Screening Experiments in Mobile Channel Measurements

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ISART
What You’ll Learn:

- What the main sources of variability in mobile channel measurements are.
- How we learn this.
Outline

1. Overview
2. The Experiment
3. Results
   - Central Tendency Variability
   - Dispersion Variability
4. Conclusions

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Overview
What do we want to learn?

What are the main sources of *variability* in mobile channel measurements?

- List all potential sources of variability:
  - _______  _______  _______  _______  _______
  - _______  _______  _______  _______  ...

- Which are the largest and most important?
- Separate the vital few from the trivial many.
Overview
What do we want to learn?

What are the main sources of *variability* in mobile channel measurements?

- List all potential sources of variability:
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  - _______  _______  _______  _______  ______

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How do we learn this?
- Experimental design
- Proper research methods

We studied 15 potential sources of variation:
- Five main effects
- Ten two-way interactions
Overview
What did we do?

We manipulated 5 variables:

- **Transmitter Height**
  - low
  - high

- **Transmitter Power**
  - 37dBm
  - 47dBm

- **Route**
  - LOS
  - non-LOS

- **Rx Vehicle Speed**
  - 20mph
  - 30mph

- **Traffic Conditions**
  - off peak
  - peak

We measured RF power on the highlighted roads. We computed **clutter loss**.
Here’s how we did it.
Transmitter and Receiver

Also varied: \textbf{Tx Power} 37dBm 47dBm

Tx Height high

Receiver Van

Route

LOS nonLOS

Speed

20mph 30mph

Traffic

peak offPeak

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Here’s how we did it.
View from LOS route looking at transmit sites (both unobstructed, but for leaves)
Here’s how we did it.

View from non-LOS route in direction of transmit sites (both obstructed)
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One Run: **47dBm** high offPeak 20mph
One Run: **47dBm** | **high** | **offPeak** | **20mph**

Data shown as time series, boxplots, and histograms.
Experimental Design
The Split-Plot

The design tells us how to set each variable and collect the data.

- Split-plot design was developed for agriculture in 1930s.
- Used when some variables are hard to change.
  - Transmitter height
  - Traffic

1930s ⇔ 2018
Agriculture ⇔ Radio Science
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1 Overview

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4 Conclusions
Results

Sources of Variation - Central Tendency

Three statistically significant sources of variation in clutter loss central tendency:

- Two main effects:
  - Route (LOS/non-LOS condition)
  - Transmitter height (low/high)

- One interaction effect:
  - Between route and transmitter height
Results

Clutter Loss Main Effects Plot - Central Tendency

Two main effects: transmitter height and route

Factors
- txHeight
- traffic
- Route
- txPwr
- speed

Mean Clutter Loss (dB)
- low
- high

nonLOS
- offPeak
- peak

20mph
- 30mph

37dBm
- 47dBm
Results

Clutter Loss Interaction Plot - Central Tendency

One interaction: between route and transmitter height

Mean Clutter Loss (dB)

Transmitter Height

Route

-2 - nonLOS
-1 - LOS

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Results

Clutter Loss Pareto Chart - Central Tendency

99% of variability in clutter loss due to only two variables!

A significant finding!
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Results
Sources of Variation - Dispersion

No statically significant effect

Another significant finding!
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Conclusions

We learned:

- Which factors in our study influence central tendency.
- No factors in our study influenced dispersion.
- We separated the vital few from the trivial many.

We found similar results for *K*-Factor and Coefficient of Variation as criterion measure. (not presented)

Impact

- Best practices
- Understanding the mobile radio channel
- Modeling

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Conclusions
Clutter Loss Regression Tree Model

A very simple model...

If condition is true, Route: LOS. Else, txHeight: high.

Going the other way: great candidate data for classification.
References I


Outline

5 Appendix
You should know about this!

**Irreproducibility Crisis**

50–95% of all published research cannot be reproduced!

- Improper use of statistics
- Arbitrary research methods
- Lack of accountability
- Political correctness
- Groupthink
- Culture

Read the *National Association of Scholars’ shocking report, “The Irreproducibility Crisis of Modern Science.”*
No statistical test is robust to a violation of the assumption of independence of observations! I had to take every fourth observation to remove dependence, as shown with the autocorrelation function plots.
# Modeling

## A Clutter Loss Linear Model

<table>
<thead>
<tr>
<th></th>
<th>Clutter Loss Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Intercept)</td>
<td>5.01 (0.31)***</td>
</tr>
<tr>
<td>Route.nonLOS</td>
<td>12.98 (0.45)***</td>
</tr>
<tr>
<td>txHeight.low</td>
<td>4.72 (0.43)***</td>
</tr>
<tr>
<td>Route.nonLOS:txHeight.low</td>
<td>13.45 (0.64)***</td>
</tr>
<tr>
<td>R²</td>
<td>0.90</td>
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<tr>
<td>Adj. R²</td>
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<tr>
<td>Num. obs.</td>
<td>604</td>
</tr>
<tr>
<td>RMSE</td>
<td>3.94</td>
</tr>
</tbody>
</table>

***p < 0.001, **p < 0.01, *p < 0.05
Modeling Impact
Clutter Loss Linear Model Residuals

Residuals vs Fitted

lm(clutter ~ route + txHeight + route*txHeight)

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