed quantities (e.g., gross counts, time data, and calibration coefficients). The more OPTIONAL data is streamed, the larger the packet, which can limit transmission frequency depending on the chosen transmission protocol.

In some cases, if an OPTIONAL type is used, then a component element is required. If a parent type is OPTIONAL but its component element is indicated as Mandatory, this means that the component element is required only if the OPTIONAL parent type is included. For example, instrumentLocation is OPTIONAL. Its component elements latitude and longitude are Mandatory. This means when instrumentLocation is present, then these two component elements are required. Any rules more specific than this are described in the details in the subclauses for each of the component elements.

Each packet contains timing data: Mandatory relativeTime (since timeStampZero), Mandatory accumulationTime (for the RadiationData packet), and OPTIONAL timeStamp providing absolute date and time.

5.3 Packet structure of gamma spectroscopic and energy calibration data

5.3.1 Gamma spectroscopic data structure

Gamma spectroscopic data from the instrument can be streamed in two ways in the `RadiationData` packet:

- a) As `channelSpectrum` – an ascending ordered list (`SEQUENCE OF`) of the raw detected counts in each MCA channel. The data can be optionally compressed by the Counting Zero algorithm (see 7.4.20).

NOTE—Energy calibration information is provided in the `Header` packet by the `energyCalibration SEQUENCE`.

- b) As spectroscopic data calculated by the instrument in energy units, that is, counts per energy bin. Such spectroscopic data consists of two components:
 - 1) `energyBinsStructure`: Provides the structure of the energy bins.
 - 2) `energyBinsCounts`: Contains the counts in each energy bin.

5.3.2 Gamma energy calibration data structure

Energy calibration data is needed for converting `channelSpectrum` (counts per MCA channel) into counts per energy. Energy calibration information is provided in the `Header` packet by the `energyCalibration SEQUENCE`. This information allows the receiving device to convert the spectrum from channels to energy, for example, keV.

There are two methods available for providing energy calibration information:

- a) In the form of a polynomial equation in which the elements of `energyBinsCoefficients SEQUENCE` must be specified. The equation converts each MCA channel into energy. This method allows linear and non-linear calibration.
- b) In a list (`SEQUENCE`) `energyBinsList` in which the lower boundaries of the energy bins are provided. This method allows non-linear calibration. Only one of the two methods applies to a particular energy calibration.

NOTE—The response of some radiation detectors can change with temperature, among other factors. As temperature dependence affects the energy calibration, some instrument developers account for this by storing a priori measured calibration sets (energies/channels) for several temperature points in the stated temperature range of the instrument. For example, the instrument stores calibration data (energies/channels) for a set of four temperatures: -10°C, 0°C, +20°C, and +40°C. Depending on the current temperature of the instrument (acquired from its temperature sensor) the appropriate calibration set is used to convert MCA channels into energy bins. This standard does not limit the number of calibration temperature points to be transmitted in the `Header` packet.

Gamma energy calibration data measured at only one temperature is provided by two lists in the `Header` packet:

- a) `calibrationEnergiesList` – Ordered list (SEQUENCE OF) of calibration energies
- b) `calibrationChannelsList` – Ordered list (SEQUENCE OF) of the channels corresponding to the calibration energies

Gamma energy calibration measured at multiple temperatures is provided by three ordered lists in the Header packet:

- a) `calibrationTemperaturesList` – Ordered list (SEQUENCE OF) of temperatures
- b) `calibrationEnergiesList` – Ordered list (SEQUENCE OF) of calibration energies
- c) `calibrationChannelsList` – Nested ordered list (SEQUENCE OF SEQUENCE OF) of channel numbers corresponding to each energy/temperature pair

An example is provided in Annex A for the order of elements in `calibrationTemperaturesList`, `calibrationEnergiesList`, and `calibrationChannelsList` based on four calibration sources providing nine calibration energies at eight calibration temperatures.

The receiving device can then use any fitting algorithm to produce an energy calibration curve from a given energy calibration.

5.4 IEEE N42.61 standard-defined ASN.1 types

The Header, InstrumentStatus, RadiationData, and Footer packets are composed of standard-defined SEQUENCE types. Each standard-defined type is defined within its mother packet and denoted using an identifier only, omitting the requirement for an additional associated type name.

5.4.1 IEEE N42.61 standard-defined ASN.1 types in addition to transmitted packets

The date and time type in this standard is defined by including fractional seconds (nanoseconds) to the default ASN.1 and ISO 8601 DATE-TIME type using the `Time=HMSF9` type setting. It is structured as a CHOICE between three TIME subtypes, differentiated by the `Local-or-UTC` type setting, to allow the representation of date and time as local time (L), UTC time (Z), and difference between local-and-UTC time (LD) conventions. The IEEE N42.61 standard-defined type, DATE-TIME-FRACTIONAL, is defined as follows:

```
DATE-TIME-FRACTIONAL ::= CHOICE
{
    local-DATE-TIME-FRACTIONAL      TIME (SETTINGS
        "Basic=DATE-TIME Date=YMD Time=HMSF9 Local-or-UTC=L"),
    utc-DATE-TIME-FRACTIONAL        TIME (SETTINGS
        "Basic=Date-Time Date=YMD Time=HMSF9 Local-or-UTC=Z"),
    local-difference-DATE-TIME-FRACTIONAL TIME (SETTINGS
        "Basic=Date-Time Date=YMD Time=HMSF9 Local-or-UTC=LD"),
    ...
}
```

There is an option to indicate the source of the timing information (e.g., NTP – Network Time Protocol, PTP – Precision Time Protocol, GPS, manually) in a free descriptive UTF8String.

NOTE—The above definition for DATE-TIME-FRACTIONAL must be included in the schema for proper encoding and decoding.

5.4.2 IEEE N42.61 standard-defined ASN.1 types in the Header packet

IEEE N42.61 Standard-Defined ASN.1 Variable Name	ASN.1 Type	Requirement	Subclause
measurementType	ENUMERATED	Mandatory	7.1.1
measurementName	UTF8String	OPTIONAL	7.1.2
measurementDescription	UTF8String	OPTIONAL	7.1.3
timeInformationHeader	SEQUENCE	Mandatory	7.2.1
timeStampZero	DATE-TIME-FRACTIONAL	Mandatory	7.2.2
timeStampZeroSource	UTF8String	OPTIONAL	7.2.3
radiationDataPacketTransmissionRate	REAL	OPTIONAL	7.2.4
instrumentStatusPacketTransmissionRate	REAL	OPTIONAL	7.2.5
instrumentInformationHeader	SEQUENCE	Mandatory	7.3.1
instrumentName	UTF8String	Mandatory	7.3.2
instrumentDescription	UTF8String	OPTIONAL	7.3.3
instrumentManufacturer	UTF8String	Mandatory	7.3.4
instrumentModel	UTF8String	Mandatory	7.3.5
instrumentSerialNumber	UTF8String	Mandatory	7.3.6
instrumentFirmware	UTF8String	OPTIONAL	7.3.7
instrumentFirmwareVersion	UTF8String	OPTIONAL	7.3.8
instrumentSoftware	UTF8String	OPTIONAL	7.3.9
instrumentSoftwareVersion	UTF8String	OPTIONAL	7.3.10
numberOfDetectors	INTEGER	OPTIONAL	7.3.11
detectorsListHeader	SEQUENCE OF	Mandatory	7.4.1
detectorInformationHeader	SEQUENCE	Mandatory	7.4.2
detectorID	INTEGER	Mandatory	7.4.3
detectorType	ENUMERATED	Mandatory	7.4.4
detectorKind	ENUMERATED	OPTIONAL	7.4.5
detectorDescription	UTF8String	OPTIONAL	7.4.6
detectorManufacturer	UTF8String	OPTIONAL	7.4.7
detectorModel	UTF8String	OPTIONAL	7.4.8
detectorSerialNumber	UTF8String	OPTIONAL	7.4.9
detectorFirmware	UTF8String	OPTIONAL	7.4.10
detectorFirmwareVersion	UTF8String	OPTIONAL	7.4.11
detectorSoftware	UTF8String	OPTIONAL	7.4.12
detectorSoftwareVersion	UTF8String	OPTIONAL	7.4.13
exposureCoeff	SEQUENCE	OPTIONAL	7.4.14
exposureCoeffEnergyList	REAL	OPTIONAL	7.4.15
exposureCoeffList	REAL	OPTIONAL	7.4.16
doseConversion	SEQUENCE	OPTIONAL	7.4.17

IEEE N42.61 Standard-Defined ASN.1 Variable Name	ASN.1 Type	Requirement	Subclause
doseConversionEnergyList	REAL	OPTIONAL	7.4.18
doseConversionCoeffList	REAL	OPTIONAL	7.4.19
spectrumCompression	BOOLEAN	OPTIONAL	7.4.20
backgroundSubtraction	BOOLEAN	OPTIONAL	7.4.21
numberOfMCACHannels	INTEGER	OPTIONAL	7.4.22
energyCalibration	SEQUENCE	OPTIONAL	7.5.1
calibrationTemperaturesList	SEQUENCE OF INTEGER	OPTIONAL	7.5.2
calibrationEnergiesList	SEQUENCE OF REAL	OPTIONAL	7.5.3
calibrationChannelsList	SEQUENCE OF SEQUENCE OF INTEGER	OPTIONAL	7.5.4
energyBinsStructure	CHOICE	OPTIONAL	7.5.5
energyBinsCoefficients	SEQUENCE OF REAL	OPTIONAL	7.5.6
energyBinsList	SEQUENCE OF REAL	OPTIONAL	7.5.7
calibrationTime	DATE-TIME-FRACTIONAL	OPTIONAL	7.5.8

5.4.3 IEEE N42.61 standard-defined ASN.1 types in the InstrumentStatus packet

IEEE N42.61 Standard-Defined ASN.1 Variable Name	ASN.1 Type	Requirement	Subclause
instrumentStatusPacketNumber	INTEGER	OPTIONAL	8.1.1
timeInformationInstrumentStatus	SEQUENCE	Mandatory	8.2.1
relativeTime	INTEGER	Mandatory	8.2.2
timeStamp	DATE-TIME-FRACTIONAL	OPTIONAL	8.2.3
timeStampSource	UTF8String	OPTIONAL	8.2.4
instrumentStatusInformation	SEQUENCE	Mandatory	8.3.1
instrumentTemperature	INTEGER	OPTIONAL	8.3.2
instrumentPower	CHOICE	Mandatory	8.3.3
instrumentBatteryRemainingCharge	INTEGER	N/A	8.3.4
instrumentBatteryVoltage	REAL	N/A	8.3.5
instrumentPowerStatus	BOOLEAN	N/A	8.3.6
instrumentHealth	BOOLEAN	OPTIONAL	8.3.7
instrumentHealthDetail	UTF8String	OPTIONAL	8.3.8
instrumentSelfCalibration	UTF8String	OPTIONAL	8.3.9
detectorsListInformationStatus	SEQUENCE OF	Mandatory	8.4.1
detectorStatusInformation	SEQUENCE	Mandatory	8.4.2
detectorID	INTEGER	Mandatory	8.4.3

IEEE N42.61 Standard-Defined ASN.1 Variable Name	ASN.1 Type	Requirement	Subclause
detectorManufacturer	UTF8String	OPTIONAL	8.4.4
detectorModel	UTF8String	OPTIONAL	8.4.5
detectorSerialNumber	UTF8String	OPTIONAL	8.4.6
detectorVoltage	REAL	OPTIONAL	8.4.7
detectorGain	REAL	OPTIONAL	8.4.8
detectorTemperature	INTEGER	OPTIONAL	8.4.9
detectorHealth	BOOLEAN	OPTIONAL	8.4.10
detectorHealthDetail	UTF8String	OPTIONAL	8.4.11
detectorSelfCalibration	UTF8String	OPTIONAL	8.4.12

5.4.4 IEEE N42.61 standard-defined ASN.1 types in the RadiationData packet

IEEE N42.61 Standard-Defined ASN.1 Variable Name	ASN.1 Type	Requirement	Subclause
radiationDataPacketNumber	INTEGER	OPTIONAL	9.1.1
timeInformationRadiationData	SEQUENCE	Mandatory	9.2.1
relativeTime	INTEGER	Mandatory	9.2.2
accumulationTime	INTEGER	Mandatory	9.2.3
timeStamp	DATE-TIME-FRACTIONAL	OPTIONAL	9.2.4
timeStampSource	UTF8String	OPTIONAL	9.2.5
instrumentLocation	SEQUENCE	OPTIONAL	9.3.1
latitude	REAL	Mandatory	9.3.2
longitude	REAL	Mandatory	9.3.3
elevation	REAL	OPTIONAL	9.3.4
azimuth	REAL	OPTIONAL	9.3.5
inclination	REAL	OPTIONAL	9.3.6
roll	REAL	OPTIONAL	9.3.7
horizontalAccuracy	REAL	OPTIONAL	9.3.8
verticalAccuracy	REAL	OPTIONAL	9.3.9
detectorsListRadiationData	SEQUENCE OF	Mandatory	9.4.1
detectorRadiationData	SEQUENCE	Mandatory	9.4.2
detectorID	INTEGER	OPTIONAL	9.4.3
counts	INTEGER	Mandatory	9.4.4
channelSpectrum	SEQUENCE OF INTEGER	OPTIONAL	9.4.5
derivedData	SEQUENCE	OPTIONAL	9.4.6
countRate	REAL	OPTIONAL	9.4.7
exposure	REAL	OPTIONAL	9.4.8
exposureRate	REAL	OPTIONAL	9.4.9
dose	REAL	OPTIONAL	9.4.10
doseRate	REAL	OPTIONAL	9.4.11
intensity	INTEGER	OPTIONAL	9.4.12
energyBinsCounts	SEQUENCE OF REAL	OPTIONAL	9.4.13
alarm1	SEQUENCE	OPTIONAL	9.4.14
alarm1Flag	BOOLEAN	OPTIONAL	9.4.15
alarm1SetPoint	REAL	OPTIONAL	9.4.16
alarm1SetPointUnits	UTF8String	OPTIONAL	9.4.17
alarm2	SEQUENCE	OPTIONAL	9.4.18

IEEE N42.61 Standard-Defined ASN.1 Variable Name	ASN.1 Type	Requirement	Subclause
alarm2Flag	BOOLEAN	OPTIONAL	9.4.19
alarm2SetPoint	REAL	OPTIONAL	9.4.20
Alarm2SetPointUnits	UTF8String	OPTIONAL	9.4.21
alarm3	SEQUENCE	OPTIONAL	9.4.22
alarm3Flag	BOOLEAN	OPTIONAL	9.4.23
alarm3SetPoint	REAL	OPTIONAL	9.4.24
alarm3SetPointUnits	UTF8String	OPTIONAL	9.4.25
deadTime	REAL	OPTIONAL	9.4.26
liveTime	REAL	OPTIONAL	9.4.27
identificationResults	SEQUENCE OF	OPTIONAL	9.4.28
identifiedMaterial	SEQUENCE	OPTIONAL	9.4.29
identifiedRadionuclide	INTEGER	OPTIONAL	9.4.30
category	ENUMERATED	OPTIONAL	9.4.31
confidenceLevel	INTEGER	OPTIONAL	9.4.32
eventData	SEQUENCE OF	OPTIONAL	9.4.33
event	SEQUENCE	OPTIONAL	9.4.34
eventTime	TIME	OPTIONAL	9.4.35
eventPosition	INTEGER	OPTIONAL	9.4.36
eventEnergy	REAL	OPTIONAL	9.4.37
eventType	ENUMERATED	OPTIONAL	9.4.38

5.4.5 IEEE N42.61 Standard-defined ASN.1 types in the Footer packet

IEEE N42.61 Standard-Defined ASN.1 Variable Name	ASN.1 Type	Requirement	Subclause
timeInformationFooter	SEQUENCE	Mandatory	10.1.1
relativeTime	INTEGER	Mandatory	10.1.2
timeStamp	DATE- TIME- FRACTION AL	OPTIONAL	10.1.3
timeStampSource	UTF8String	OPTIONAL	10.1.4
lastInstrumentStatusPacketNumber	INTEGER	OPTIONAL	10.2.1
lastRadiationDataPacketNumber	INTEGER	OPTIONAL	10.2.2
averageCountRate	REAL	OPTIONAL	10.2.3
rowRatio1	REAL	OPTIONAL	10.2.4
rowRatio2	REAL	OPTIONAL	10.2.5
rowRatio3	REAL	OPTIONAL	10.2.6

6. StreamedPacket specification

The specification of the top-level packet (StreamedPacket) is the following:

StreamedPacket

Format:

CHOICE

```
{
    header          Header,
    instrumentStatus InstrumentStatus,
```

```

radiationData      RadiationData,
footer             Footer
}

```

Requirement:

Mandatory

Unit:

N/A

Default value:

N/A

Description:

The StreamedPacket prescribes which of the four available data packet types is streamed. The four available packets are: Header, InstrumentStatus, RadiationData, Footer.

NOTE—When writing a Standard-defined packet in ASN.1 notation, the StreamedPacket type must be referenced by an identifier name, for example, “streamedPacket StreamedPacket.” The identifier name must begin with a lowercase letter. The choice of identifier name is arbitrary and does not get transmitted.

7. Header packet specification

The Header packet contains information that is not changing often over the course of the streaming session (e.g., instrument manufacturer, make, model, serial number, firmware version, list of all detectors with their parameters, energy calibration, and dosimetric coefficients data). Instruments may generate and stream updated Header packets at any time if a change is made (e.g., updated energy calibration). It is left to the manufacturer or developer’s discretion to decide what OPTIONAL data to include.

In the Header, the following data fields are contained; organized within distinct SEQUENCES for clarity.

7.1 Measurement type

There are three measurement types supported: background measurement, calibration measurement, source or object of interest measurement, and other measurement that can be identified by the designer.

7.1.1 measurementType

Format:

ENUMERATED

```

{
    background                (0) ,
    calibration                (1) ,
    objectOfInterest          (2) ,
    ...
}

```

Requirement

Mandatory

Unit:

N/A

Default value:

N/A

Description:

At the beginning of the streaming session, the value indicates what type of measurement is following – a background measurement, a calibration measurement, or a measurement of the source or object of interest.

7.1.2 measurementName

Format:

UTF8String

Requirement

OPTIONAL

Unit:

N/A

Default value:

N/A

Description:

String field provided for an optional instrument-specified or user input unique measurement name.

7.1.3 measurementDescription

Format:

UTF8String

Requirement

OPTIONAL

Unit:

N/A

Default value:

N/A

Description:

String field provided for an optional measurement description including instrument-specific parameters.

7.2 Time information in the Header packet

The time information SEQUENCE of the Header packet is an ASN.1 ordered SEQUENCE describing the timing parameters of the measurement. The SEQUENCE follows the format below.

7.2.1 timeInformationHeader

Format:

SEQUENCE

```
{
    timeStampZero,
    timeStampZeroSource,
    radiationDataPacketTransmissionRate,
    instrumentStatusPacketTransmissionRate
    ...
}
```

Requirement:

Mandatory

Unit:

N/A

Default value:

N/A

Description:

The time information portion of the Header packet is an ASN.1 ordered SEQUENCE describing the timing parameters of the measurement. The SEQUENCE elements follow the format below.

7.2.2 timeStampZero

Format:

DATE-TIME-FRACTIONAL

Requirement:

Mandatory

Unit:

local-DATE-TIME-FRACTIONAL "YYYY-MM-DDTHH:MM:SS.fffffffff"

utc-DATE-TIME-FRACTIONAL "YYYY-MM-DDTHH:MM:SS.fffffffffZ"

local-difference-DATE-TIME-FRACTIONAL "YYYY-MM-DDTHH:MM:SS.fffffffff±hh"

local-difference-DATE-TIME-FRACTIONAL "YYYY-MM-DDTHH:MM:SS.fffffffff±hh:mm"

Default value:

utc-DATE-TIME-FRACTIONAL : "0000-01-01T00:00:00.000000000Z"

Description:

Absolute time of the beginning of streaming, specified by the transmitting instrument. DATE-TIME-FRACTIONAL can accept either local time, UTC time, or local time with the time difference between local and UTC time. YYYY is the year, MM is the month, DD is the day, T is the ASCII character "T," HH is the hours, MM is the minutes, SS is the seconds (integer), and ffffffff is the fractional seconds. For example, if local time is 11:40:59 and 250 milliseconds on January 1, 2022, and is three hours ahead of universal (UTC) time, the date and time can be denoted as one of the following:

local-DATE-TIME-FRACTIONAL "2022-01-01T11:40:59.250000000"

utc-DATE-TIME-FRACTIONAL "2022-01-01T08:40:59.250000000Z"

local-difference-DATE-TIME-FRACTIONAL "2022-01-01T11:40:59.250000000+03"

If the time difference between local and UTC time is hours and minutes (for example, India is 5.5 hours ahead of UTC), then the difference (5 hours, 30 minutes) would be included as follows:

local-difference-DATE-TIME-FRACTIONAL "2022-01-01T11:40:59.250000000+05:30"

7.2.3 timeStampZeroSource

Format:

UTF8String

Requirement:

OPTIONAL

Unit:

N/A

Default value:

N/A

Description:

String field for providing source of the timing information for TimeStampZero. For example: Network Time Protocol (NTP), Precision Time Protocol (PTP), GPS, manually, etc.

7.2.4 radiationDataPacketTransmissionRate

Format:

REAL

Requirement:

OPTIONAL

Unit:

Hz (s⁻¹)

Default value:

1

Description:

Rate of radiation data packet transmission from the instrument during streaming.

7.2.5 instrumentStatusPacketTransmissionRate

Format:

REAL

Requirement:

OPTIONAL

Unit:

Hz (s⁻¹)

Default value:

N/A

Description:

Rate of instrument status packet transmission from the instrument during streaming.

7.3 Instrument information in the Header packet

The instrument information portion of the Header packet is an ASN.1 ordered SEQUENCE identifying the transmitting instrument. The SEQUENCE `instrumentInformationHeader` follows the format below.

7.3.1 instrumentInformationHeader

Format:

SEQUENCE

```
{
    instrumentName,
    instrumentDescription,
    instrumentManufacturer,
    instrumentModel,
    instrumentSerialNumber,
    instrumentFirmware,
    instrumentFirmwareVersion,
    instrumentSoftware,
    instrumentSoftwareVersion,
    numberOfDetectors,
    ...
}
```

Requirement:

Mandatory

Unit:

N/A

Default value:

N/A

Description:

Sequence containing quantities related to instrument information for the instrument.

7.3.2 **instrumentName**

Format:

UTF8String

Requirement:

Mandatory

Unit:

N/A

Default value:

N/A

Description:

String field provided for manufacturer-specified or user-programmed unique instrument name.

7.3.3 **instrumentDescription**

Format:

UTF8String

Requirement:

OPTIONAL

Unit:

N/A

Default value:

N/A

Description:

String field provided for an optional instrument description to be included by manufacturer/user programmer.

7.3.4 **instrumentManufacturer**

Format:

UTF8String

Requirement:

Mandatory

Unit:

N/A

Default value:

N/A

Description:

String field provided for the name of instrument manufacturer.

7.3.5 **instrumentModel**

Format:

UTF8String

Requirement:

Mandatory

Unit:

N/A

Default value:

N/A

Description:

String field provided for the name of instrument model.

7.3.6 instrumentSerialNumber

Format:

UTF8String

Requirement:

Mandatory

Unit:

N/A

Default value:

N/A

Description:

String field provided for the manufacturer-specified instrument serial number.

7.3.7 instrumentFirmware

Format:

UTF8String

Requirement:

OPTIONAL

Unit:

N/A

Default value:

N/A

Description:

String field provided for the specified current instrument firmware.

7.3.8 instrumentFirmwareVersion

Format:

UTF8String

Requirement:

OPTIONAL

Unit:

N/A

Default value:

N/A

Description:

String field provided for the specified current instrument firmware version.

7.3.9 instrumentSoftware

Format:

UTF8String

Requirement:

OPTIONAL

Unit:

N/A

Default value:

N/A

Description:

String field provided for the specified current instrument software.