Interface Control Table (ICT)
Templates for the TT&C RFCLB Tool
(compatible with RFCLB Rev. 5)

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) spreadsheet 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 conditions and corresponding 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 Rev. 5, the three tables support up to 242 different entries from the three ICTs – massively 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 spreadsheets.

- 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 (accidently) 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 ex-/imported.
  - Clearing all Cells in a Row, or intentionally redefining a Row for a different "Parameter" and/or "Unit" will cause the entire Row being 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 the import or export of data can start.
- Parameter values in the Columns labelled "NOMINAL", "ADVERSE" and "FAVOURABLE" should be numeric. If a Cell is left 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 boarders 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 not consider	
Elevation	deg	*20*	*Elevation* in *Slant Range* calc.	
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	dBi	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	dB°K	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-Bandwidt BL, or	
Integration Time (N/A)	s	N/A	Integration Time to be specified !	
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 not consider	
Elevation	deg	20	Elevation in Slant Range calc.	
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	dB°K	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 is relevant <u>only for users of the RFCLB spreadsheet tool</u>; it describes the data transfer into, or from, the three ICTs and the application of the *ICT Im-/Export* buttons
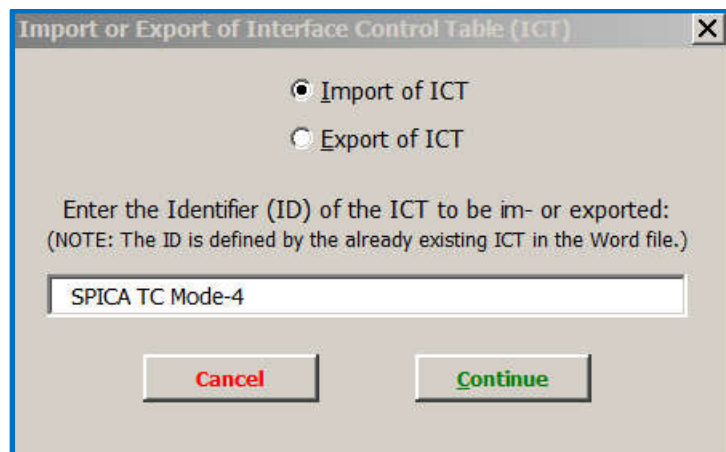

Using the *ICT Im-/Export* feature requires an Object Library from the additional "Available References":

- Microsoft Word 16.0 Object Library, if Excel 2016 is used.

The required Library depends on the Excel version that is used to run RFCLB. (After a new user has provided the "RFCLB-User-Information", the fully functional RFCLB Workbook will be configured and delivered for the relevant Excel version and Object Library.)

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

The user selects either "Import of ICT" or "Export of ICT", and enters the relevant "Identifier (ID) of the ICT" template that resides already in a Word file and which 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 1st 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 is fast (taking usually less than one 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.