



Coding and Modulation Working Group (C&MWG) – Report @ IOP-4

Les Deutsch, Jet Propulsion Laboratory, California Institute of Technology

Gian Paolo Calzolari, European Space Agency

December 2018

© 2018. All rights reserved

Team Membership

Gian Paolo Calzolari (ESA) and Les Deutsch (NASA) Co-chairs

Jean-Marc Soula (CNES)

Stefan Veit (DLR)

Enrico Vassallo (ESA)

Haleh Safavi (NASA)

**Contributions from
ASI, CSA, CNES, DLR, ESA, JAXA,
and NASA**

Supporting members:

Victor Sank (NASA)

Jon Hamkins (NASA)

Massimo Bertinelli (ESA)

The Statement of Problem

CCSDS standards have successfully allowed a new era of international space exploration and cross support, however during the years the number of coding and modulation schemes available in those standards has grown significantly.

Currently, the expectation is all core standards in the IOAG service catalog should be implemented at applicable participating ground stations but this approach would require large investment by Agencies.

Moreover, there is currently no incentive, beyond their superior performance, to use newer (better) standards

C&MWG purpose and process

The C&MWG was chartered by the IOAG at the IOAG-18 meeting (ASI, Rome - February 2014) as a focused sub-team to identify a subset of preferred modulation and coding that pertain to these core standards. It has then

- Surveyed IOAG member agencies to see which standards are being used today or planned for the future;
- Analyzed the results to identify standards that are most likely to be used in the future;
- Developed a preferred list of core standards for coding and modulation.

C&MWG message in the report

The IOAG C&MWG encourage missions seeking cross-support services to choose coding and modulations from the preferred list such that ground stations by member agencies should become capable of supporting the applicable standards from the preferred list.

This DOES NOT place any restrictions on missions using any other standard (or even proprietary) codes or modulations – as long as they do not expect to receive international cross-support standard services.

C&MWG results

“Recommendations on Preferred Coding and Modulation Schemes” were approved at IOAG-19d in April 2016.

Consequently:

- The Service Catalogs WG (SCWG) updated the IOAG Service Catalogs to refer to the Report
- IOAG informed CCSDS about preferred list
- IOAG encouraged adherence to the Preferred List for missions requiring international cross-support services

Summary of Preferred Lists

- The recommendations indicated the following likely reductions in standards used by new missions

Category	Number of CCSDS Standards	Preferred	Possible future*	Percentage Reduction
Telecommand Modulation	3	3	0	0%
Telecommand Coding	2	1	1	50%
Telemetry Modulation	15	14	0	7%
Telemetry Coding	16	8	7	50%

* These are standards we expect will be preferred in the future, replacing some in the current “preferred” column

C&MWG future

Based on discussions at IOAG 22a in June 2018, the C&MWG will do the following in the future:

- Periodically review the CCSDS list of coding and modulation standards
- Consider reviewing the report (when appropriate) and possibly adding new membership to reflect actual IOAG participation and changes
- Update (when required) the list of preferred standards

NOTE: Approximately a 5-year cycle is expected for the updates

Backup Material

The Preferred (and possibly Preferred) Codes

Coding - Telecommand

CCSDS 231.0-B

BCH (with Randomizer) /via CLTU service

CCSDS 231.0-B

LDPC Codes /via TBD service **(Possibly Future)**

Coding - Telemetry

CCSDS 131.0-B

Convolutional 1/2

CCSDS 131.0-B

RS (255, 223) E-16

CCSDS 131.0-B

RS (255, 239) E-8

*

CCSDS 131.0-B

Concatenated 1/2 + E=16

CCSDS 131.0-B

Turbo 1/2

CCSDS 131.0-B

Turbo 1/3

CCSDS 131.0-B

Turbo 1/4

CCSDS 131.0-B

Turbo 1/6

CCSDS 131.0-B

LDPC 223/255 **(Possibly Future)**

**

CCSDS 131.0-B

LDPC 1/2 **(Possibly Future)**

**

CCSDS 131.0-B

LDPC 2/3 **(Possibly Future)**

**

CCSDS 131.0-B

LDPC 4/5 **(Possibly Future)**

**

CCSDS 131.0-B

LDPC Codes with Slicing **(Possibly Future)**

**

CCSDS 131.2-B

SCCC **(Possibly Future)**

**

CCSDS 131.3-B

SLP over ETSI DVB-S2 Standard **(Possibly Future)**

**

- Limited to 8PSK-TCM modulation

** Evolution and implementations monitored before driving conclusions. May be subject to designated profiles.

The Preferred Modulations

Modulation - Telecommand

CCSDS 401.0-B

PCM/PSK/PM

CCSDS 401.0-B

PCM/Bi-Phase/PM

CCSDS 401.0-B

BPSK

Modulation - Telemetry

CCSDS 401.0-B

PCM/PSK/PM

CCSDS 401.0-B

PCM/Bi-Phase/PM

CCSDS 401.0-B

(Filtered) BPSK ≤ 2 Msps

CCSDS 401.0-B

Filtered OQPSK ≤ 2 Msps

CCSDS 401.0-B

GMSK ≤ 2 Msps

CCSDS 401.0-B

Filtered OQPSK > 2 Msps

CCSDS 401.0-B

GMSK (BTS=0.25) > 2 Msps

CCSDS 401.0-B

GMSK (BTS=0.5) > 2 Msps

CCSDS 401.0-B

Filtered OQPSK

CCSDS 401.0-B

Filtered 8PSK

CCSDS 401.0-B

GMSK

CCSDS 401.0-B

GMSK (BTS=0.5)

CCSDS 401.0-B

Filtered OQPSK

CCSDS 401.0-B

GMSK (BTS=0.25)

Modulation - Space to Space Links

CCSDS 415.1-B-1

Spread Spectrum