CCSDS SLS-RFM WG MEETING

Darmstadt, Germany, 21-24 October 2019

Fall 2019 CCSDS RF & Modulation (RFM) Working Group Meeting Minutes

1. Action items review (from Spring 2019)

AI #	AI Description	Actionee
AI_19-01	Revisit draft recommendation 2.6.13	D. Lee
AI_19-02	Check draft recommendation 2.6.13 with European transponder manufacturers	M. Bertinelli
AI_19-03	Propose a rec similar to 2.6.14 for the ISS 22/26 GHz bands	D. Lee
AI_19-04	Produce an informed opinion about the four options proposed by ESA on APSK radii ratios for non SCCC and non DVB-S2 codes	J. Hamkins
AI_19-05	Check if GMSK+PN ranging on the uplink is needed by lunar gateway and in case propose its addition to the charter	D. Lee
AI_19-06	Check the concept in SLS-CS_19-10 for 128/256APSK performance assessment and come back with comments	All

AI_19-01 is closed by SLS-RFM_19-17.
AI_19-02 remains open.
AI_19-03 is closed by SLS-RFM_19-14.
AI_19-04 is closed by SLS-RFM_19-19.
AI_19-05 is closed by SLS-RFM_19-16.
AI_19-06 is closed by SLS-C&S_19-14 (discussed at joint RFM/C&S session).

2. New recommendations

2.1 Turnaround Ratios for 23/27 GHz Inter-Satellite Service bands

Document SLS-RFM 19-14 was presented by D. Lee (NASA). The document, in response to AI_19-03, proposed different candidate transponder turnaround frequency ratios (TTFRs) for the 23.15-23.55 GHz and 27.0-27.5 GHz bands. The pairing of these two frequency bands is of interest because the SFCG has recently recommended them for lunar orbit-to-surface and lunar surface-to-orbit links, respectively. The document identified 3 candidate TTFRs, namely 2407/2800, 2407/2808, and 2407/2816, which had been selected based on criteria used for the 22/26 GHz TTFRs. It was noted that a single TTFR could cover about 93% of the 27.0-27.5 GHz band, while two TTFRs were required for full coverage. The draft recommendation in the document proposed using only a single turnaround ratio, 2407/2808, with the idea of producing a simpler recommendation.

In the subsequent discussion, the RFM working group decided that two TTFRs would not add too much complexity and would allow for full coverage of the 27 GHz band. The WG decided to recommend two TTFRs; namely, 2407/2800 and 2407/2816. This approach has the additional advantage that one of the TTFRs is the same as in Recommendation 2.4.16 for the 22/26 GHz turnaround ratios (i.e., 2407/2816), which could allow for some transponder and/or parts re-use. D. Lee took the action (AI_19-07) to revise the draft recommendation in the document accordingly, and submit it for the next RFM meeting.

2.2 Flexible Turnaround Ratios for MSPA (Multiple Spacecraft Per Aperture)

Document SLS-RFM_19-17 was presented by D. Lee. Written in response to AI_19-01, the document proposed several additional flexible X-band TTFRs to be used for MSPA support in draft Recommendation 2.6.13. With the flexible turnaround ratio method, spacecraft supported by MSPA share a common uplink frequency transmitted from a single ground station but downlink telemetry on separate frequencies using different TTFRs assigned to each spacecraft. The previous draft of Recommendation 2.6.13 was only sufficient to support two spacecraft simultaneously using MSPA, which was less than the requirement to support of 4 spacecraft via MSPA from one CCSDS member agency.

Document SLS-RFM-19-17 proposed to fix this shortcoming by relaxing some of the criteria used to select the TTFRs used with MSPA. In particular, the document noted that there was an existing turnaround ratio in the CCSDS Proximity-1 Physical Layer Blue Book that used even values in both the numerator and denominator of the TTFR. Previously the selection criteria for TTFRs required an odd number in the numerator (749 for X-band) and an even number in the denominator, which reduced the likelihood of harmonics in the downlink transmitter chain from interfering with the uplink receiver. However given the design of modern Software Defined Radios (SDRs), this criterion may no longer be absolutely necessary and thus it would be feasible to select an odd number in both the numerator and denominator of the turnaround ratio. The document proposed updating draft Rec. 2.6.13 with two sets of flexible TTFRs: one which could support 4 spacecraft simultaneously using MSPA, and another which could support 3 spacecraft simultaneously.

During the WG discussion, a question was raised as to whether large prime factors in the denominator of the TTFR would also be permissible given the design of modern SDRs – which would further relax the TTFR selection criteria. Another comment was that the draft recommendation did not specifically cover the case of 2 spacecraft using MSPA, and that it might be better to simply list all the recommended TTFRs and let mission managers decide on which ones to use. However, it was pointed out that some TTFRs did not have overlap in their range of supported frequencies so it was necessary to give guidance in the recommendation on which subsets of the TTFRs could be used for MSPA. AI_19-08 was accepted by D. Lee to check whether the large prime factor restriction on the TTFR selection was really needed, and to modify the draft of Recommendation 2.6.13 for the next RFM meeting based on the provided WG feedback.

2.3 GMSK+PN Ranging for High Data Rate Uplinks and Simultaneous Ranging

Document SLS-RFM_19-16 was presented by D. Lee. This document, in response to AI_19-05, noted that GMSK+PN ranging was one of the modulations capable of simultaneous high rate uplink and ranging being considered for the future Lunar Gateway mission. In addition, the document pointed out that the existing CCSDS uplink modulation recommendations did not cover data rates above 2.048 Msps. As such, the input paper recommended that the RFM charter be amended to include work on developing a high rate uplink modulation recommendation for data rates up to 200 Msps (particularly in regards to the 22.55-23.15 GHz Earth-to-space band), as well as development of a recommendation for simultaneous high data rate uplinks and ranging (which could be based on GMSK+PN or other suitable method).

During the WG discussion, a concern was raised as to whether high Doppler frequencies, especially for near-Earth missions in the 22.55-23.15 GHz band, could negatively impact the GMSK+PN receiver performance in terms of a higher likelihood of bit slips and/or degraded interference cancellation. AI_19-09 was issued to ESA and NASA representatives to study the suitability of GMSK+PN for high data rate uplinks, and to examine the impact of high Doppler and Doppler rates on the GMSK+PN receiver performance. The working group also agreed to add development of a recommendation for high rate uplink and simultaneous ranging to the RFM WG charter.

2.4 Uplink Modulations for 22 GHz High Rate Lunar Links

Document SLS-RFM_19-20 was presented by A. Modenini (ESA). In the document, lunar links from the recently completed Future Lunar Communications Architecture report from the IOAG were described. Of particular interest, the IOAG Lunar Architecture report listed use of Filtered-OQPSK and GMSK modulations for high rate links in the 22 GHz band. The ESA document also noted that the current CCSDS 401.0 uplink recommendations only cover standard telecommand up to 2 Msps, while the IOAG report foresees 50 Msps uplinks in the 22 GHz band in the near future and possibly extending beyond to 200 Msps.

During the WG discussion, a concern was raised about the IOAG assuming particular modulations for the 22 GHz uplink in their Lunar architecture study before the CCSDS had made a modulation recommendation for that band or even done any analysis for it. The viewpoint of the working group was that the CCSDS has the responsibility for doing the technical studies and creating the relevant recommendations, and it seemed that the IOAG had overstepped its boundaries in presupposing a certain outcome for the 22 GHz modulations. Since some participants in the CCSDS also attend IAOG meetings, it was decided to relay these concerns to them offline.

3. Existing recommendations

3.1 APSK Ring Radii Ratios in Recs. 2.4.18 and 2.4.23

Document SLS-RFM_19-19 was presented by J. Hamkins (NASA). This document, written in response to AI_19-04, proposed ring radii ratios for 16-APSK and 32-APSK constellations suitable for VCM when used with TM codes in the 131.0-B-3 Blue Book. The ring radii ratios for VCM with SCCC and DVB-S2 codes are currently defined in 131.2-B-1 and 131.3-B-1, respectively, but remain undefined when used for VCM with the TM codes in 131.0-B-3. Simulation results from the document showed that for 16-APSK, the choice of ring radii ratio had only a minor effect on the Eb/No required to reach a 10^{-4} CWER. The optimum radii ratio was between 3 to 3.25, while increasing the radii ratio to as high as 10 only caused a 0.25 dB increase in the required Eb/No.

Thus the document proposed to select ring radii ratios for use with the TM codes using the recommended ring radii for the nearest coding rate in the DVB-S2 standard. Specifically, it proposed to modify Tables 2.4.18-2 and 2.4.23-1 in Recommendations 2.4.18 and 2.4.23, respectively, in the 401.0 Blue Book to include ring radii ratios for 16-APSK and 32-APSK from the DVB-S2 standard. In addition, the VCM standard (currently 431.1.-R-1) would have a note added below Table 3-2 which would reference the aforementioned tables in the 401.0 Blue Book for the appropriate ring radii ratios to be used.

A marked-up version of the revised 401.0 Recommendations 2.4.18 and 2.4.23 was drafted and reviewed during the meeting. The WG agreed to approve the revised Recommendations 2.4.18 and 2.4.23 for agency review pending publication of the 431.1 VCM standard. This delay was necessary because the revisions include text referencing the 431.1-B VCM book which has not been formally published yet.

3.2 Proximity-1 Frequency Channel Assignments

Document SLS-RFM_19-13 was presented by D. Lee. This document proposed the specification of additional UHF channel center frequencies for forward and return proximity links in Proximity-1 Physical Layer Blue Book (211.1-B-2). It was noted that the currently the 211.1-B Blue Book only defines frequencies for Prox-1 Channels 0 thru 3, while the frequencies for Channel 4 thru 15 are left undefined. Given the influx of upcoming Mars missions requiring proximity frequencies, it was suggested that defining UHF frequencies for these other Prox-1 channels would help avoid potential interference between missions. The proposed additional channel center frequencies are based on those in the Electra UHF Radio specification for the Mars Science Laboratory (MSL) mission. The additional frequencies for Channels 4 thru 15 are spaced roughly 1 MHz apart with gaps to accommodate the pre-existing frequencies on Channel 0 thru 3. The proposed revisions to 211.1-B-2 would be limited to section 3.3.2.4.2, including augmenting Table III-4 which provides the frequency assignments for the different UHF channels.

During the WG discussion, a typographical error was pointed out where the Channel 0 and Channel 1 frequencies had been swapped in Table III-4 of the Annex. A question was also raised as to why the return frequencies on Channel 0 (401.585625 MHz) and Channel 4 (401.4 MHz) were so close to each other. The frequencies for these channels was confirmed from the MSL Electra Radio specification, and D. Lee took an action to inquire (AI_19-11) with the authors of the Electra specification as to the reason. A suggestion was also made to add a footnote to the recommendation clarifying that the channels in the table are only meant to define the center frequencies and do not constrain the signal bandwidth to be within a single channel. These fixes will be incorporated in a new version of the document and submitted to the next RFM meeting.

3.3 Deep Space Frequency Channels (Rec. 3.1.6B)

Document SLS-RFM_19-15 was presented by D. Lee. This document proposed revisions to the deep space frequency channels in Recommendation 3.1.6B of the 401.0 Blue Book. The revisions are needed to correct some small frequency rounding errors in the existing recommendation, and the changes mirror those made recently to SFCG Recommendation 7-1R6. In the existing CCSDS recommendation, the X-band and Ka-band frequency channels for both the uplink and downlink are derived (and rounded) individually from the S-band uplink frequency. As a result of this rounding, a number of the X-band and Ka-band uplink and downlink channel center frequencies have an error of 1 or 2 Hz relative to the frequencies one would expect using the ideal turnaround ratio (e.g., 749/880 for X-up/X-down). The solution agreed to at the SFCG (and incorporated into REC SFCG 7-1R6) was to using the X-band uplink frequencies are the basis for deriving the other channels. This would limit the number of cases where the channel center frequencies did not correspond to the ideal turnaround ratio to a small subset of Ka-up/Ka-down channels. A footnote was added to the draft CCSDS recommendation to alert users to possibility of a small frequency rounding error in these cases. A marked up version of the proposed Recommendation 3.1.6B revisions was shown at the end of document.

The RFM working group agreed to approve the revised Recommendation 3.1.6B for agency review after the next meeting. Since there was only one Recommendation ready for agency review from this meeting, a decision was made to formally submit the revised recommendation for agency review at the next meeting.

4. Agency Review of CCSDS 401.0-RP-29.1

Document SLS-RFM_19-18 was presented by D. Lee. The document noted that no RIDs had been received during the agency review of the 401.0-RP-29.1 Red/Pink Sheets. The Red/Pink Sheets included new Recommendations 2.1.9 (on multiple uplink carrier for SRS earth station support of MSPA) and 2.6.14 (TTFRs for the 22/26 GHz Category A SRS bands), and a revision to Recommendation 2.3.7 on earth station oscillator frequency stability.

The RFM WG agreed to request publication of new Recommendations 2.1.9 and 2.4.16, and publication of revised Recommendation 2.3.7.

5. Charter discussion

The RFM WG agreed to add development of a recommendation for high data uplinks with simultaneous ranging to the RFM charter. In addition, the milestone dates for development of the flexible turnaround ratio recommendation, the 22 GHz modulations recommendation, and the wideband PN DDOR recommendation were adjusted to reflect the current state of progress.

6. Joint meeting with C&S and DDOR WGs

A joint session with the Coding & Synchronization and Delta-DOR working groups was held in the afternoon of October 22.

6.1 Telemetry randomizer (HOMs and random OID) [Copied from C&S WG Meeting Minutes]

Presentation SLS-RFM_19-21 given by R. Garello (PoliTo), on the telemetry randomizer, considering in particular OID, the impact of coding and the use of high order modulations. The presentation reminded how the PN17 randomizer proposed by NASA has obvious advantages over the current standard PN8, leaving however the issue of OID frames unsolved. In particular, peaks in the PSD are still quite evident, when OID frames are transmitted.

The solution proposed is to fill the OID frames by using a 32-cell LFSR, even though it is recognized that a shorter one would be enough. The initialization of the LFSR for the OID is an open question, and several alternatives are proposed. The recommendation is to update the randomizer itself, based on the NASA proposed PN17, as well as to introduce a recommendation for the OID generation based on the discussion above.

Simulation results with higher order modulation (16-, 32- and 64-APSK) were shown, without introducing any significant difference compared to QPSK and 8PSK simulations. The impact of LDPC coding itself was assessed (the behaviour or turbo-like codes is well known from the literature), to verify the spectral properties. With random payload data, it was shown that LDPC didn't have any impact on the spectrum. With a (almost1) fixed and repeated frame, instead, it was shown how the PN17 wouldn't solve the problem, at high data rates, considering that the randomizer is initialized at each frame. It was however remarked how such case is more typical of low data rate (e.g. housekeeping telemetry), less susceptible to the problem itself.

An action (C&S AI-19-08) was taken by agencies representatives (D. Lee/NASA, V. Sank, NASA, R. Abello/ESA) to check internally and report about the feasibility (ground and space segment) of the PN17. Depending on the (positive) outcome of such action, M. Bertinelli/ESA took the action (C&S AI-19-09) of creating a new project in CWE, to be submitted to CESG approval. Additionally, M. Bertinelli/ESA took the action (C&S AI-19-10) to liaise with the SLP WG, forwarding the proposal agreed during the meeting for the generation of non-zeros OIDs, i.e. PN32 sequences initialized once per mission and then left running.

6.2 SCCC Extension (SCCC-X) [Copied from C&S WG Meeting Minutes]

Presentation SLS-CS_19-12 given by A. Modenini (ESA) on the work done for the CCSDS 131.20-O (SCCC-X), showing both the draft book itself and the work done in term of implementation for both space and ground segment.

C&S Action AI_19_11 was taken by A. Modenini/ESA in order to add an annex documenting the simulation results. M. Bertinelli/ESA took action C&S AI_19_12 to distribute the draft book, once updated, and to initiate the WG review.

6.3 DVB-S2X [Copied from C&S WG Meeting Minutes]

Presentation SLS-CS_19-13 given by M. Nakadai (JAXA) on the measurements obtained with a prototype transmitter implementing DVB-S2X. Transmitter (Mitsubishi) and receiver (HDR-4G+ from Safram) were independently designed, in order to allow verification of the implementation. Up to 600 MBauds and 64-APSK were considered in the measurement campaign. Noise was added (external noise source) at the down-converter stage. No other impairments, e.g. non-linear amplification, was added. VCM operation were tested under noiseless conditions. The prototype was based on a Xilinx Virtex-7.

The WG expressed the interest in having further results, including non-linear distortion. JAXA could not agree at this time, pending internal assessment.

6.4 Channel Model [Copied from C&S WG Meeting Minutes]

Presentation SLS-CS_19-14 (ESA) given by A. Modenini on the assessment of the channel model proposed for simulation in SLS-CS_19-10 (Spring 2019, NASA). The main issues raised were about the use of un-coded performance and the fact that the effects of pulse shaping (e.g. scattering of the constellations) were not considered. Besides, the model didn't include a pre-distorter that is considered essential when working with high order modulations.

ESA proposal would be to have instead a detailed channel model to be used for simulations. The main advantage, in ESA opinion, would be the production of "realistic" simulations, with possible use beyond CCSDS, e.g. support system design and HW development. M. Bertinelli/ESA and A. Modenini/ESA took the action (C&S AI_19_13) to provide such a model (mostly based on information already available in the SCCC Green Book) to the WG, for comments.

6.5 Wide-band DDOR

Document RFM_19-12 on PN-spread DDOR was presented by C. Volk (NASA). According to the document, the leading source of error (~20%) in the DDOR error budget at X-band is instrumental dispersive phase. This error source can be reduced by replacing the single frequency DDOR tone with a PN-spread signal that more closely matches the wideband quasar signal used as the reference source. A wideband signal will provide an averaged phase estimate over the DDOR measurement bandwidth, rather than a phase estimate at a single frequency. The document proposes to use Gold codes for the PN spreading. PN-spread DDOR has the advantage that a separate DDOR tone for ambiguity resolution is no longer needed.

The document stated that a wideband DDOR signal with a flat amplitude response (within 1 dB) across at least 90% of the DDOR measurement bandwidth is desired. Using SRRC pulse shaping, this requires use of a small roll-off factor in the SRRC filter which can be difficult to implement. Increasing the chip rate can widen the flat portion of the PN DDOR spectrum without having to reduce the SRRC roll-off factor, but this allocates more power outside the DDOR measurement bandwidth which is wasted. A 7.2 Mcps PN-spread DDOR signal using a SRRC roll-off factor of 0.1 was implemented on the NASA IRIS radio, and plots of the PN DDOR output spectrum were presented. Pre-compensation was implemented in the IRIS radio to help maintain a flat amplitude response in the PN DDOR spectrum.

A draft new Recommendation 401.0 (2.5.7) was presented at the end of the document. During the discussion, J. Border (NASA) noted that the DDOR WG had come up with several additional changes which had not been incorporated yet. C. Volk (NASA) took action to send out a revised version of the draft recommendation which includes the additional edits from the DDOR WG. W. Fong (NASA) noted that amplifier distortion could cause distortion of the PN DDOR spectrum and expressed concern that the distortions could affect DDOR measurement accuracy. M. Bertinelli stated that ESA needs more time to consult with the transponder manufacturer regarding the suitability of the proposed PN DOR parameters. ESA expects to have a response by the next meeting.

During the discussion, V. Sank (NASA) noted that the diagrams for the PN code generator were potentially ambiguous and that the polynomial generator nomenclature was not consistent between CCSDS books in general. Action item AI_19-10 was issued to S. Rodriguez (NASA) to propose a standardized convention for drawing the PN generator diagram and for expressing the PN generator polynomial that could be used consistently across the CCSDS books, including the new PN DDOR recommendation.

7. Resolutions

The WG agreed to request publication of new Recommendations 2.1.9 and 2.4.16, along with revised Recommendation 2.3.7 of 401.0-B.

The WG agreed to proceed to agency review of revised Recommendation 3.1.6B of 401.0-B after the Spring 2020 RFM meeting.

The WG agreed to proceed to agency review of revised Recommendations 2.4.18 and 2.4.23 following publication of the 431.1 VCM standard.

Annex 1 - Action Item List

AI #	AI description	Actionee	Due date
AI_19-02	Check draft recommendation 2.6.13 with European transponder manufacturers	M. Bertinelli	(1)
AI_19-07	Provide updated draft 23/27 GHz TTFR recommendation with 2 turnaround ratios to cover the entire 27-27.5 GHz return link bandwidth	D. Lee	(1)
AI_19-08	Check if large prime factors in TTFRs are acceptable for implementation in software defined radios, and update draft flexible turnaround ratio recommendation based on comments received at the Fall 2019 RFM meeting	D. Lee	(1)
AI_19-09	Provide analysis on the suitability of GMSK+PN for high data rate uplinks, including the effects of high Doppler in the 22 GHz band on GMSK+PN performance	E. Vassallo, S. Rodriguez, D. Lee	(1)
AI_19-10	Propose a standardized diagram and generator polynomial convention to describe PN code generation, and provide modifications to make the CCSDS books consistent with the proposed convention	S. Rodriguez	(1)
AI_19-11	Check on reason for why the return frequencies for Prox-1 Channels 0 and 4 in the Electra UHF Radio specification are so close together	D. Lee	(1)

(1) 2 weeks prior to the Spring 2020 meeting. All inputs have to be announced 4 weeks prior to the meeting.

CCSDS SLS-RFM WG MEETING

Darmstadt, Germany, 21-24 October 2019

Annex 2 - List of Participants

RF and Modulation Meeting

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NOTE: This list of participants only applies to the RFM WG meeting. Interested readers should also check the relevant WG's minutes for joint meeting participants from other WGs.

CCSDS SLS-RFM WG MEETING

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Annex 3 - List of Input Papers

	Radio Frequency and Modulation: Paper Title	**Available/ Distributed**	**Author**
SLS-RFM_19-XX			
12	Proposed Recommendation for DDOR PN Spread Spectrum Systems	Y/Y	C. Volk
13	Additional Frequency Channel Assignments for Proximity-1 Physical Layer Recommendation	Y/Y	D. Lee
14	Proposed Transponder Turnaround Ratio for 23.15-23.55 GHz and 27.0-27.5 GHz Bands	Y/Y	D. Lee
15	Update of Deep Space Frequency Channels in Recommendation 3.1.6B	Y/Y	D. Lee
16	GMSK+PN Ranging for Uplink	Y/Y	D. Lee
17	Flexible Transponder Turnaround Ratios for MSPA Revisited (Draft Rec. 2.6.13)	Y/Y	D. Lee
18	RIDs of Agency Review of CCSDS 401.0-RP-29.1	Y/Y	Chair and co-chair
19	Ring ratios in VCM (AI_19-04)	Y/Y	J. Hamkins
20	22 GHz Uplink Modulations for High Rate Lunar Links	Y/Y	M. Lanucara, A. Modenini, M. Martinez, G. Sessler
21	Telemetry randomizer (HOMs and random OID)	Y/Y	R. Garello, F. Chiaraluce, M. Battaglioni
SLS-C&S_19-YY	**C&S WG papers for joint meeting**		
12	Draft Experimental Verification, CCSDS 131.20-O, SCCC Extension (SCCC-X)	Y/Y	A. Modenini
13	JAXA DVB-S2X measurements for a high data-rate application by prototype transmitter	Y/Y	M. Nakadai
14	Comments to channel model in SLS-CS_19-10	Y/Y	A. Modenini

CCSDS SLS-RFM WG MEETING

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Annex 4 - Agenda

Date	Item		Comments / Input Papers
Oct 21 – p.m.	1	Action items review	Minutes of meeting
	2	New recommendations	
	2.1	Turnaround Ratios and MSPA	SLS-RFM_19-17 SLS-RFM_19-14
	2.2	GMSK+PN Ranging for Uplink	SLS-RFM_19-16
	2.3	22 GHz Uplink Modulations for High Rate Lunar Links	SLS-RFM_19-20
Oct 22 – a.m.	3	Existing recommendations	
	3.1	REC 2.4.18 and 2.4.23 (APSK radii)	SLS-RFM_19-19
	3.2	Proximity-1 Frequency Channel Assignment	SLS-RFM_19-13
	3.3	Deep Space Frequency Channels (Rec 3.1.6B)	SLS-RFM_19-18
	4	Agency Review of CCSDS 401.0-RP-29.1	SLS-RFM_19-15
	5	Charter discussion	Oct-18 charter
Oct 22 - p.m.	6	Joint RFM/C&S/DDOR meeting	
	6.1	Telemetry randomizer (HOMs and random OID)	SLS-CS_19-11
	6.2	SCCC Extension (SCCC-X)	SLS-CS_19-12
	6.3	DVB-S2X	SLS-CS_19-13
	6.4	Channel Model	SLS-CS_19-14
	6.5	Wide-band DDOR	SLS-RFM_19-12
Oct 24 - p.m.	7	SLS Plenary	