



Understanding Radio Channel – Part 1:

LTE device and base station performance testing
– Bridging the gap between lab and field testing

Tommi Jämsä & Janne Kolu,
22/02/2012

Speaker Presentations

Janne Kolu

Vice President at EB



Tommi Jämsä

Senior Product Manager at EB



Webinar Content

LTE systems use Multiantenna tech. (MIMO) to deliver capacity.

Quality = Need to verify performance in all network conditions

Lab Testing

Standard models


Only few scenarios

Field testing

Good coverage

Not repeatable

Gap between lab
and field testing!



"Virtual Drive Testing" to bridge the gap between
field testing and lab testing

Detect problems earlier in the R&D phase

Resolve problems faster in the lab environment.

Design great products by understanding its true performance

EB Today



- Customers are leading companies in wireless and automotive markets
- In Wireless EB offer R&D services, device platforms, defense and test products
- In Automotive EB offers in-car infotainment solutions, human machine interfaces (HMI), ECU software, driver assistance solutions
- Technical core competences:
 - Wireless technologies and solutions
 - System and software architectures
 - Automotive-grade software
- Net Sales of MEUR 162 in 2011
- Listed on Nasdaq OMX Helsinki
- Over 1600 employees in 7 countries, 3 continents

EB Prosim® F8

Test Solutions for

- Cellular Operators
- Chipset Vendors
- Defense Authorities
- Device OEM's
- Network & Infra OEM's
- Public Safety Vendors
- Research Institutes & Universities
- Satellite & Aerospace



- Conformance and Performance test cases
- Aerospace
- Geometric Modeling
- MANET / Mesh
- MIMO OTA
- Virtual Drive Test
- Supporting all wireless technologies from LTE-A to 802.11ac



Challenge

Performance Testing Challenges

Throughput of the network is not as high as planned?

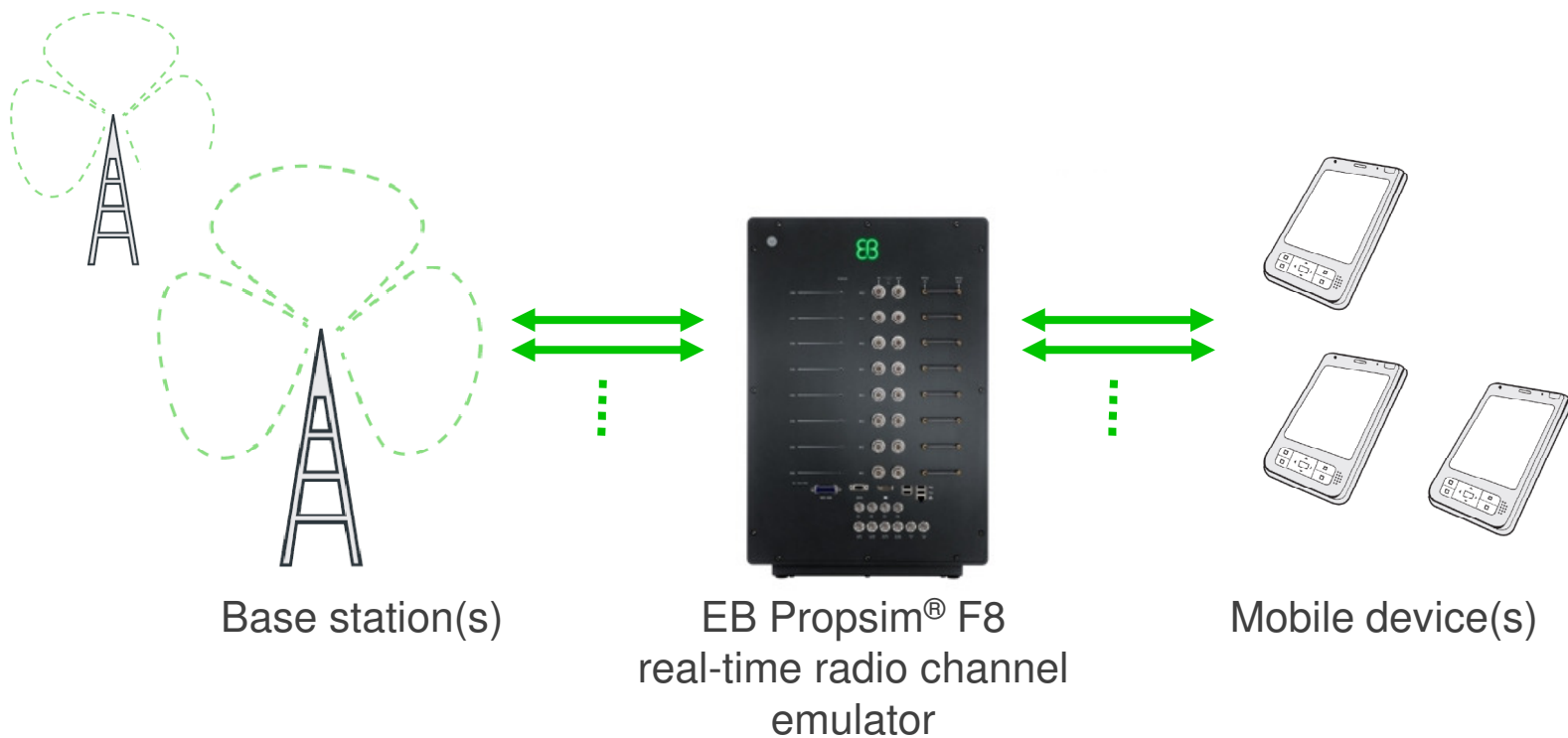
Field testing gives **different results** even nothing has changed in the design?

Product passes conformance tests, but **results don't correlate** with field performance?

What is the **performance difference** between different design versions?



A Test System is needed!

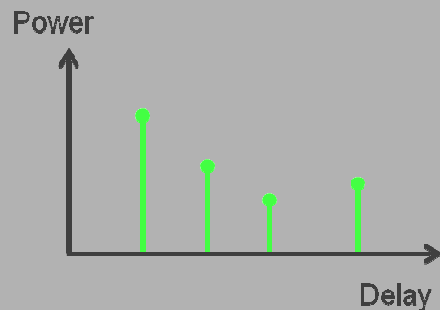


Standardized LTE Testing

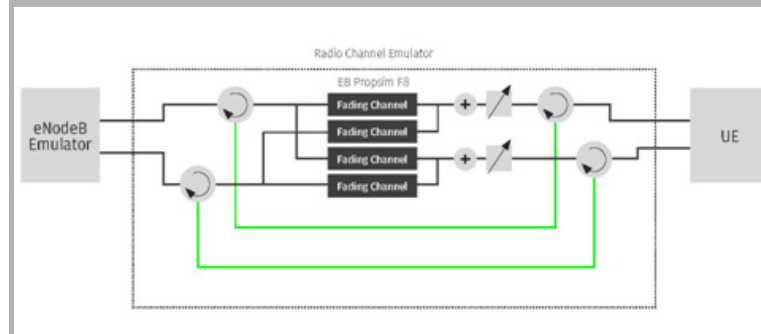
- In 3GPP, the LTE test models are based on Tapped Delay Line models and per-channel artificial correlation matrices.

The Model

Excess tap delay [ns]	Relative power [dB]
0	0.0
30	-1.0
70	-2.0
90	-3.0
110	-8.0
190	-17.2
410	-20.8



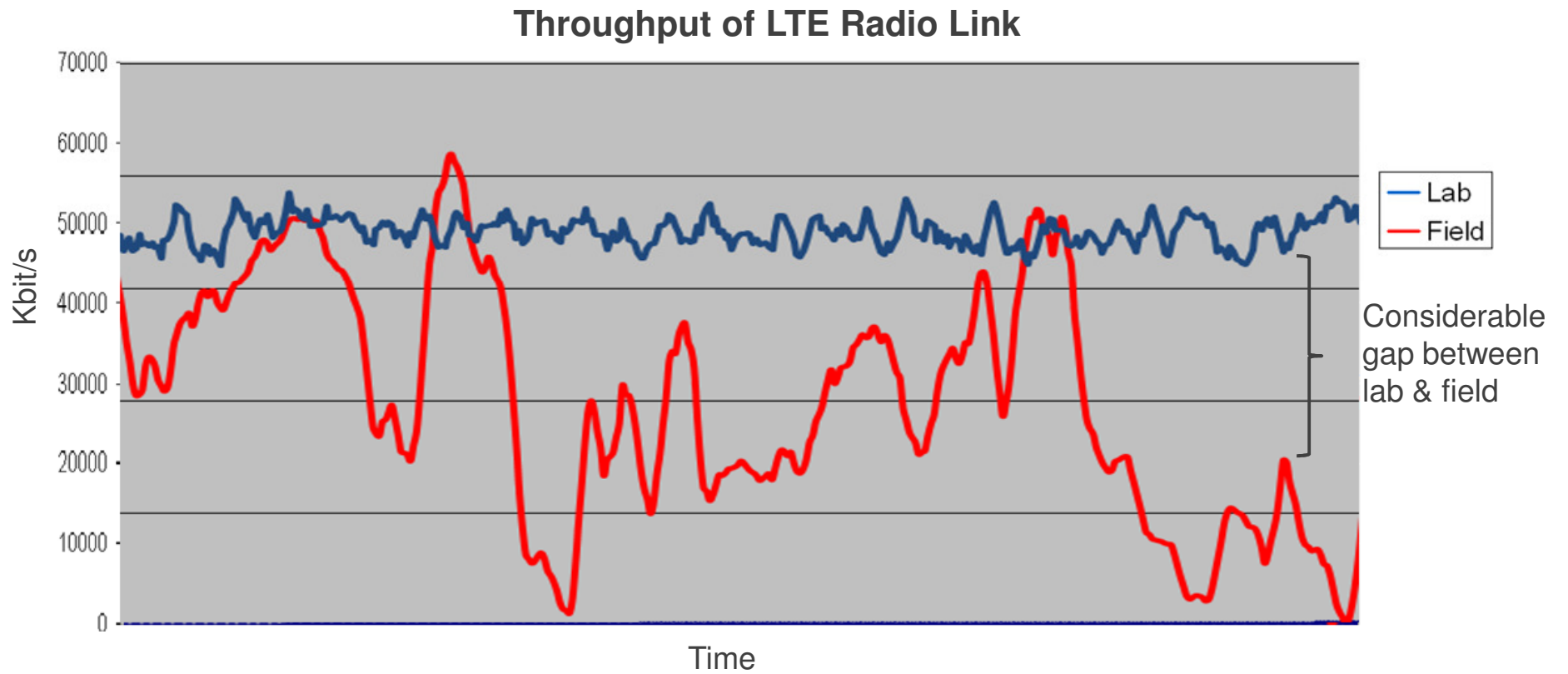
The Test Setup



Is the Standard Model Enough?

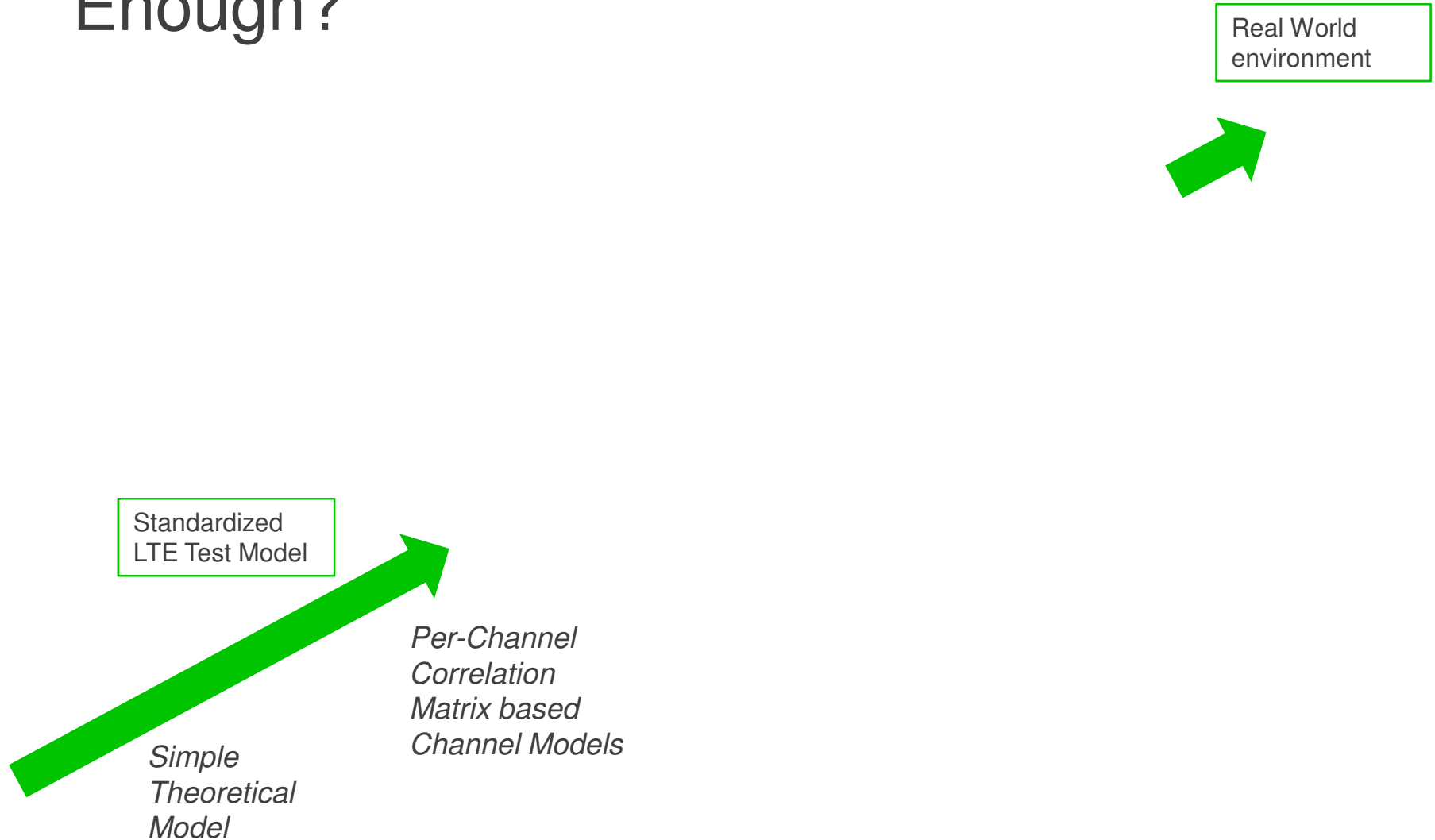


LTE Lab vs. Field Test

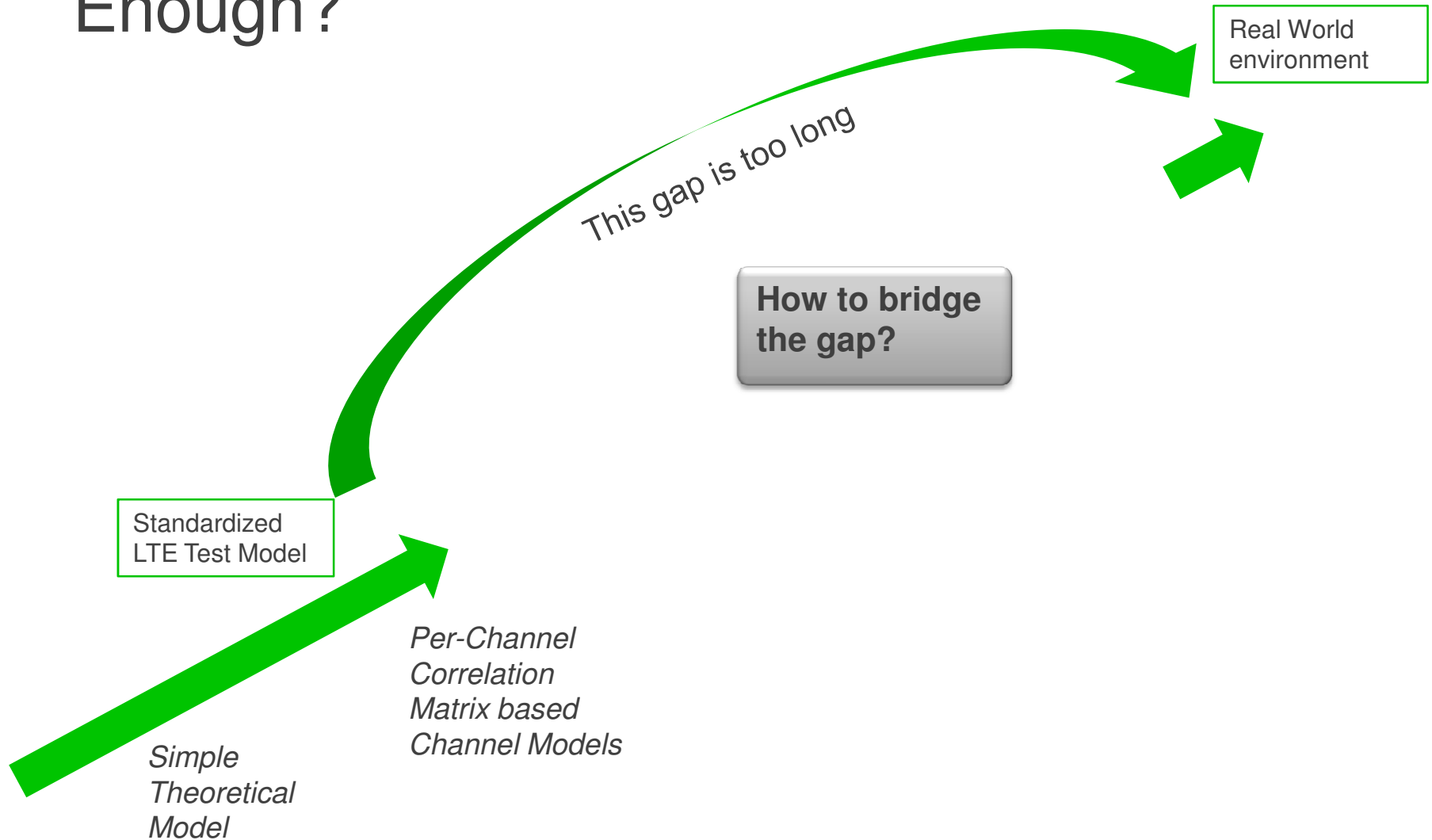


Solution

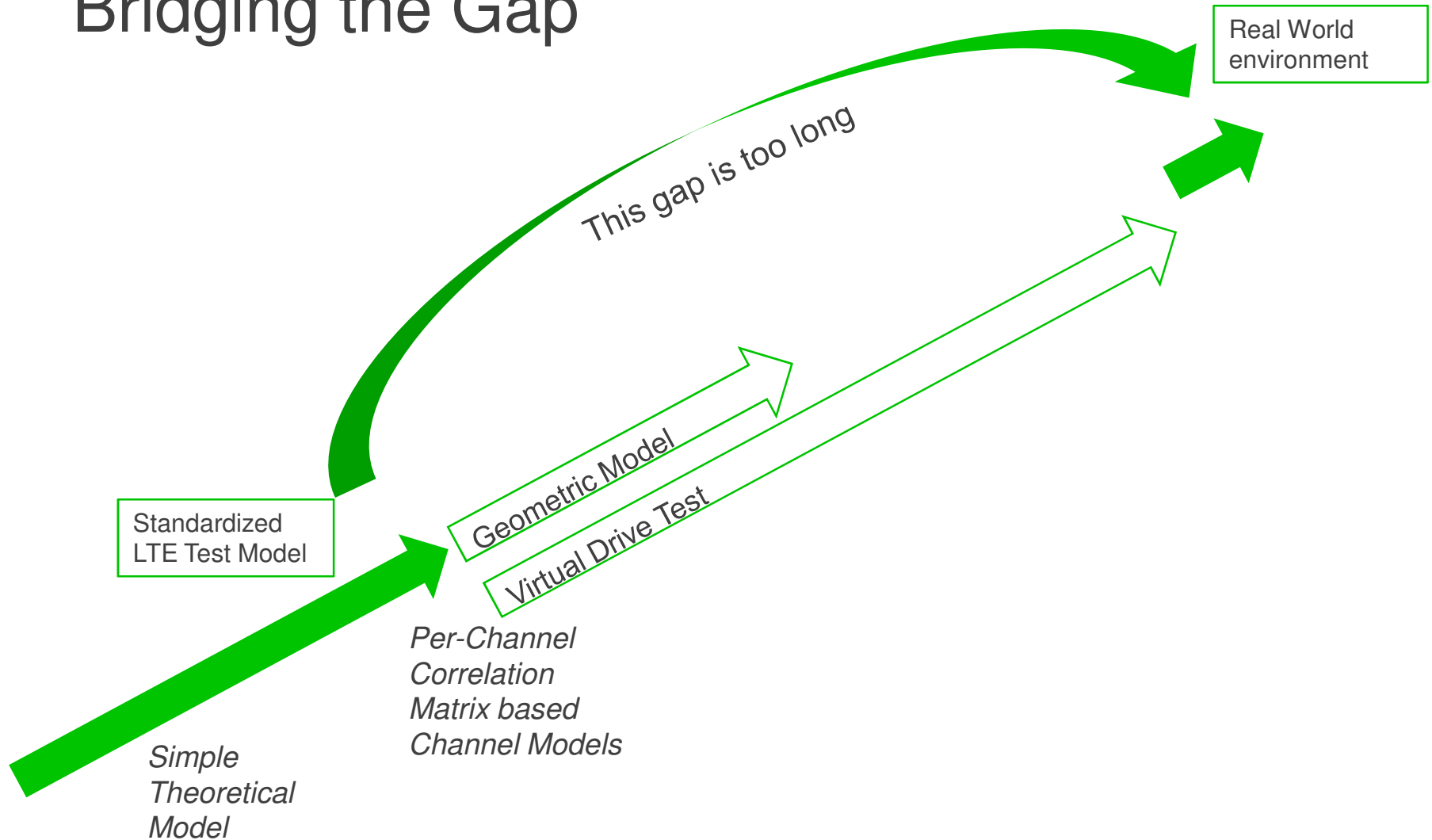
Are the Channel Models Accurate Enough?



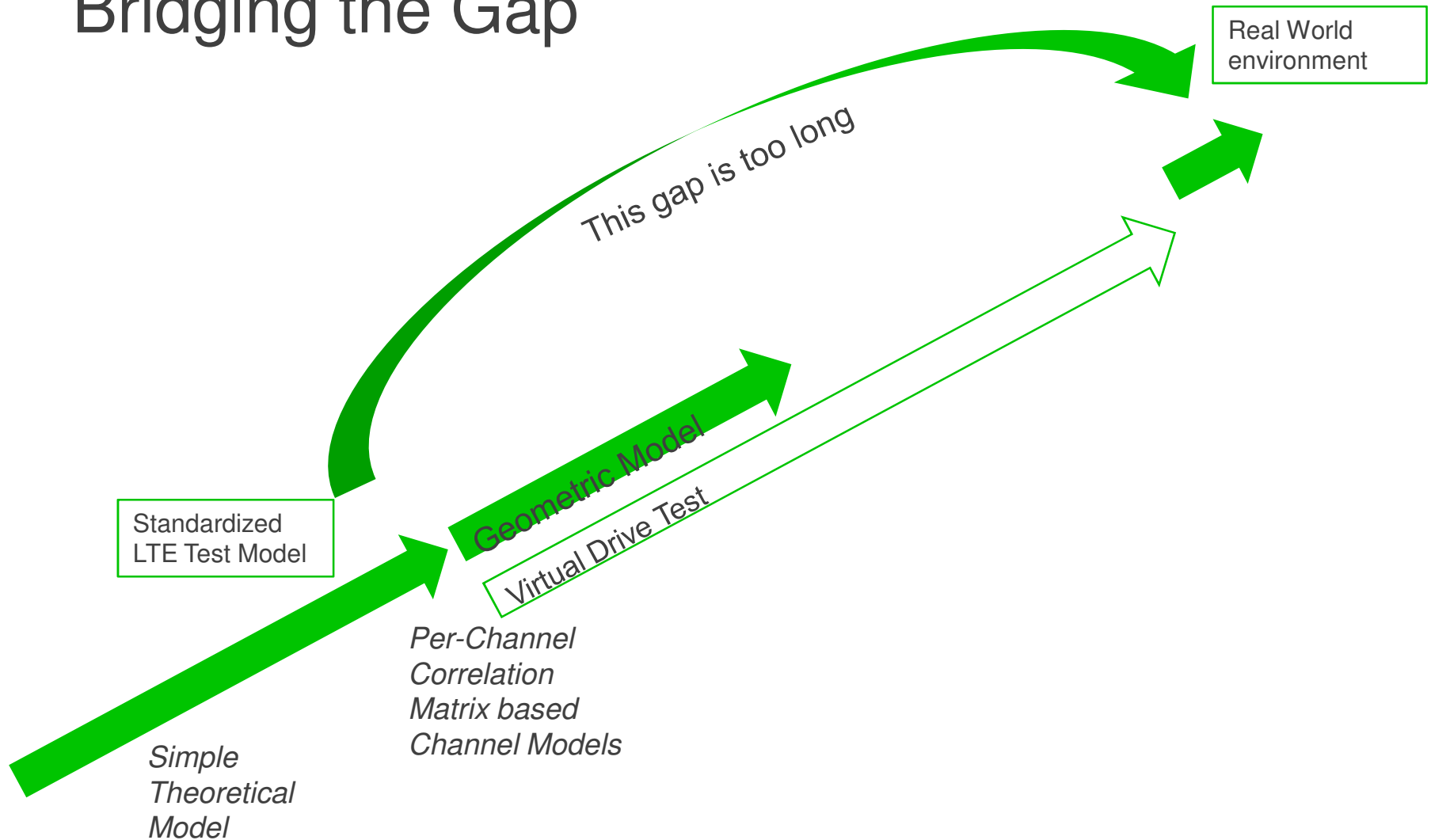
Are the Channel Models Accurate Enough?



Bridging the Gap

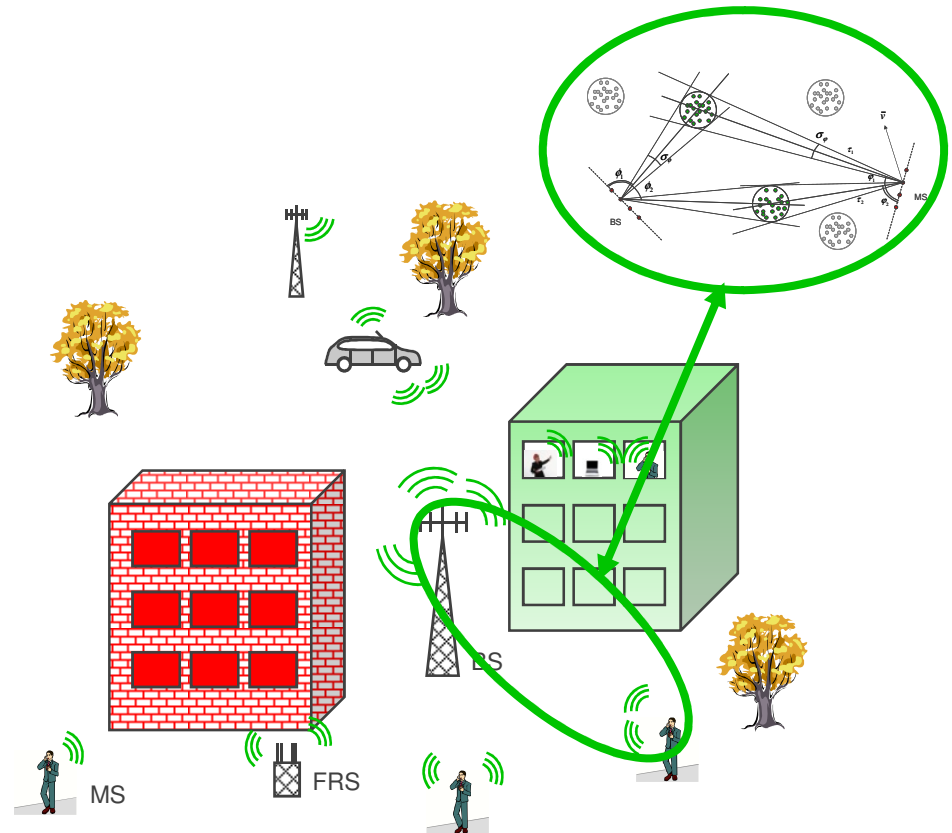


Bridging the Gap

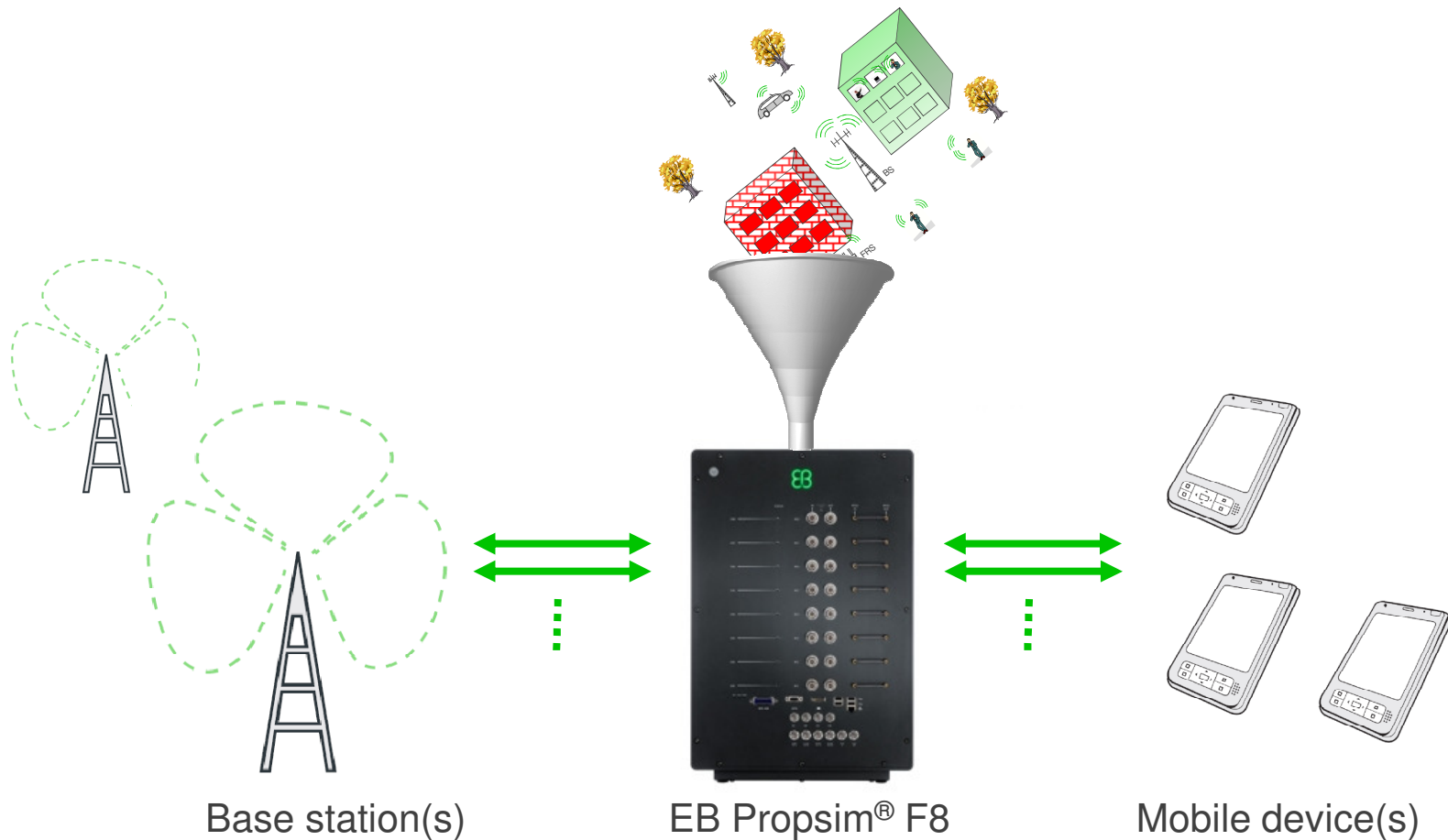


Bridging the Gap: Understanding Radio Channel

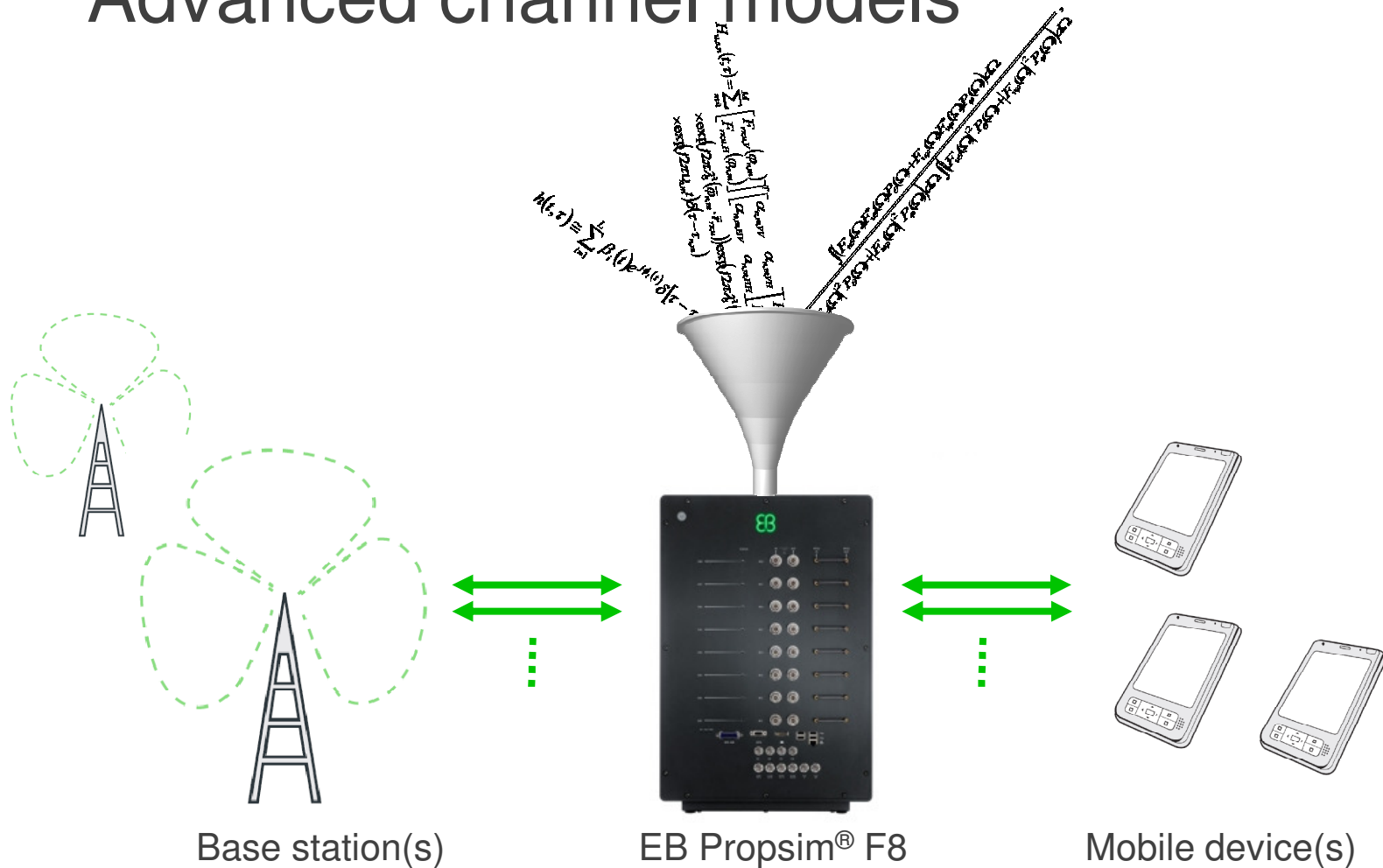
- Several base stations (BSs) and mobile terminals (MTs).
- Performance depends on
 - propagation
 - antennas
 - interferences
 - link and network algorithms
 - practical implementations
 - interworking of BSs and MSs
 - etc.



Replacing the Radio Channel with a Radio Channel Emulator



Bridging the Gap (1/2): Advanced channel models



Conventional SISO Channel Model

- Radio channel is characterized in two domains
 - Time
 - Frequency

$$h(t, \tau) \cong \sum_{i=1}^L \beta_i(t) e^{j\phi_i(t)} \delta[\tau - \tau_i(t)]$$

delay spread \Leftrightarrow frequency selectivity
(coherence bandwidth)

frequency



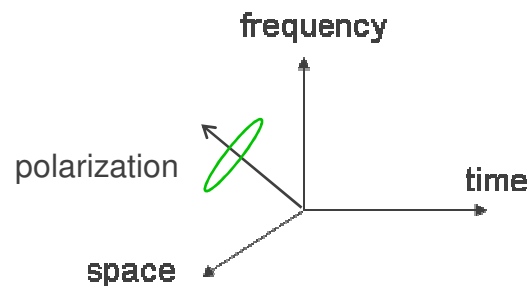
Doppler spread \Leftrightarrow time selectivity
(coherence time)

Extension to MIMO

- Radio channel is characterized in four domains
 - Time
 - Frequency
 - Space
 - Polarization

$$\begin{aligned}
 H_{u,s,n}(t;\tau) = & \sum_{m=1}^M \begin{bmatrix} F_{rx,u,V}(\phi_{n,m}) \\ F_{rx,u,H}(\phi_{n,m}) \end{bmatrix}^T \begin{bmatrix} \alpha_{n,m,VV} & \alpha_{n,m,VH} \\ \alpha_{n,m,HV} & \alpha_{n,m,HH} \end{bmatrix} \begin{bmatrix} F_{tx,s,V}(\phi_{n,m}) \\ F_{tx,s,H}(\phi_{n,m}) \end{bmatrix} \\
 & \times \exp(j2\pi\lambda_0^{-1}(\bar{\phi}_{n,m} \cdot \bar{r}_{rx,u})) \exp(j2\pi\lambda_0^{-1}(\bar{\phi}_{n,m} \cdot \bar{r}_{tx,s})) \\
 & \times \exp(j2\pi\nu_{n,m}t) \delta(\tau - \tau_{n,m})
 \end{aligned}$$

delay spread \Leftrightarrow frequency selectivity
(coherence bandwidth)



Doppler spread \Leftrightarrow time selectivity
(coherence time)

angle spread \Leftrightarrow spatial selectivity (coherence distance)
➤ azimuth, elevation

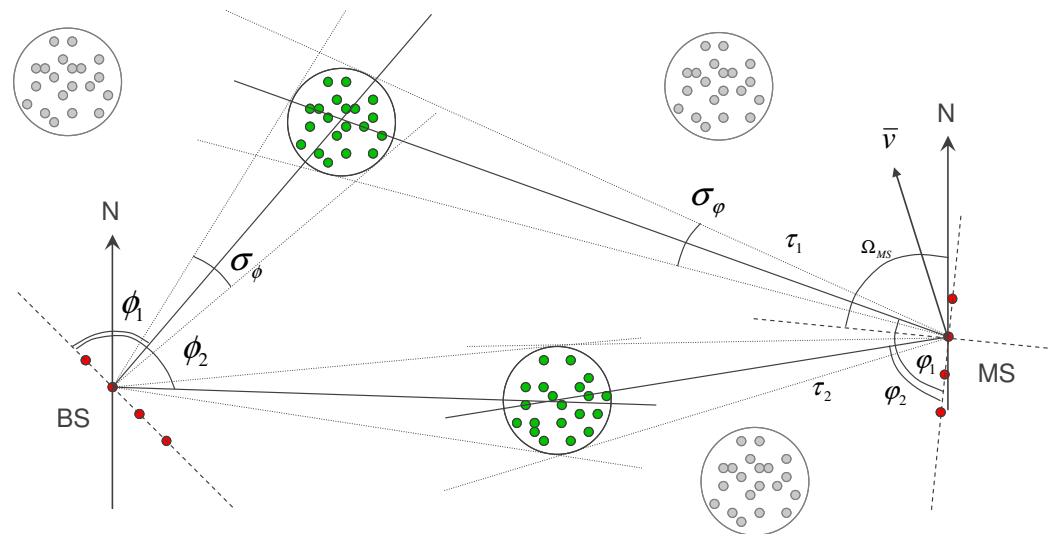
Geometry-based Stochastic Channel Models (GSCMs)

What are they?

- Theoretical models adapted to physical phenomena of the real propagation channel

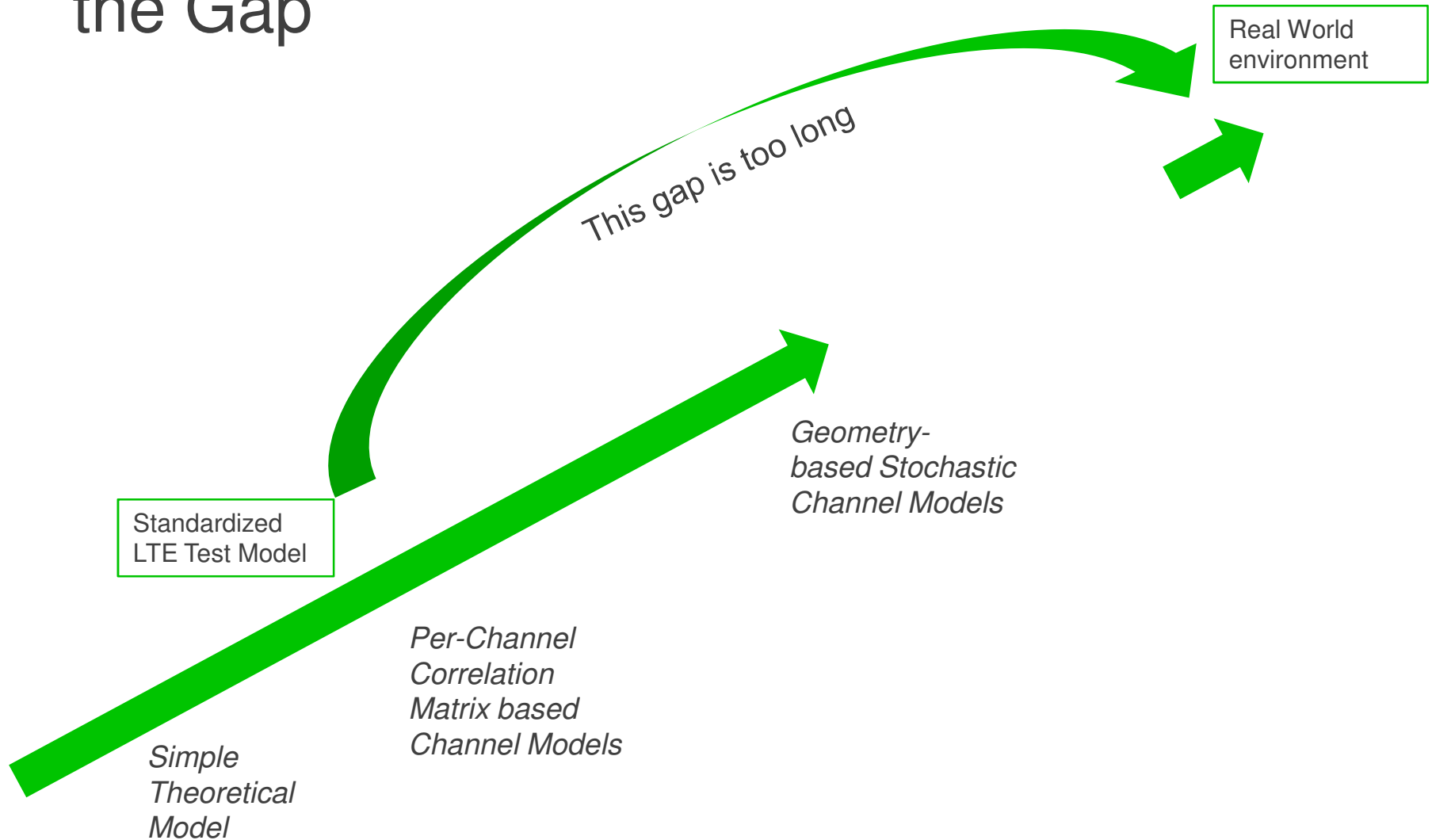
Benefits:

- Scalability
- Antenna independency
- Based on measurements
- Both link level and system level channel models
- Wide scenario coverage via statistically varying parameters
- Suitability for MIMO Over-the-Air (OTA) testing
- Easy to generate correlation matrix based model

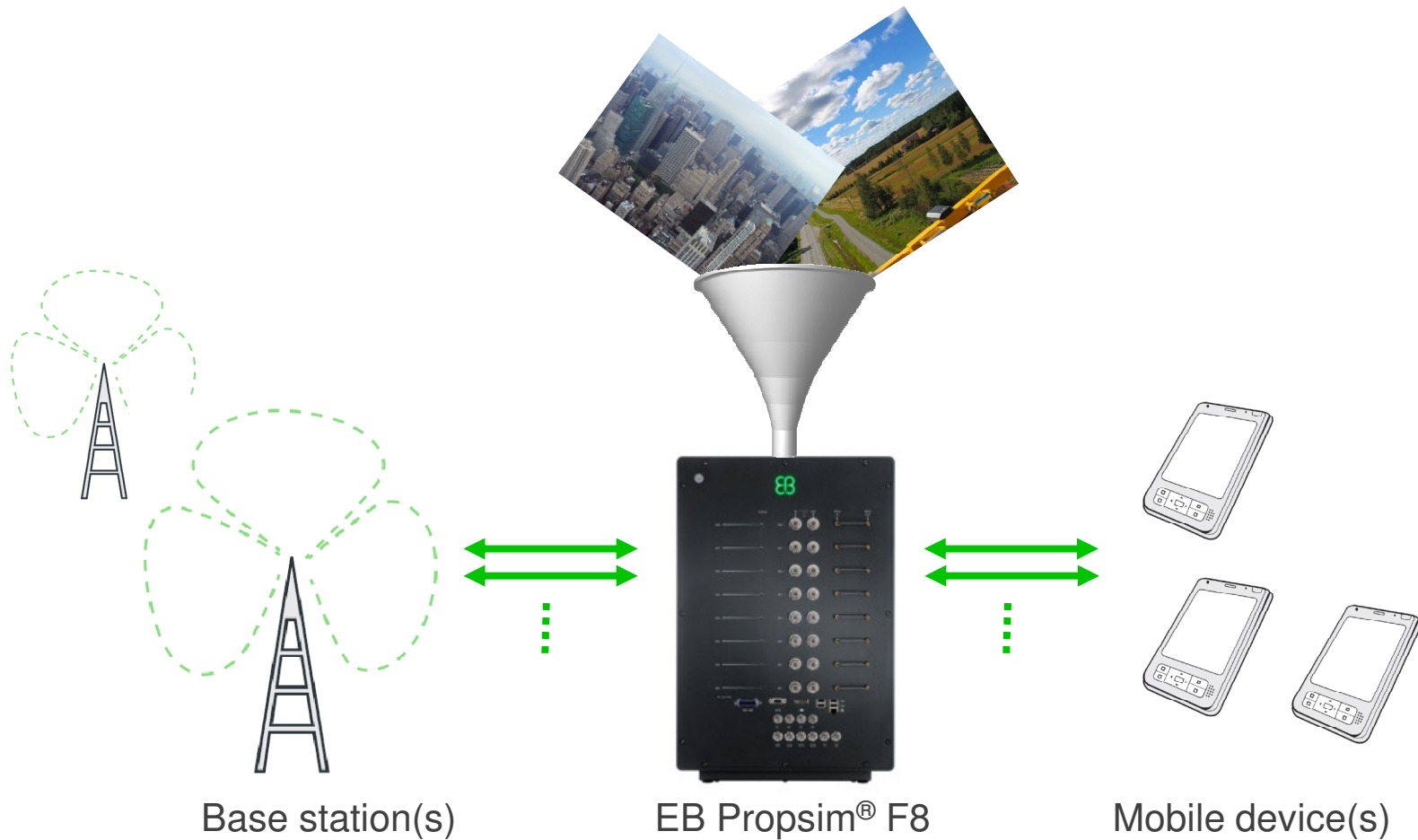


**The Family of GSCMs:
3GPP/3GPP2 SCM, SCME,
WINNER, WINNER II, WINNER+,
IMT-Advanced (LTE Advanced,
IEEE 802.16m)**

Geometry-based MIMO Model shortens the Gap



Bridging the Gap (2/2): Real Measured Channel



EB Virtual Drive Testing (VDT) Solution

Three easy steps

1. Measure

Characterization of the radio environment to be emulated

- Scanner
- Test terminal
- Channel Sounder

2. Model

- Data analysis
- Drive route and creation of its characteristics
- Visualization of measured channel conditions

3. Test

Repeatable emulation of the wireless environment in laboratory conditions

Step 1. Measure – Tools



Step 1. Measure – Parameters

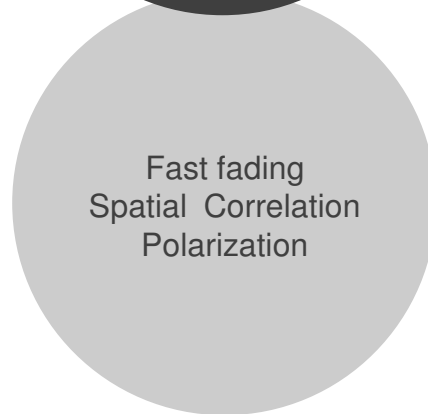
- Typical parameters to be measured
 - RSRP (Reference Signal Receive Power) (all cells)
 - CINR (Carrier to Interference and Noise Ratio) (all cells)
 - Power Delay Profiles (all cells)
 - GPS coordinates
 - Data throughput (serving cell)



Step 2. Model – a Novel Method



Channel model is based on measurements



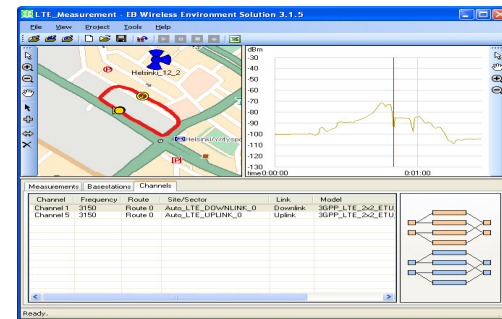
Measurement-based statistical channel model is applied for small scale effects

The trade-off between reality and generality is adjustable: the more you measure the more realistic the model will be.

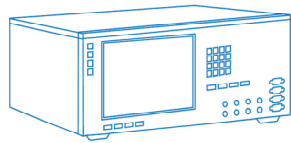
Step 2. Model

- VDT software package processes measurement data
 - Analyzes measurement results
 - Filters the analyzed data
 - Generates measurement-based statistical fading parameters
 - Combines measurement data and model optimally
 - Generates channel realizations for a desired MIMO setup
 - Visualizes the channel data in a map format
 - Maps the measured data into the hardware radio channel emulator

EB Virtual Drive Test App



Step 3. Test – Link Level Setup



**Comm. Tester or
Base Station**

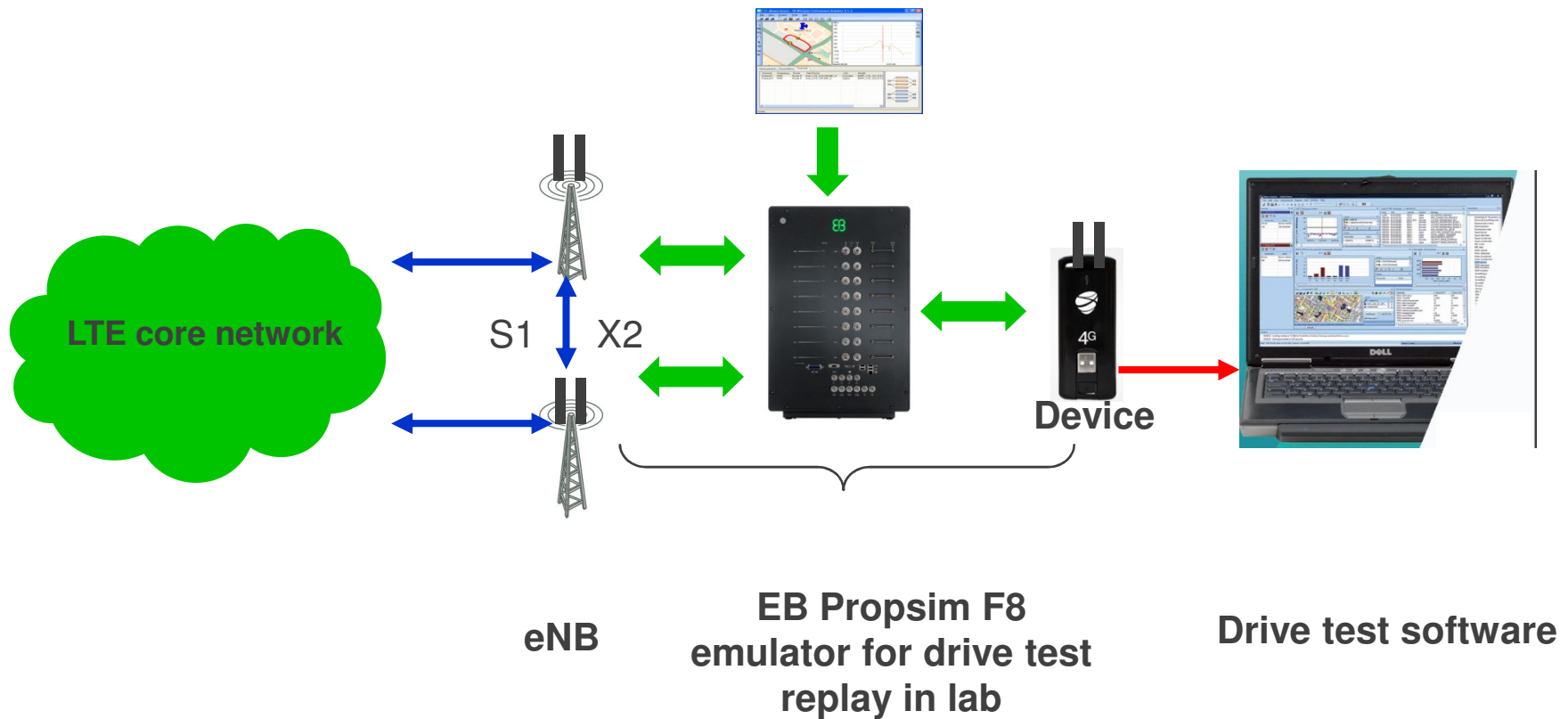


**Radio Channel
Emulator**



**Device Under
Test**

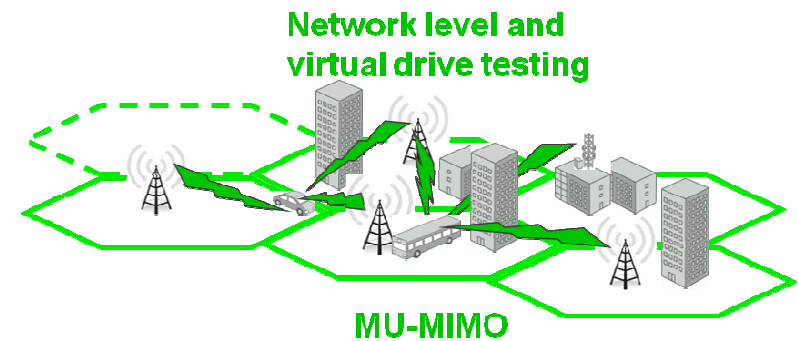
Step 3. Test – Advanced Setup



Step 3. Test – Test Cases

- Throughput measurement
- Call Success rate testing
- Handover testing
- Mobility testing
- Power control
- Interference mitigation
- Stability & Performance testing
- etc.

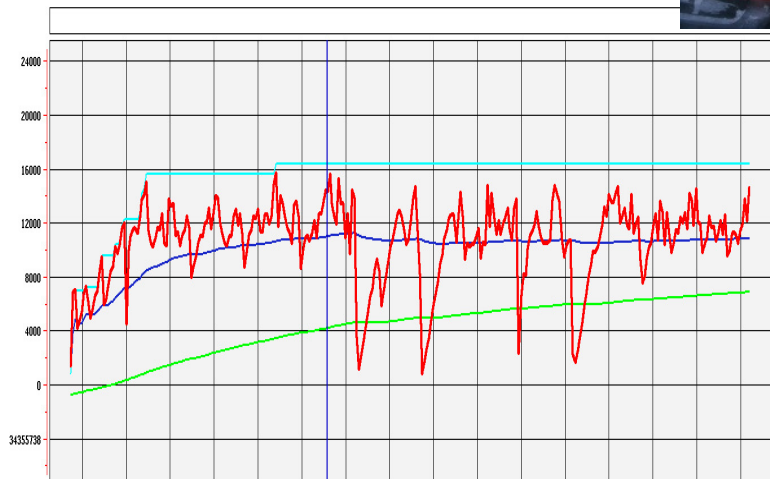
→ All the above items are tested in repeatable and realistic conditions!



Actual Results

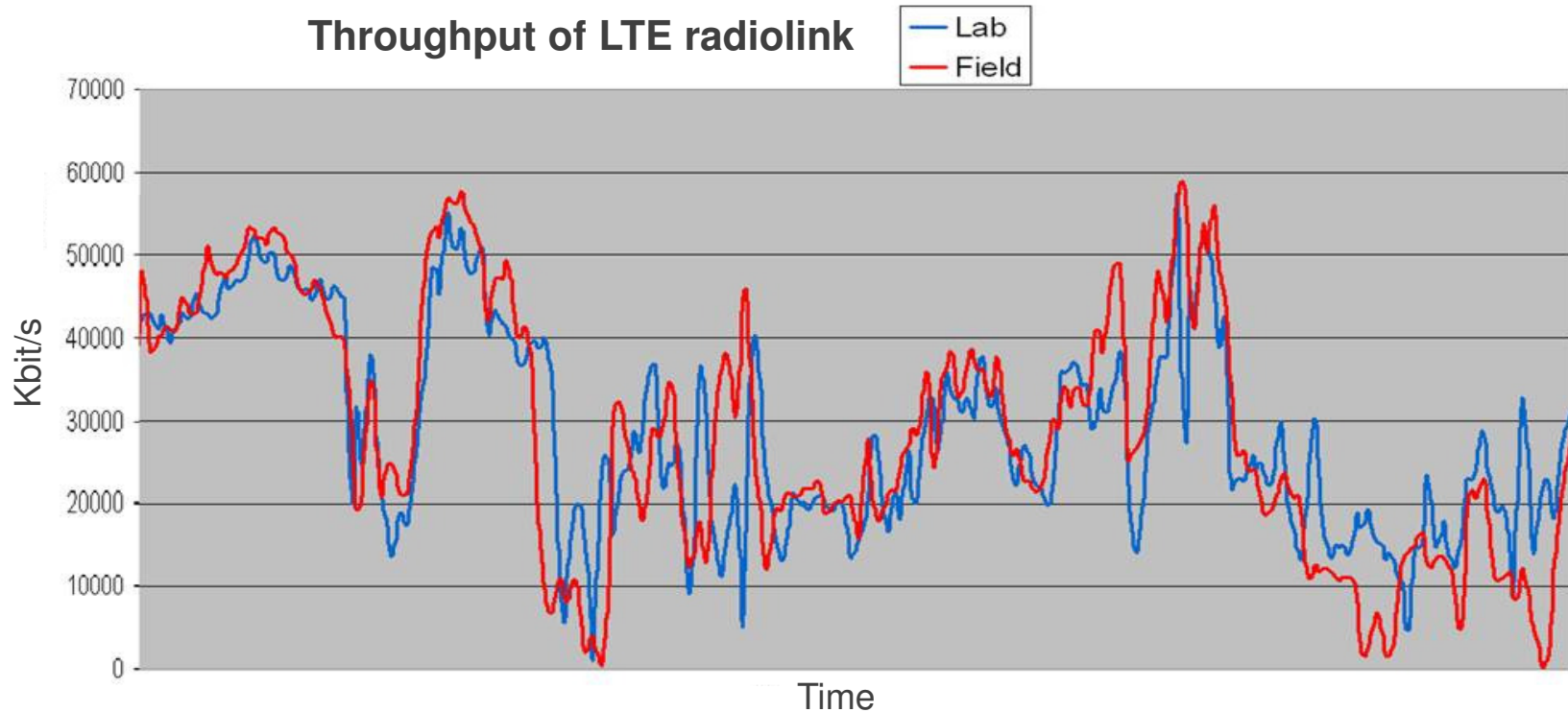
Measurements in Oulu, Finland, on 8th Feb. 2012

- Quick setup: installation of devices and drive test
 - < 30 minutes all together.
- GPS, TSMW, ROMES, Measurement antennas, throughput measurement by an LTE dongle.



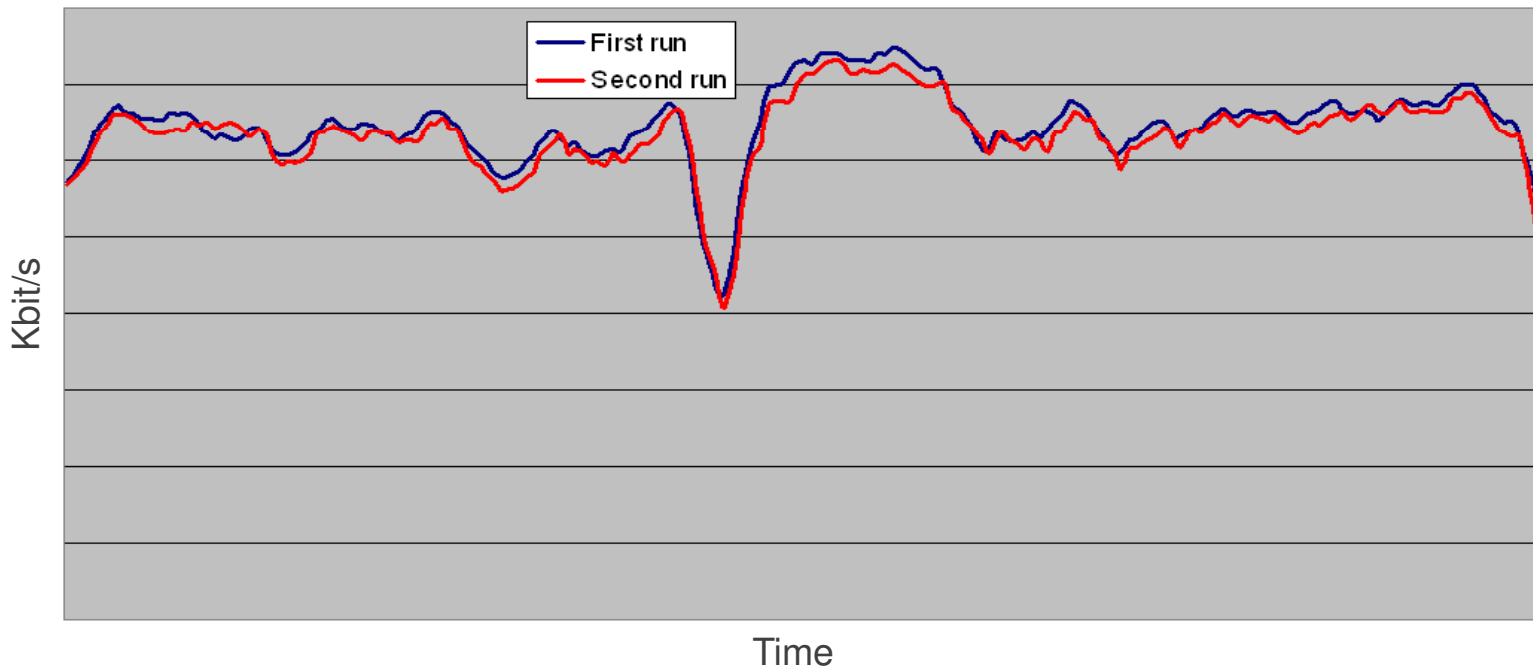
Lab vs. field results

Example of LTE downlink throughput performance measured in field vs. lab with a test terminal.

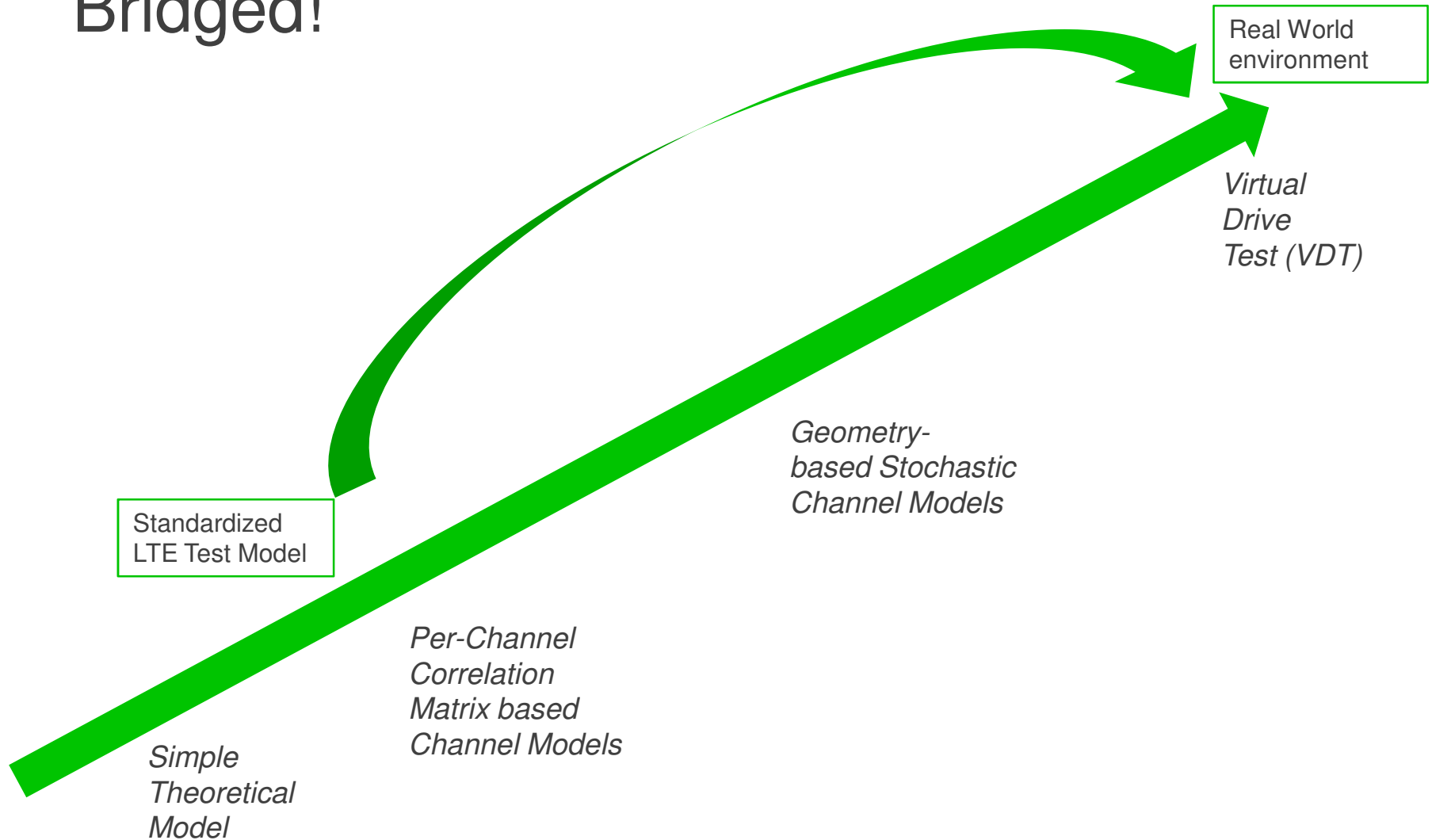


Repeatability

Throughput in lab (two runs)



The Gap between Lab and Field Test is Bridged!



What do you gain with VDT?

	Virtual Drive Testing	Standard LTE Testing	Field Testing
Realistic test cases	YES	NO	YES
Automated 24/7 testing	YES	YES	NO
100 % repeatable	YES	YES	NO
Track and solve problems faster	YES	NO	NO
Low Operating Cost	YES	YES	NO

Summary

- Testing with standard LTE models does not provide wide enough test coverage
- Field testing has test coverage but no control
- EB has developed a virtual drive test solution to bridge gap between field testing and lab testing.
- Solution provides **test coverage with control!**

For more information please visit

www.elektrobit.com/ebpropsim



Thank You!

Questions?



www.elektrobit.com