4G In Vitro – Radio Channel Abstraction

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Journée recherche et expérimentations

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LTE transmission modes

- **BLER performance depends on transmission mode and receiver architecture**

LTE Transmission Modes
1. Single Antenna
2. TX Diversity
3. Open-loop Spatial Multiplexing
4. Closed-Loop Spatial Multiplexing
5. Multi-user MIMO
6. Closed-loop rank 1 precoding
7. UE-specific single layer
8. UE-specific dual layer
9. UE-specific 8-layer
10. UE-specific 8-layer (CoMP)

Most commonly used transmission modes

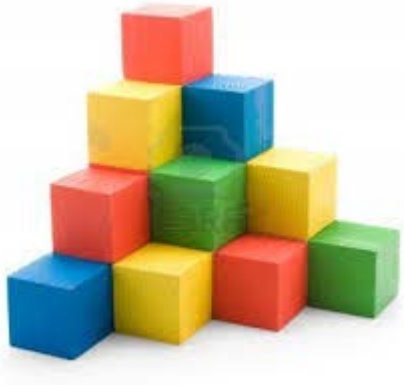
Focus of this work

Challenges in PHY abstraction for TM3/4

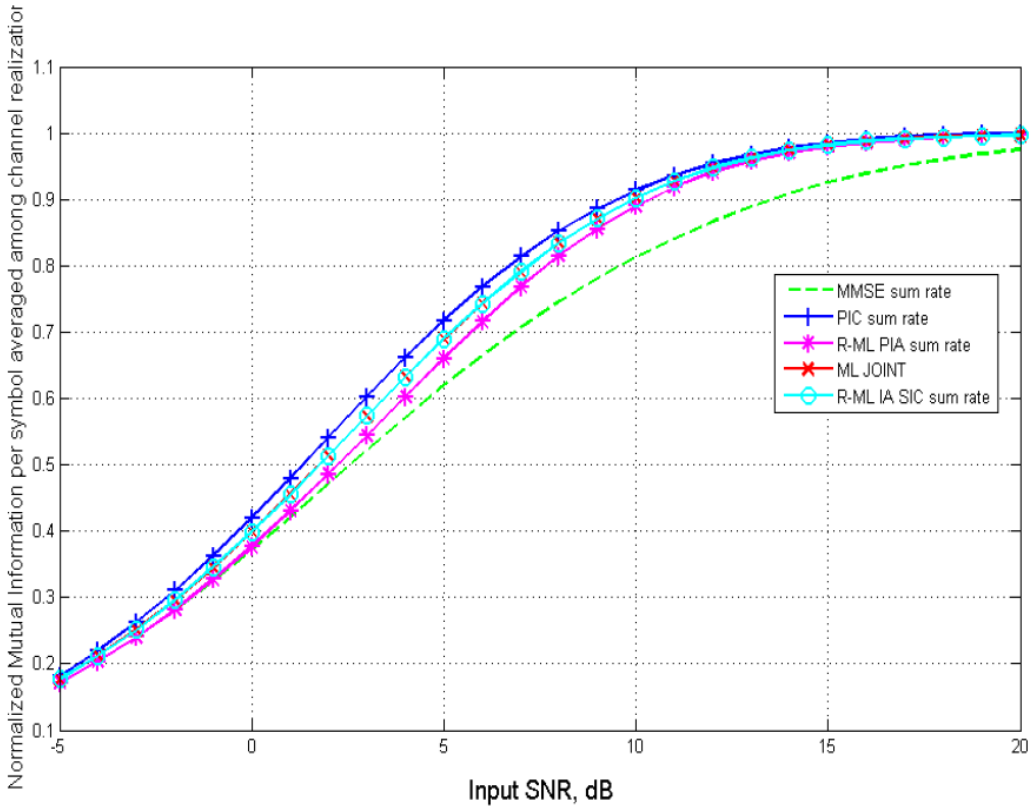
- **Standard, linear receivers (e.g. MMSE) can be abstracted using post-processing SINR**
- **Advanced, non-linear receivers based on reduced complexity maximum likelihood (R-ML)**
  - Joint detection (JD)
  - Parallel interference aware detection (PIA)
  - Successive interference cancelling (SIC)
- **Each receiver has different performance and requires different abstraction methodology**

Our approach

- **Building a set of tools to be reused for different LTE and LTE-A configurations with various receivers architectures:**
  - TM3/4 SU-MIMO R-ML PIA
  - TM3/4 SU-MIMO R-ML SIC with HARQ



Mutual information analysis



$$C_{PIC} > \underbrace{I\left(S_1, S_2; \mathbf{Y}|\mathbf{H}, \mathbf{P}\right)}_{\text{joint detection}} = \underbrace{I\left(S_2; \mathbf{Y}|\mathbf{H}, \mathbf{P}\right) + I\left(S_1; \mathbf{Y}|S_2, \mathbf{H}, \mathbf{P}\right)}_{\text{IA-SIC detection}} \geq$$

$$\underbrace{I\left(S_1; \mathbf{Y}|\mathbf{H}, \mathbf{P}\right) + I\left(S_2; \mathbf{Y}|\mathbf{H}, \mathbf{P}\right)}_{\text{Parallel IA detection}} > C_{MMSE}$$

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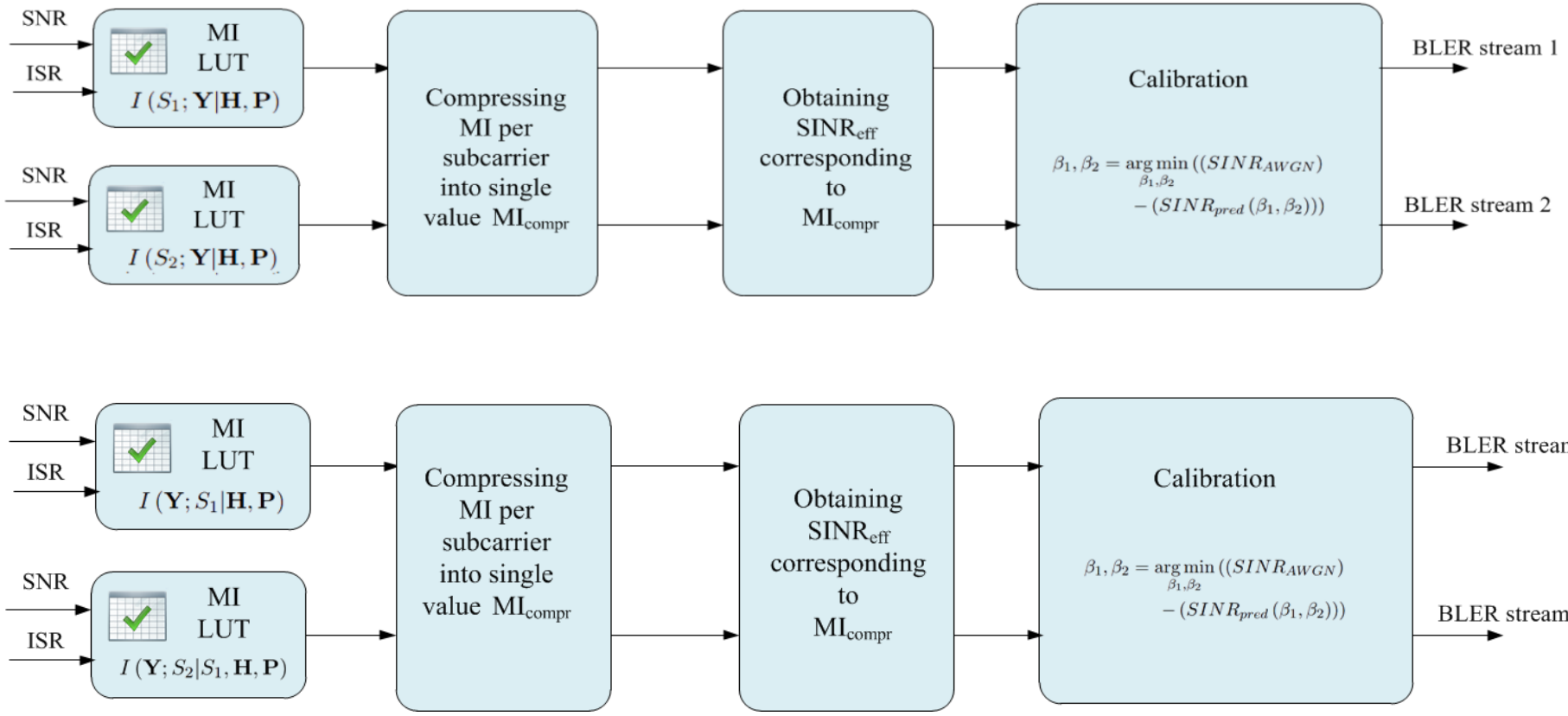
Building MI mapping block

- **Direct computation – very time consuming!**
- **Polynomial approximation [1] – needs to be extended for IA**
- **Look-up Table [2] – offline computation, easy to reuse and adapt for different cases:**
  - Detection strategies
  - HARQ
  - Different constellations of desired and interfering signal

[1] IEEE, “ 802.16m Evaluation Methodology Document (EMD),” January 2009
[2] I. Latif, Scalable system level evaluations for LTE using PHY abstraction. PhD thesis, Thesis, 08 2013.

LUT for R-ML PIA and R-ML IA-SIC



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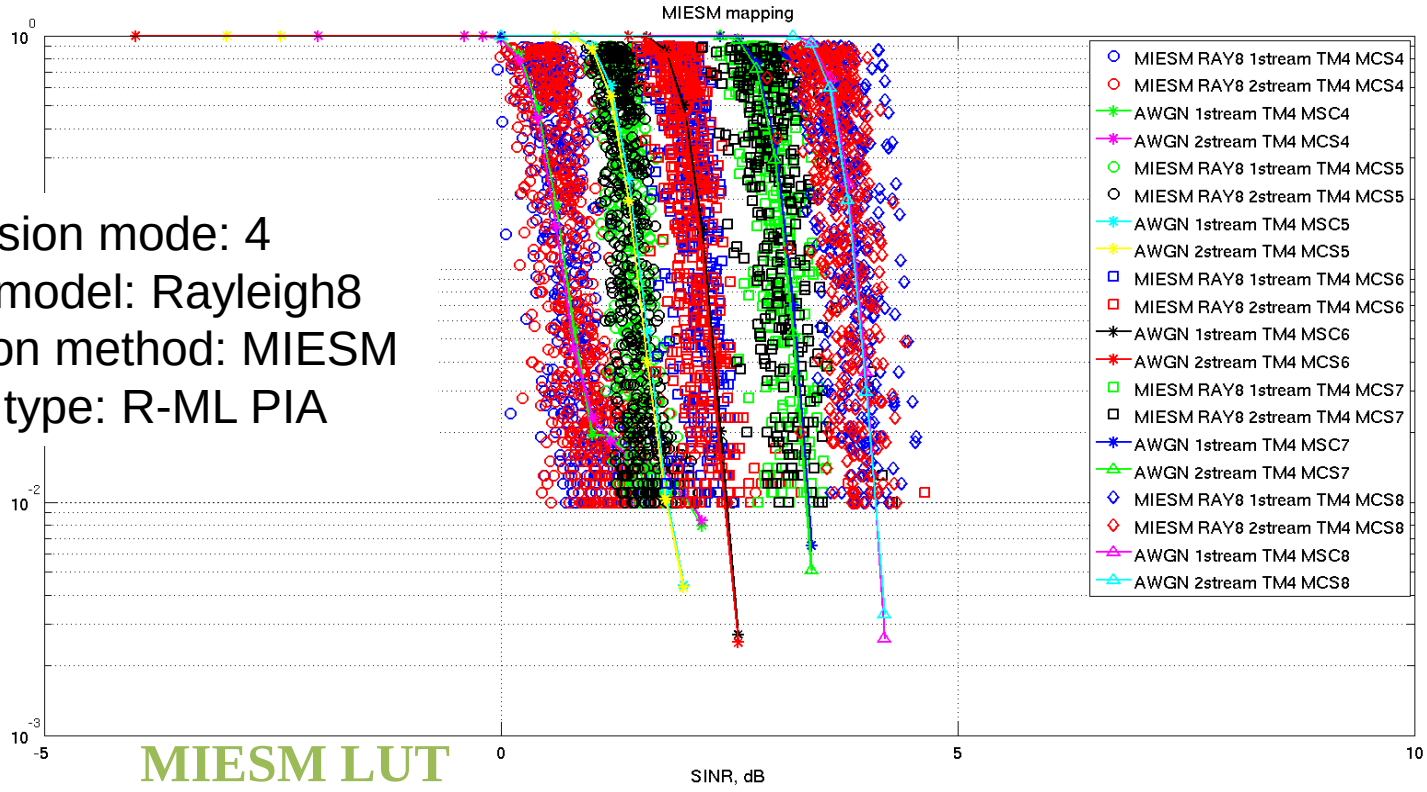
Validation methodology

1. **Link-layer simulations using OpenAirInterface**
2. **Drive tests in Sophia Antipolis using comm4innov LTE test network & TEMS**
   - Traces will be compared with results from mobipass installed on site

OpenAirInterface calibration results

Transmission mode: 4
Channel model: Rayleigh8
Abstraction method: MIESM
Receiver type: R-ML PIA



MIESM LUT

	MCS4	MCS5	MCS6	MCS7	MCS8
$\beta_{1averaged}$	0.4692	0.3817	0.4109	0.4507	0.4805
$\beta_{2averaged}$	0.6422	0.3710	0.5518	0.7988	1.0016
$MSE_{averaged}$	0.1540	0.0408	0.0497	0.0619	0.0496

$MSE_{LUT} > MSE_{direct}$ 0.01 dB

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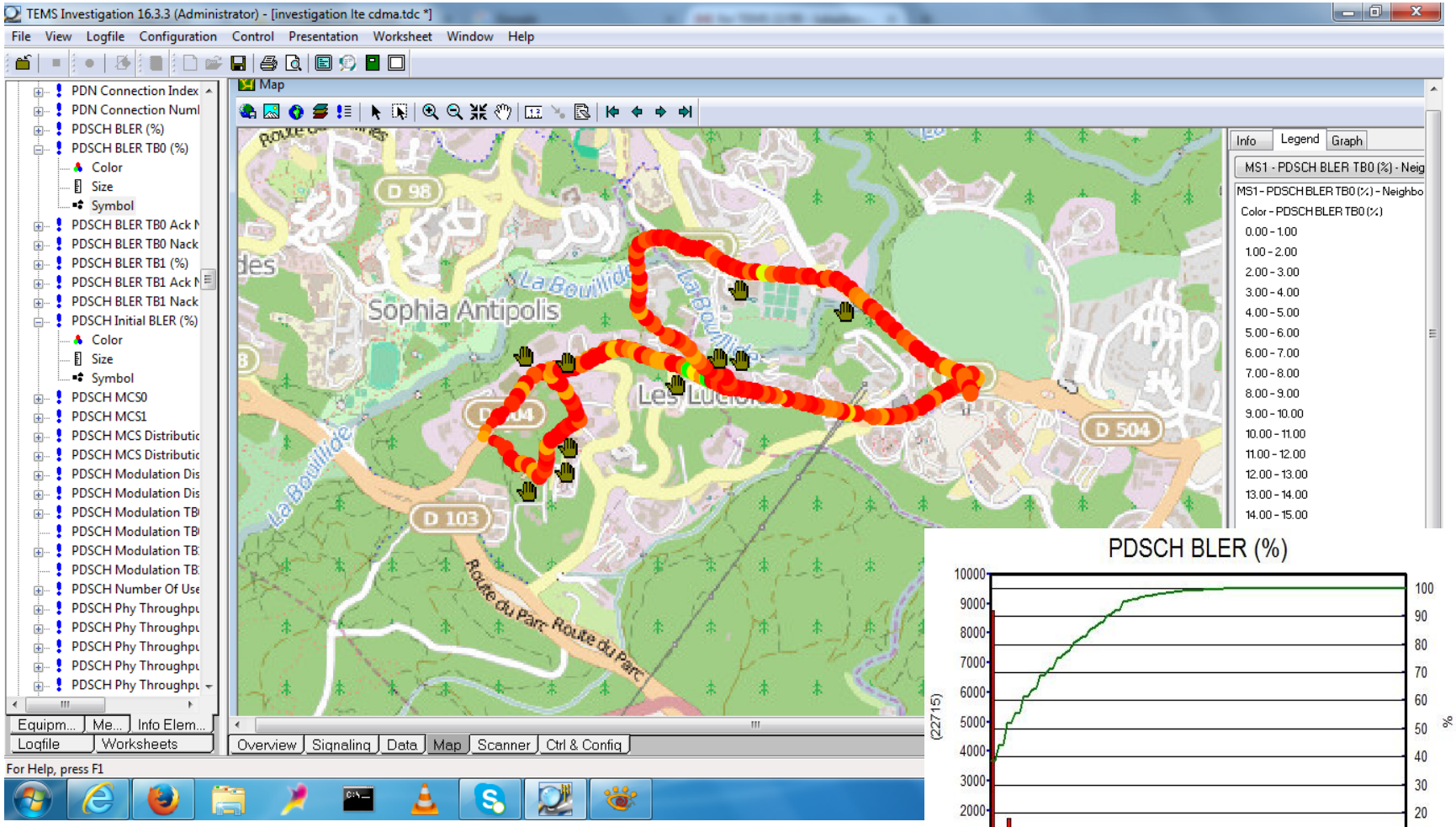
What do we learn from drive tests: BLER



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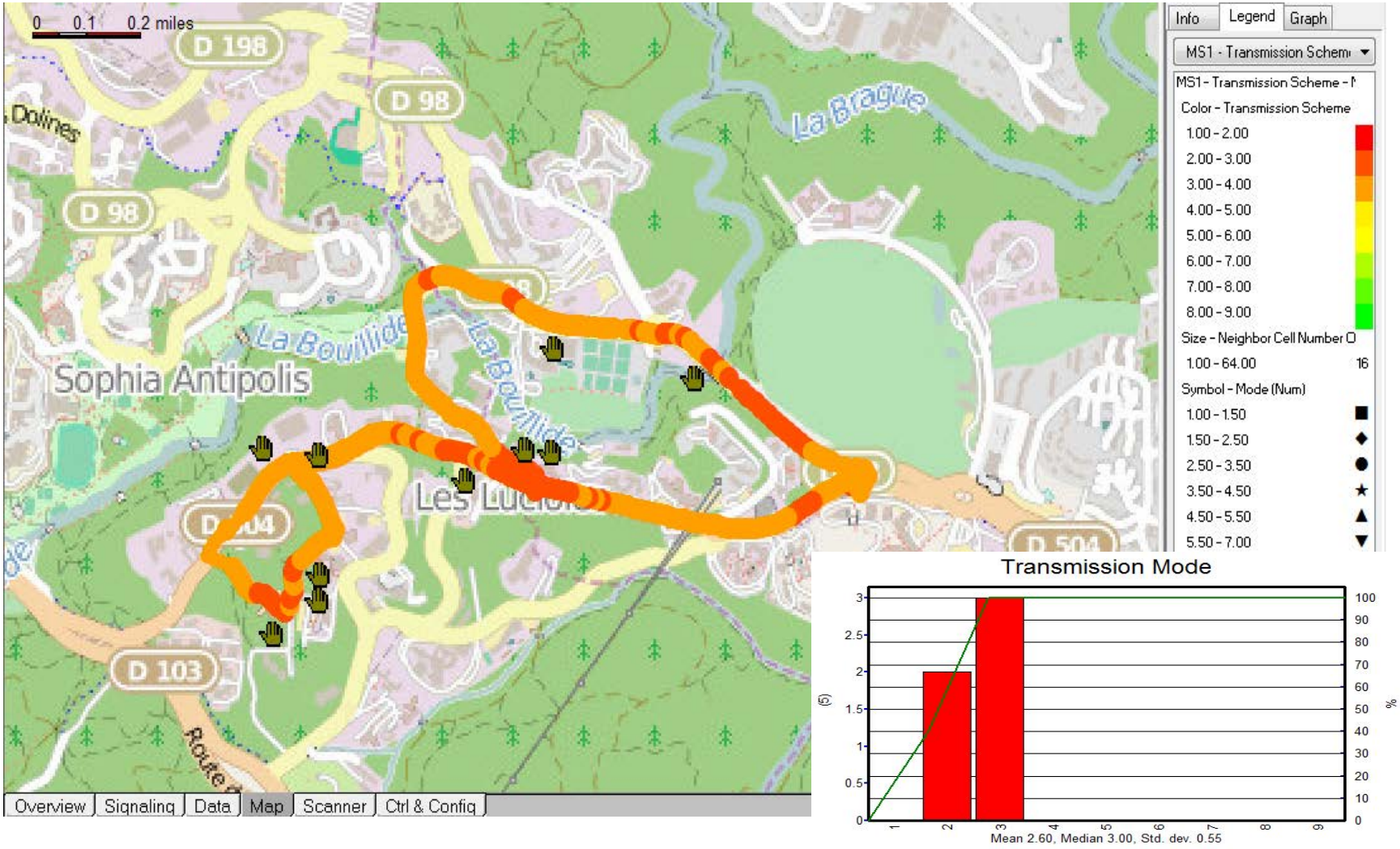
What do we learn from drive tests: Transmission modes



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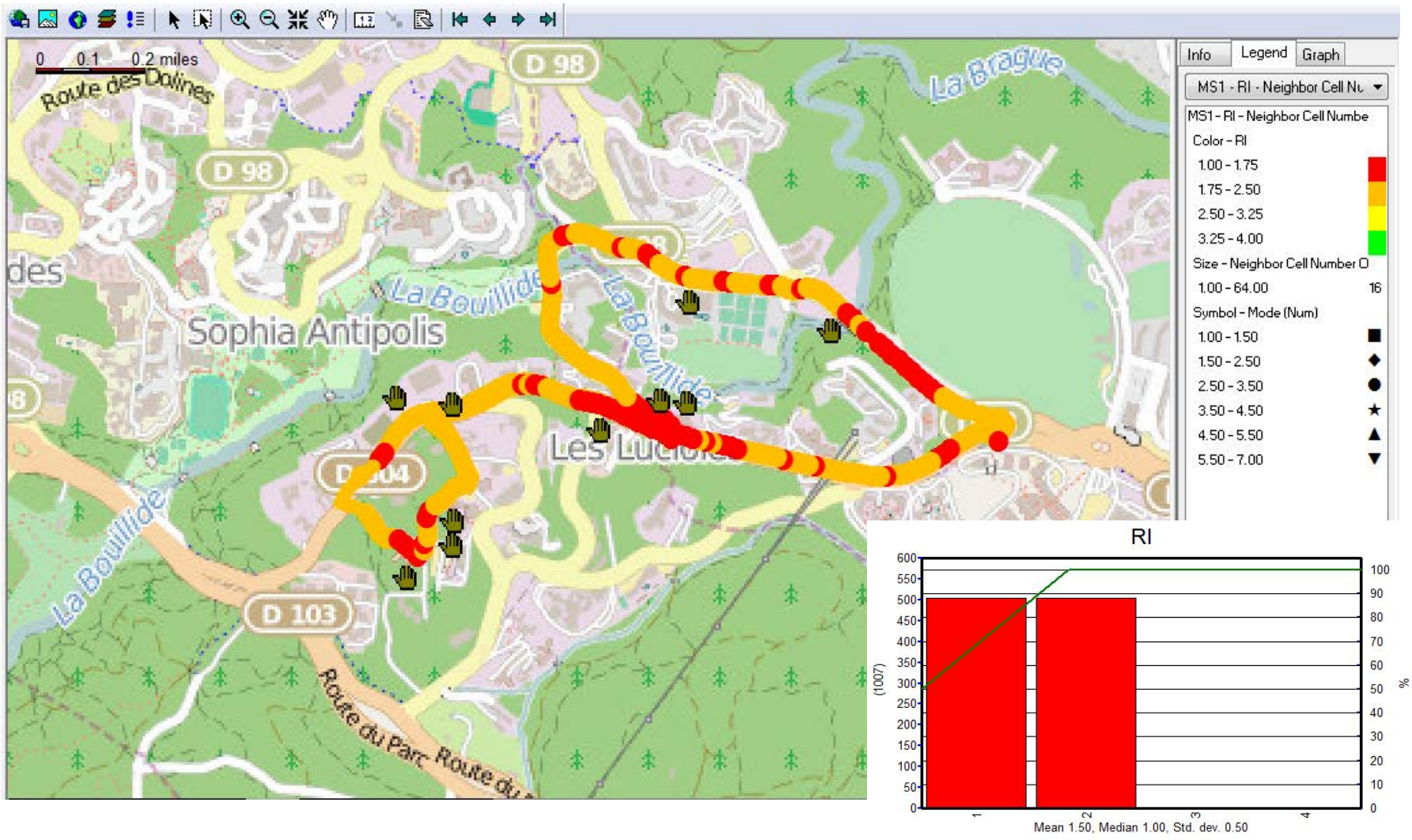
What do we learn from drive tests: Rank indicator



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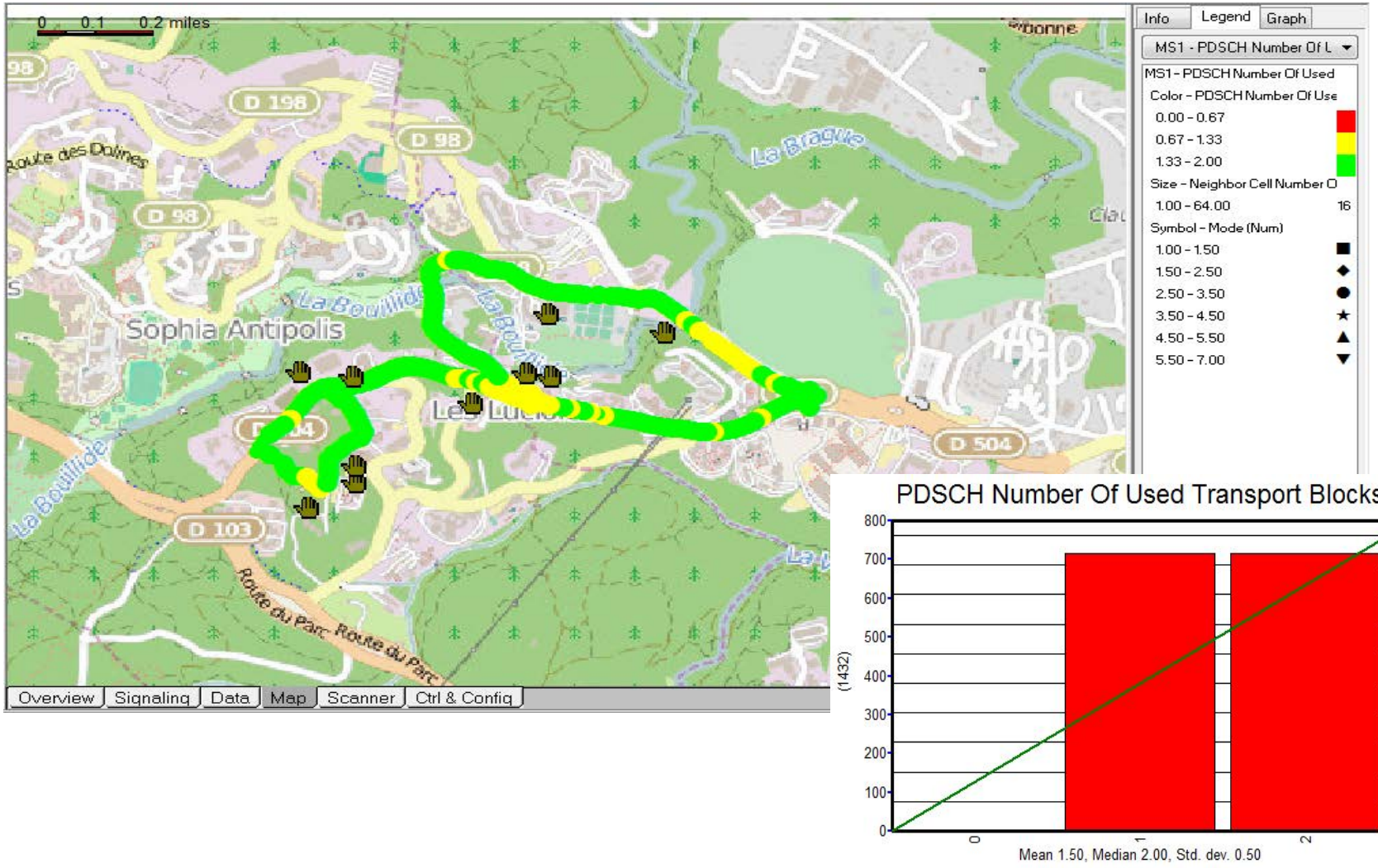
What do we learn from drive tests: number of codewords



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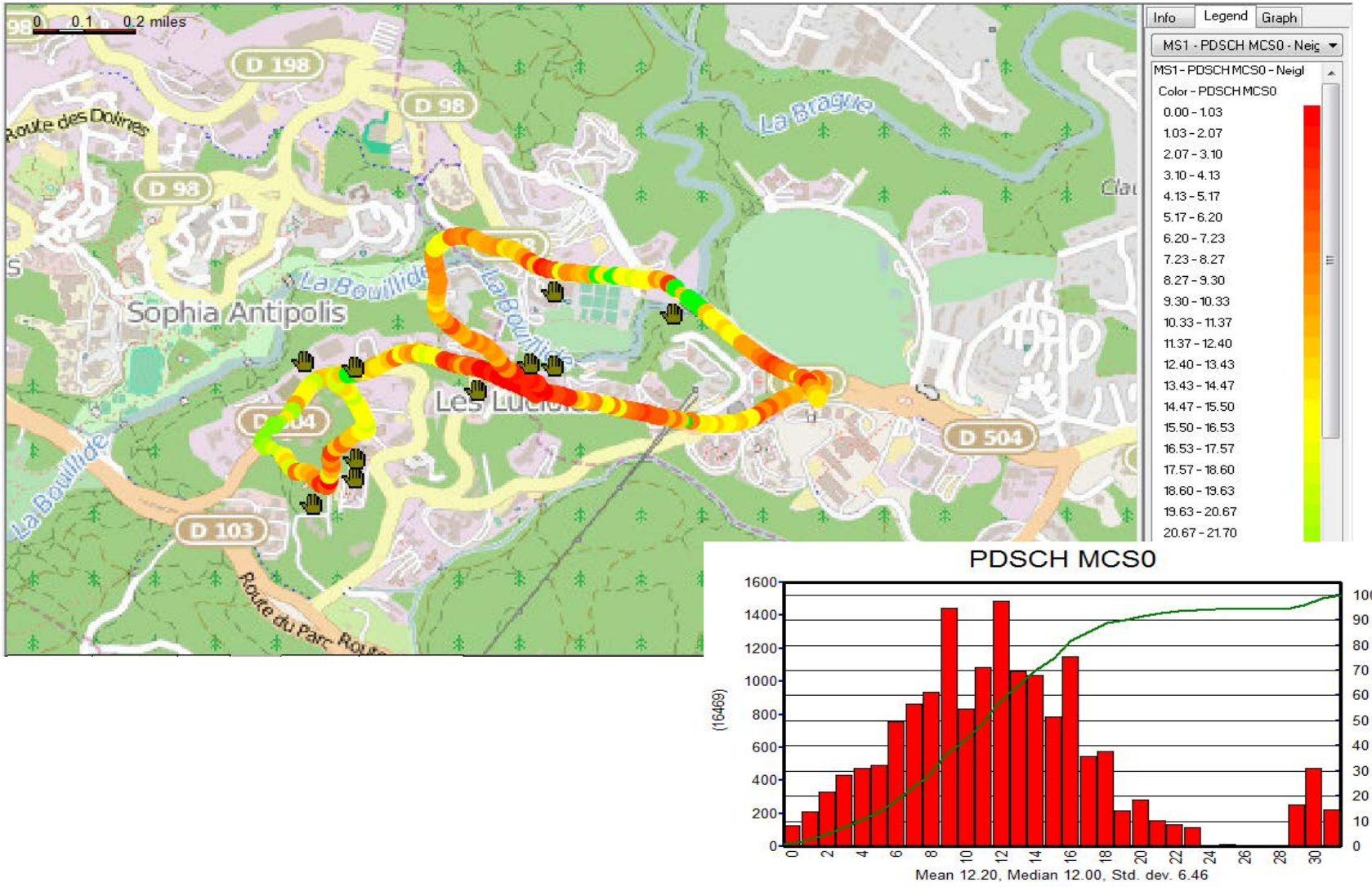
What do we learn from drive tests: MCS



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Conclusions

- **PHY abstraction for LTE-Advanced important for**
  - eNB/UE testers (e.g. ercom mobipass)
  - System level simulators (e.g., OpenAirInterface, NS-3)
- **PHY abstraction for advanced transmission modes and receivers is non-trivial**
- **Validation of methodology using OpenAirInterface and comm4innov platforms**