5.1 RF AND MODULATION WORKING GROUP

Title of Group	**5.1 RF and Modulation Working Group**
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5.1.1 RATIONALE

Agencies are planning demanding missions to the Moon or supported by data relay satellites with links at 2 GHz for low data rates and 22 (the band near 22 GHz)/26 GHz for very high data rates, as well as missions to Mars with 32 GHz trunk links. The 22 (the band near 22 GHz), 26 and 32 GHz frequency bands are not covered by the existing RF and Modulation Blue Book (401.0-B-16). New techniques may be needed for the 2 GHz links to the Moon.

Additionally, developing requirements on phase/amplitude imbalance and phase noise for the advanced modulation schemes of the current Blue Book (recommendation 2.4.17A) is needed.

The bandwidth-efficient modulations Green Book (413.0-G-1) needs has to be updated to reflect the recent changes in the Blue Book relating to recommendation 2.4.17B, 2.4.18 as well as a number of nomenclature changes (bit and symbol rate definition, OQPSK filtering, T-OQPSK suppression, etc.) Moreover, a mixture of informative and normative information exists in the current Green Book, which is confusing. The normative part has to be removed from the Green Book and inserted in 2.4.17A, 2.4.17B and 2.4.18.

Additionally, 2.4.17A includes a number of modulations that have not been used to date nor are expected to be used in the foreseeable future. Re-opening discussion on 2.4.17A could solve this problem and provide a basis to respond to the request from IOAG on trying to limit the number of schemes allowed by 2.4.17A.

The Green Book (412.0-G-1) on RF Spacecraft-Earth Station Compatibility Test Procedure has to be reviewed and updated in line with current practices if deemed necessary.

The Proximity-1 Physical Layer Blue Book (211.1-B-3) has to undergo the 5-years review; additionally, the other two layers Blue Books and the Green Book have to be reviewed for what concerns the requirements having RF&Modulation implications.

Additionally, this WG will develop a Green Book that will include, on the one hand those requirements on local planetary communications in support to future manned and unmanned missions to the moon, Mars and other solar system bodies such as asteroids, and on the other hand state-of-the-art system concepts, techniques and technologies candidates for possible standardization.

The requirements will focus on offering increased data transfer capability as compared with current standards (Proximity-1), but also consider networking capability and increased interoperability.

5.1.2 GOALS

The goals of this Working Group are to:

1) Develop modulation recommendations for 22 (the band near 22 GHz), 26 and 32 GHz high rate links;

2) Develop recommendations for Lunar missions or missions supported by data relay satellites to operate at 2 GHz with other users;

3) Revise the recommended schemes in 2.4.17A and develop necessary companion recommendations on imbalances and other impairments;

4) Update 413.0-G-1 in line with recent changes to 401.0-B-16 and move normative text from 413 to 401 (as attachments to 2.4.17A, 2.4.17B and 2.4.18);

5) Update the RF and Modulation Book CCSDS 401.0-B-16 set of recommendations on modulation techniques as per items 1 to 4 above and possible changes required by technical or regulatory issues;

6) Review the RF and Modulation Compatibility Test Procedures Book CCSDS 412.0-G-1 and update it if necessary;

7) Study future Earth Exploration-Satellite-Service requirements in terms of modulation schemes with signaling efficiency better than the schemes in recommendation 401 (2.4.18) for the 8025-8400 MHz band and possibly the 25.5-27.0 GHz band, and study performance of the advanced modulation schemes proposed by the coding and synchronization WG;

8) Study efficient way to combine high rate telemetry and PN ranging with suppressed carrier modulations for the space research service bands;

9) Study the NGU requirements for file uploading and as a consequence update recommendation 2.2.8;

10) Study the NGU requirements for MSPA support and as a consequence develop flexible turn-around ratios recommendations for the 7/8, 34/32 and 40/37 GHz bands or an alternative technique to provide MSPA (multi-carrier operations, CDMA, etc.);

11) Study impairments for 4D-8PSK TCM and propose relevant recommendations;

12) Review the Proximity-1 Blue and Green Books and propose changes if needed;

13) Perform 5-years review of 413.0-G-2 and update it as needed;

14) Co-operate with SLS-C&S for ACM/VCM techniques for the 26 GHz EESS channel;

15) Study turn-around ratios for the new EESS uplink allocation at 7 GHz in association with the 8 GHz downlink and propose relevant recommendation;

16) Propose changes to DDOR recommendation 2.5.6B for low cost missions;

17) Study telemetry ranging concept and propose relevant recommendation;

18) Study modulation technique and position for pilot symbols of high order modulations used in conjunction with the codes of CCSDS 131.0-B-2;

19) Develop high order modulations recommendation for space research (Cat. A) missions in the 8450-8500 MHz band based (subset) on the ones for earth exploration satellites;

20) Propose changes to DDOR recommendation 2.5.6B for more performing and less interfering wideband pseudo-noise (WB PN) DDOR signal.

5.1.3 SCHEDULE AND DELIVERABLES

Date	Milestone
September 2006	WG kick-off
April 2007	Concept papers for recommendations on 22 (the band near 22 GHz), 26 and 32 GHz modulation, and on 2 GHz modulation for Moon missions; proposals for revised 2.4.17A, and editorially revised 2.4.17B and 2.4.18, and draft companion recommendations; proposals for editorially revised 413.0-G; assessment of amount of work needed and affected sections for a revised 412.0-G.
November 2007	Review of SFCG-26/27 and WRC-07 decisions affecting 401.0-B; White-1 recommendation on 22 (the band near 22 GHz), 26 GHz modulation; White recommendations on 32 GHz modulation, and on 2 GHz modulation for Moon missions or missions supported by data relay satellites; Pink 2.4.17A/B, 2.4.18 and Red companion recommendations; Draft revised 413.0-G ready for approval by CESG;
November 2008	Red recommendations on 32 GHz modulation, and; Blue 2.417A/B, 2.4.18 and Red companion recommendations; Revised 413.0-G; Position documents on high rate telemetry and PN ranging; Proposed updates (pink) of CCSDS 401.0-B Recommended Standard on modulation from SFCG and WRC-07.
May 2009	White recommendation on 2 GHz modulation missions supported by data relay satellites; Blue 401, and Green 413; Position documents on EESS requirements for more efficient modulation schemes.

Date	Milestone
October 2009	Initial studies on 8PSK, 16-APSK, 32-APSK and 64-APSK in support of coding and synchronization WG; Review Prox-1 Physical layer (211.1-B-3) book and extract idle pattern sections for coding and synchronization WG.
April 2010	Red recommendation on 2 GHz modulation missions supported by data relay satellites.
November 2010	Pink recommendation 2.2.8;
April 2011	White recommendation on high rate telemetry and PN ranging; White recommendation on 26 GHz modulations; Blue recommendation on 2 GHz modulation missions supported by data relay satellites; Draft Green Book on 2 GHz modulation missions supported by data relay satellites; Blue recommendation 2.2.8; White Prox-1 BB revision;
October 2011	White recommendation on high rate telemetry and PN ranging; Green Book (draft 2) on 2 GHz modulation missions supported by data relay satellites; White recommendation 2.4.21 (4D-8PSK impairments); Position documents on comms requirements in emergency; Red Prox-1 BB revisions;
April 2012	White recommendation on high rate telemetry and PN ranging; Red recommendation on 26 GHz modulations for SRS; Green Book on 2 GHz modulation missions supported by data relay satellites; White recommendation 2.4.18 aligned with red recommendation on 26 GHz modulations; White recommendation 2.4.21 (4D-8PSK impairments); Revised draft Prox-1 BB and draft GB.

Date	Milestone
October 2012	Blue recommendation on 26 GHz modulations for SRS; White recommendation 2.4.18 aligned with red recommendation on 26 GHz modulations; White recommendation 2.4.21 (4D-8PSK impairments); Draft Prox-1 BB and GB.
April 2013	Prox-1 BB and Draft Prox-1 GB; White recommendation 2.5.6B (DDOR); Pink PN Ranging book (3-years review) and accompanying revised GB;
October 2013	White recommendation on high rate telemetry and PN ranging; Position paper on 26 GHz modulations for EESS; Pink recommendation 2.4.18 for EESS; Pink recommendation 2.4.12A (8PSK impairments); Prox-1 GB; Red recommendation 2.5.6B (DDOR); Blue PN Ranging book (3-years review) and accompanying revised GB; Planetary Communications GB table of contents.
April 2014	Red recommendation on high rate telemetry and PN ranging; White recommendation on 26 GHz modulations for EESS; Blue recommendation 2.4.18 for EESS; Blue recommendation 2.4.12A (8PSK impairments); Blue recommendation 2.5.6B (DDOR); First draft of Planetary Communications GB.
November 2014	Blue recommendation on high rate telemetry and PN ranging; Draft Green Book on high rate telemetry and PN ranging; Red recommendation on 26 GHz modulations for EESS; White recommendation 2.4.18 aligned with 26 GHz EESS recommendation; Second draft of Planetary Communications GB; Initial position paper on VCM.

Date	Milestone
April 2015	Draft Green Book on high rate telemetry and PN ranging; Red recommendation on 26 GHz modulations for EESS; Draft Magenta Book on VCM for 26 GHz EESS with SLS-C&S;
November 2015	Draft Green Book on high rate telemetry and PN ranging; Red recommendation on 26 GHz modulations for EESS; Draft Pink recommendation 2.4.18 aligned with 26 GHz EESS recommendation; Updated draft Magenta Book on VCM for 26 GHz EESS with SLS-C&S;
April 2016	Green Book on high rate telemetry and PN ranging; Blue recommendation on 26 GHz modulations for EESS; Draft-2 pink recommendation 2.4.18 aligned with 26 GHz EESS recommendation; Magenta Book on VCM for 26 GHz EESS with SLS-C&S.
November 2016	Pink recommendation 2.4.18 aligned with 26 GHz EESS recommendation; Draft update to Green Book 413.0 including 26 GHz EESS modulations White recommendations on flexible turn-around ratios or alternative MSPA technique; White recommendation on 22 GHz (the band near 22 GHz) modulations and accompanying green book; Initial position papers on ACM for 26 GHz EESS with SLS-C&S; Initial position papers on EESS 7/8 GHz turn-around ratios; Pink DDOR recommendation 2.5.6B; White recommendation on telemetry ranging; Initial position papers on modulation technique and position for pilot symbols of high order modulations for CCSDS 131.0-B-2 codes.

Date	Milestone
April 2017	Blue recommendation 2.4.18 aligned with 26 GHz EESS recommendation; Draft-2 update to Green Book 413.0 including 26 GHz EESS modulations White recommendation on EESS 7/8 GHz turn-around ratios; Blue DDOR recommendation 2.5.6B; White-2 recommendation on telemetry ranging; White recommendation on modulation technique and position for pilot symbols of high order modulations for CCSDS 131.0-B-2 codes.
November 2017	Update to Green Book 413.0 including 26 GHz EESS modulations; Red recommendations on MSPA policy; Red recommendation on EESS 7/8 GHz turn-around ratios; White-2 recommendation on telemetry ranging; White-2 recommendation on modulation technique and position for pilot symbols of high order modulations for CCSDS 131.0-B-3 codes.
April 2018	Blue recommendation on EESS 7/8 GHz turn-around ratios; Blue recommendations on MSPA policy; White recommendations on flexible turn-around ratios for MSPA and accompanying Green Book; White recommendations on multi-carrier operations for MSPA and accompanying Green Book; White recommendation 2.5.6B including WB PN DDOR signal; Red recommendation on telemetry ranging; Red recommendation on modulation technique and position for pilot symbols of high order modulations for CCSDS 131.0-B-3 codes; White recommendation on HOMs for SRS in the 8450-8500 MHz band.

Date	Milestone
November 2018	White-2 recommendation on flexible turn-around ratios for MSPA; Pre-Red recommendation on multi-carrier operations for MSPA; Blue recommendation on telemetry ranging; White recommendation on 22/26 GHz turn-around ratios; Blue recommendation on modulation technique and position for pilot symbols of high order modulations for CCSDS 431.1-B codes; Blue recommendation on HOMs for SRS in the 8450-8500 MHz band.
April 2019	White recommendation on 22 GHz (the band near 22 GHz) modulations; Red recommendation on flexible turn-around ratios for MSPA; Red recommendation on multi-carrier operations for MSPA; Red recommendation on 22/26 GHz turn-around ratios; White-2 recommendation 2.5.6B including WB PN DDOR signal.
Fall 2019	~~Red recommendation on 22 GHz (the band near 22 GHz) modulations;~~ White-2~~Blue~~ recommendation on flexible turn-around ratios for MSPA; Blue recommendation on multi-carrier operations for MSPA; Blue recommendation on 22/26 GHz turn-around ratios; ~~Red-2~~White- recommendation 2.5.7~~6~~B including WB PN DDOR signal.
Spring 2020	White recommendation on high data uplink with simultaneous ranging; Red recommendation on flexible turn-around ratios for MSPA; White~~Blue~~ recommendation on 22 GHz (the band near 22 GHz) modulations; Red~~-~~2 recommendation 2.5.7~~6~~B including WB PN DDOR signal.

Date	Milestone
Fall 2020	Red recommendation on 22 GHz (the band near 22 GHz) modulations; Red recommendation on high data uplink with simultaneous ranging; Blue recommendation on flexible turn-around ratios for MSPA; Blue recommendation 2.5.7B including WB PN DDOR signal.
Spring 2021	Blue recommendation on 22 GHz (the band near 22 GHz) modulations; Blue recommendation on high data uplink with simultaneous ranging.

5.1.4 RISK MANAGEMENT STRATEGY

5.1.4.1 Technical Risks

No technical risks have been identified.

5.1.4.2 Management Risks

Schedules are dependent upon Agency participation until ~~October~~April 2021~~0~~.

5.1.5 RESOURCE REQUIREMENTS

Review support as required	CNES, DLR, ESA, NASA, FSA, JAXA