

Research and Development for
Space Data System Standards

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| XML SCHEMA DEFINITION FOR RF LINK BUDGETS |

Draft Experimental Specification

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FOREWORD

This document describes a schema definition for capturing the results of a radio-frequency link budget into an XML digital file.

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PREFACE

This document is a CCSDS Experimental Specification. Its Experimental status indicates that it is part of a research or development effort based on prospective requirements, and as such it is not considered a Standards Track document. Experimental Specifications are intended to demonstrate technical feasibility in anticipation of a ‘hard’ requirement that has not yet emerged. Experimental work may be rapidly transferred onto the Standards Track should a hard requirement emerge in the future.

DOCUMENT CONTROL

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# Introduction

## Purpose

The purpose of this Orange Book is to provide a specification for the definition of XML files, based on the XML schemas in the SANA registry [1], for the digitalization of radio frequency (RF) *link design control table* (see [2]), also known as *link budgets*. Such specification takes the name of *Link Budget Digital Format* (LBDF).

## Scope

The intent of LBDF is to create a standardized XML format for exchanging RF link budget data, thus enhancing communication efficiency and precision among CCSDS agencies when designing space mission. XML files compliant to LBDF (onwards denoted simply as *LBDF files*) can represent link budgets for *tracking, telemetry and command* (TT&C) and *payload data telemetry* (PDT) systems.

Notice that, for keeping independency, confidentiality, and not being limited by possible licensing schemes of CCSDS agencies’ link budget software tools, the LBDF files record only the inputs and the results, but not the calculation methodology.

## Applicability

This Experimental Specification pertains to the establishment of Agency standards and to forthcoming data communications across space links among Consultative Committee for Space Data Systems (CCSDS) Agencies during cross-support scenarios. The Experimental Specification encompasses a comprehensive definition of data formats for inter-Agency cross-support operations.

## Document Structure

This Experimental Specification is organized as follows:

* Section 1 presents the purpose, scope, applicability, terminology, and references;
* Section 2 provides an overview of the LBDF;
* Section 3 gives the specification, main core of this document.

## References

The following publications contain provisions which, through reference in this text, constitute provisions of this Experimental Specification. At the time of publication, the editions indicated were valid. All publications are subject to revision, and users of this Experimental Specification are encouraged to investigate the possibility of applying the most recent editions of the documents indicated below. The CCSDS Secretariat maintains a register of currently valid CCSDS publications.

1. SANA registry “Link Budget Digital Format XML” – available at <https://sanaregistry.org/>, in the “Candidate registries”.
2. *Radio Frequency and Modulation Systems—Part 1: Earth Stations and Spacecraft.* Issue 32. Recommendations for Space Data System Standards (Blue Book), CCSDS 401.0-B-32. Washington, D.C.: CCSDS, October 2021.
3. *TC synchronization and channel coding.* Issue 4. Recommendations for Space Data System Standards (Blue Book), CCSDS 231.0-B-4. Washington, D.C.: CCSDS, July 2021.
4. *TM synchronization and channel coding.* Issue 5. Recommendations for Space Data System Standards (Blue Book), CCSDS 231.0-B-5. Washington, D.C.: CCSDS, September 2023.
5. *Flexible Advanced Coding and Modulation Scheme for High Rate Telemetry.* Issue 2. Recommendations for Space Data System Standards (Blue Book), CCSDS 131.2-B-2. Washington, D.C.: CCSDS, February 2023.
6. *Pseudo-Noise (PN) ranging systems.* Issue 3. Recommendations for Space Data System Standards (Blue Book), CCSDS 414.1-B-3. Washington, D.C.: CCSDS, January 2022.
7. *CCSDS Space Link Protocols over ETSI DVB-S2 Standard.* Issue 2. Recommendations for Space Data System Standards (Blue Book), CCSDS 131.3-B-2. Washington, D.C.: CCSDS, April 2022.
8. *ESA, ESA-TECEST-TN-2023-000747, “LBDF Definition Document”*, March 2023*.*

## Acronyms

|  |  |
| --- | --- |
|  |  |
| ***LBDF*** | *Link budget digital format* |
| ***PDT*** | *Payload data telemetry* |
| ***PN*** | *Pseudo-noise (ranging)* |
| ***RF*** | *Radio frequency* |
| ***RFDN*** | *Radio frequency distribution network* |
| ***SANA*** | *Space assigned authority number* |
| ***TM*** | *Telemetry* |
| ***TT&C*** | *Tracking, telemetry, and command* |
| ***XML*** | *Extensible markup language* |

# Overview

LBDF is a methodology for defining XML files, based on the XML schema definition in the SANA registry at [1], that captures link budgets. In this way, link budgets can be easily shared between parties as digital and numeric files, without constraining and disclosing the computation methodology.

An example of usage is depicted in Figure 1. The CCSDS agency performs the link budget with their own software, and it does an export of the input and results into one or more LBDF files, that can be shared with another agency or generic third party. The other party, once received the LBDF files, can import them into their own link budget software, do a re-calculation of the budget, and cross-check the results.

Notice that software tools for doing the import/export of LBDF files are not part of this specification. Thus, CCSDS agencies interested in importing/exporting LBDF files from their link budgets, need to develop their own conversion tool.



Figure 1: Sketch with example of usage of LBDF.

The remainder of this section focuses on the description of the LBDF schema, giving the basics for understanding later the normative clauses, and it is organized as follows:

* Section 2.1 provides an overview of the schema classes groups;
* Section 2.2 describes the schema files organization in the SANA registry;
* Section **Error! Reference source not found.** gives a summary of the RF-modulations and coding-&-synchronization standards for which its link design control table can represent.

## Classes groups and UML diagram

LBDF files shall comply with the XML schema files in the SANA registry at [1]. These schema files are available freely for download from <https://sanaregistry.org/>, under the entry ‘Link Budget Digital Format XML’ in ‘Candidate Registries’.

The schema files define the classes to be adopted in the LBDF files, whose organization is given by the UML diagram available into the \*.pdf file in [1]. A high-level outlook of such UML diagram is provided in Figure 2.

NOTE – as per scope of the SANA registry, the XML schema files can change upon approval of the registration authority, without need of updating the current Experimental Specification (e.g., for minor fix). As such, this document does not report the deep-level details of the files in the registry, and the user has always to refer to the latest version of the registry at [1].

From the figure it can be seen that LBDF is organized in the following major group, each representing a subset of classes: *Assets*, *Link definition*, *Data types*, *link budget results*, and *link budget*.



Figure 2: UML class diagram organization of the LBDF.

The group named *LBDF Link Budgets* contains the main class LBDF used as starting point for defining an LBDF file.

The LBDF class has as a single element, the link budget, defined by the subset of classes named *Link Budget*. Each of these classes represent different types of link budgets (e.g., uplink/downlink only, TT&C link budget with/without ranging, PDT link budget, etc.).

The subset of classes named *Link definition* envelopes instead all types of links included in the standard (e.g., uplink, downlink). These classes are used for defining the link entity, that gives the link parameters, that is part of the link budget classes above mentioned.

The subset of classes named *Assets* contains all types of assets (such as Ground Stations, Spacecrafts, and User Terminals) that can represent a transmitting or receiving end. These classes, in turn, contain entities (based on sub-classes in the same group) that specify the link budgets elements corresponding to their subsystems (e.g., transmitter, receiver, antenna, RFDN).

The subset of classes named *Data Types* defines all the data types foreseen by the standard. They mostly represent unit of measurement for the various link budget entries.

The subset of classes named *Link Budget Results* defines all the expected results from the link budget computation. For instance, it includes classes that represent the margins, the SNR, the total received power, etc. These classes are divided according to the type of link and the communication protocol used.

## Registry files

Table 1 list the files stored at the SANA registry at [1], with the related description and reference to which of the groups above mentioned belongs to.

|  |  |  |
| --- | --- | --- |
| File name | Description | Group (sub-set of classes) |
| Asset.xsd | XML schema defining an abstract entity for an asset that can be represented a Spacecraft, Ground Station, or User Terminal | Assets |
| DataType.xsd | XML schema defining data types for the LBDF (e.g., dB, percentages, adverse values, etc.) | Data Types |
| GroundStation.xsd | XML schema defining the ground station asset, its elements (e.g., transceiver, receiver, antenna)  and figure of merit (e.g., EIRP, G/T, PLL bandwidth) | Assets |
| LBDF.xsd | XML schema defining the allowed kind of link budgets that are supported by a single LBDF XML file (e.g., TTC Uplink and Downlink with/without Ranging) | LBDF Link Budgets |
| LBDF\_Model.pdf | PDF file providing the UML diagram for all elements and types given in the XSD files of this registry | N/A |
| Link.xsd | XML schema providing all abstract types for the definition of the link waveform characteristics (e.g., frequency, modulation scheme, required Eb/N0, etc.) | Link Definition |
| LinkBudget.xsd | XML schema providing unique identifiers for the link budget, including, mission name, mission’s owner, orbit, and providing the definition of the kind Link Budgets, selectable by LBDF.xsd | Link Budget |
| ResultSummary.xsd | XML schema that defines several metrics, for assessing link budget results (e.g., Data Recovery margins, Downlink SNR) | Results Summary |
| Spacecraft.xsd | XML schema defining the spacecraft asset, its elements (e.g., transceiver, transponder, antenna) and figure of merit (e.g., EIRP, G/T). | Assets |
| TMCoding.xsd | XML schema defining the possible coding schemes that can be adopted for TM links in the LBDF | Link Definition |
| UserTerminal.xsd | XML schema defining the User Terminal asset, its elements (e.g., transceiver, transponder, antenna)  and figure of merit (e.g., EIRP, G/T) | Assets |

Table 1: list of the LBDF files in the SANA registry.

Most of the schema files do an include of the other files, following the tree logic specified in Figure 3 (e.g., LBDF.xsd includes LinkBudget.xsd).



Figure 3: tree logic for the includes done by the LBDF schema files in the SANA register.

## Supported CCSDS standards

Currently LBDF allows to effectively share the cases of RF link budgets shown in Table 2. For each kind of link budget, the table shows the related CCSDS standards for which the LBDF can be representative.

NOTE – Since LBDF is an Experimental Specification, it is not guaranteed that CCSDS will maintain it up to date with additional link features that may appear in future issues of the CCSDS recommended standards. For this reason, the user has to pay special attention to the versioning of the CCSDS recommended standards that are supported by LBDF.

|  |  |  |
| --- | --- | --- |
| Group | Kind of link budget | CCSDS standards  |
| TT&C | TC Uplink only | 231.0-B-4131.0-B-5401.0-B-32 |
| TM Downlink only |
| TC Uplink and TM Downlink (coherent/non coherent) |
| Ranging (transparent generic or regenerative PN) | 414.1-B-3401.0-B-32 |
| DDOR | 401.0-B-32 |
| PDT | TM downlink | 131.0-B-5401.0-B-32 |
| SCCC | 131.2-B-2401.0-B-32 |
| DVB-S2 | 131.3-B-3401.0-B-32 |
| Intersatellite link | bi- directional | 231.0-B-4131.0-B-5401.0-B-32 |
| Proximity-1 | 211.1-B-4211.2-B-3 |
| Ranging (regenerative PN) | 414.1-B-3401.0-B-32 |

Table 2: related CCSDS standards for which the LBDF link budgets are representative.

# Experimental specification

This section provides the normative clauses for the implementation of LBDF files. Since the core of the standard is the XML schema files, the normative clauses are brief, making this experimental specification mostly based on the SANA registry in [1]

## General

### *Link budgets*, denoted also as *link design control tables*, shall be stored in XML files that are compliant to the XML Schema in the SANA Register at [1].

### Each XML file shall contain a single link budget in compliance to CCSDS 401 (4.1.2)-B-1,[2].

### Separate link budgets, and thus XML files, shall be produced for all different parameter combinations (e.g., different Earth Stations, bit rates, modulations, etc).

## Attributes and Elements

### Attributes and elements required by the LBDF shall be used together with the nomenclature and meaning provided in CCSDS 401 (4.1.3)-B-1,[2].

### Elements required by the LBDF that foresees a probability density function as attribute, shall specify it in compliance to CCSDS 401 (4.1.4)-B-1, [2].

### The semantics adopted in the XML files shall have class naming as PascalCase, while element and attribute naming as snake\_case.

### For all the link budget elements, it shall be specified the attribute lbdf\_version and it shall be equal to the version reported in LBDF.xsd.

NOTES

– the LBDF version of this Experimental Specification is 0.2.0.

– Reference [8] is a former version of the LBDF, developed initially by ESA for European missions only. Such version is identified as 0.1.0.

# ANNEX A. Tutorial to the implementation (INFORMATIVE)

This annex provides a tutorial to the implementation of LBDF files, for helping users in getting familiar with this Experimental Specification. The style of writing was done with particular attention to people that are not expert in XML but are knowledgeable of link budgets and have basics of programming.

## A.1 Getting started

The user has to download the schema files \*.xsd from the SANA registry [1], and put it in a folder accessible by the working directory, i.e., where the LBDF file will be created. In the tutorial will be considered the directory structure reported below, where CCSDS\_example.xml is the LBDF file to be written.

.

├── schemas/

│ ├── Asset.xsd

│ ├── DataType.xsd

│ ├── GroundStation.xsd

│ ├── LBDF.xsd

│ ├── Link.xsd

│ ├── LinkBudget.xsd

│ ├── ResultsSummary.xsd

│ ├── Spacecraft.xsd

│ ├── TMCoding.xsd

│ └── UserTerminal.xsd

└── examples/

 └── CCSDS\_example.xml

For a more efficient and dynamic implementation of LBDF files, it is recommended to the user to adopt software tools specific for XML. The software tools that were adopted in writing this tutorial are:

* **Xmllint**: for validating the LBDF files against the schema ones. It is freely available under GNOME with GNU license;
* **Eclipse IDE**: for implementing LBDF files and visualize schema files. Freely available under Eclipse public license;
* **xsddiagram**: for visualization of schema files. Freely available under GNU license.

It is pointed out that these are indicated only as reference, and they are not required by the LBDF. The user is free to use any other software tool that can support XML and schema files.

## A.2 Writing a first link budget

This section shows the manual steps for writing a small LBDF file. It is pointed out that such approach is just for tutorial purposes, and it is not the one meant for LBDF. Users are expected to implement a software that does automatically the export from their link budget tool to the LBDF files.

Additionally, for sake of clarity, the example will be limited to the minimum entities required, i.e., specifying just the mandatory ones, and optional ones only if required for the specific link budget example.

The reference link budget, that will be exported into CCSDS\_example.xml as LBDF, is shown in Table A-3. It refers to a PDT link budget, for a LEO satellite, in S-Band, where the modulation is QPSK, uncoded, 2.5 Mbps.

|  |  |  |
| --- | --- | --- |
| Parameter | Value | Notes |
| Slant range | 2200 km |  |
| Frequency | 2200 MHz |  |
| S/C EIRP | -5 dBW |  |
| Path losses | 166.14 dB | Computed  |
| G/S G/T | 21.5 |  |
| *Carrier synchronization* |
| Loop bandwidth | 2.5 kHz |  |
| Req. C/N | 25 |  |
| Margin | 19.98 | dB |
| *Data demodulation* |  |  |
| Demodulation losses | 2.00 |  |
| Req. Eb/N0 | 9.6 dB | Uncoded QPSK |
| Bit rate | 2500 kbps |  |
| Margin  | 3.38 dB | Computed |

Table A-3: reference link budget for the exporting in LBDF.

Starting from an empty LBDF file, the first entity to be specified is <lbdf> whose class is defined in the root file LBDF.xsd with namespace https://www.esa.int/LBDF. Such class can be visualized in Eclipse as shown in Figure A-4. Notice that it requires an element selection (identified by the symbol ) among those that are available (<uplink\_budget>, <ttc\_link\_budget>, etc.).



Figure A-4: Eclipse visualization of lbdf class.

Since the link budget in subject is for a PDT link, the element <pdt\_link\_budget> is required. Thus, the initial structure of the LBDF file CCSDS\_example.xml shall be

|  |
| --- |
| <lbdf xmlns="https://www.esa.int/LBDF"><pdt\_link\_budget>  <!-- here the will be content of PDT link budget --> </pdt\_link\_budget></lbdf>> |

The element <pdt\_link\_budget> is based on the class PDTLinkBudget that, in turn, contains other entities and attributes that may be or not mandatory. By using again the Eclipse visualization (shown in Figure A-5), it can be seen that the class PDTLinkBudget requires <downlink> as element and, by means of heritage (from EarthSpaceLinks and LinkBudget classes) can contain the elements <object\_radius>, <orbit\_altitude>, <min\_elevation\_angle>, etc., and the attributes owner\_ccsds\_agency, mission\_name, etc.





Figure A-5: Eclipse visualization of PDTLinkBudget class and inherited classes.

Of these, from inspection of the source code[[1]](#footnote-2), the only mandatory are mission\_category, date\_time, lbdf\_version (that shall be 0.2.0), and <slant\_range>. As such, the LBDF file can be expanded as

|  |
| --- |
| <lbdf xmlns="https://www.esa.int/LBDF"><pdt\_link\_budget mission\_category="A" date\_time="2025-01-01T12:00:00" lbdf\_version="0.2.0"> <slant\_range nom\_value="2200" fav\_value="2200" adv\_value="2200" unit="km" /> <downlink> <!-- here the will be content of downlink --> </downlink></pdt\_link\_budget></lbdf> |

NOTE – the XML schema files bind also the order of the elements. Thus, in the snapshot above <slant\_range> shall be defined before <downlink>. The same holds for the elements later included.

The same exercise shall be repeated for the sub-elements. For <slant range> and <downlink> all elements shown in Figure A-5 are mandatory, but <data\_mod\_index>, <pfd\_rs>, <pn\_rs>. Thus, the LBDF file evolves as

|  |
| --- |
| <lbdf xmlns="https://www.esa.int/LBDF"><pdt\_link\_budget mission\_category="A" date\_time="2025-01-01T12:00:00" lbdf\_version="0.2.0"> <slant\_range nom\_value="2200" fav\_value="2200" adv\_value="2200" unit="km" /> <downlink> <tm></tm> <prop></prop> <rx></rx> <tx></tx> <rs\_rs></rs\_rs> <ct\_rs></ct\_rs> <dr\_rs></dr\_rs> </downlink></pdt\_link\_budget></lbdf> |

where for the slant range, it was specified the first numerical value coming from the link budget example. Since the example is done only for nominal conditions, but LBDF (in compliance to [2]) still requires favourable and adverse conditions, the same value can be used for all three cases.

The element <tm> is meant for specifying the minimum link parameters, that from the example are frequency, bit rate, modulation, and coding. This is done as

|  |
| --- |
| <tm><freq fav\_value="2200" nom\_value="2200" adv\_value="2200" unit="MHz" /> <bit\_rate unit="kbps" value="2500"/> <req\_eb\_n0 unit="dB" value="9.6"/> <tm\_link mod\_scheme="QPSK"> <tm\_coding> <uncoded /> </tm\_coding> </tm\_link></tm> |

The element <prop> instead is used for capturing the atmospheric propagation losses. Since the example considered ideal losses only due to free space propagation, <prop> shall be set with 0 dB as

|  |
| --- |
| <prop> <ionospheric\_loss nom\_value="0" fav\_value="0" adv\_value="0" unit="dB" /> <atmospheric\_loss nom\_value="0" fav\_value="0" adv\_value="0" unit="dB"/></prop> |

The elements <rx> and <tx> instead specify the receiver and transmitter characteristics, respectively, as

|  |
| --- |
| <rx> <g\_over\_t nom\_value="21.5" fav\_value="21.5" adv\_value="21.5" unit="dB/K" /><demod\_tech\_loss nom\_value="2.0" fav\_value="2.0" adv\_value="2.0" unit="dB" /> <req\_cn\_tracking nom\_value="17" fav\_value="17" adv\_value="17" unit="dB"/> <pll\_bw\_2bl nom\_value="2500" fav\_value="2500" adv\_value="2500" unit="Hz" /></rx><tx> <eirp nom\_value="25.0" fav\_value="25.0" adv\_value="25.0" unit="dBm" /></tx> |

Finally, the results summary of the link budgets is reported. In particular, the results for the received signal, <rs\_rs> is written as

|  |
| --- |
| <rs\_rs><free\_space\_loss nom\_value="166.14" fav\_value="166.14" adv\_value="166.14" unit="dB" />  <polarization\_mismatch nom\_value="0" fav\_value="0" adv\_value="0" unit="dB" />  <total\_propagation\_loss nom\_value="166.14" fav\_value="166.14" adv\_value="166.14" unit="dB" /> <sn0 nom\_value="78.96" fav\_value="78.96" adv\_value="78.96" unit="dB" /></rs\_rs> |

Notice that since polarization mismatch is a mandatory parameter, even if not assumed by the link budget in the example, it shall be defined as specified as 0 dB.

After the received signal results, margin computations follow, first on the carrier recovery, <ct\_rs>, and then on data recovery, <dr\_rs>. This is done as

|  |
| --- |
| <ct\_rs> <carrier\_suppression nom\_value="0" fav\_value="0" adv\_value="0" unit="dB" />  <rx\_cn nom\_value="44.98" fav\_value="44.98" adv\_value="44.98" unit="dB" />  <rx\_cn0 nom\_value="78.96" fav\_value="78.96" adv\_value="78.96" unit="dB\*Hz" />  <margin nom\_value="27.98" fav\_value="27.98" adv\_value="27.98" unit="dB" /></ct\_rs><dr\_rs> <modulation\_loss nom\_value="0" fav\_value="0" adv\_value="0" unit="dB" /> <rx\_ebn0 nom\_value="12.98" fav\_value="12.98" adv\_value="12.98" unit="dB"/> <margin nom\_value="3.38" fav\_value="3.38" adv\_value="3.38" unit="dB" /></dr\_rs> |

where it can be noticed that SNR values for carrier and data (rx\_cn, rx\_cn0, rx\_ebn0) shall be explicitly reported.

With this last snapshot, LBDF file CCSDS\_example.xml is completed.

For the reader convenience, the full code is reported in the following page.

|  |
| --- |
| <lbdf xmlns="https://www.esa.int/LBDF"> <pdt\_link\_budget mission\_category="A" date\_time="2025-01-01T12:00:00" lbdf\_version="0.2.0"> <slant\_range nom\_value="2200" fav\_value="2200" adv\_value="2200" unit="km" /> <downlink> <tm> <freq fav\_value="2200" nom\_value="2200" adv\_value="2200" unit="MHz" /> <bit\_rate unit="kbps" value="2500"/> <req\_eb\_n0 unit="dB" value="9.6"/> <tm\_link mod\_scheme="QPSK"> <tm\_coding> <uncoded /> </tm\_coding> </tm\_link> </tm> <prop> <ionospheric\_loss nom\_value="0" fav\_value="0" adv\_value="0" unit="dB" /> <atmospheric\_loss nom\_value="0" fav\_value="0" adv\_value="0" unit="dB"/> </prop> <rx> <g\_over\_t nom\_value="21.5" fav\_value="21.5" adv\_value="21.5" unit="dB/K" /> <demod\_tech\_loss nom\_value="2.0" fav\_value="2.0" adv\_value="2.0" unit="dB" /> <req\_cn\_tracking nom\_value="17" fav\_value="17" adv\_value="17" unit="dB"/> <pll\_bw\_2bl nom\_value="2500" fav\_value="2500" adv\_value="2500" unit="Hz" /> </rx> <tx> <eirp nom\_value="25.0" fav\_value="25.0" adv\_value="25.0" unit="dBm" /> </tx> <rs\_rs> <free\_space\_loss nom\_value="166.14" fav\_value="166.14" adv\_value="166.14" unit="dB" />  <polarization\_mismatch nom\_value="0" fav\_value="0" adv\_value="0" unit="dB" />  <total\_propagation\_loss nom\_value="166.14" fav\_value="166.14" adv\_value="166.14" unit="dB" /> <sn0 nom\_value="78.96" fav\_value="78.96" adv\_value="78.96" unit="dB\*Hz" />  </rs\_rs> <ct\_rs> <carrier\_suppression nom\_value="0" fav\_value="0" adv\_value="0" unit="dB" />  <rx\_cn nom\_value="44.98" fav\_value="44.98" adv\_value="44.98" unit="dB" />  <rx\_cn0 nom\_value="78.96" fav\_value="78.96" adv\_value="78.96" unit="dB\*Hz" />  <margin nom\_value="27.98" fav\_value="27.98" adv\_value="27.98" unit="dB" /> </ct\_rs> <dr\_rs> <modulation\_loss nom\_value="0" fav\_value="0" adv\_value="0" unit="dB" /> <rx\_ebn0 nom\_value="12.98" fav\_value="12.98" adv\_value="12.98" unit="dB"/> <margin nom\_value="3.38" fav\_value="3.38" adv\_value="3.38" unit="dB" /> </dr\_rs> </downlink> </pdt\_link\_budget></lbdf> |

## A.3 LBDF Validation

The file CCSDS\_example.xml can be validated easily by using a schema validation tool. For instance, by using the **xmllint**, and considering the directory organization reported at the beginning of this Annex, from shell it can be successfully validated as

|  |
| --- |
| $ xmllint --schema ../schema/LBDF.xsd CCSDS\_example.xmlCCSDS\_example.xml validates |

## A.4 LBDF Developments

As mentioned, LBDF is not meant for manual implementation. Considering that the main objective of LBDF is the quick export/import of LBDF files and their comparison (see Figure 1), the LBDF user is expected to implement some software tools.

Users requested by another party to provide their link budget, need as minimum an export tool, that automatically maps the value of their link budgets into a LBDF, and does the validation.

Users that instead request another party to provide their link budgets, need as minimum an import tool, for doing the importation of the received LBDF file into their link budget and doing the re-computation. Then, they need also an export tool, for exporting their re-computation, and a comparison tool, for highlighting the differences between the received LBDF file, and re-computed LBDF file.

# ANNEX BSECURITY, SANA, AND PATENT CONSIDERATIONS(INFORMATIVE)

## B.1 SECURITY CONSIDERATIONS

This section presents the results of the analysis of security considerations applied to the technology specified in this Experimental Specification.

## B.2 CONSEQUENCES oF NOT APPLYING SECURITY TO THE TECHNOLOGY

The consequences of not applying security to the systems and networks on which this Experimental Specification is implemented could include potential loss, corruption, and theft of data. Because these XML files are used in defining the spacecraft waveform characteristics for its commanding, telemetry, and ranging, the consequences can include the compromise or the loss of the mission, if malicious tampering of a particularly severe nature occurs.

## B.3 POTENTIAL THREATS AND ATTACK SCENARIO

Potential threats or attack scenarios include, but are not limited to,

1. unauthorized access to the programs/processes that generate and interpret the XML files, and
2. unauthorized access to the XML files during transmission between exchange partners.

It is strongly recommended that potential threats or attack scenarios, applicable to the systems and networks of the partners using this Experimental Specification, are addressed by the management of those systems and networks.

## B.4 DATA PRIVACY, INTEGRITY, and Transfer

Privacy and integrity of data formatted should be assured by the systems and networks of the partners using this Experimental Specification. The transfer of data between the communicating entities should be accomplished via secure mechanisms approved by the information technology security functionaries of exchanging partners.

## B.5 Unauthorized access

Unauthorized access to the programs/processes that generated and interpret the XML files should be prohibited in order to minimize potential threats and attack scenarios.

## B.6 SANA considerations

The following LBDF-related items have been registered with the SANA Operator:

* XML schema files
	+ Asset.xsd
	+ DataType.xsd
	+ GroundStation.xsd
	+ LBDF.xsd
	+ Link.xsd
	+ LinkBudget.xsd
	+ ResultSummary.xsd
	+ Spacecraft.xsd
	+ TMCoding.xsd
	+ UserTerminal.xsd
* UML diagram
	+ LBDF\_Model.pdf

The registration rule for new entries, or their modifications, in the SANA registry is the approval of new requests by the CCSDS Area or Working Group responsible for the maintenance of the LBDF at the time of the request.

New requests for this registry shall be sent to SANA (mailto:info@sanaregistry.org).

## B.7 Patent considerations

This Experimental Specification has no patent issues.

1. Optional entities or attributes are identified in the schema files by the attributes minOccurs=”0” or use=”optional”. [↑](#footnote-ref-2)