

## Interface Control Table (ICT)

### Templates for the TT&C RFCLB Tool

(compatible with RFCLB Rev. 5, June 15, 2023)

This Note provides three Templates. They support the automated import and export of Interface Control Tables (ICTs) into/from the TT&C Radio Frequency Communications Link Budget (RFCLB) Excel Workbook tool. Each template can be copied into MS-Word documents – such as Ground-Space Interface Control Documents (G/S ICD) or other (TT&C) spacecraft design documents – and be filled according to TT&C link-parameter values that may be specific for each project or operational mode. The RFCLB Import/Export tool searches MS-Word document files for the relevant ICTs, which define the design data for

- “TT&C Uplink”, residual- or suppressed-carrier modulation; or
- “TT&C Downlink”, residual- or suppressed-carrier modulation; or
- “Payload Data Transmission (PDT)”.

In RFCLB Rev. 5.1, the three ICT tables support up to 242 different entries – much reducing the repetitive typing effort of manual data transfer into/from TT&C link budget spreadsheets.

For the templates, only a few simple rules apply that enable a smooth exchange of data with the RFCLB Workbook.

- The structure of the ICTs must be preserved.
  - This applies especially for the sequence of Rows, and for the Columns per each Row.
  - No merging or unmerging (splitting) of Cells in the ICTs.
  - Deleting any Row should be avoided; if a Row is (accidentally) deleted, only the Rows above the deleted Row will be recognized; all lower Rows will be ignored.
- If an entry in the two Columns labelled “PARAMETER” or “UNIT” is (intentionally or unintentionally) changed, the corresponding (entire) Row will not be im-/exported.
  - Clearing all Cells in a Row, or intentionally redefining a Row for a different “Parameter” and/or “Unit” will cause the entire Row to be ignored during the data exchange.
- The ICT-Identifier (top Row #1) shall unambiguously identify the ICT in the Word document. The RFCLB user is asked for this ICT-Identifier before RFCLB can start the import or export of data.
- Parameter values in the Columns labelled “NOMINAL”, “ADVERSE” and “FAVOURABLE” should be numeric. If a Cell is empty (because the value might be unknown), or a Cell includes a non-numeric entry (e.g., TBD; N/A; ?; etc.), the corresponding (entire) Row will be ignored during the data exchange. This feature allows the user to tailor the same ICT layout to different TT&C (sub-)modes (e.g., either residual-carrier or suppressed-carrier modulation; or different ranging modes).
- The light-grey coloured Cells are available for optional comments. The light-blue and -green Cells provide headings for the following Rows; the text may be modified.
- Cells may be reformatted for a different number formatting, different font, colour, font-size, cell borders or filling; word wrapping in table cells should however be avoided. – A table caption may be inserted above or below (outside) the table and is irrelevant for the data transfer. – An ICT may expand from one page onto the next following page (but an ICT must not be split into separate tables). – In general, it is recommended to maintain the formatting of the provided ICT tables when copied into other Word documents.
- At the bottom of each ICT up to 5 Rows may be added for additional parameters etc.; the added Rows are ignored during data transfer.

| Spica TC Mode-5                         |         |         |  |            |
|---|---------|---------|--|------------|
| Orbit                                   | L2      |         | grey-filled cells for comments   |            |
| Station                                 | CEB     |         |  |            |
| PARAMETER                               | UNIT    | NOMINAL | ADVERSE  | FAVOURABLE |
| Altitude / Distance                     | 1000km  | 1770    | Distance does <u>not</u> consider the<br>Elevation relevant for <i>Slant Range</i> |            |
| Elevation                               | deg     | 20      |  |            |
| Telecommand Symbol Rate                 | ksymb/s | 8       |  |            |
| Ground Station Transmission             |         |         |  |            |
| G/S Transmit Power                      | dBW     | 33.01   | 33.01  | 33.01      |
| Circuit Loss                            | dB      | 0.6     | 1.0  | 0.6        |
| G/S Antenna TX Gain (co-polar)          | dBi     | 65.5    | 65   | 65.5       |
| G/S Antenna TX Axial Ratio              | dB      | 1.0     | 1.0  | 1.0        |
| Pointing Loss                           | dB      | 0.5     | 0.5  | 0.5        |
| Propagation Channel                     |         |         |  |            |
| Frequency                               | GHz     | 7.192   |  |            |
| Atmospheric Loss                        | dB      | 0.5     | 0.5  | 0.5        |
| Ionospheric Loss                        | dB      | 0       | 0  | 0          |
| Spacecraft Reception                    |         |         |  |            |
| S/C Antenna RX Gain (co-polar)          | dBi     | 27.0    | 25.0   | 29.0       |
| Pointing Loss                           | dB      | 1.0     | 1.5  | 1.0        |
| S/C Antenna RX Axial Ratio              | dB      | 5.5     | 5.5  | 5.5        |
| Antenna Noise Temperature               | K       | 150     | 150  | 150        |
| VSWR, at Antenna-Port                   | : 1     | 1.5     |  |            |
| VSWR, at RX/LNA-Port                    | : 1     | 1.25    |  |            |
| Interconnection Physical Temp           | °C      | 20      | 55   | -30        |
| Interconnection Loss                    | dB      | 0.6     | 0.66   | 0.54       |
| Circuits Physical Temperature           | °C      | 30      | 55   | -30        |
| RFDN Circuit Loss                       | dB      | 4.5     | 5.0  | 4.2        |
| Transponder Diplexer Loss               | dB      | 0.5     | 0.6  | 0.4        |
| RX/LNA Noise Figure                     | dB      | 2.0     | 2.2  | 1.7        |
| Carrier Acquisition Threshold           | dBm     | -135    |  |            |
| Telecommand RX Threshold                | dBm     | -128    |  |            |
| Residual-Carrier Modulation             |         |         |  |            |
| Modulation Indices                      |         |         |  |            |
| Telecommand                             | rad-pk  | 1.0     | 1.05   | 0.95       |
| Ranging, PN- or Tone-RNG                | rad-pk  | 0.2     | 0.21   | 0.19       |
| Ranging, Tone-2                         | rad-pk  | 0       | e.g., comment on variation   |            |
| Signal-Component: Carrier Recovery      |         |         |  |            |
| PLL-Bandwidth, at Threshold             | Hz      | 100     | 120  | 80         |
| Tracking Technical Loss                 | dB      | 1.0     | 1.0  | 1.0        |
| Required C/N in PLL-Bandwidth           | dB      | 10      | e.g., comment on variation   |            |
| Signal-Component: Telecommand Detection |         |         |  |            |
| Detection Technical Loss                | dB      | 1.0     | 1.5  | 0.5        |
| Required Eb/No                          | dB      | 9.6     |  |            |
| Transponder Transparent Tone-Ranging    |         |         |  |            |
| RNG Channel Noise-Bandwidth             | kHz     | 1032    |  |            |
| Tone-RNG Technical Loss                 | dB      | 1.5     | 1.6  | 1.2        |
| Suppressed-Carrier Modulation           |         |         |  |            |
| Signal-Component: Carrier Recovery      |         |         |  |            |
| Demodulator Squaring Loss SL            | dB      | 0.00    | 0.00   | 0.00       |
| Carrier-Loop Bandwidth                  | Hz      | 100     | 120  | 80         |
| Required Loop-SNR                       | dB      | 15.0    | 15.2   | 15.0       |
| Signal-Component: Telecommand Detection |         |         |  |            |
| Detection Technical Loss                | dB      | 1.00    | 1.50   | 0.50       |
| Required Eb/No                          | dB      | 9.60    |  |            |
| Transponder Regenerative PN-Ranging     |         |         |  |            |
| CTL Noise-Bandwidth BL                  | Hz      | 1.00    |  |            |
| CTL Technical Loss                      | dB      | 1.0     | 1.0  | 0          |
| Uplink PN Chip-Rate                     | Mchip/s | 1.0     |  |            |
| Required Ranging (S/No)                 | dBHz    | -10     |  |            |

Interface Control Table (ICT) Template for TT&C Uplink; filled with placeholder sample values.

| Spica TM Mode-4   |         |          |   |            |
|---|---------|----------|---|------------|
| Orbit   | L2      |          | common with Uplink ICT  |            |
| Station   | CEB     |          | common with Uplink ICT  |            |
| PARAMETER   | UNIT    | NOMINAL  | ADVERSE   | FAVOURABLE |
| Altitude / Distance                                     | 1000km  | 1.77E+03 | common with Uplink ICT  |            |
| Elevation   | deg     | 20       | common with Uplink ICT  |            |
| Telemetry Bit Rate                                      | kbit/s  | 50.00    |   |            |
| Spacecraft Transmission                                 |         |          |   |            |
| S/C Transmit Power                                      | dBW     | 13.00    | 13.00   | 13.00      |
| Transponder Diplexer Loss                               | dB      | 0.50     | 0.60  | 0.40       |
| RFDN Circuit Loss                                       | dB      | 0.50     | 0.70  | 0.30       |
| Interconnection Loss                                    | dB      | 1.00     | 1.30  | 0.80       |
| VSWR, at Transmitter-Port                               | : 1     | 1.10     |   |            |
| VSWR, at Antenna-Port                                   | : 1     | 1.35     |   |            |
| S/C Antenna TX Gain (co-polar)                          | dBi     | 5.00     | 4.00  | 5.00       |
| S/C Antenna TX Axial Ratio                              | dB      | 5.50     | 5.50  | 5.50       |
| Pointing Loss   | dB      | 1.00     | 1.00  | 1.00       |
| Propagation Channel                                     |         |          |   |            |
| Frequency   | GHz     | 8.450    | for any comment   |            |
| Atmospheric Loss  | dB      | 0.50     | 0.50  | 0.46       |
| Ionospheric Loss  | dB      | 0.00     | 0.00  | 0.00       |
| Ground Station Reception                                |         |          |   |            |
| G/S Antenna RX Gain (co-polar)                          | dBi     | 68.20    | 68.20   | 68.20      |
| Pointing Loss   | dB      | 0.20     | 0.20  | 0.00       |
| G/S Antenna RX Axial Ratio                              | dB      | 1.00     | 1.00  | 1.00       |
| System Noise Temperature                                | dBK     | 20.56    | 21.03   | 20.07      |
| Residual-Carrier Modulation                             |         |          |   |            |
| Modulation Indices                                      |         |          |   |            |
| Telemetry   | rad-pk  | 1.20     | 1.32  | 1.08       |
| Ranging, PN- or Tone-RNG                                | rad-pk  | 0.20     | 0.22  | 0.18       |
| Signal-Component: Carrier Recovery                      |         |          |   |            |
| PLL-Bandwidth   | Hz      | 200      | 220   | 180        |
| Required Loop SNR                                       | dB      | 17.00    | 17.30   | 17.00      |
| Signal-Component: Telemetry Detection                   |         |          |   |            |
| Detection Technical Loss                                | dB      | 0.90     | 1.00  | 0.80       |
| Required Eb/No  | dB      | 2.90     |   |            |
| Transparent Tone-Ranging                                |         |          |   |            |
| Tone-Tracking Technical Loss                            | dB      | 3.00     | 4.00  | 0.50       |
| Required S(Tone)/N                                      | dB      | 19.00    | for any comment   |            |
| Suppressed-Carrier Modulation                           |         |          |   |            |
| Signal-Component: Carrier Recovery                      |         |          |   |            |
| Demodulator Squaring Loss SL                            | dB      | 0.39     | 0.54  | 0.12       |
| Carrier-Loop Bandwidth                                  | Hz      | 300      | 330   | 270        |
| Required Loop-SNR                                       | dB      | 17.00    | 17.20   | 17.00      |
| Signal-Component: Telemetry Detection                   |         |          |   |            |
| Detection Technical Loss                                | dB      | 0.40     | 0.50  | 0.30       |
| Required Eb/No  | dB      | 2.70     |   |            |
| Regenerative PN-Ranging (Closed- or Open-Loop Tracking) |         |          |   |            |
| RNG Noise-Bandwidth BL                                  | Hz      | 2.00     | Either RNG Noise-Bandwidth BL, or<br>Integration Time to be specified ! |            |
| Integration Time (N/A)                                  | s       | N/A      |   |            |
| RNG Technical Loss                                      | dB      | 1.00     | 1.00  | 0.00       |
| Downlink PN Chip-Rate                                   | Mchip/s | 2.00     |   |            |
| Required Ranging-(S/No)                                 | dBHz    | -10.00   |   |            |

Interface Control Table (ICT) Template for TT&C Downlink; filled with placeholder sample values.

| Spica PDT Mode-2                      |        |          |   |            |
|---------------------------------------|--------|----------|---|------------|
| Orbit                                 | L2     |          | grey-filled cells for comments            |            |
| Station                               | CEB    |          |   |            |
| PARAMETER                             | UNIT   | NOMINAL  | ADVERSE                                   | FAVOURABLE |
| Altitude / Distance                   | 1000km | 1.77E+03 | Distance does <u>not</u> consider         |            |
| Elevation                             | deg    | 20       | Elevation relevant for <i>Slant Range</i> |            |
| Telemetry Bit Rate                    | Mbit/s | 50.00    |   |            |
| Spacecraft Transmission               |        |          |   |            |
| S/C Transmit Power                    | dBW    | 17.40    | 16.90                                     | 17.90      |
| RFDN Circuit Loss                     | dB     | 0.80     | 1.00                                      | 0.80       |
| Interconnection Loss                  | dB     | 0.00     | 0.00                                      | 0.00       |
| VSWR at Transmitter-Port              | : 1    | 1.00     |   |            |
| VSWR at Antenna-Port                  | : 1    | 1.50     |   |            |
| S/C Antenna TX Gain (co-polar)        | dBi    | 38.47    | 38.47                                     | 38.47      |
| S/C Antenna TX Axial Ratio            | dB     | 1.50     | 1.50                                      | 1.50       |
| Pointing Loss                         | dB     | 0.57     | 0.57                                      | 0.00       |
| Propagation Channel                   |        |          |   |            |
| Frequency                             | GHz    | 26.100   |   |            |
| Atmospheric Loss                      | dB     | 0.71     | 0.71                                      | 0.71       |
| Ionospheric Loss                      | dB     | 0.00     | 0.00                                      | 0.00       |
| Ground Station Reception              |        |          |   |            |
| G/S Antenna RX Gain (co-polar)        | dBi    | 76.28    | 76.28                                     | 76.28      |
| Pointing Loss                         | dB     | N/A      | 0.00                                      | 0.00       |
| G/S Antenna RX Axial Ratio            | dB     | 1.00     | 1.50                                      | 0.50       |
| System Noise Temperature              | dBK    | 21.42    | 21.94                                     | 20.07      |
| Carrier Tracking at Ground Station    |        |          |   |            |
| Demodulator Squaring Loss SL          | dB     | 0.22     | 0.30                                      | 0.13       |
| Carrier-Loop Bandwidth                | Hz     | 1.E+04   | 1.1E+04                                   | 0.9E+04    |
| Required Loop-SNR                     | dB     | 17.00    | 17.20                                     | 17.00      |
| Telemetry Detection at Ground Station |        |          |   |            |
| Detection Technical Loss              | dB     | 0.90     | 1.00                                      | 0.80       |
| Required Eb/No                        | dB     | 2.63     |   |            |

Interface Control Table (ICT) Template for Payload Data Transmission (PDT);  
filled with placeholder sample values.

## Annex

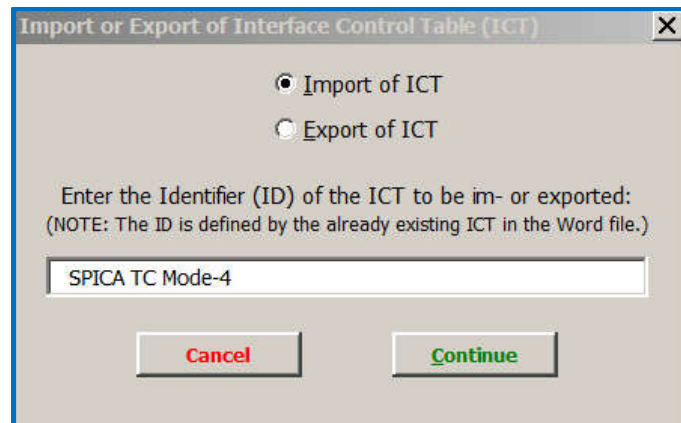
This Annex describes the data transfer into, or from, the three ICTs and the application of the *ICT Im-/Export* button

### *ICT Im-/Export*

Using the *ICT Im-/Export* feature requires the Microsoft Word Object Library selected from the additional “Available References”:

Clicking in the Worksheet “DISCLAIMER” the button “RFCLB Interface-Info” will check if in Excel the MS Word Object Library is enabled. If the library is not available, follow the related instruction in the file “Read Me First”.

Clicking in RFCLB spreadsheets the *ICT Im-/Export* button will open a Userform:



Import or Export of Interface Control Table (ICT)

☒ Import of ICT  
☐ Export of ICT

Enter the Identifier (ID) of the ICT to be im- or exported:  
(NOTE: The ID is defined by the already existing ICT in the Word file.)

SPICA TC Mode-4

Cancel Continue

The user selects either “Import of ICT” or “Export of ICT”, and enters the relevant “Identifier (ID) of the ICT” template that must exist already in a Word file and is either the source (in case of Import) or the destination (in case of Export) for the data exchange with RFCLB. The Identifier (ID) is the content of the Cell in the 1<sup>st</sup> top row of the relevant ICT in the Word file. (When selecting the Identifier (ID) text field a drop-down list is enabled from which the Identifier (ID) of the last relevant imported or exported ICT can be selected.)

After clicking the button **Continue** a second window will appear where the user should browse and select the Word file that includes the relevant ICT from which data shall be imported, or into which data shall be exported. (If the Word file is not found an error message will be displayed, and the ICT Im-/Export is cancelled.) It is convenient (but not necessary) to place the relevant Word file with the ICT and the RFCLB Workbook file both in the same directory folder.

RFCLB includes three *ICT Im-/Export* buttons. Each button initiates the im-/export of a specific ICT. For instance, the *ICT Im-/Export* button on the page for the “BASIC DOWNLINK” in the “Link Budget” Worksheet of RFCLB enables the search in the selected Word file for an ICT table with the specified Identifier (ID) and relevant for the two link budget pages of “BASIC DOWNLINK” and “DOWNLINK SIGNAL-COMPONENTS” in RFCLB. Depending on the button status of “Apply SUPPRESSED-CARRIER MODULATION (Downlink)” in the spreadsheet, design values are also exchanged with the separate “Suppressed-Carrier Modulation” Worksheet, provided this Worksheet is configured for Downlink (instead of Uplink) before clicking on *ICT Im-/Export*. – A corresponding approach applies for exchanging TT&C data of “BASIC UPLINK” and “UPLINK SIGNAL-COMPONENTS”, again relevant for residual- or suppressed-carrier modulation.

Accordingly, the [ICT Im-/Export](#) button on the page for the “BASIC DOWNLINK” in the “Payload Data Transmission (PDT)” Worksheet enables the search in the selected Word file for an ICT table with the specified Identifier (ID) and relevant for the “BASIC DOWNLINK” and “DOWNLINK SIGNAL-COMPONENTS” for the PDT case.

The data transfer usually takes less than a minute but depends on the length of the processed Word file and the total number of other (unrelated) tables in the same document. At completion of the data transfer, every Row in the RFCLB Workbook where data has been imported, is marked with “[ICT ->](#)” on the left of the budget table. In case of exported data, the marking is “[ICT <-](#)”. The tags allow for a quick verification of the im-/exported data, and to check if a specific data exchange did not occur because of an unintended, or by the user intended, mismatch between the provided ICT table and the ICT formats expected by RFCLB. The tags “[ICT ->](#)” or “[ICT <-](#)” can subsequently be deleted all together on the active Worksheet (and visible portion of up- or downlink) by pressing CTRL+Shift+C or by double-clicking any Cell that shows the “[ICT ->](#)” or “[ICT <-](#)” tag.

This Word file provides the three ICT templates with included placeholder data entries. It is recommended to use a copy of this Word file to test the [ICT Im-/Export](#) and to familiarise with the data transfer approach in RFCLB, before individual templates are copied into other Word files.