

Enriching Formal Statistical Modelling with Graphs

HIERARCHICAL RESPONSE MODELS FOR DESIGN OF EXPERIMENTS

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Statcon=Statistical Consulting

Consulting:

Six Sigma, QBD, MSA, DoE, Reliability,.....

Training

Intro to JMP, Stats using JMP

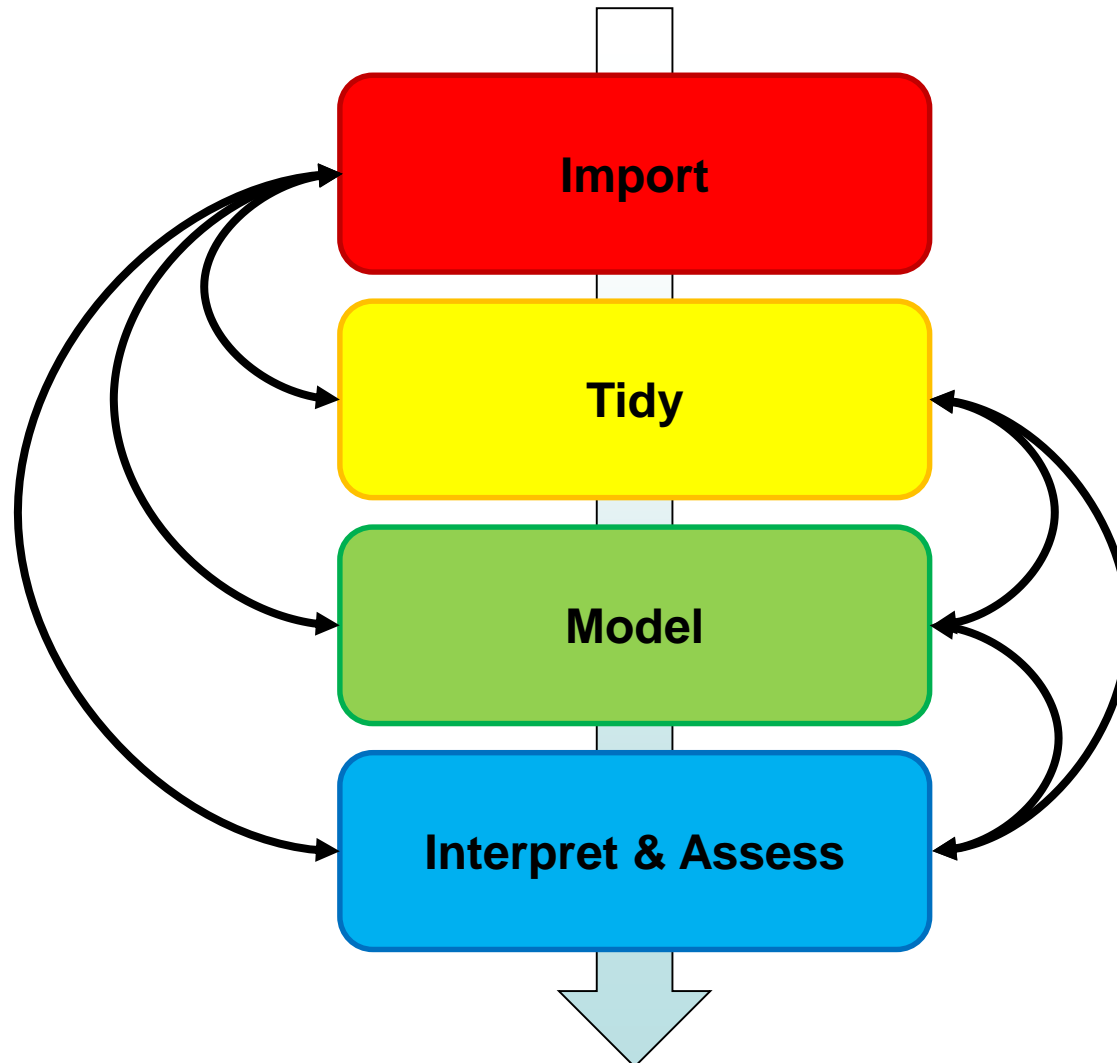
Scripting

Automation of repetitive analysis, reporting, ...

Exploratory Data Analysis

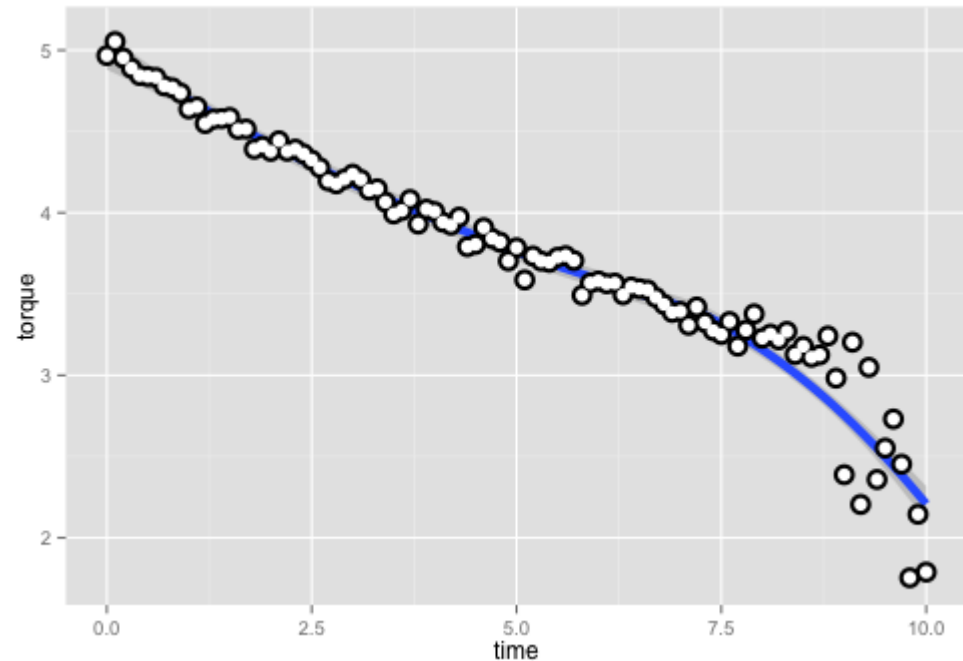
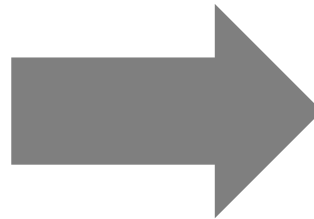
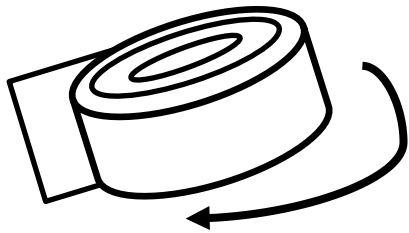
- Graph the data
- Visualize data problems
- Clean / tidy the data

Interactive Data Analysis



STATISTICAL MODELING

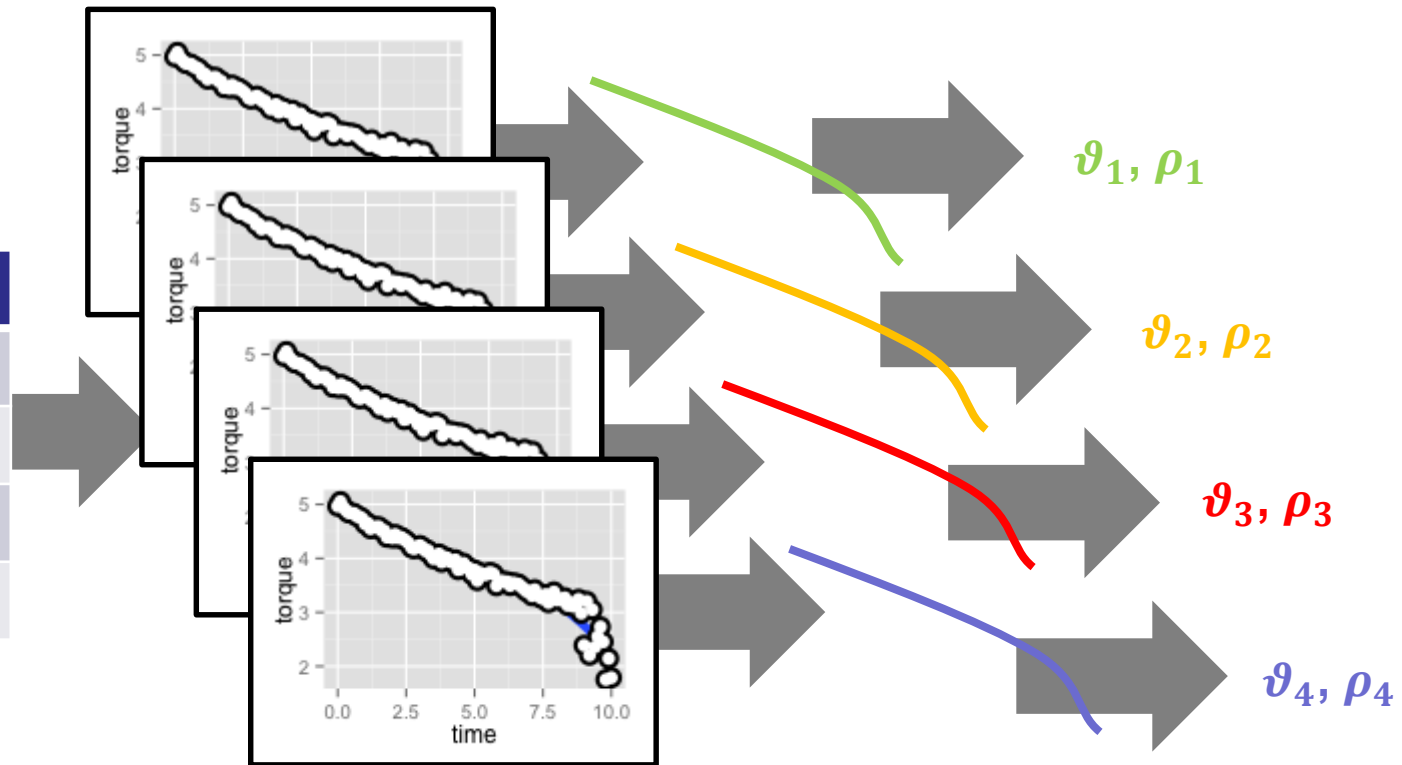
Example: Springs



- A DoE was performed to analyse the relationship of multiple factors on the torque-profile of a spring.
- The customer wanted to know how the torque of the spring behaves after a drilled spring was released.

A Hierarchical Model

Run	X1	X2	X3
1	1	1	1
2	-1	1	-1
3	-1	-1	-1
...



$$\hat{\vartheta} = \beta_0 + \beta_1 X1 + \beta_2 X2 + \beta_3 X3 + \dots$$

$$\hat{\rho} = \beta_0 + \beta_1 X1 + \beta_2 X2 + \beta_3 X3 + \dots$$

Statistical Modeling

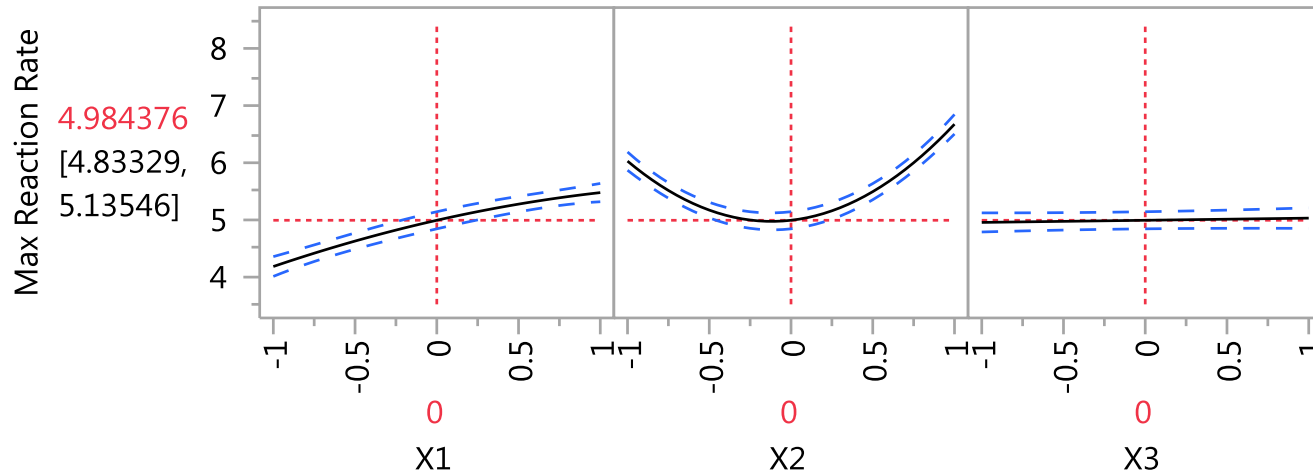
- Overall goal: Find a meaningful model for the given problem.
- Therefore provide information about:
 - the importance of different factors
 - How the model looks like
- Allow the user to change the model interactively and see the results!

Pareto-Plot & Model Profiler

Effect Summary

Source	LogWorth	PValue
X2*X3	15.521	0.00000
X2*X2	13.332	0.00000
X1	11.697	0.00000
X2	6.674	0.00000 ^
X1*X1	1.412	0.03871
X3	0.419	0.38071 ^

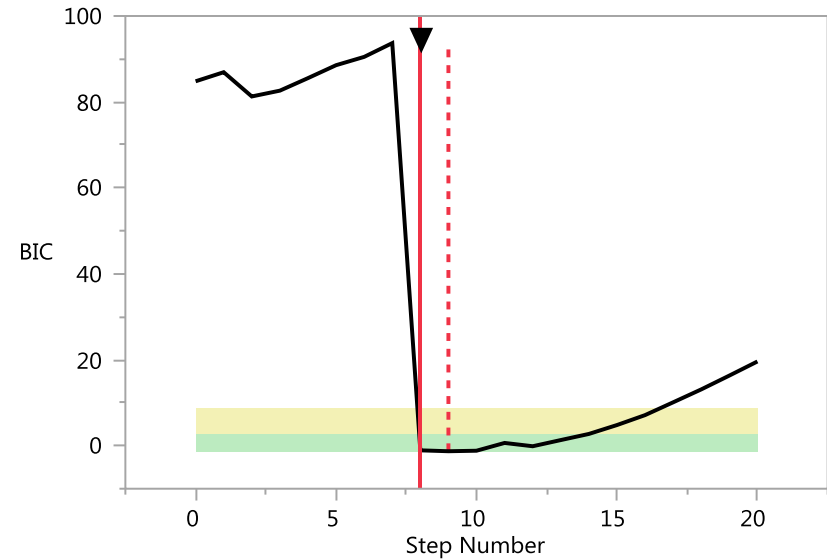
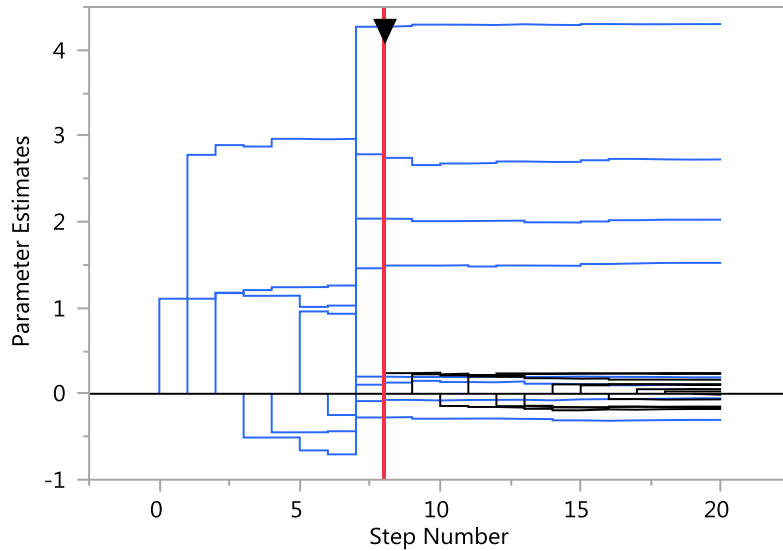
Prediction Profiler



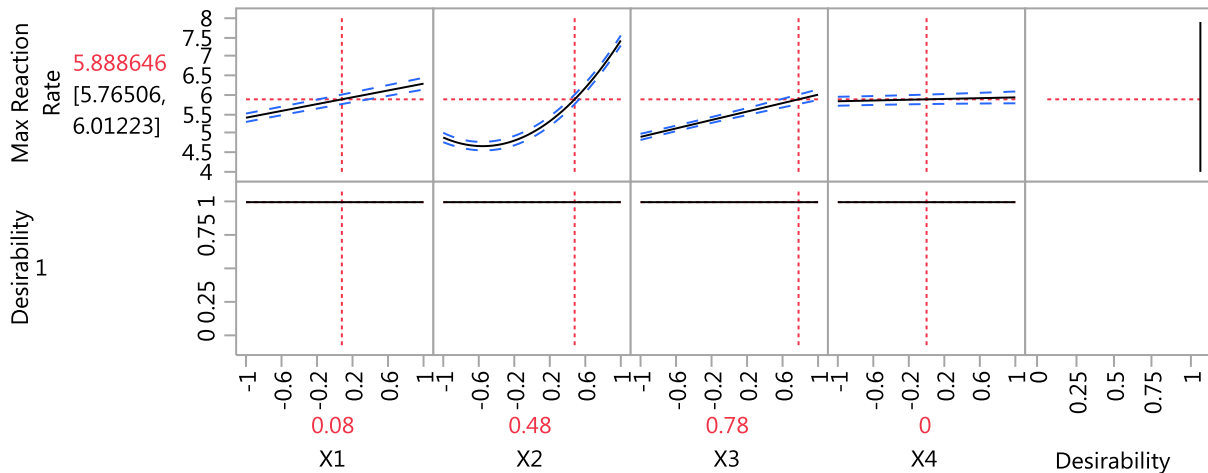
Forward Selection with BIC



Solution Path



Prediction Profiler



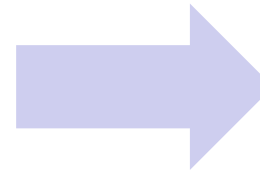
MODEL INTERPRETATION

Model Interpretation

Problem

It is hard to interpret the relationship between factors and parameters of the nonlinear fit.

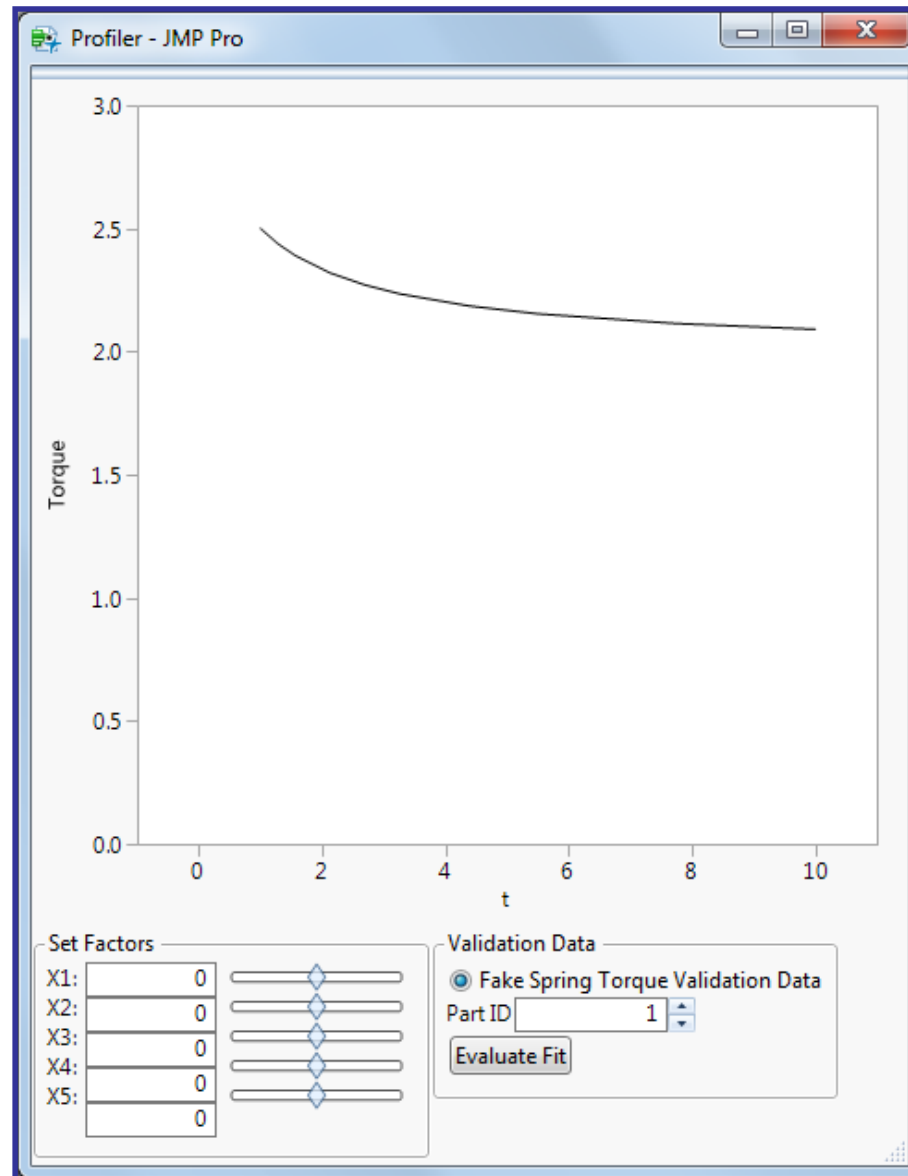
Parameter Estimates				
Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	4.8002418	0.08568	56.03	<.0001 *
X1	0.5779569	0.050959	11.34	<.0001 *
X2	0.2748737	0.050111	5.49	<.0001 *
X3	-0.079808	0.050027	-1.60	0.1263
X1*X1	0.2182677	0.087588	2.49	0.0216 *
X2*X2	1.206335	0.08754	13.78	<.0001 *
X2*X3	1.193457	0.05987	19.93	<.0001 *

 a ax $b+x$

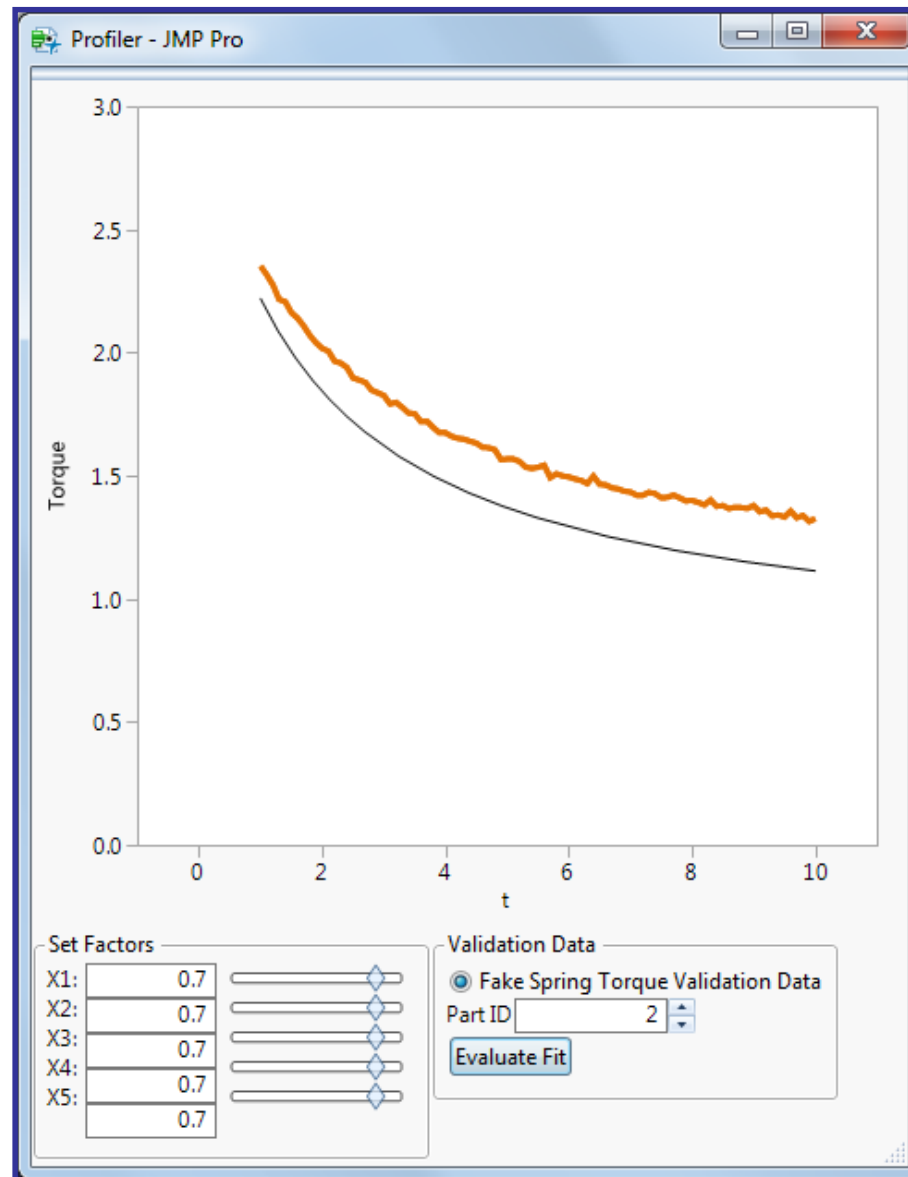
Michaelis-Menten:

$$\frac{ax}{b+x}$$

Solution: A Custom Profiler



Visual Model Validation



Conclusions

- A hierarchy of models can be extremely useful
- Model diagnostics on each level are important
- Interactive graphs are an absolute necessity in multi layered analysis
- The approach was very helpful to the engineers