



**Jet Propulsion Laboratory**  
California Institute of Technology

# **Variable Coded Modulation Red Book**

## **C&S WG Response to CESG Poll**

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# Results of CESG Poll Ending Aug. 1, 2017

Poll result:

- Abstain: 0 (0%)
- Approve Unconditionally: 6 (85.71%) (Barkley, Merri, Burleigh, Cola, Calzolari, He)
- Approve with Conditions: 1 (14.29%) (Shames\*)
- Disapprove with Comment: 0 (0%)

\* Spirited email correspondence after the poll led to possible alternate interpretations that (a) the vote had been changed to reject, or (b) the Working Group had withdrawn the book for being incomplete.

After further investigation and verbal discussions, Peter Shames indicated that he would approve the book if the conditions he outlined were resolved. The Working Group has not withdrawn the book and looks forward to a satisfactory resolution of the conditions.

# Approval Conditions: Burleigh

Scott Burleigh (Approve Unconditionally):

“No conditions, but three comments.

- (1) On page 1-2, I think it would be good to define ‘ASM’.”
- (2) On page 2-1, I would have liked to have seen a note on why this protocol is not applicable to uplink.
- (3) On page 4-1: a personal preference, I think "static" would be better than ‘permanent’.”

Response:

- (1) The document has been updated to define ASM.
- (2) Currently, the options for codes on the uplink are limited: BCH and (just recently approved) short LDPC codes. There is not enough infrastructure to build a VCM protocol around. In the event that this becomes more important, we can revisit the issue with pink sheets.
- (3) The term “permanent” to describe the non-changing managed parameters is used in both the SCCC and DVB-S2 books (131.2-B-1 and 131.3-B-1). If “static” is desired, it should be coordinated with Pink Sheets to handle all three books at the same time.

# Approval Conditions: Shames (1/9)

Peter Shames (Approve with Conditions):

“The document is in quite good shape, but it leaves a key point somewhat vague and does not include the SANA, Security, and Patent Annexes. And there are a number of other technical and editorial issues that should be attended to prior to sending it out for agency review.

These are all covered in the attached marked-up copy of the document. Here is a high level summary:

- 1) The SANA, Security, and Patent Annexes are missing.
- 2) The explicit definitions of pilots appears ambiguous (pg 3-1)
- 3) Some of the explanations of the relationships among this doc, and [2] and [4] could be clearer. See pos 1-1, 3-1, 3-2, and Annex B.
- 4) Sec 4 could reference, even if in passing, that these ‘Managed Parameters’, in a compliant CCSDS cross support deployment, would be handled by CCSDS Service Management.”

# Approval Conditions: Shames (2/9)

Response to high level summary:

1) The SANA, Security, and Patent Annexes are missing.

Response: Accepted. SANA, Security, and Patent Annexes have been added (Annex B).

2) The explicit definitions of pilots appears ambiguous (pg 3-1)

Response: Accepted. Section 3.2.1.6 and Figure 3-2 have been added to clarify the insertion of pilot symbols.

3) Some of the explanations of the relationships among this doc, and [2] and [4] could be clearer. See pos 1-1, 3-1, 3-2, and Annex B.

Response: Accepted. Significant additional clarifying language has been added in Section 3.2.

4) Sec 4 could reference, even if in passing, that these “Managed Parameters”, in a compliant CCSDS cross support deployment, would be handled by CCSDS Service Management.

Response: Accepted. Language to this effect has been added in Section 4.1.

# Approval Conditions: Shames (3/9)

Response to marked up copy of document.

- Context: “[Forward] This document was contributed to CCSDS by NASA.”

Comment: “This seems like an unusual sort of statement.”

Inferred condition: Remove this statement.

**Response: Accepted. This statement has been removed from the Forward.**

- Context: “[Table of contents] Annex A Informative References”

Comment: “SANA? Security? Patent?”

Inferred condition: Add these sections.

**Response: Accepted. A new annex, Annex B, describes SANA, security, and patent considerations.**

# Approval Conditions: Shames (4/9)

Response to marked up copy of document:

Context: “[1.1 Background] CCSDS has three Recommended Standards defining channel codes and one Recommended Standard defining modulations for use on the space-to-Earth link. The first of the existing coding standards includes convolutional codes, Reed-Solomon codes, turbo codes, and Low-Density Parity-Check (LDPC) codes (reference [1]), to be used with recommended modulations (reference [5]). No VCM protocol is specified in references [1] and [5]. A second Recommended Standard specifies a set of Serially Concatenated Convolutional Codes (SCCCs), together with a set of modulations and a VCM protocol (reference [2]). A third Recommended Standard specifies a mechanism to communicate CCSDS Transfer Frames using an existing ETSI standard for Digital Video Broadcasting by Satellites (DVBS2), which uses BCH codes concatenated with LDPC codes (references [3] and [4]). The DVB-S2 standard (reference [4]), and thus the CCSDS standard (reference [3]), specifies a VCM protocol as well as method for the receiver to monitor quality-of-reception parameters and to communicate this back to the transmitter, as part of an adaptive coded modulation (ACM) protocol.”

Comment: “It feels like there could be another paragraph here, to the effect that this spec adapts the very similar VCM specs defined in [2] and [4] to create a VCM spec for direct use with standard CCSDS codes [1] and modulations [5].”

**Response: Accepted. This suggested paragraph is in the first paragraph of Section 1.2 Purpose and Scope.**

# Approval Conditions: Shames (5/9)

Response to marked up copy of document:

Context: “[1.2] Except as called for in references [2] and [3], the VCM protocol is not required for CCSDS compliance. That is, the codes in reference [1] and modulations in reference [5] can be used without the VCM protocol described here.”

Comment: “This is a peculiar statement. It seems to say ‘We are defining this VCM spec, but we are not requiring, or maybe even recommending, its use. We only recommend it in these other contexts [3] & [4]. But the whole point of this spec is to make VCM available as a recommended approach for all of the CCSDS codes and modulations. Please change the wording to make this more clear.”

Response: Accepted. The wording has been clarified in Section 1.2 to explain that:

- When VCM is used, it is to follow this VCM recommendation (which is compatible with [2] and [3]).
- This VCM recommendation does not require all transmissions to use a VCM protocol.
- For example, CCSDS TM codes and RF modulations can be used without VCM, as described in 131.0-B-3 and 401.0-B-26.

# Approval Conditions: Shames (6/9)

Response to marked up copy of document:

- Context: “[3.1] ... and optionally inserting pilot symbols...”

Comment: “Since the use of this approach with standard CCSDS coding and synch is the whole point of this, this statement seems suspect. What more work is needed to fully specify the pilot symbols for [1]?”

Inferred condition: Update document to clarify pilot symbol specification.

Response: Accepted. Section 3.2.1.6, along with Figure 3-2 have been added to clarify the pilot symbol insertion. No additional work is needed to fully specify the pilot symbols.

The footnote suggesting “further work” was requested by Enrico Vasallo, in order to be identical with wording present in the most recent RFM Blue Book (401.0-B-26), which was recently approved unconditionally.

In subsequent communication, Enrico confirmed that the situation would be resolved by the clarifying language, including specifying which values of S and P are being used. This has now been done.

# Approval Conditions: Shames (7/9)

Response to marked up copy of document:

- Context: “[3.2] ... Each PLFRAME shall comprise: ...modulation symbols from either 1 codeword or 16 codewords...”

Comment: “Does this really mean ‘or’ or should it be ‘up to’?”

Inferred condition: Double check that the document is correct as written.

Response: Accepted. The document really means “or,” meaning, do it the DVB-S2 way (1 codeword) or do it the SCCC way (16 codewords).

Section 3.2 has been rewritten to make this clear, by defining Type 1 VCM and Type 2 VCM, which are now described in separate sections. In these sections, the construction of the PLFRAME is now well-defined.

# Approval Conditions: Shames (8/9)

Response to marked up copy of document:

- Context: “[3.2] ... using a VCM mode from a VCM mode table in 3.3”

Comment: “replace ‘a’ with ‘one of the’.”

**Response: Accepted. The entire Section 3.2 has been rewritten to make clear which VCM mode tables may be used in which situations – see Table 3-2.**

- Context: “[4.1] Through the use of a management system, management conveys the required information to the modulation, synchronization, and channel coding systems. In this section, the managed parameters used by systems applying this Recommended Practice are listed. These parameters are defined in an abstract sense and are not intended to imply any particular implementation of a management system.”

Comment: “You might at least acknowledge that in a compliance CCSDS cross support system that these parameters would be specified by CSS Service Management.”

**Response: Accepted. The document has been updated as suggested.**

# Approval Conditions: Shames (9/9)

Response to marked up copy of document:

- Context: “[4.3] NOTE – No Variable Managed Parameters are presently defined.”

Comment: “In effect the exchange of ‘variable managed paramters’ are what the VCM protocol itself provides.”

Inferred condition: None.

**Response: Accepted.**

- Context: “[Annex B] INFORMATIVE SUMMARY OF VCM PROTOCOLS IN REFERENCES [2] AND [3].”

Comment: “Why not include this spec as well, along side the other two?”

**Response: Accept, in part. This spec is a choice between using one or the other of the two VCM specs given in the table, what we now call Type 1 or Type 2 VCM. Wording has been added to clarify.**



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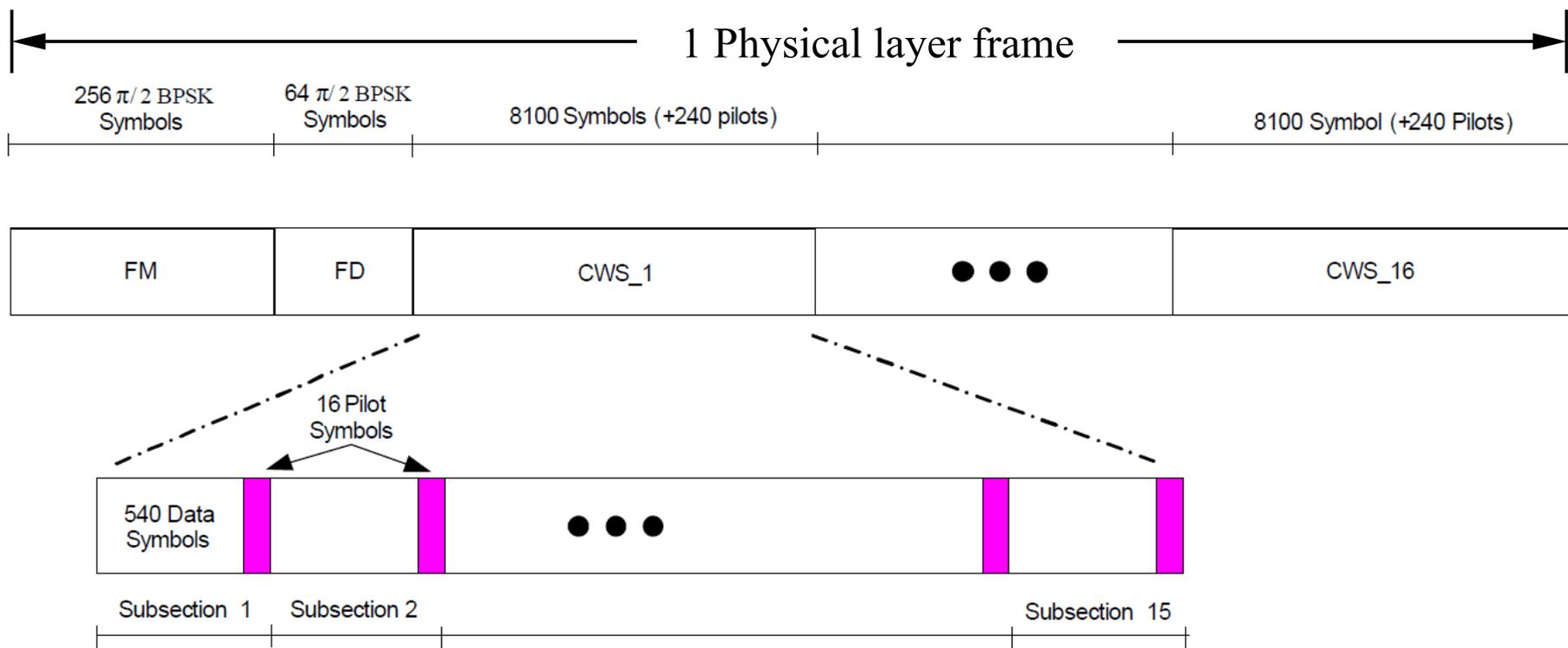
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[jpl.nasa.gov](http://jpl.nasa.gov)

# Backup

# Pilot Tones – SCCC (131.2-B-1)

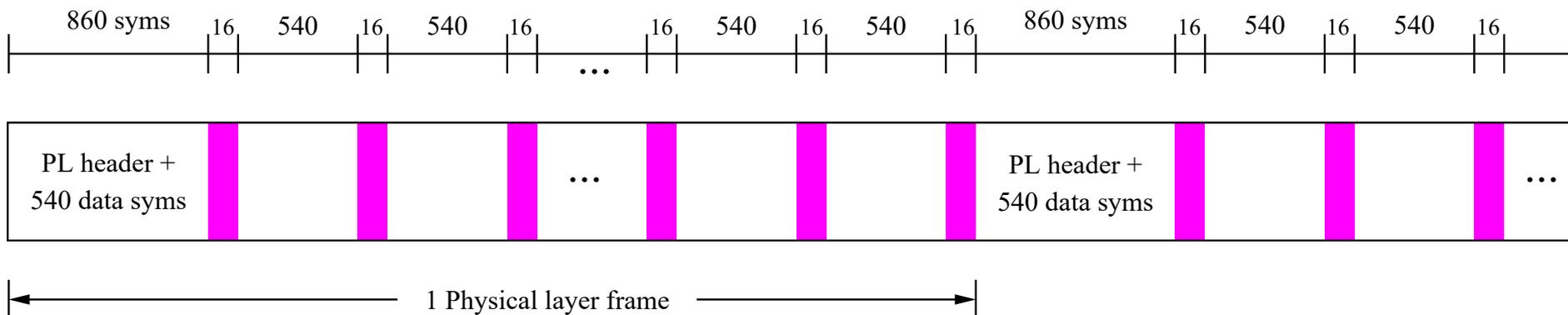
One physical layer frame comprises a header (FM and FD) and 16 codeword sections:



- 16 pilot symbols are inserted after every 540 codeword symbols
- Each codeword section has  $8100/540=15$  pilot symbol blocks (regardless of VCM mode)
- Each codeword section ends with a pilot symbol block (regardless of VCM mode)

# Pilot Tones – SCCC (131.2-B-1)

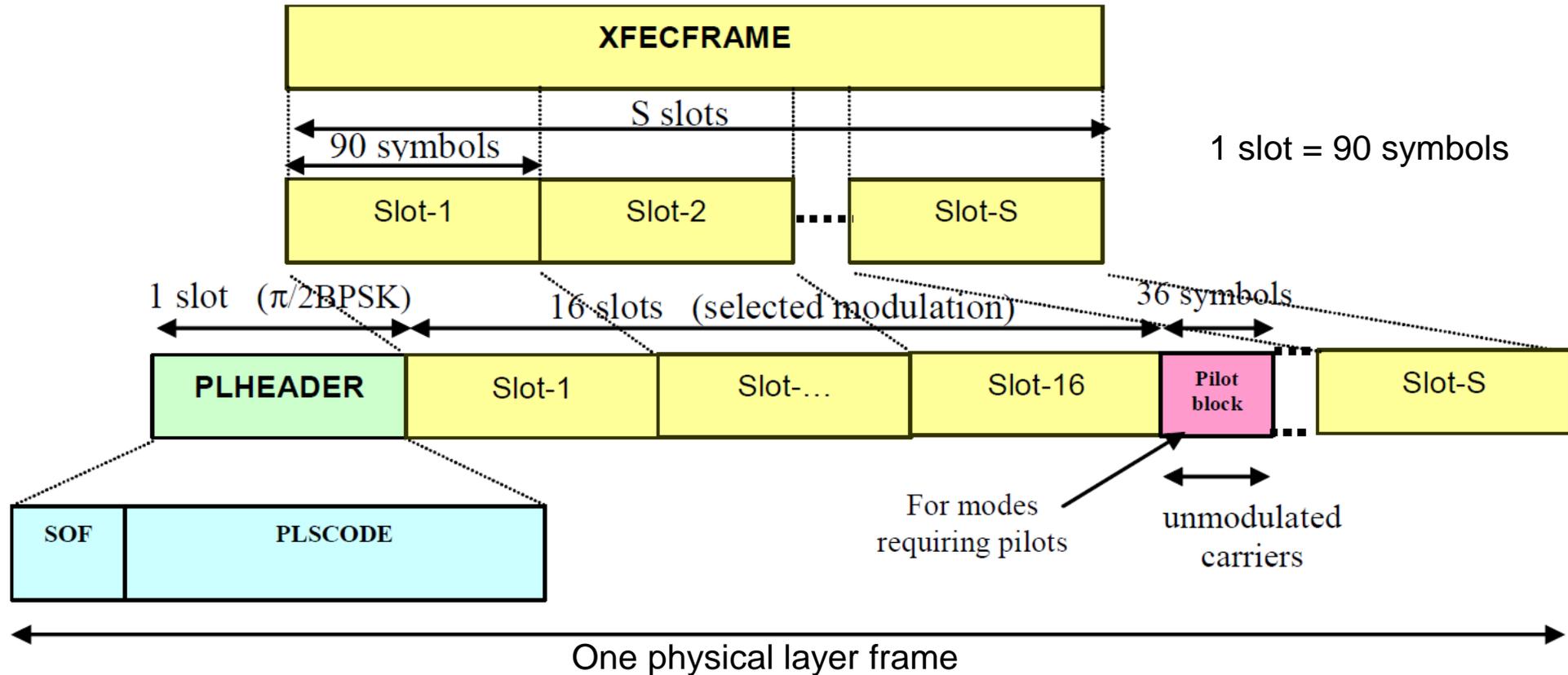
Overall, the receiver sees this spacing of pilot symbols:



- There are  $S=540$  symbols between each block of  $P=16$  pilot symbols...
- ... except at physical layer frame boundary, where there are 860 symbols (320 header + 540 data symbols) between pilot blocks.

# Pilot Tones – DVB-S2 (131.3-B-1/ETSI EN 302 307)

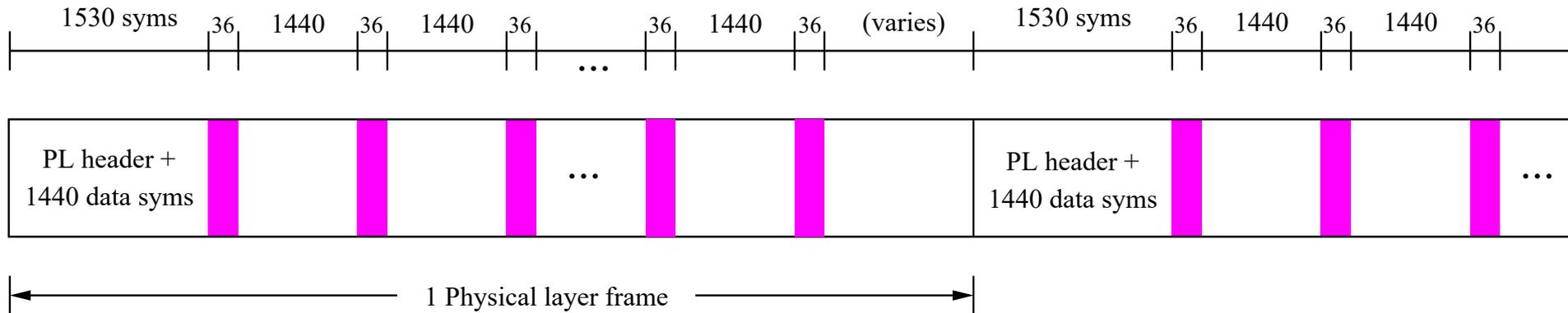
One physical layer frame comprises a header and 1 codeword section (XFECFRAME):



- 36 pilot symbols are inserted after every 16 slots (1440 symbols)
- The header (PLHEADER) is 1 slot (90 symbols)
- The length of XFECFRAME is 36, 45, 60, 90, 144, 180, 240 or 360 slots – these are mostly not multiples of 16 slots

# Pilot Tones – DVB-S2 (131.3-B-1/ETSI EN 302 307)

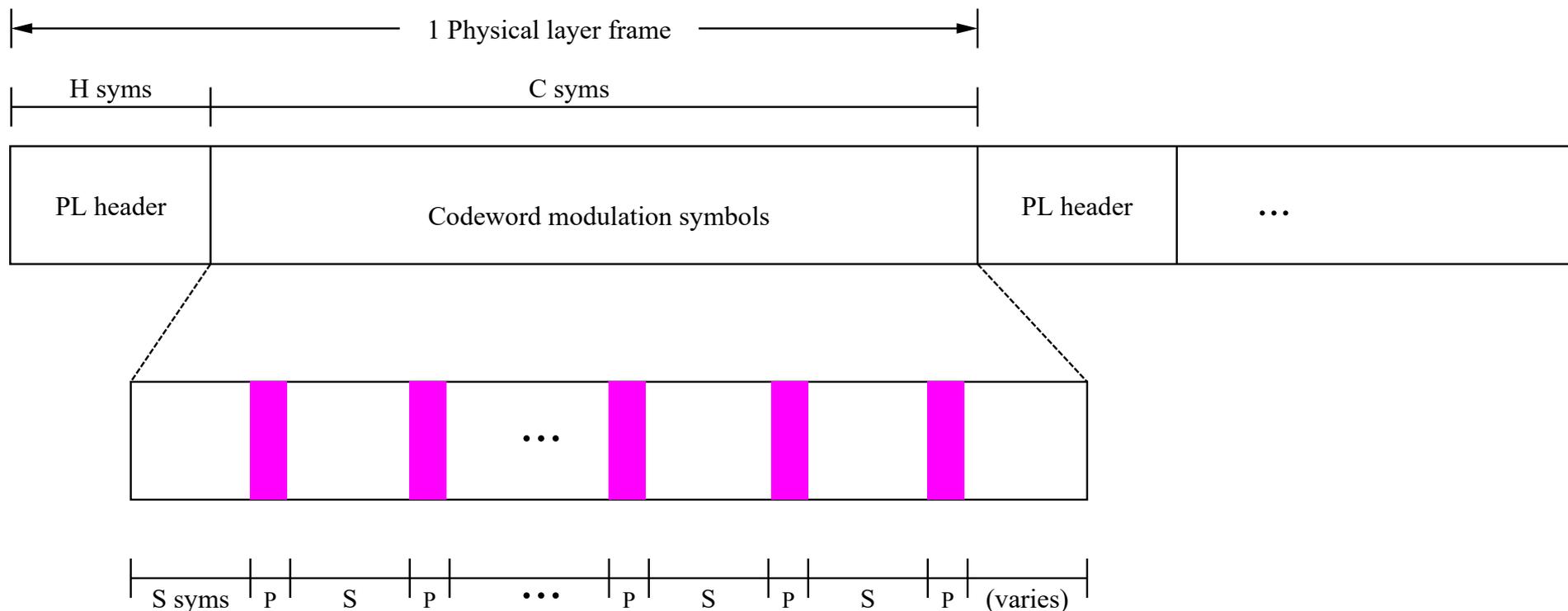
Overall, the receiver sees this spacing of pilot symbols:



- There are  $S=1440$  symbols between each block of  $P=36$  pilot symbols...
- ... except at physical layer frame boundary, where there are 1890 to 2700 symbols (90 header + 1440 data symbols + 360 to 1440 symbols at end of prior frame) between pilot blocks, depending on the VCM mode.

# Pilot Tones – VCM Red Book

How pilot symbols are inserted:



- P pilot symbols are inserted after every S codeword symbols
- The physical layer header is H symbols; the physical layer frame payload is C symbols
- C may or may not be a multiple of S