

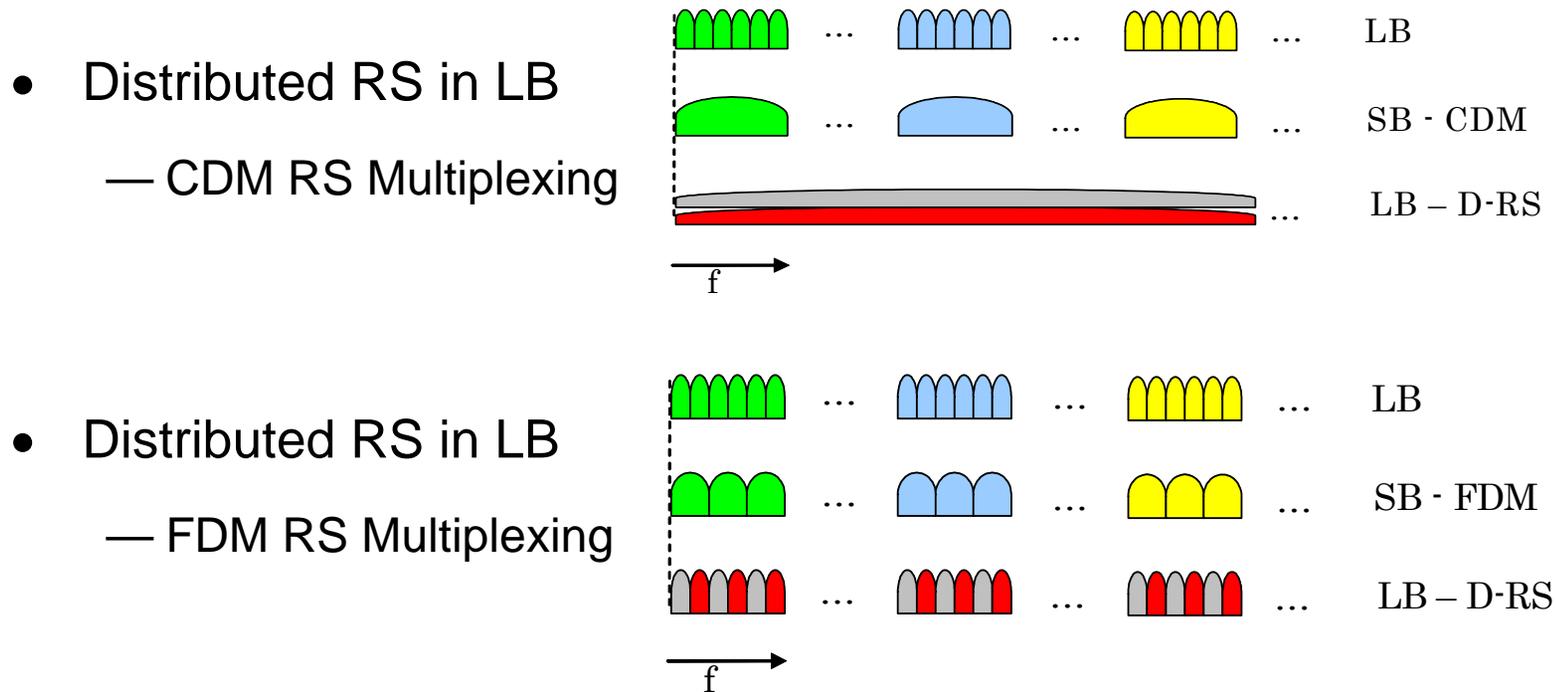
# Overview of Distributed (“Sounding”) Reference Signal Multiplexing Methods in EUTRA Uplink R1-062643

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# Introduction

- Distributed RS multiplexing for CQI Measurement has been decided to enable Frequency Dependent Scheduling in EUTRA UL
- Three Distinct Options have been proposed
  - Multiplexing distributed RS in LBs (option 1)
  - Multiplexing distributed and localized RS in the same SB (option 2)
  - Multiplexing distributed RS in separate SB from localized RS (option 3)

# Distributed RS in LBs (Option 1)



Distributed RS are MUX in one or more LBs in each sub-frame

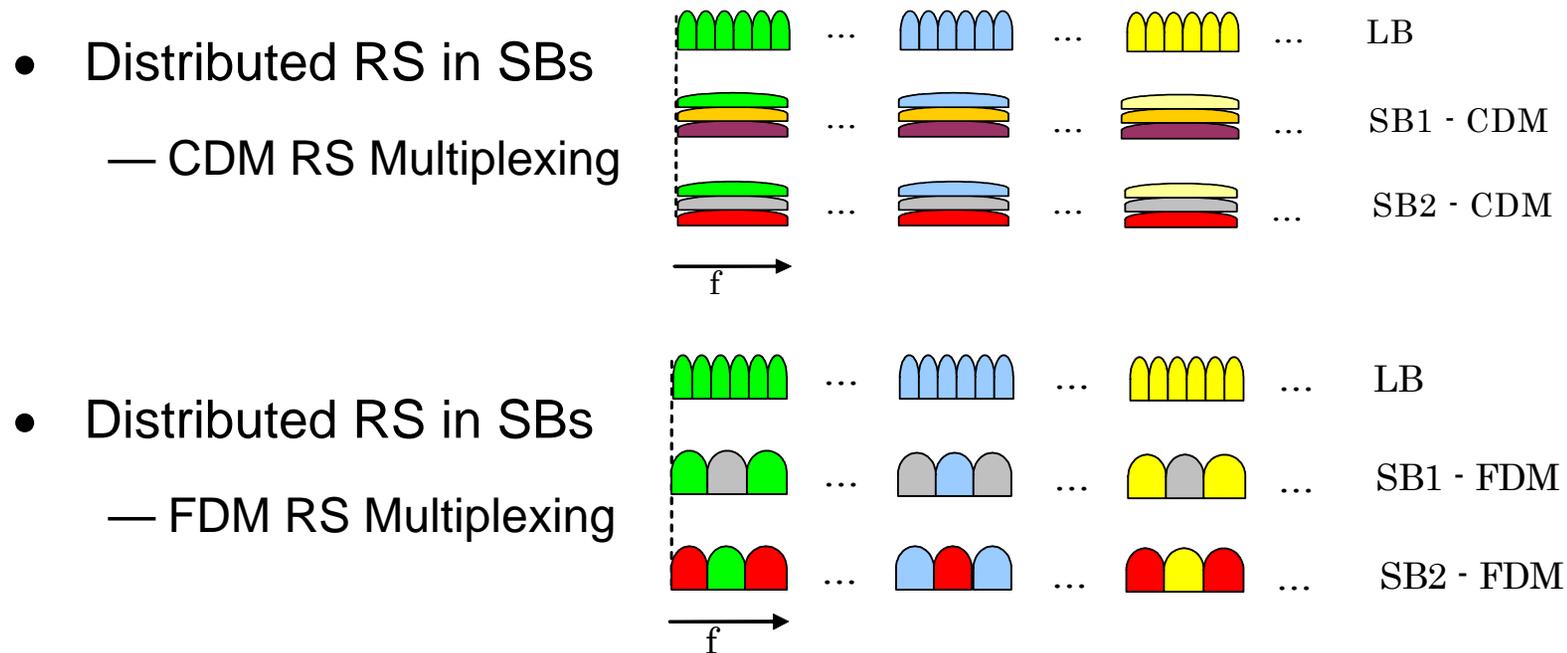
— CDM is preferable to FDM

- CDM: 10-12 distributed RS can be multiplexed per LB – more RS sequences, large CQI robustness to interference
- FDM: 10-12 distributed RS can be multiplexed for RPF=10-12 – less for smaller RPF. The larger the RPF<sub>3</sub>, the smaller the number of RS sequences and the smaller the CQI robustness to interference.

## Distributed RS in LBs (Option 1) - Attributes

- Optimum Channel Estimation Performance (SBs have localized RS)
  - Simple Distributed RS Multiplexing
  - Additional UE Tx power (separate distributed RS) – impact on battery life
  - Significant Overhead
    - 10 (20) distributed RS can be MUX every 2 msec using 1 (2) LB per TTI for an overhead of 8.33% (16.67%).
    - Overhead may be reduced (increased) with slower (higher) RS MUX rate
    - UEs at cell edge need transmit several distributed RS for CQI estimation.
    - Multiple distributed RS per antenna are needed for UL SU-MIMO.
    - Additional distributed RS from UEs in different BWs need to also be accommodated (for switching BWs to exploit all available BW for scheduling).
- Overhead of at least 10%-15% is required

## Multiplexing Localized and Distributed RS in Same SB (option 2)



Distributed RS are MUX in one or more SBs in each sub-frame

— FDM is preferable to CDM due to PAPR

- CDM: 8-10 distributed RS can be multiplexed – RS of different BW are not orthogonal – multi-carrier RS transmission needed for orthogonality but this will increase PAPR
- FDM: 8-10 distributed RS can be multiplexed for RPF=5-6 – less for smaller RPF. Smaller RPF may be needed (a RB may be shared with other UE antennas (SU-MIMO) or other UEs (MU-MIMO, TBD for ACK/NAK, CQI)). The larger the RPF, the smaller the number of RS sequences and the CQI robustness to interference.

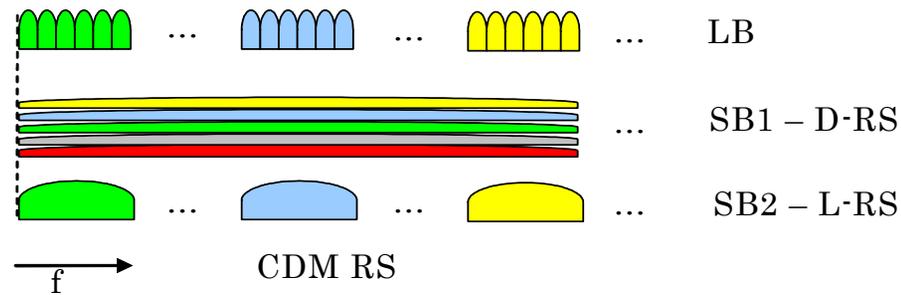
## Multiplexing Localized and Distributed RS in Same SB (option 2)

- Optimum Channel Estimation Performance (SBs have localized RS)
  - Localized RS sequence length decreases by the number of combs
  - Distributed RS sequence length decreases by the number of combs
  - RS multiplexing may be complicated
  - Additional UE Tx power (separate distributed RS) – impact on battery life
  - 8-10 RS for RPF = 6. Only 2 RS for RPF = 2. (per sub-frame)
    - UEs at cell edge need transmit several distributed RS for CQI estimation. Multiple distributed RS per antenna are needed for UL SU-MIMO. Distributed RS from UEs in different BWs need to be accommodated.
    - Then, with RPF=2, only 8 (16) distributed RS can be MUX within 2 (4) ms
- ➔ Option 2 has limited to no scheduling capability for a sufficient number of RS sequences and CQI robustness to inter-cell MAI (small RPF)

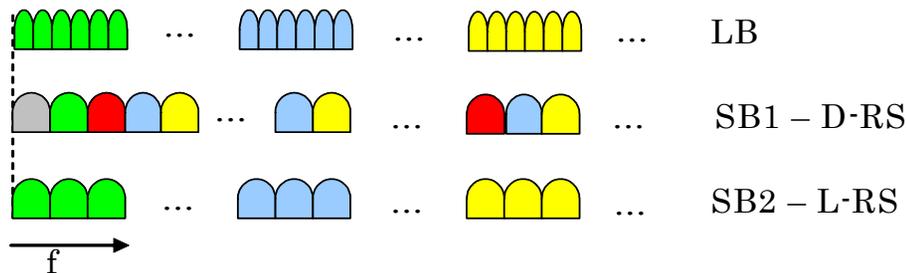
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## Multiplexing Distributed RS in SB1, Localized RS in SB2 (option 3)

- Distributed RS in SB1
  - CDM RS Multiplexing



- Distributed RS in SB1
  - FDM RS Multiplexing



Distributed RS are MUX in one or more SBs in each sub-frame

— CDM is preferable to FDM

- CDM: 5-6 distributed RS can be multiplexed – more RS sequences – large CQI robustness to interference
- FDM: 5 distributed RS can be multiplexed for RPF=6 – less for smaller RPF. Smaller RPF may be needed (a RB may be shared with other UE antennas (SU-MIMO) or other UEs (MU-MIMO, TBD for ACK/NAK, CQI)). The larger the RPF, the smaller the number of RS sequences and the CQI robustness to interference. <sup>7</sup>

## Multiplexing Distributed RS in SB1, Localized RS in SB2 (option 3)

- Channel estimation loss of 0.0-0.2 dB (due to distributed RS in 1 SB)
    - Loss depends on ratio of scheduling BW to data BW - minimal loss for data scheduling (more than 1 RB allocations)
  - Preserves the large distributed RS sequence number of CDM and provides adequate number of Zadoff-Chu sequences with low CM
  - Preserves the large MAI immunity of CDM for accurate CQI estimation
  - Simple distributed RS multiplexing
  - Additional UE Tx power for separate distributed RS not needed for UEs with UL data Tx → better battery life
  - RS overhead for separate distributed RS not needed for UEs with UL data Tx → less interference (better system level performance)
- Option 3 is advantageous for UL frequency dependent scheduling

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# Comparison of Distributed RS Multiplexing Options

	TF Resource Overhead	Number of Distributed RS	Data Channel Performance	Additional UE Tx Power for Distributed RS	Number of Sequences (for planning) - CQI robustness	Additional Interference
Option 1	Large	Large	Optimum	Always	More	No
Option 2	None	Large (Small)	Optimum	Always	A lot Less (Less)	Yes
Option 3	None	Large	0.0-0.2 dB loss from optimum	Only for Infrequently Scheduled UEs	More	No

**→ Option 3 is preferred for Distributed RS Multiplexing**