Assessing the Performance of the Scrambled Sobol' Quasi-Number Generator: an application to Interoperability of Smart Electricity Grids

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Outline

Objectives

The Case Study

The Experimental Set-up

The Results

Conclusions and Future Work

The Objective

To assess the performance of:

the scrambled Sobol' quasi-random number generator

against

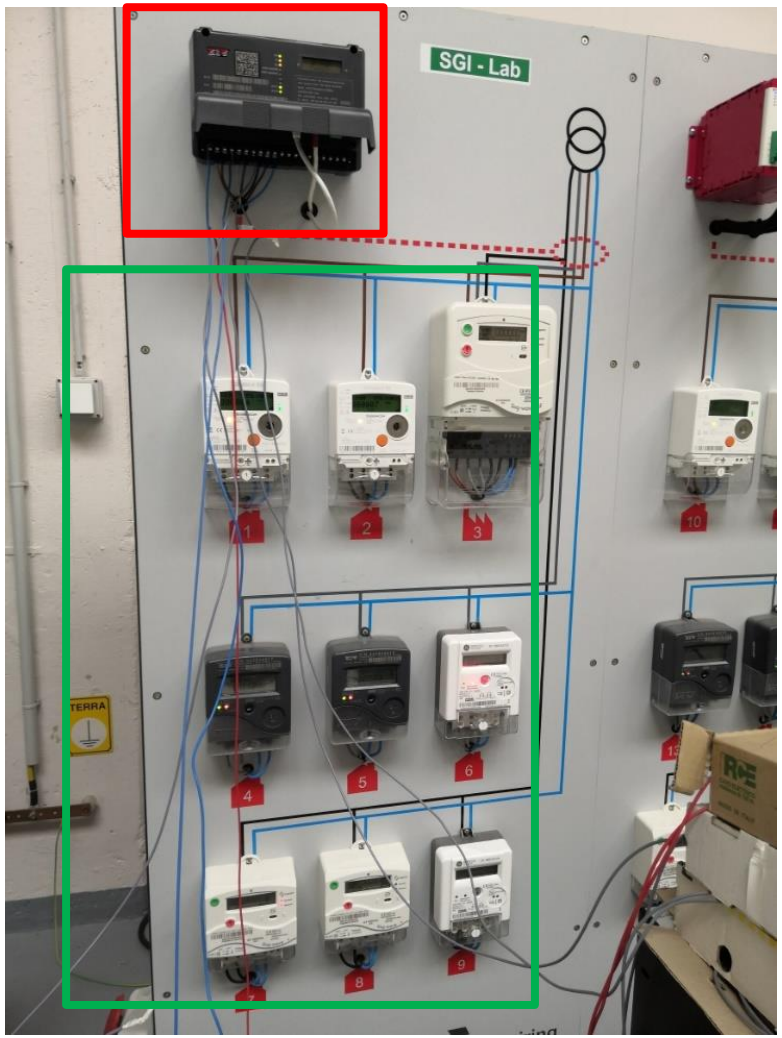
the classic Sobol' quasi-random sampling

for the estimation of global sensitivity indices.

The Case Study

Stress-test the communication between a set of

9 smart meters and one data concentrator



The Case Study

The concentrator interrogates the set of smart meters and pulls power data from them.

The data file for two smart meters

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<Cnc Id="ZIV0004397666">
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</Cnc>
</Report>
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The Case Study

Tests are performed at the European Interoperability Centre for Smart Grids and Electric Vehicles located at the JRC Ispra

The Input Factors

Input 1 = Number of smart meters that can be connected to one concentrator X1 = [1, 2, …, 8];

Input 2 = Frequency of data pulling. The concentrator pulls data from each smart meter at predefined time points X2 = [15 s, 30 s, 1 min, 2 min, 5min, 10 min, 15 min, 30 min];

Input 3 = Physical distance between the concentrator and the smart meters X3 = [0 mt, 100 mt, 200 mt, 300 mt]

The Output of Interest

… is the success rate of the communication btw the meters and the concentrator

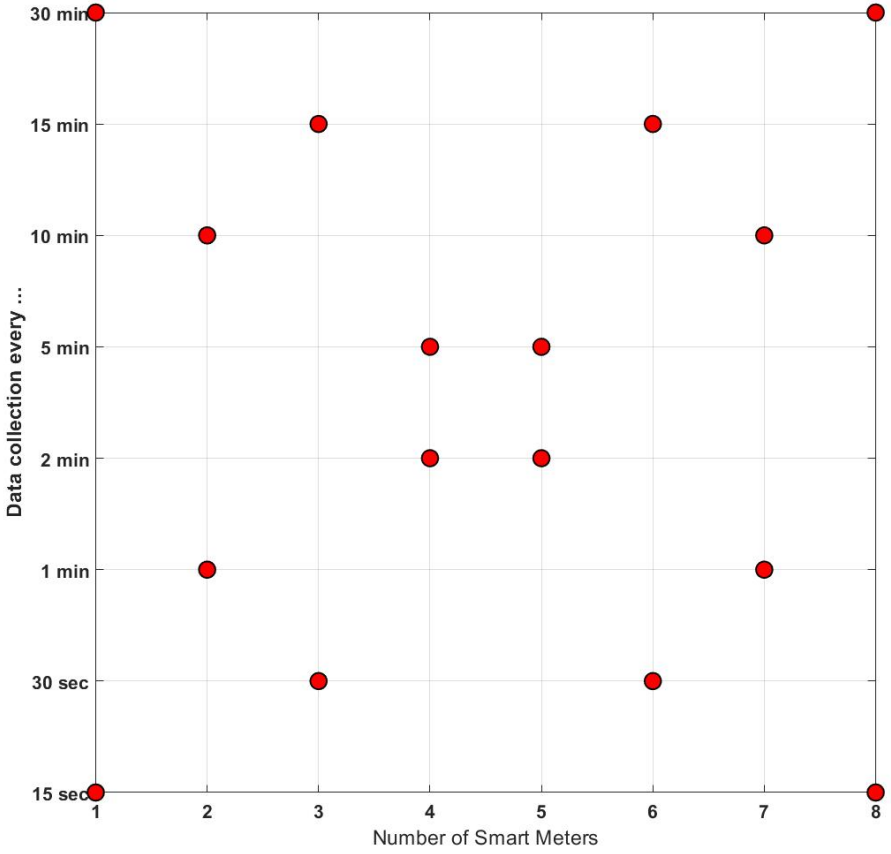
The concentrator pulls data from the smart meters "N" times and "n" of them are successfully delivered: $\gamma = n/N$.

Example: 749 data packets successfully delivered to the concentrator out of 1000

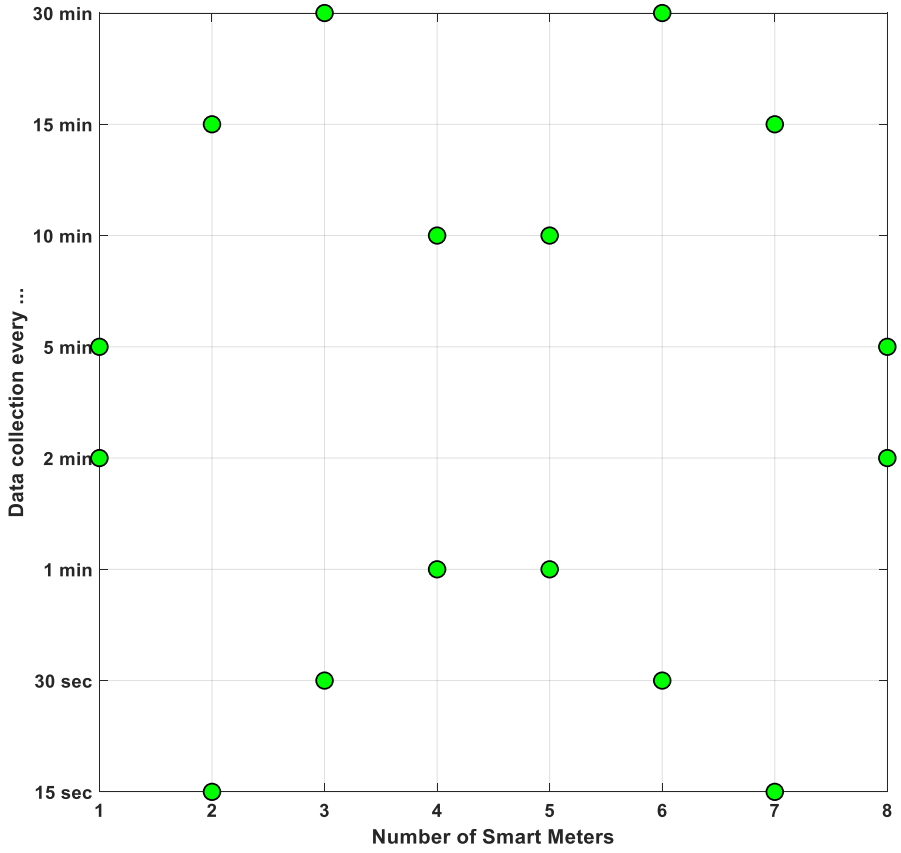
$\gamma = 0.749$

N=16 pts $X1$ *vs* $X2$

Sobol' classic



Scrambled Sobol'



The Results – PCE Main Effects

Sobol' Classic	*Scrambled Sobol'*
$S_1 = 0.39 \pm 0.08$	$S_1 = 0.37 \pm 0.14$
$S_2 = 0.28 \pm 0.08$	$S_2 = 0.35 \pm 0.14$
$S_3 = 0$	$S_3 = 0$

Smaller confidence bounds of sensitivity indices when using classic Sobol' quasi-random generator

The Results – PCE Total Effects

Sobol' Classic	*Scrambled Sobol'*
$T_1 = 0.68 \pm 0.08$	$T_1 = 0.56 \pm 0.14$
$T_2 = 0.58 \pm 0.08$	$T_2 = 0.55 \pm 0.14$
$T_3 = 0$	$T_3 = 0$

Smaller confidence bounds of sensitivity indices when using classic Sobol' quasi-random generator

The Results

S1 ~ S2

Success of communication decreases when increasing the number of smart meters and when increasing the data request per unit time

S3 ~ 0

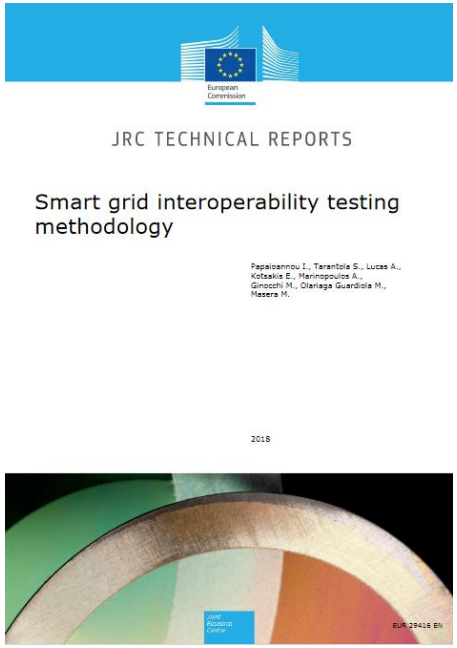
Distances up to 300 m do not affect success of communication

Conclusions

The devices used in the test do not comply with the future requirements of the smart grid.

GSA is part of the JRC methodology for interoperability testing .

European standard bodies (CEC, CENELEC, ETSI) are using JRC methodology to set minimum standards for putting these devices on the market.



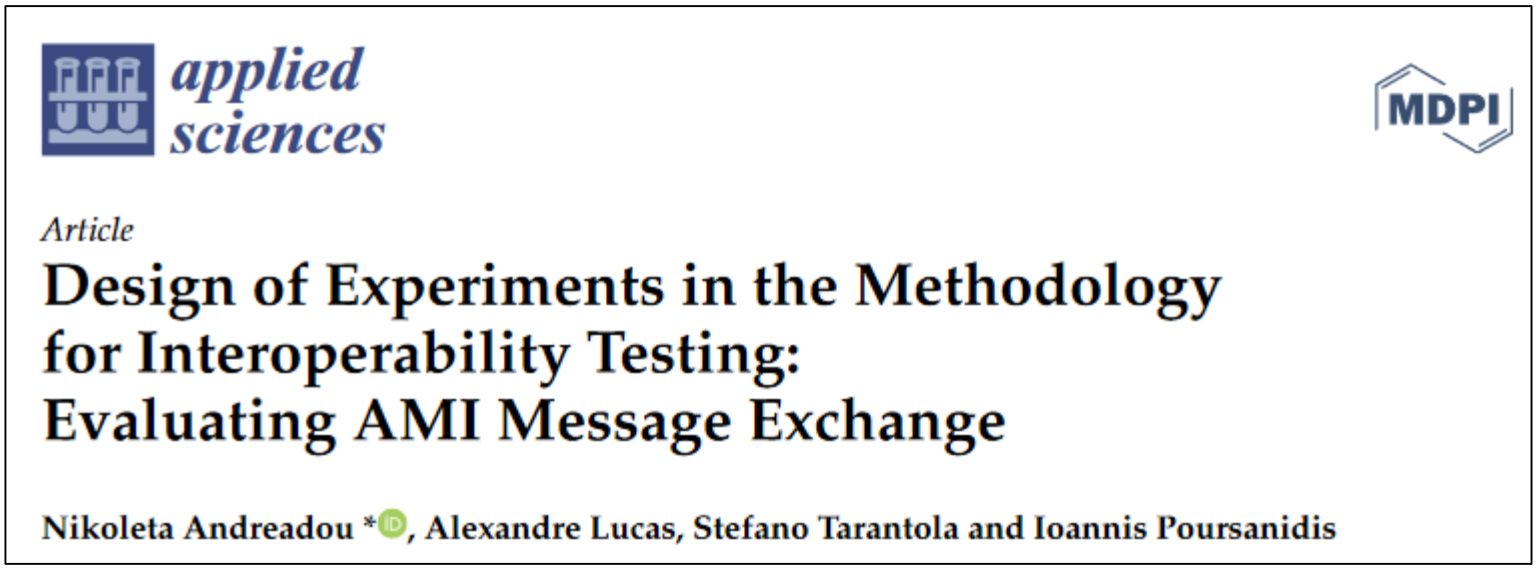
Future Work

Tests when devices are further away (eg, 1 Km)?

Get sensitivity information keeping number of tests to the minimum

Working on a European regulation for which manufacturers will have to test their products following this methodology before putting them into the market.

European Commission

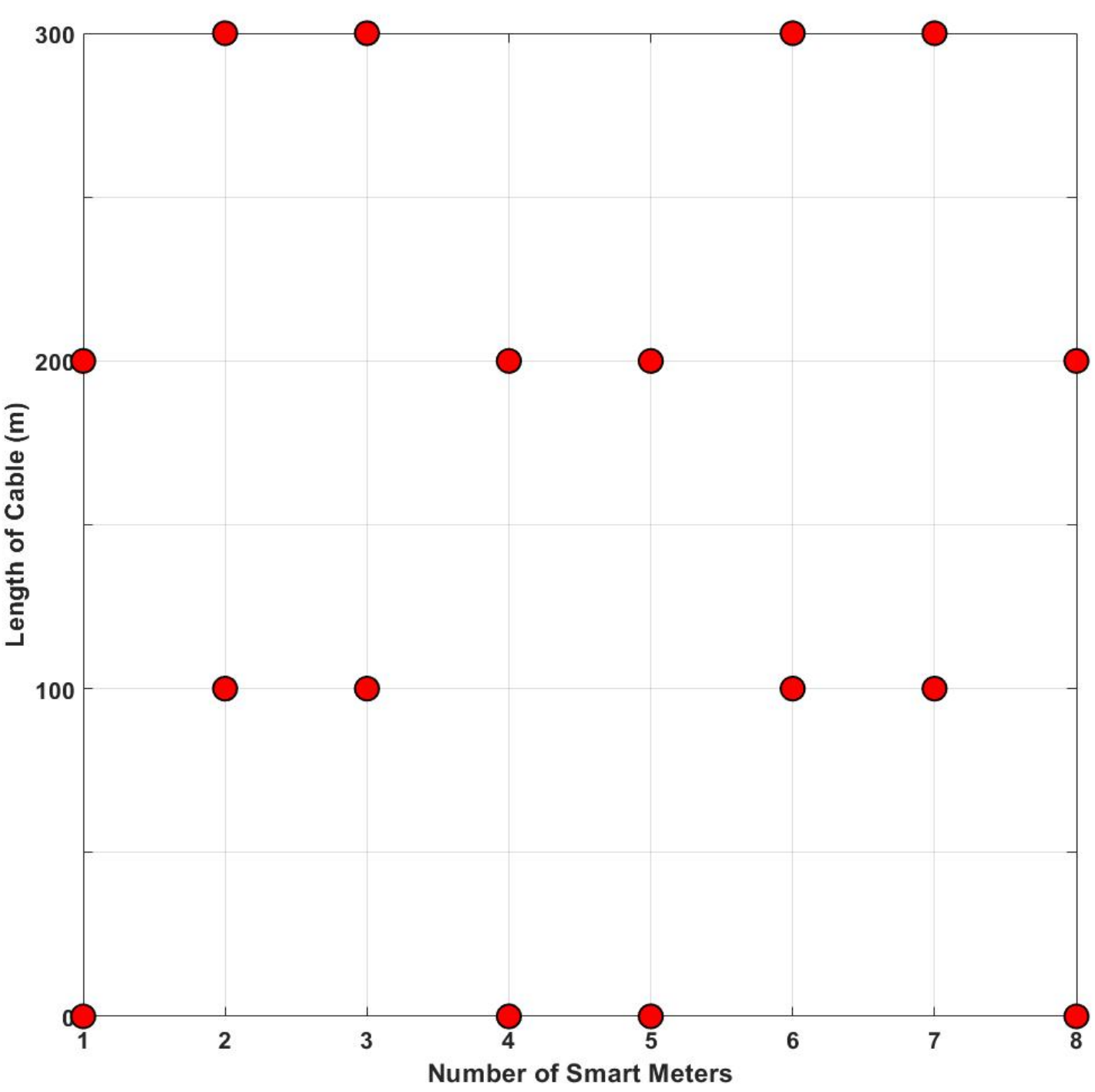


QUESTIONS?

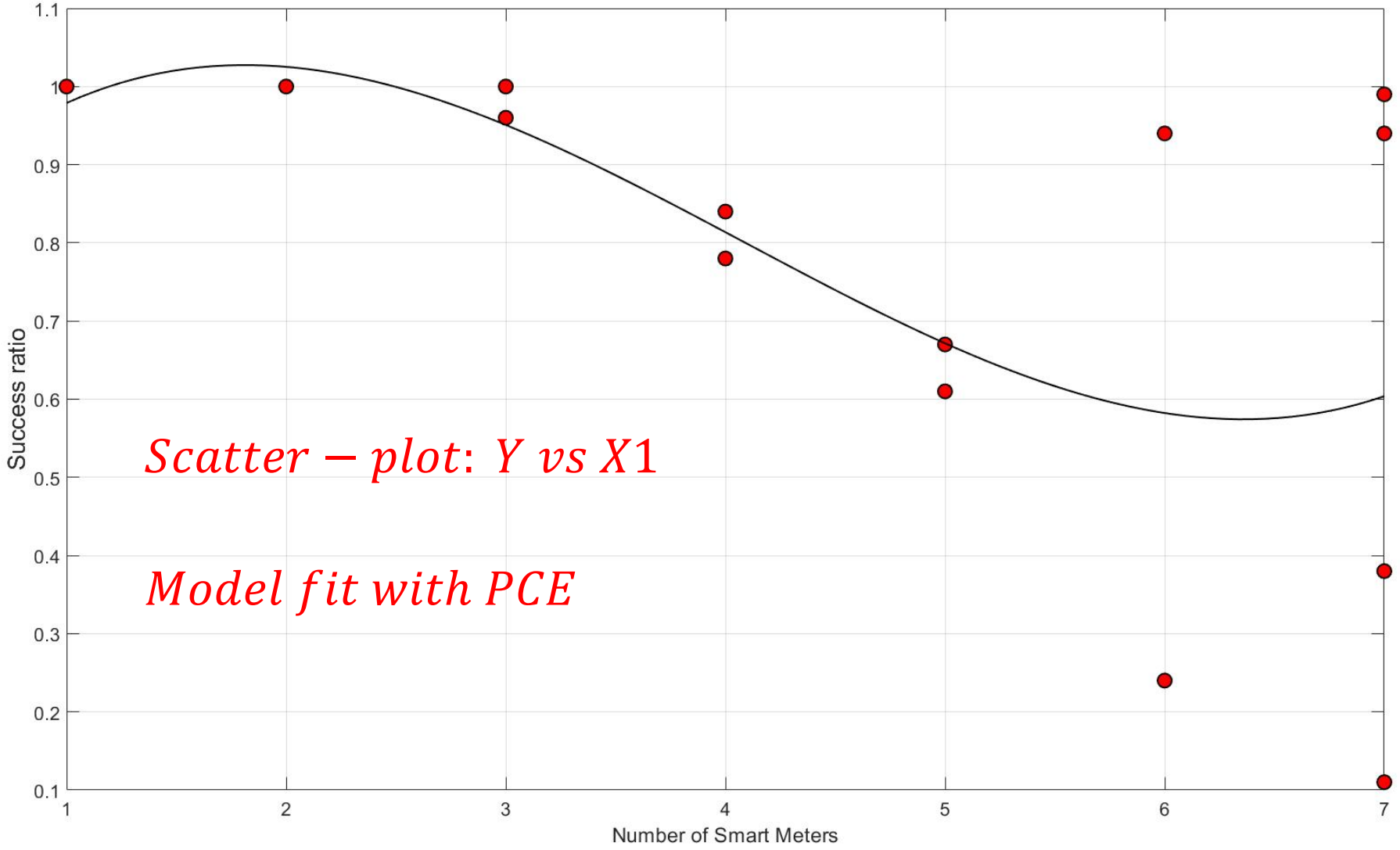
Sobol' – QR sampling

N=16 pts

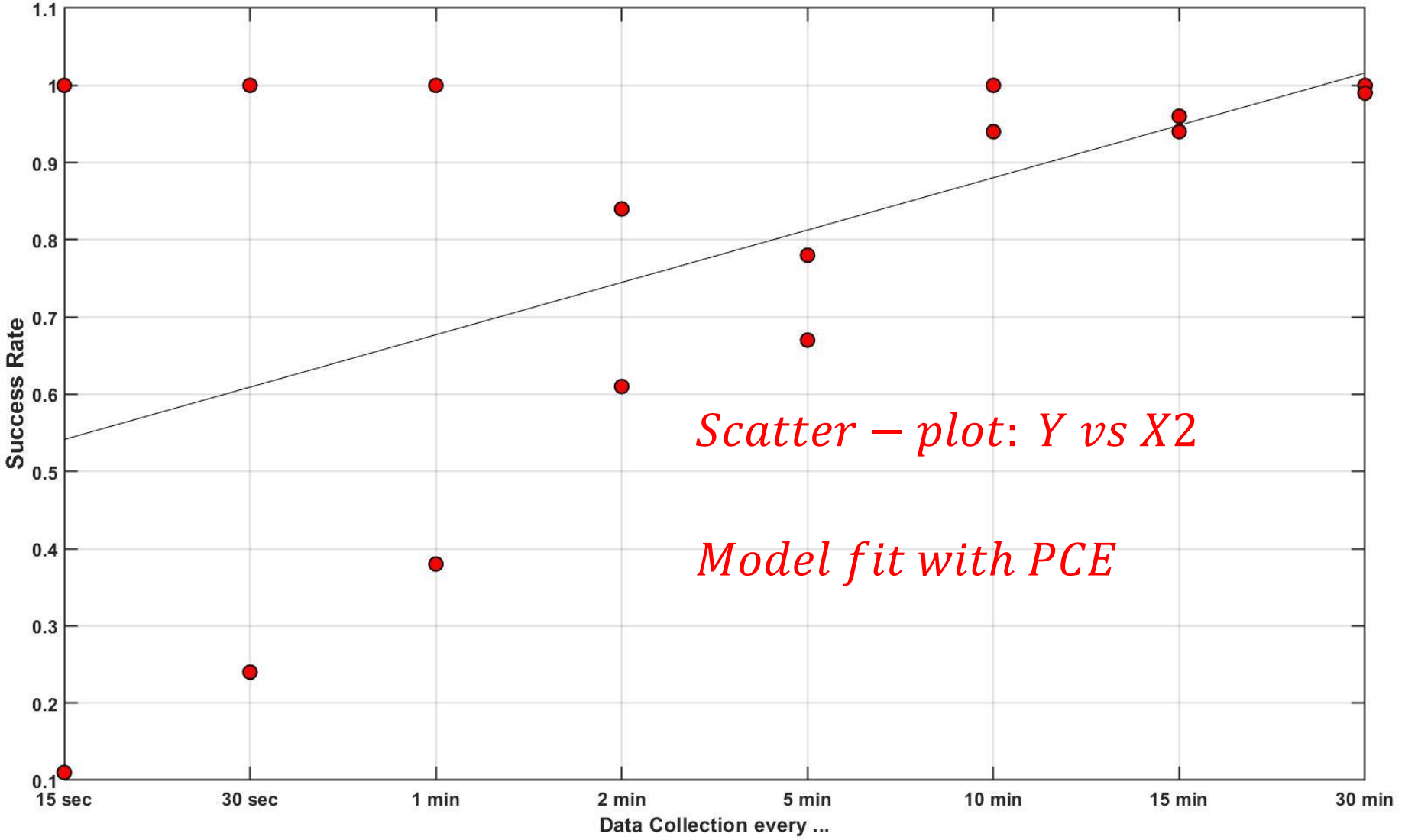
$X1\ vs\ X3$



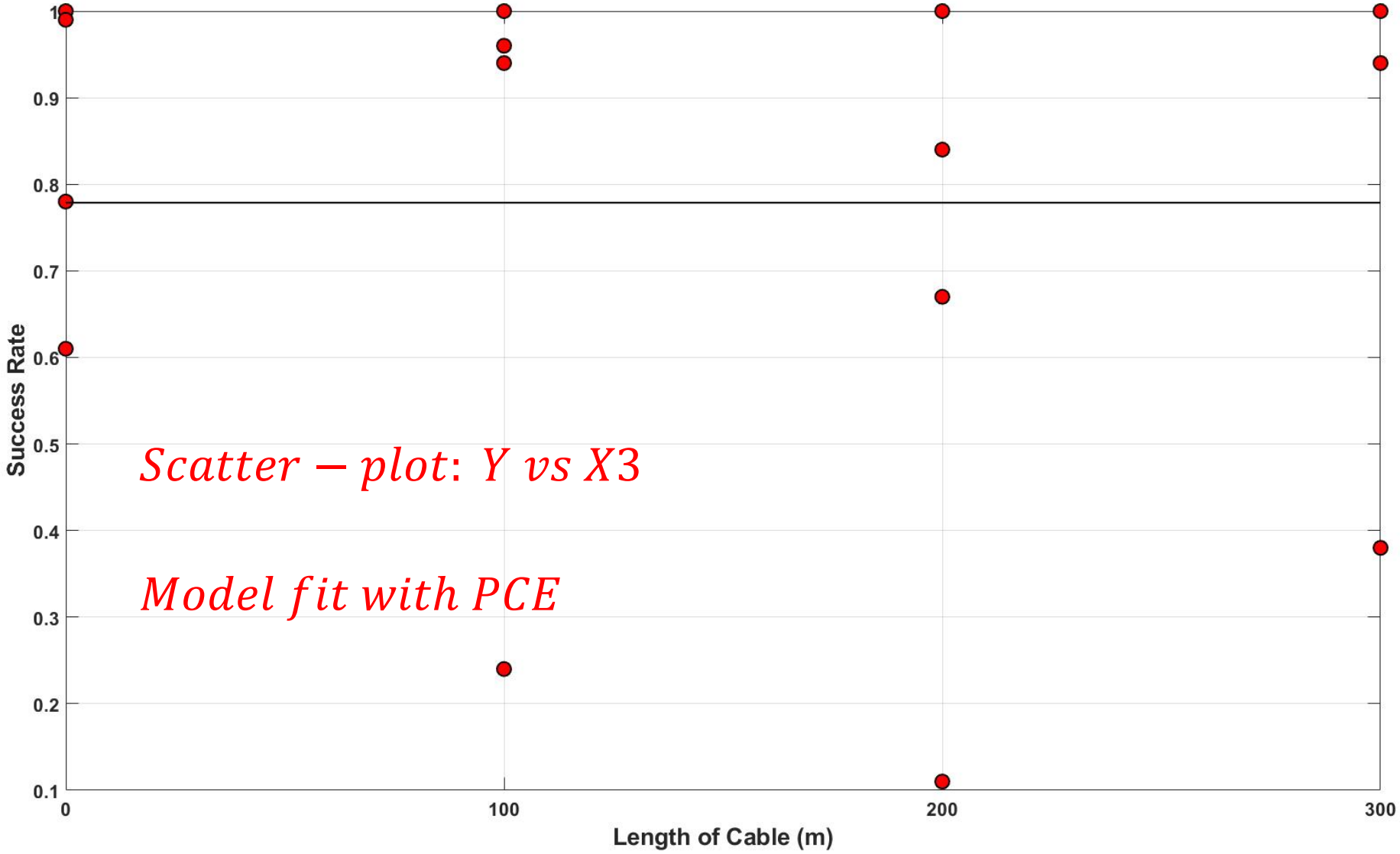
Interoperability deteriorates with increasing number of SM



Interoperability deteriorates with increasing sampling frequency.



Distances up to 400 m do not affect interoperability.



$Scatter - plot: Y\ vs\ X3$

$Model\ fit\ with\ PCE$