PHY Link Channel for EPoC TDD Mode

Nicola Varanese, Qualcomm

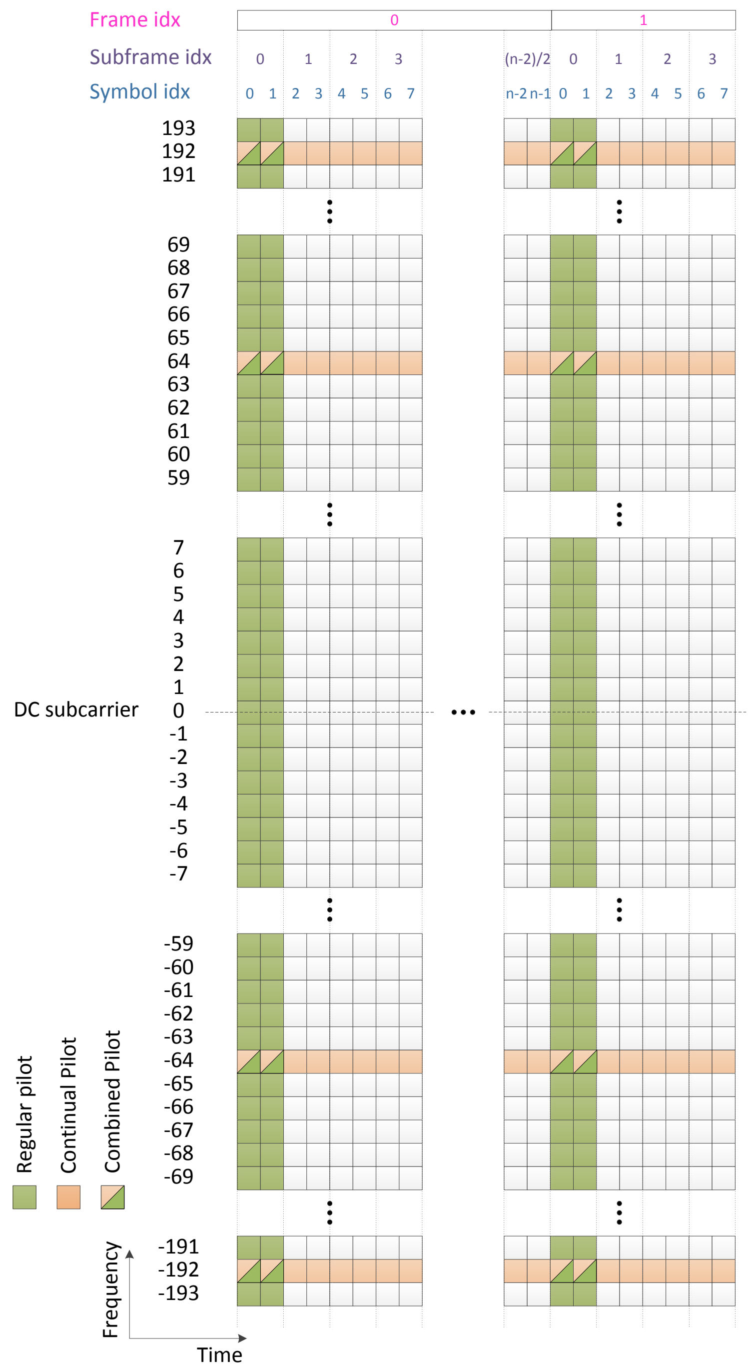
Supporters

- Ed Boyd, BCOM

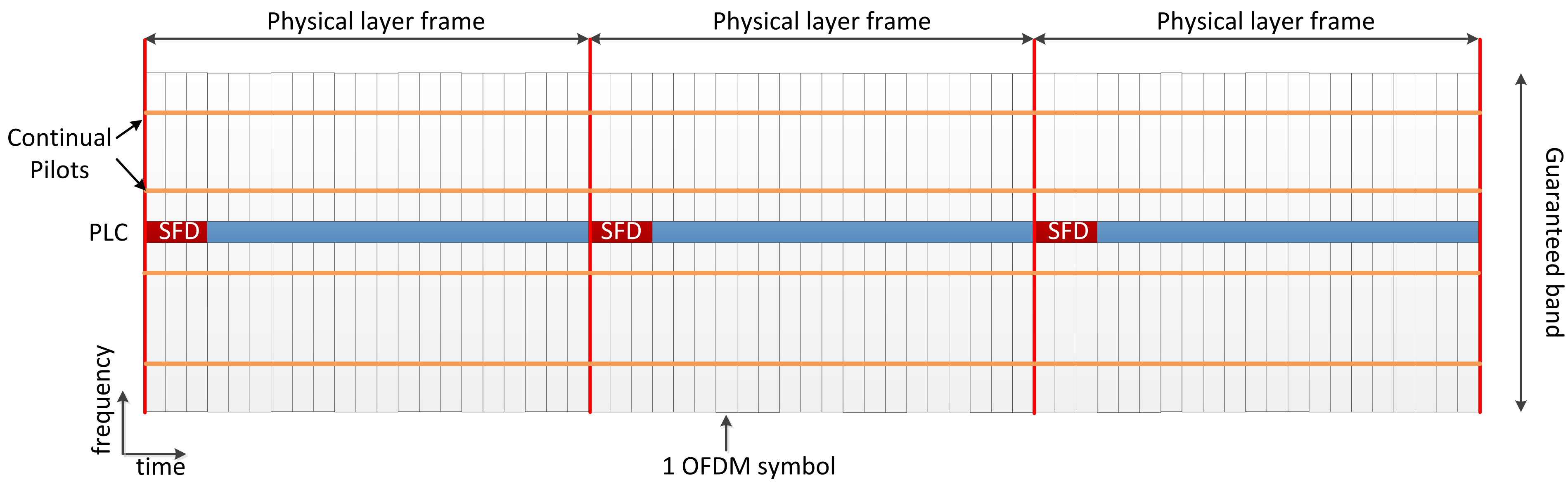
Proposed PHY Frame Structure

- **Regular pilot symbols** (this example shows the TDD configuration)

- **Continual pilot symbols**:
  - Present in every OFDM symbol (just like PLC)
  - E.g., with 50kHz spacing, continual pilot symbols occur every 128 subcarriers (i.e., at the borders of legacy 6MHz channels)
  - **Not** transmitted within exclusion bands
  - **Additional continual pilots** are present around the subcarriers reserved for the PLC
  - **Additional continual pilots** can be used as edge pilots at the borders of each exclusion band (configured via PLC)
  - Used to track channel variations (e.g., phase tracking), improve channel estimate, **acquire PLC location**

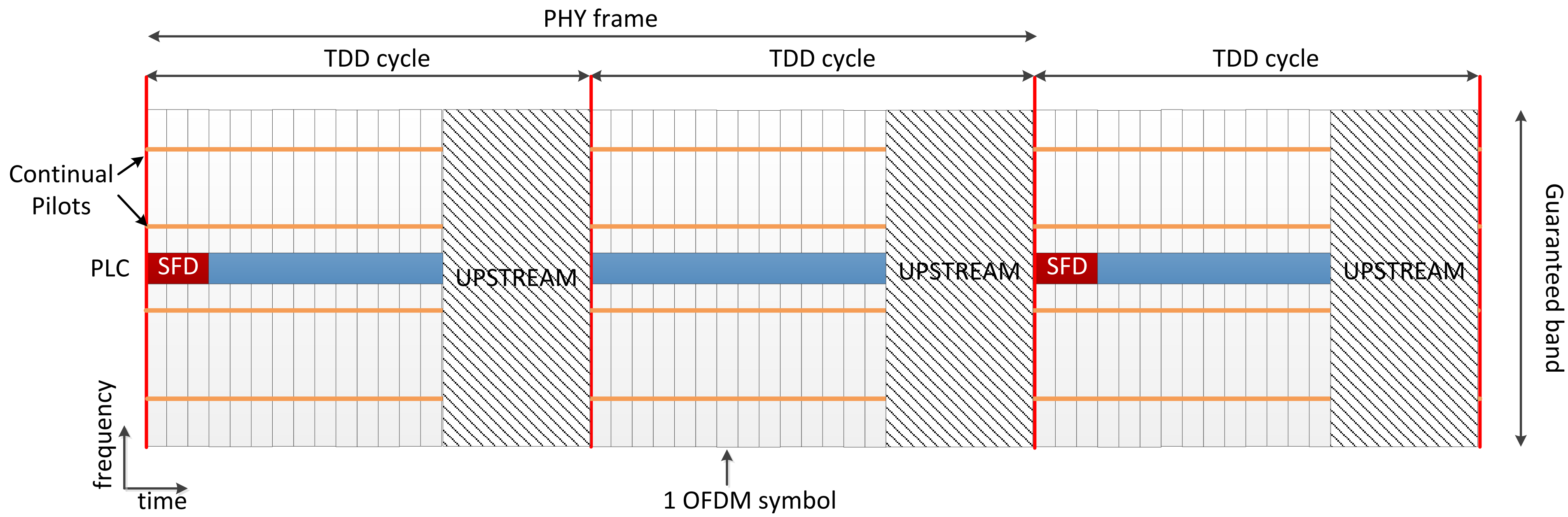


Resources Reserved for PLC - FDD



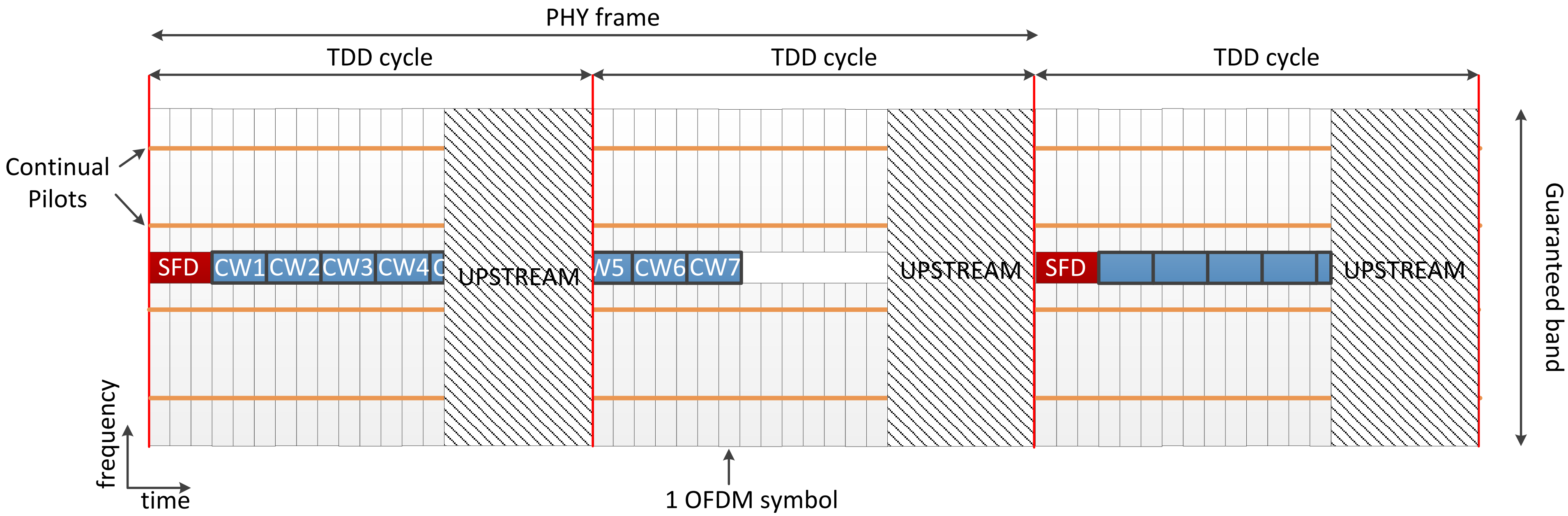
- The standard will define the notion of **minimum guaranteed continuous band**
  - No exclusion bands and nulled subcarriers are allowed within at least a portion of the channel as wide as this minimum band
  - Possible values: **6MHz, 12MHz, 24 MHz**
- PLC is placed at the center of such a band
- **Additional continual pilots** are placed within such a band, **symmetrically** with respect to the PLC (see figure)
- **Searcher algorithm** is based on the continual pilots related to the PLC

TDD-specific Aspects



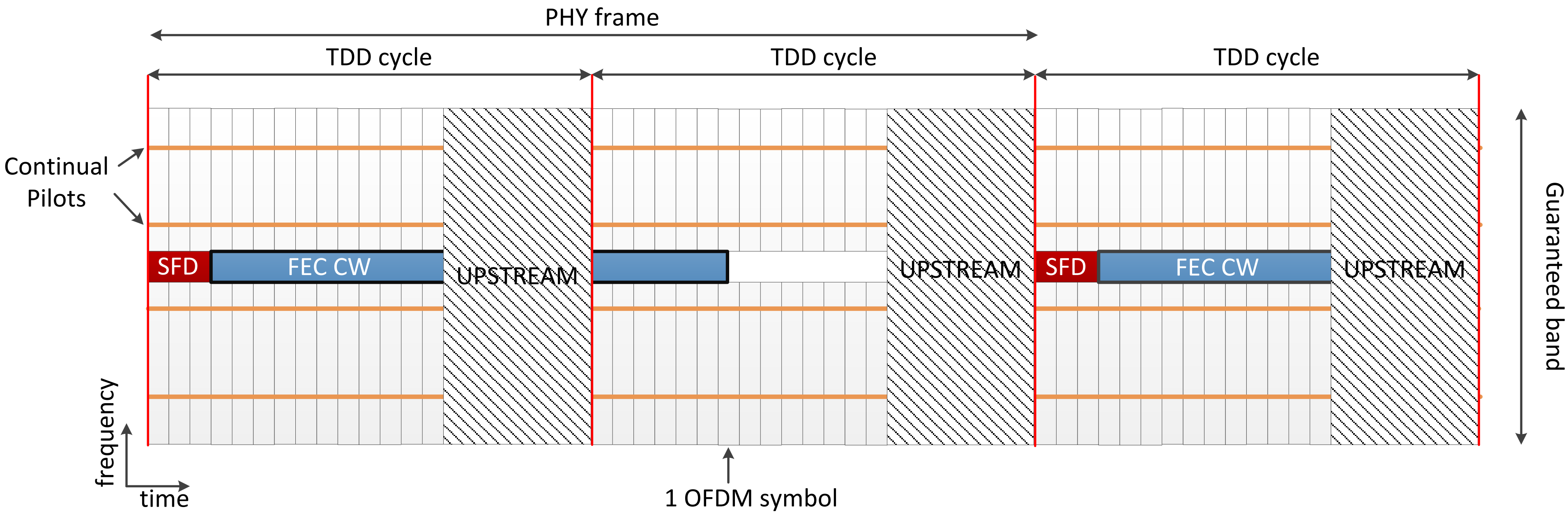
- SFD and PLC data repeated every 256 (128) OFDM symbols (TDD DS PHY frame duration)
- SFD located **at the start of a DS time-slot**
  - As for FDD, PLC enables PHY frame synchronization and **alignment to the TDD DS/US cycle**
- **PLC provides** information on
  - **TDD cycle duration** and **DS/US split** (i.e., DS and US time-slot duration)
  - **TDD guard interval** duration

PLC Data - FEC



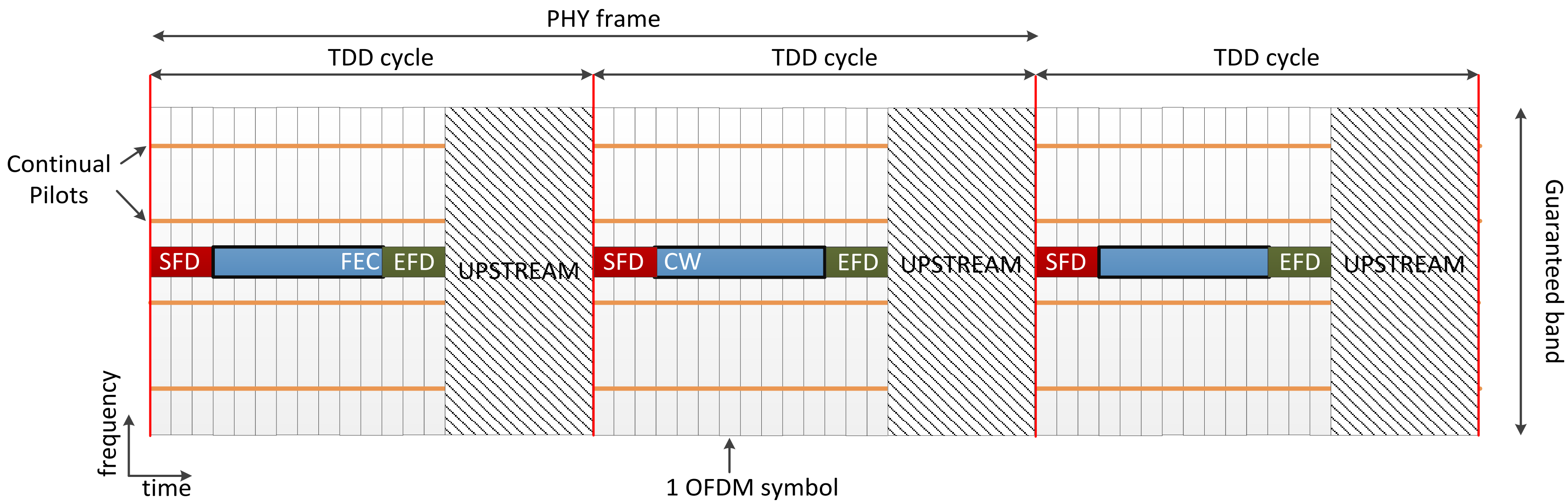
- Can the PLC data payload provide information on the TDD cycle structure **in a timely fashion** (namely before the DS window actually ends)? Yes, provided that:
  1) The FEC codeword length is short enough that at least one codeword is contained in the DS window for all possible TDD cycle structures (namely all the possible durations of the DS window)
  2) The first codeword of the PLC data payload (CW1 in the figure) contains information related to the PHY channel structure (at least the TDD cycle structure)
     – In general, the first *n* codewords of the PLC payload may be designed to carry critical information related to the PHY channel structure (TDD cycle structure, PHY frame structure, Exclusion bands, active Multiple Modulation Profiles, etc) in hierarchical order of importance.
- With only 8 subcarriers reserved for the PLC, this approach could **heavily condition the minimum DS window duration and selectable TDD cycle structures**

PLC Data - FEC



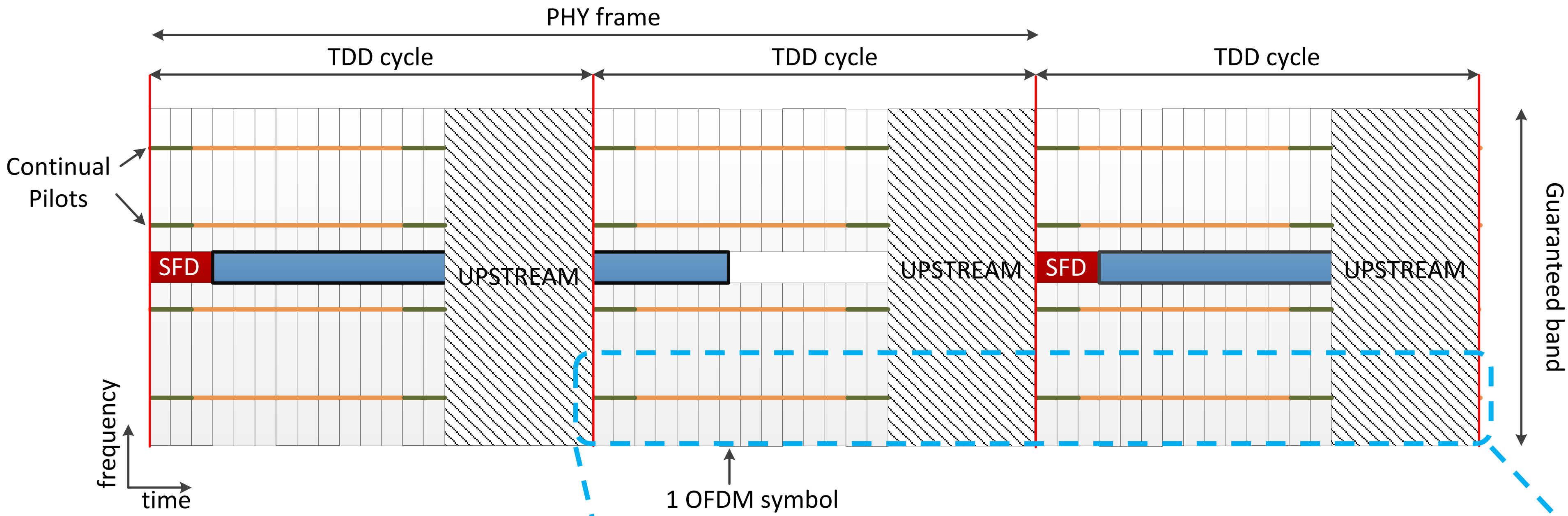
- **Proposal: TDD cycle structure and DS/US window duration is <u>not</u> bound to FEC codeword length**
  - FEC codeword is allowed to extend over multiple TDD cycles (see figure)
  - Minimum selectable TDD DS window is conditioned uniquely on PHY reference signals (namely continual pilots, regular pilots and PLC SFD)
  - Enable the use of long codewords and efficient FEC code
- If FEC codewords extend over multiple TDD cycles, how can the receiving CNU know about the TDD cycle structure before the end of the DS window ?

Solution 1: Use End-of-Frame Delimiter

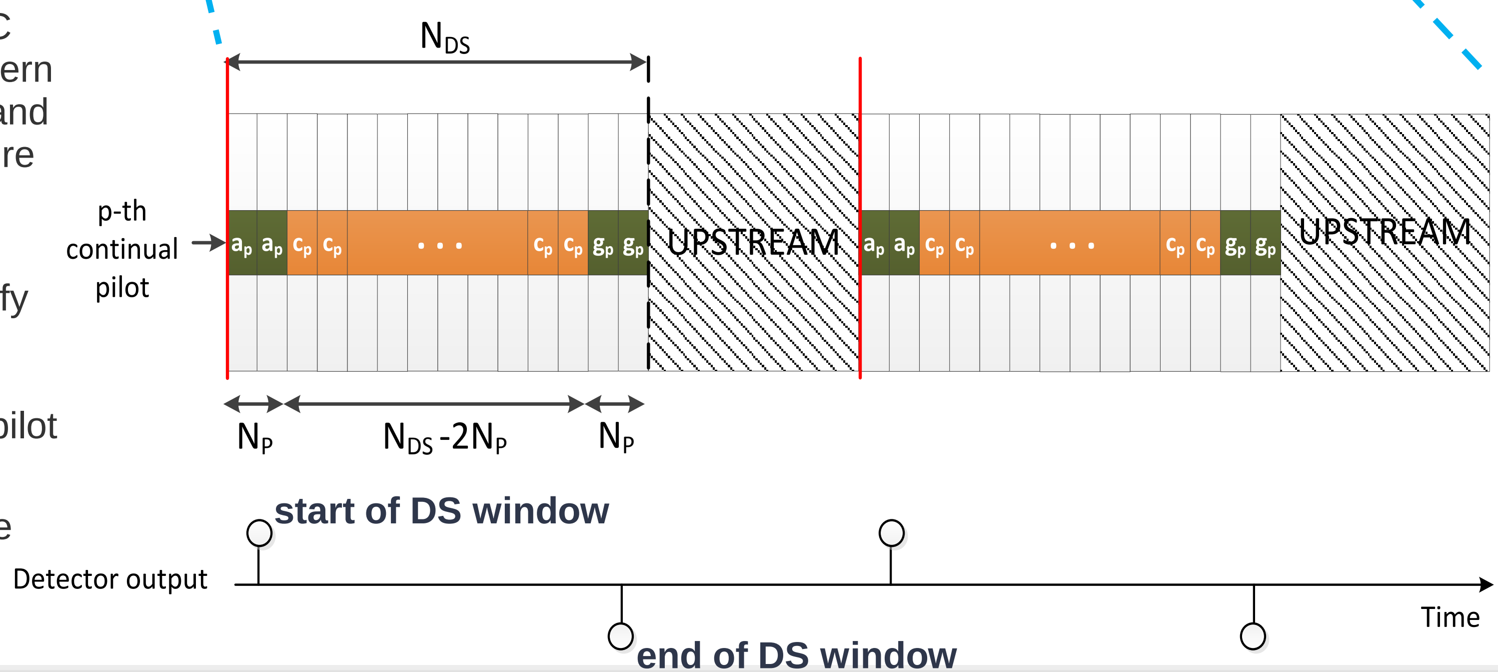


- SFD is repeated at the start of every DS window
- The end of the DS window is signalled via an End-of-Frame delimiter (or post-amble)
- FEC codeword(s) can span multiple DS windows
- CNU will obtain information on guard time and US window duration from the PLC data
- Simple approach, but:
  - Overhead over the PLC is further increased (will influence the CNU bring-up time)
  - We do not have a unique identifier for the start of the PHY frame

Solution 2: Use Continual Pilots



- Continual pilots around the PLC carry a specific modulation pattern that allows to identify the start and end of the DS window (see figure on the right)
- For example, a dedicated detection algorithm could identify start and end of DS window by looking at the phase difference between successive continual pilot symbols
- As an example, we may choose
  $a_p = +1, c_p = -1, g_p = +1$



Initial Acquisition Sequence

- The sequence below is an example and is implementation dependent
  1. Find FFT size and CP size using correlation
  2. Find FFT boundaries
  3. Find fractional frequency offset
  4. Find continual pilots (and integer frequency offset)
  5. Find phase jumps in continual pilots
  6. Find SFD (or preamble)
  7. Estimate channel using SFD

  All should be accomplished in a single Preamble period on the average

- Decode PLC Data to find messages describing OFDM channel parameters (center frequency, available sub-carriers, FEC/Interleaving pointers, profile, pilots …)

- Start Admission process and Ranging

- Begin receiving Data

thank you