



Hello
my name is

Stefan Conrady

Simulation Meta-Modeling

Using Bayesian Networks & BayesiaLab

Today's Agenda

Motivation & Challenge

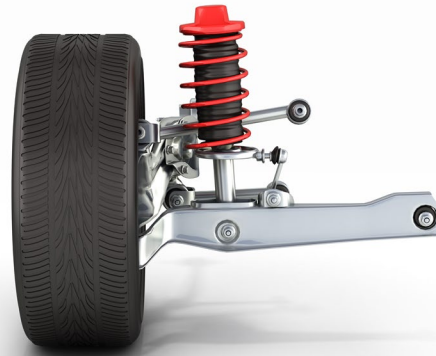
- Simulations, Fast and Slow

Objective

- “Simulating the Simulation”

Case Study Topic

- Optimizing the Parameters of a Vehicle Suspension



20 min.

Today's Agenda (cont'd)

Workflow

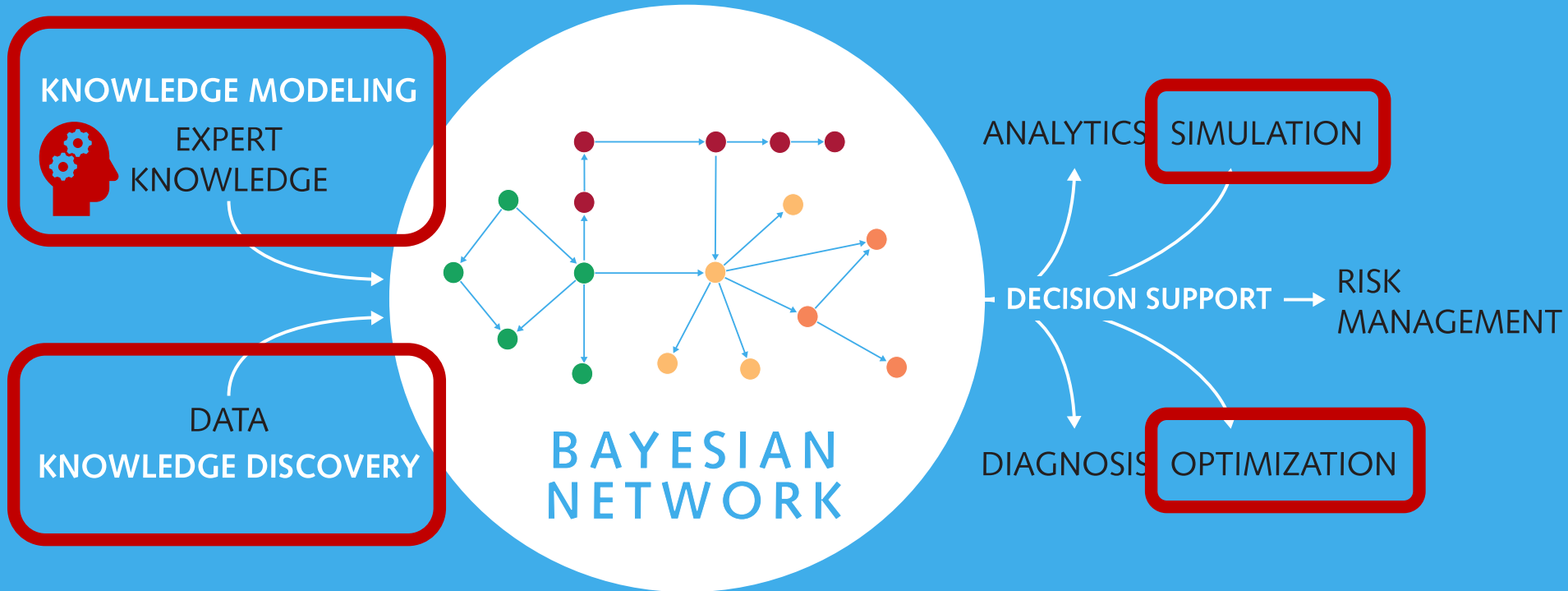
- In Simulation Tool (e.g. MATLAB, Simulink, SystemModeler, etc.)
 - Create Mathematical Simulation Model
 - Simulate Model in the **Time Domain**
 - Perform Fourier Transform
- In BayesiaLab
 - Learn Bayesian Network Model in the **Frequency Domain**
 - Simulate Response to Parameter Variations
 - Optimize Parameters
- In WebSimulator
 - Publish Bayesian Network Simulator

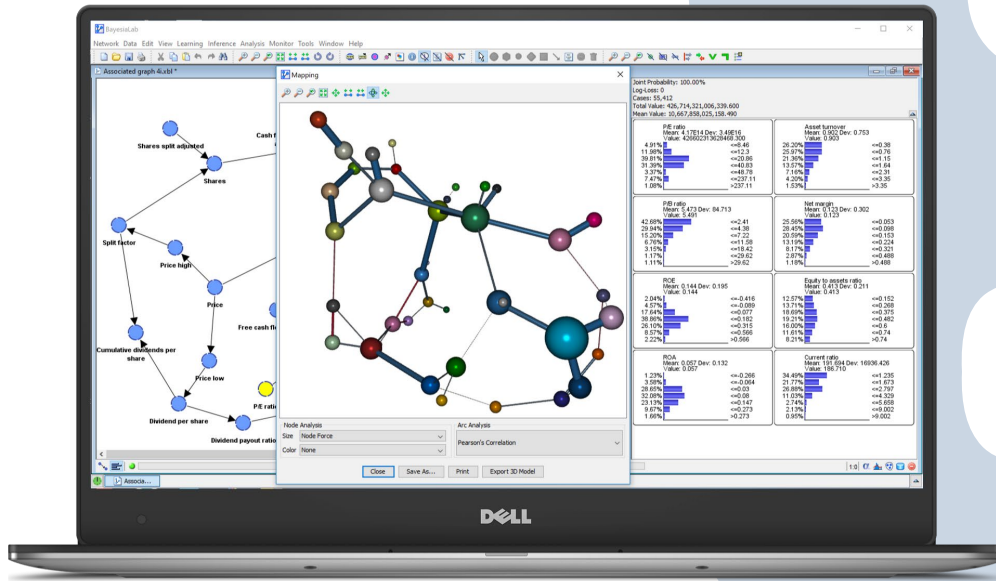
Prepared Offline



40 min.

Today's Workflow



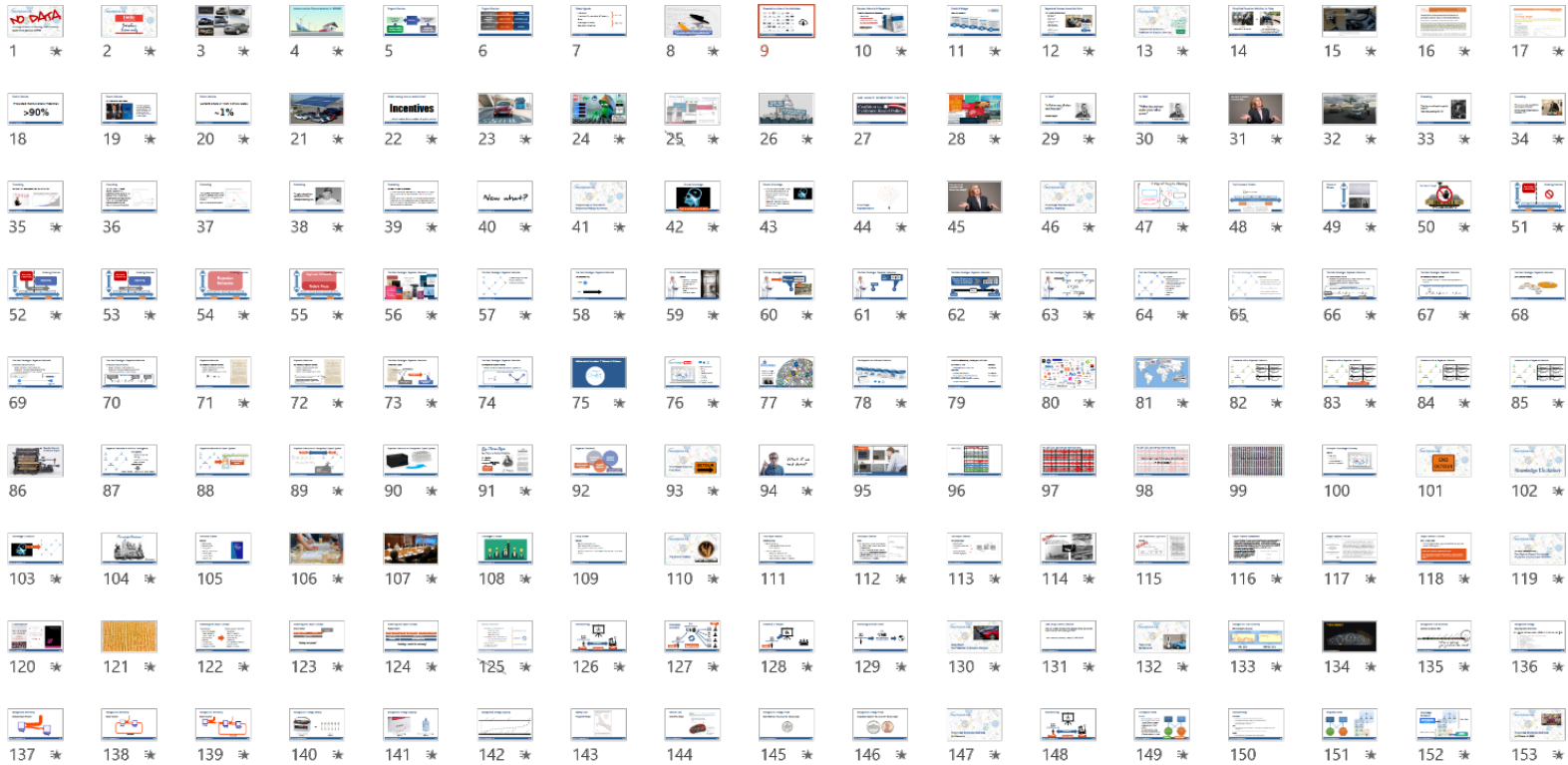


A desktop software for:

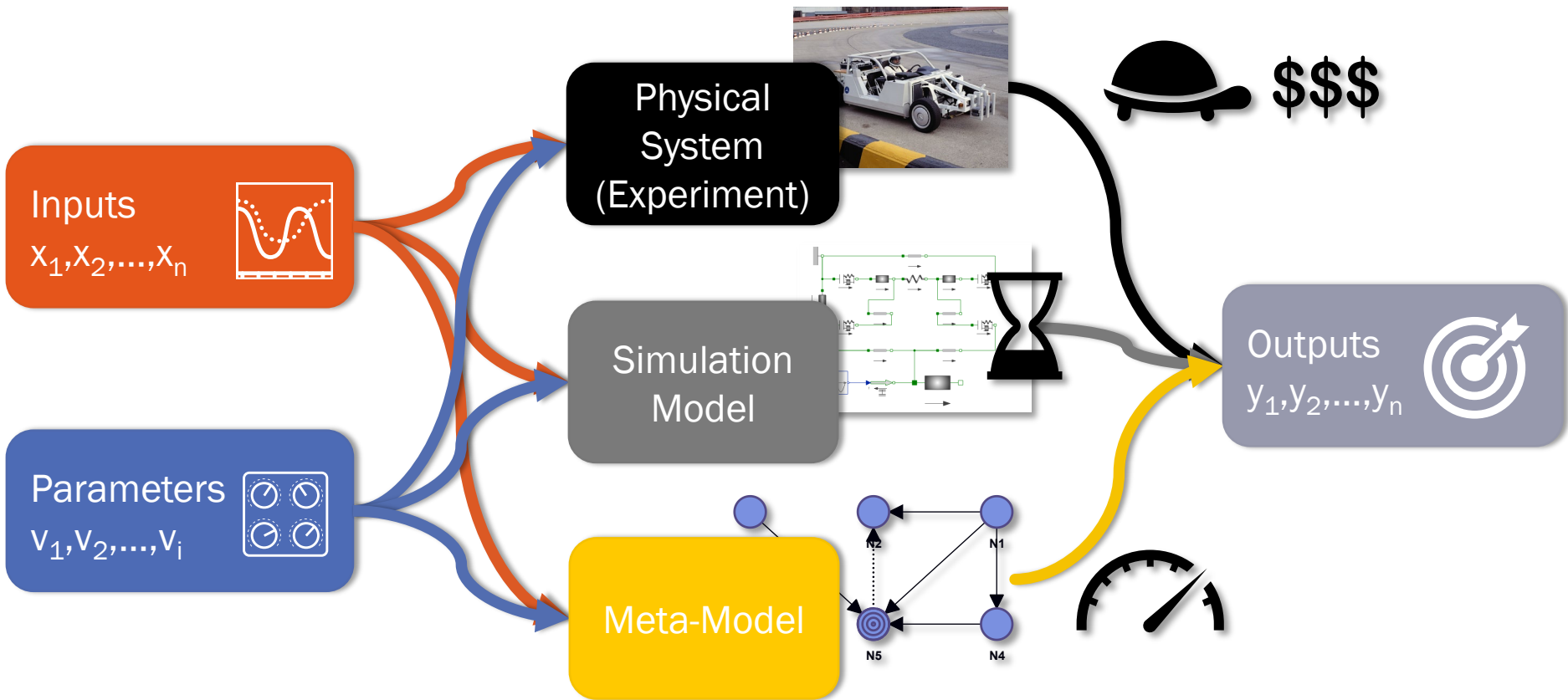
- encoding
- learning
- editing
- performing inference
- analyzing
- simulating
- optimizing

with Bayesian networks.

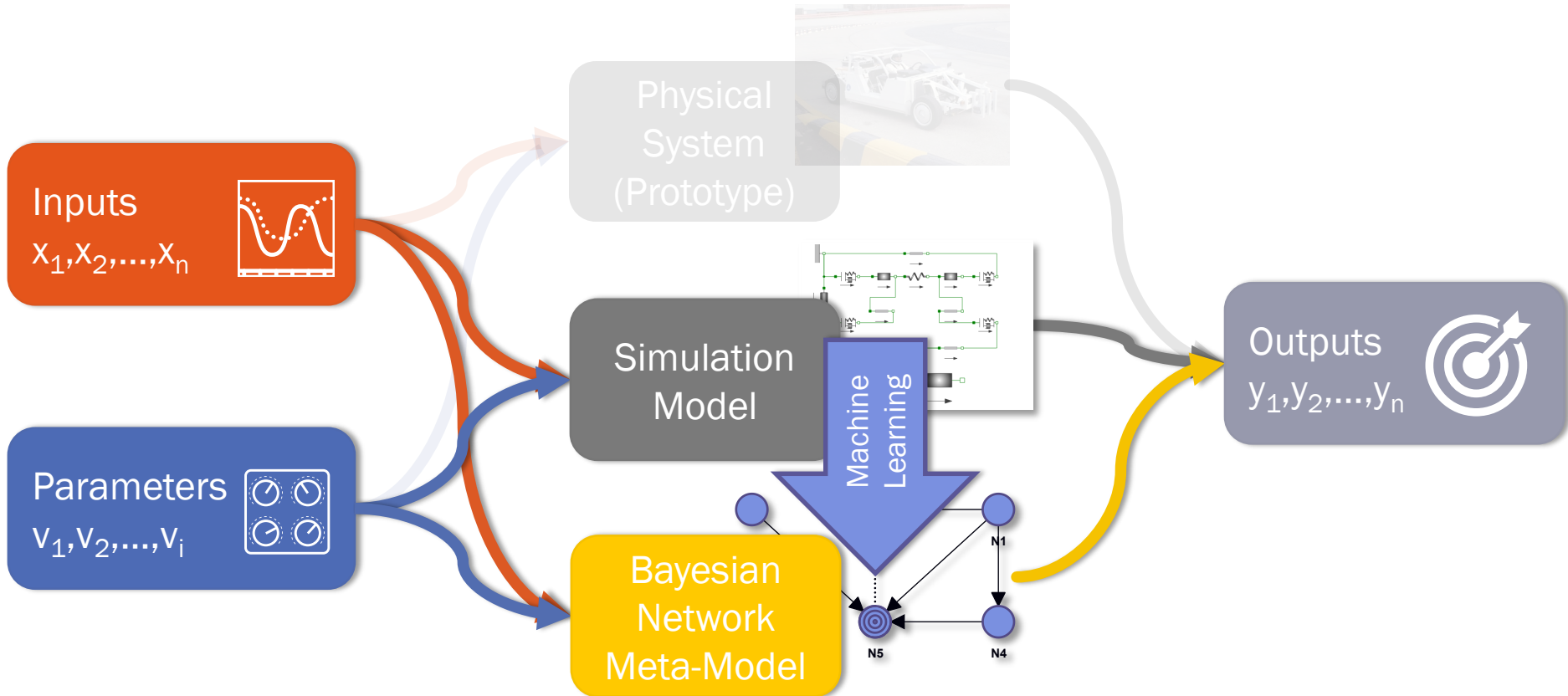
Slides, networks, and video will be available



Motivation: Simulations, Fast and Slow

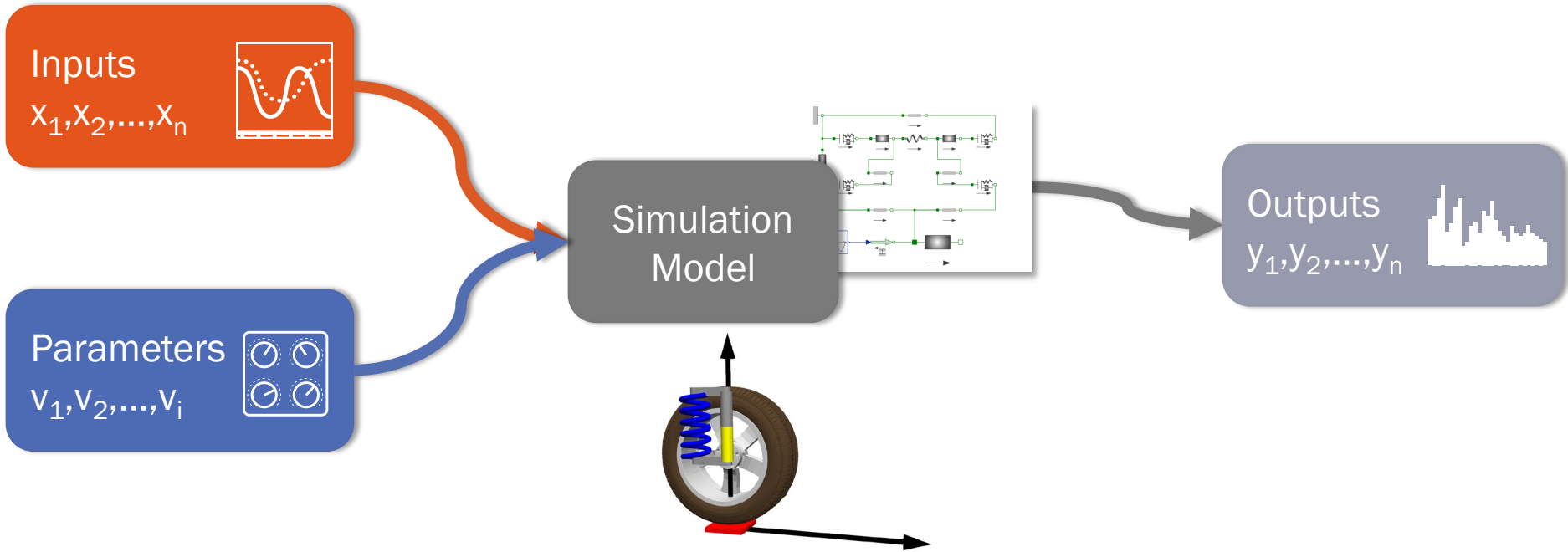


Objective: Simulating the Simulation



Simulation Model

Problem Domain: Vehicle Suspension



Case Study Caveat

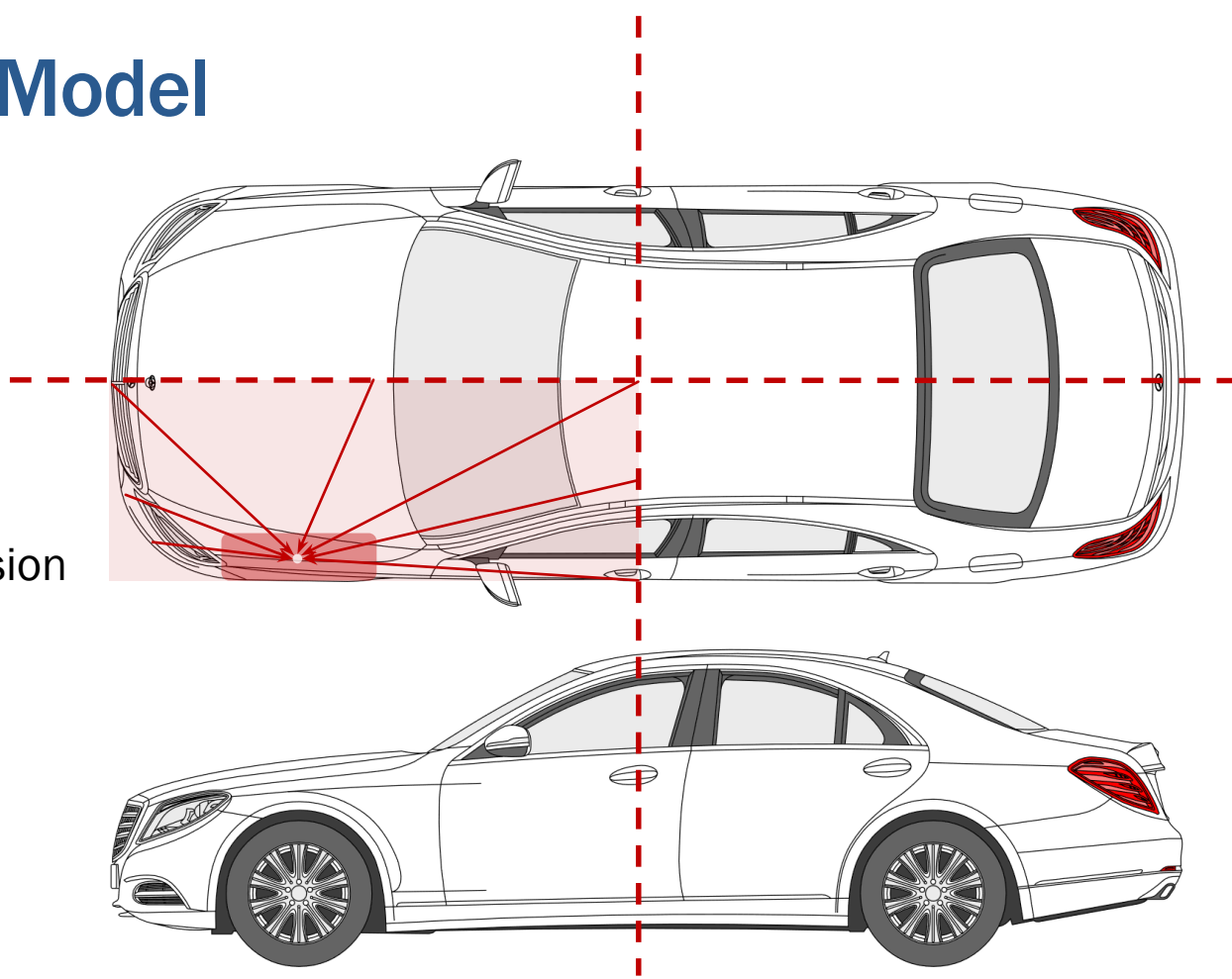


Simplified
Example!

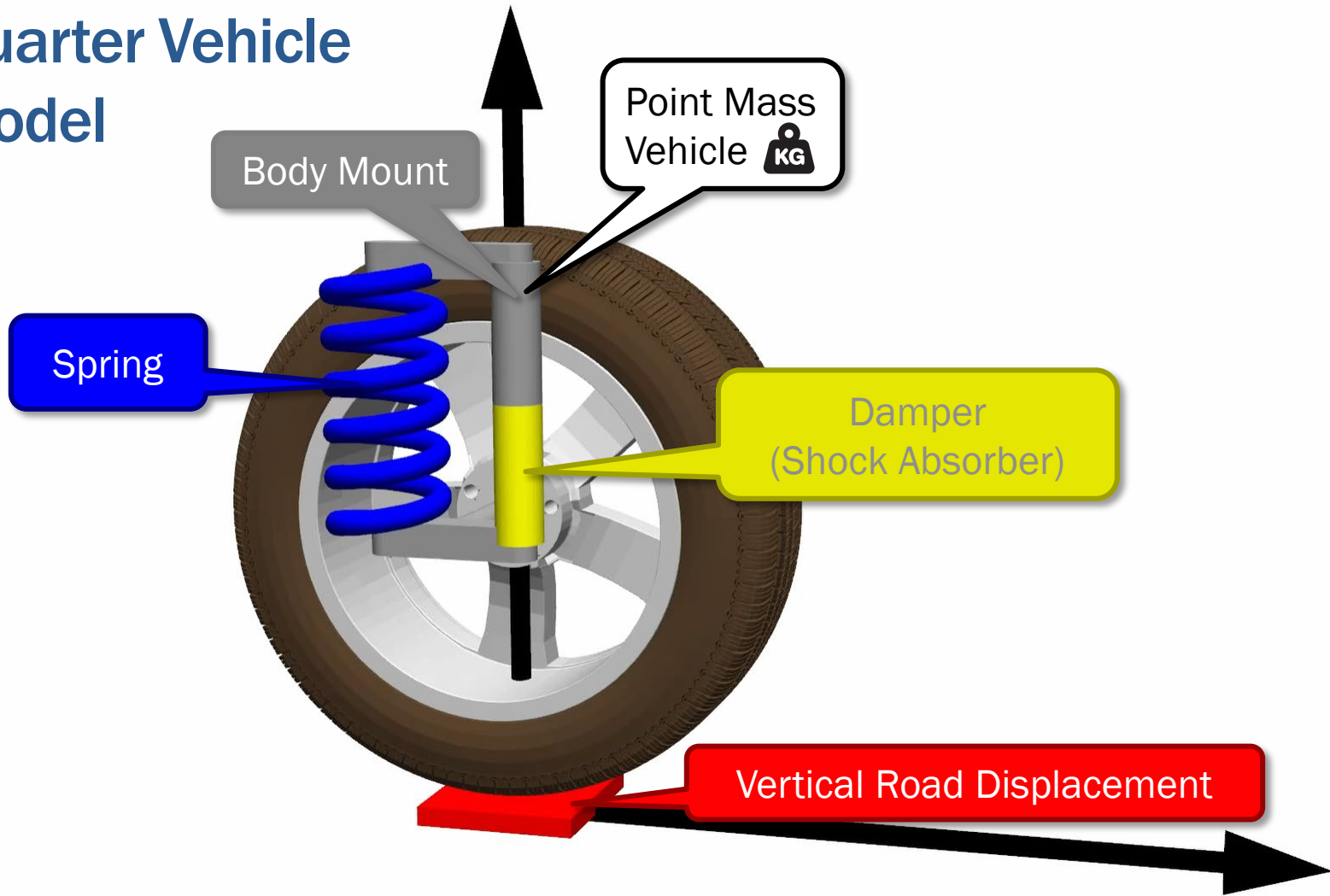
Quarter Vehicle Model

Simplification of Vehicle

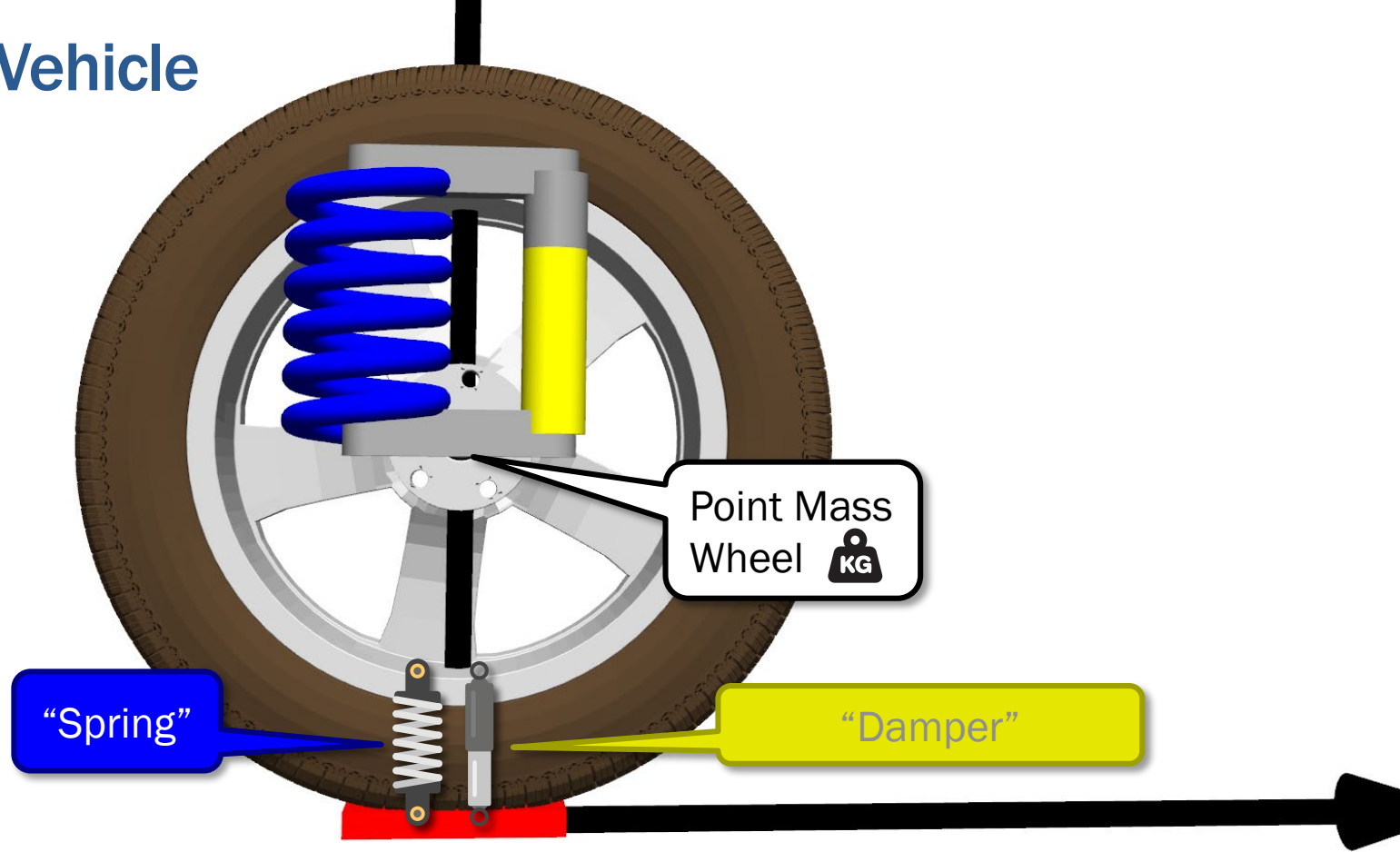
- Considering only one “quarter”, i.e., one wheel/tire and the corresponding suspension and body components.



Quarter Vehicle Model



Quarter Vehicle Model

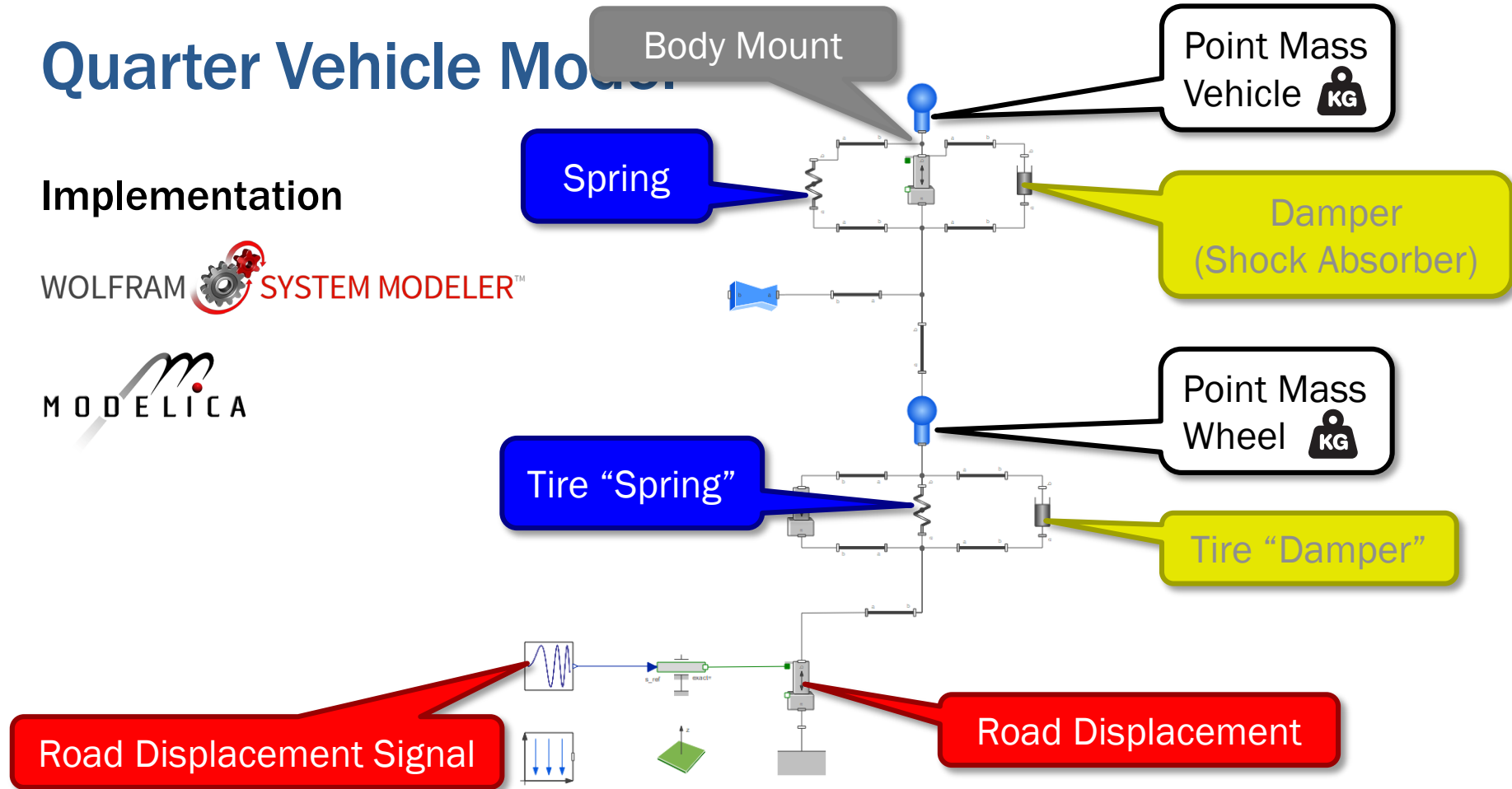


Quarter Vehicle Model

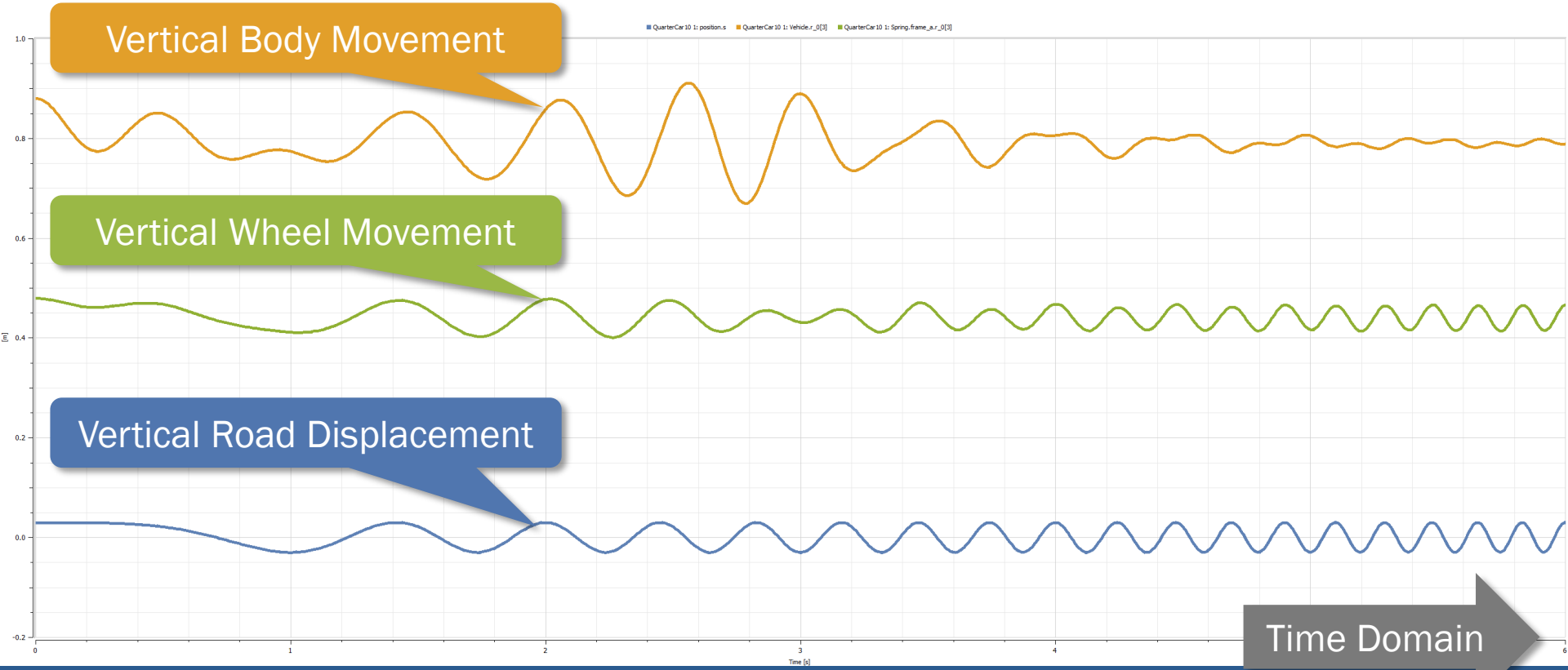
Implementation


WOLFRAM  SYSTEM MODELER™

 MODELICA

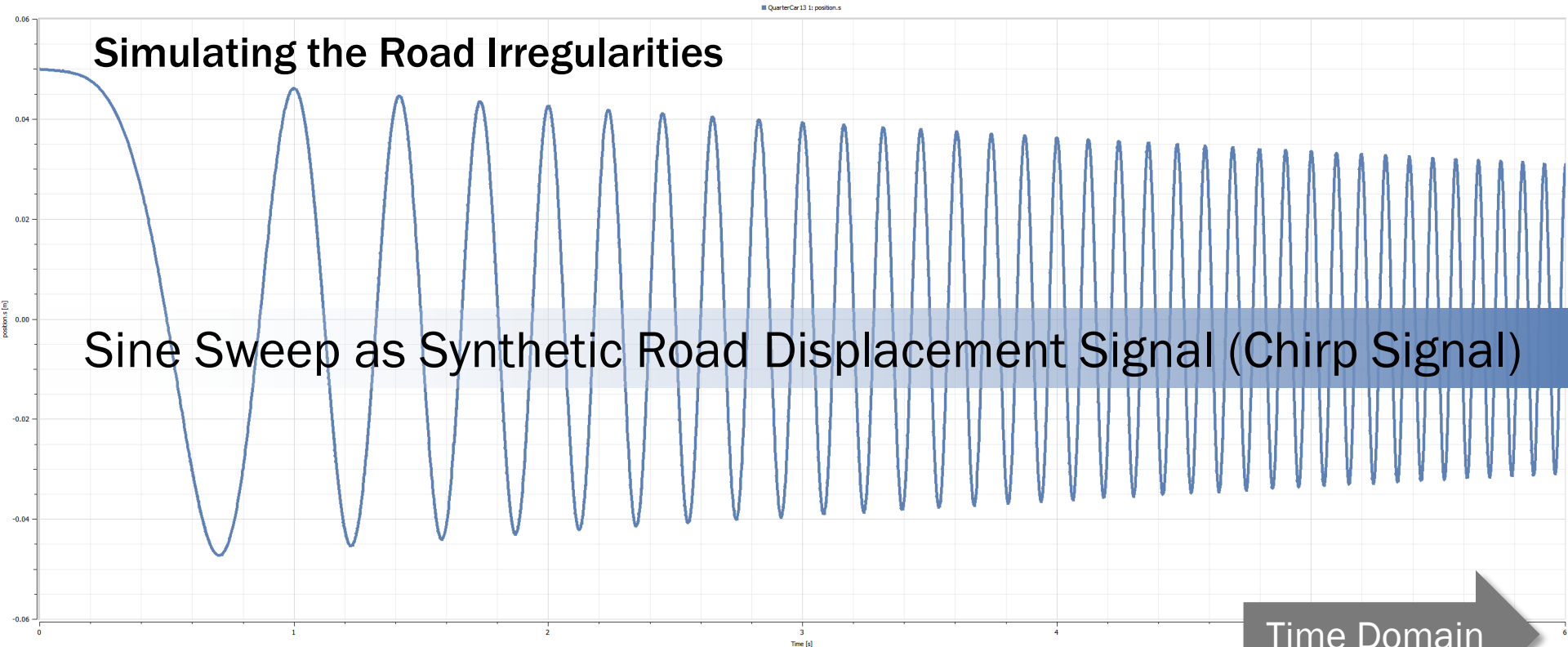


Quarter Vehicle Simulation

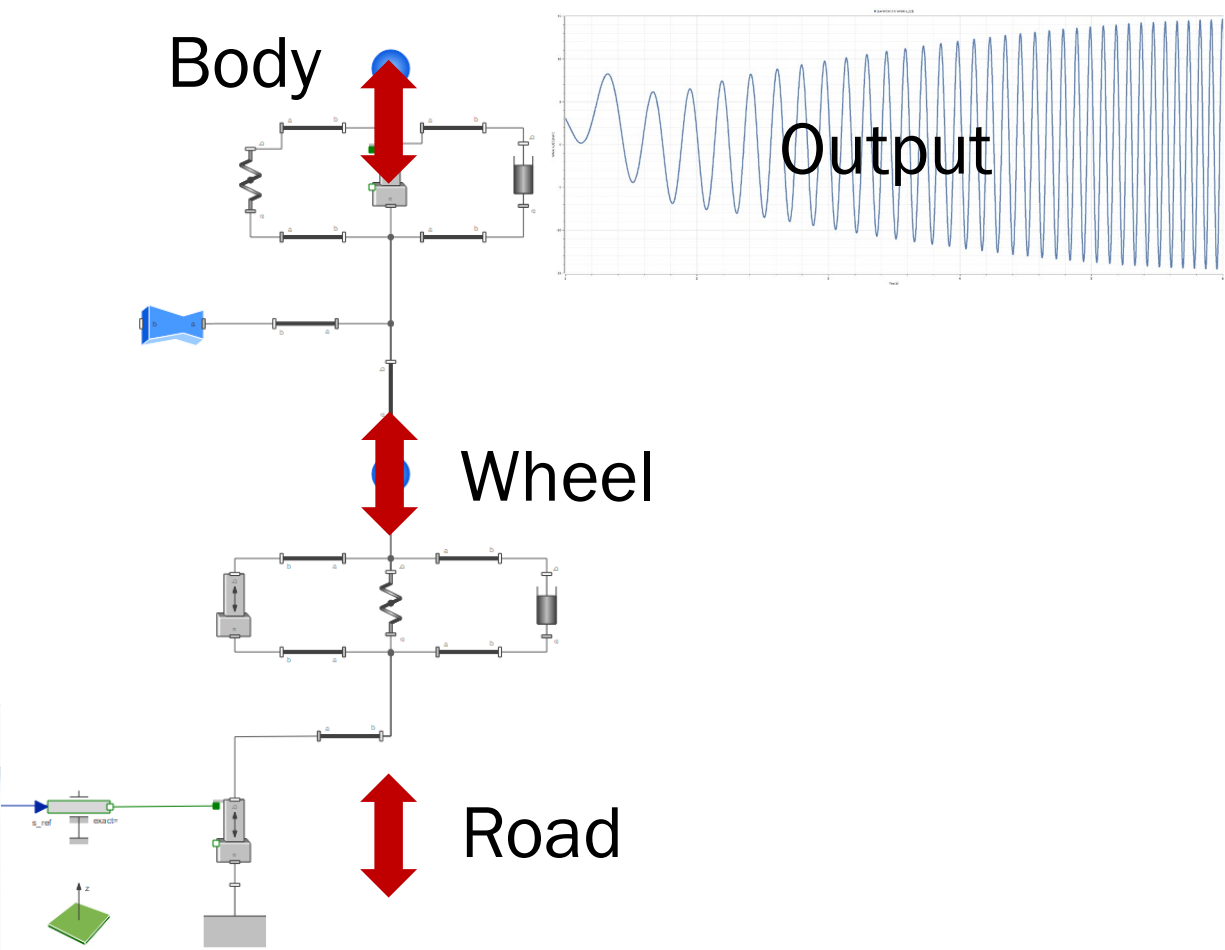
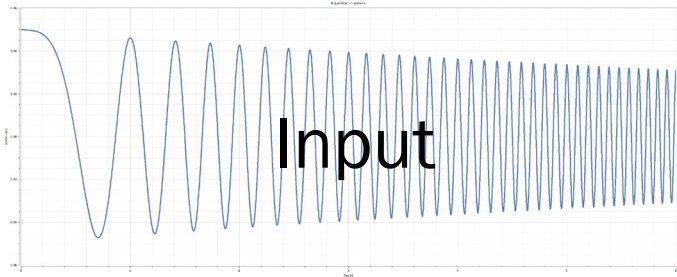


Time Domain 

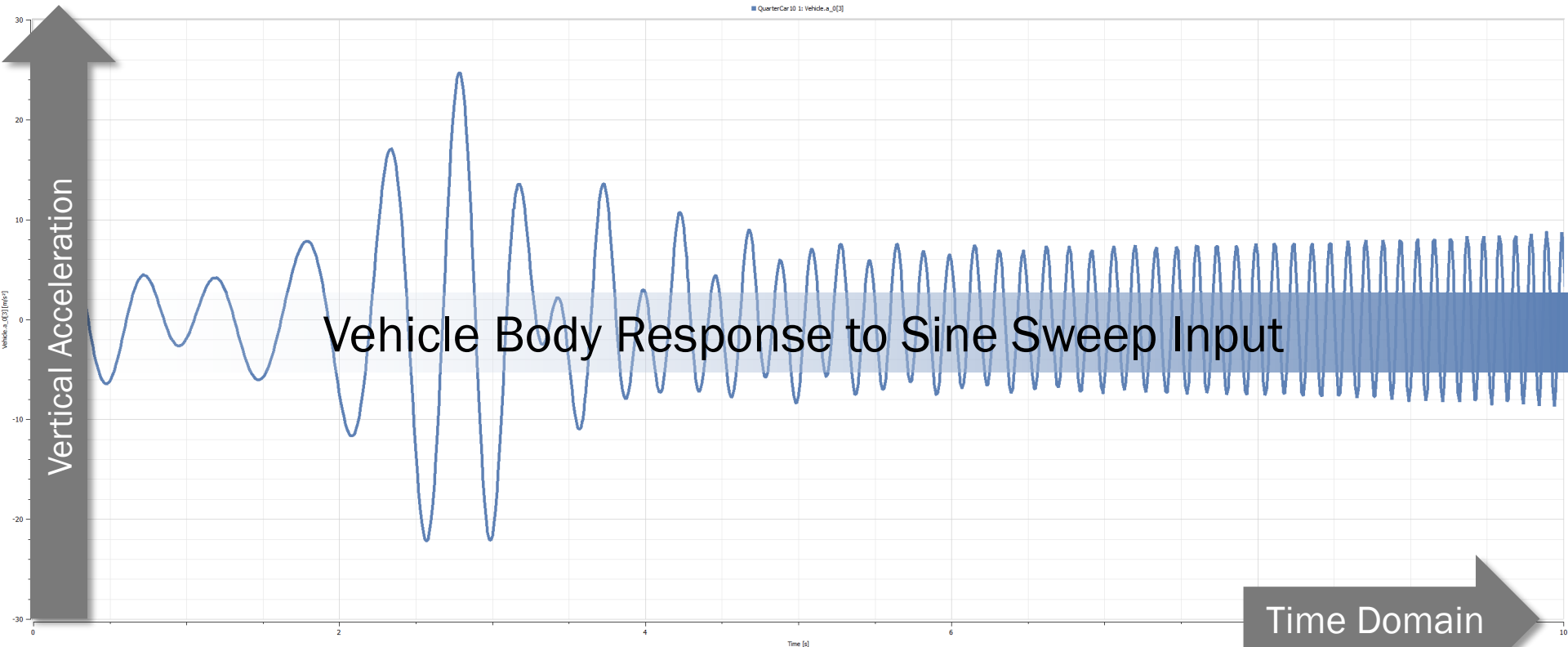
Quarter Vehicle Simulation



Quarter Vehicle Model

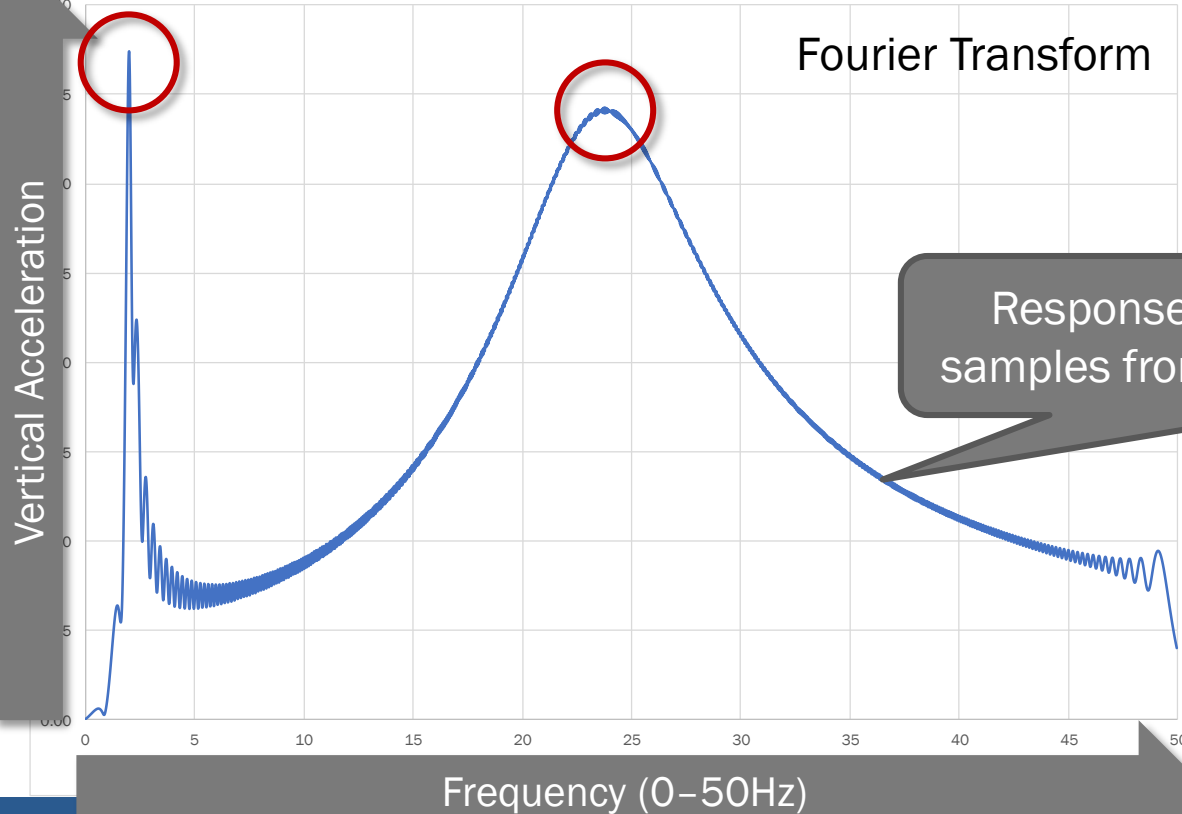


Quarter Vehicle Simulation



Quarter Vehicle Simulation

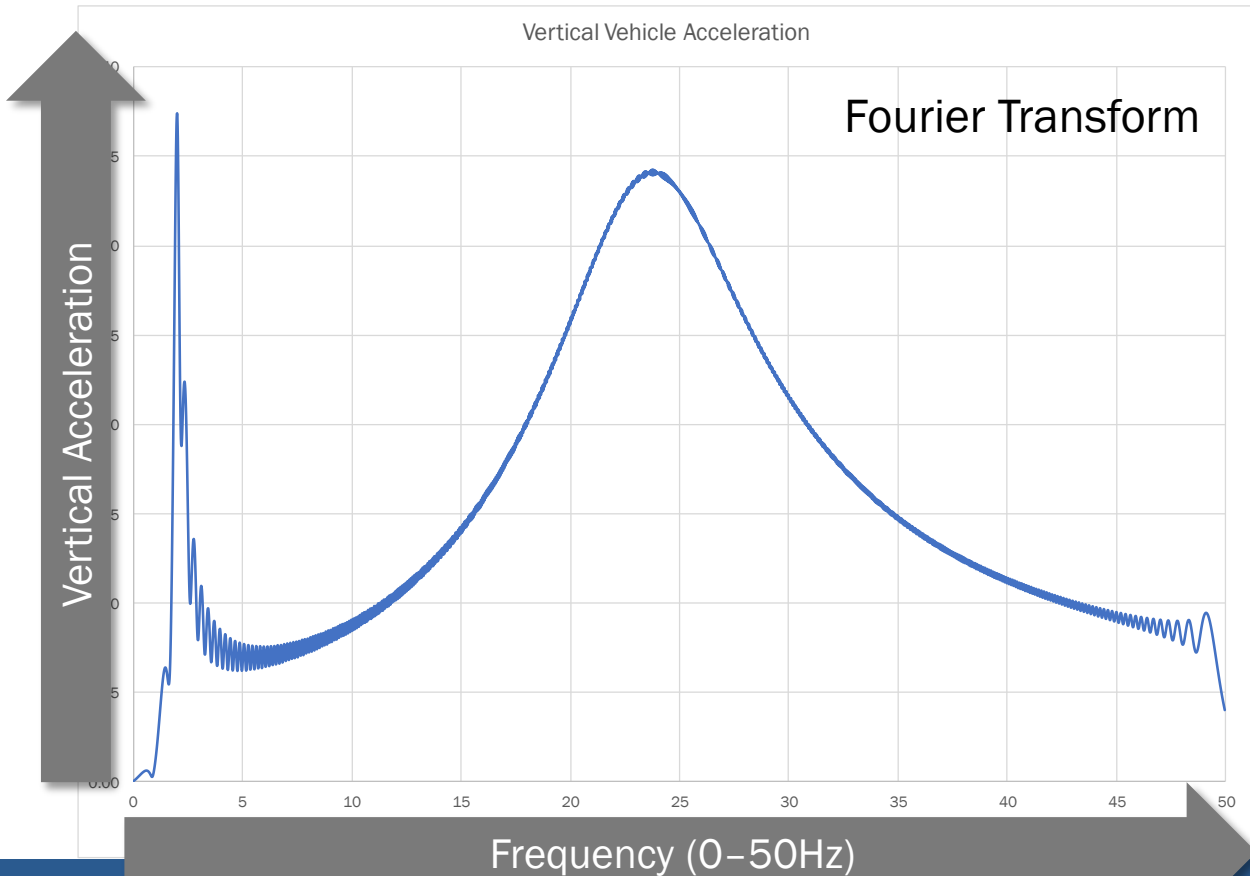
Vertical Vehicle Acceleration



Response Curve is the FFT of 5000 samples from the time series simulation

Damper
 $d=1500\text{Ns/m}$

Quarter Vehicle Model



Damper
 $d=3000\text{Ns/m}$



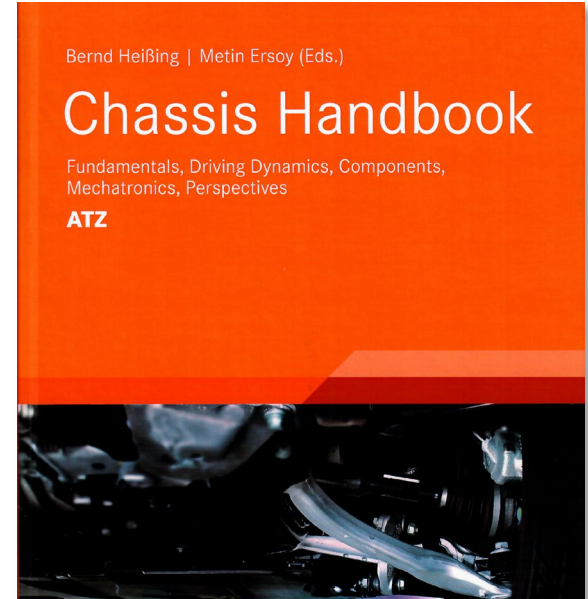
Damper
 $d=1500\text{Ns/m}$



Quarter Vehicle Model

Initial Parameter Values

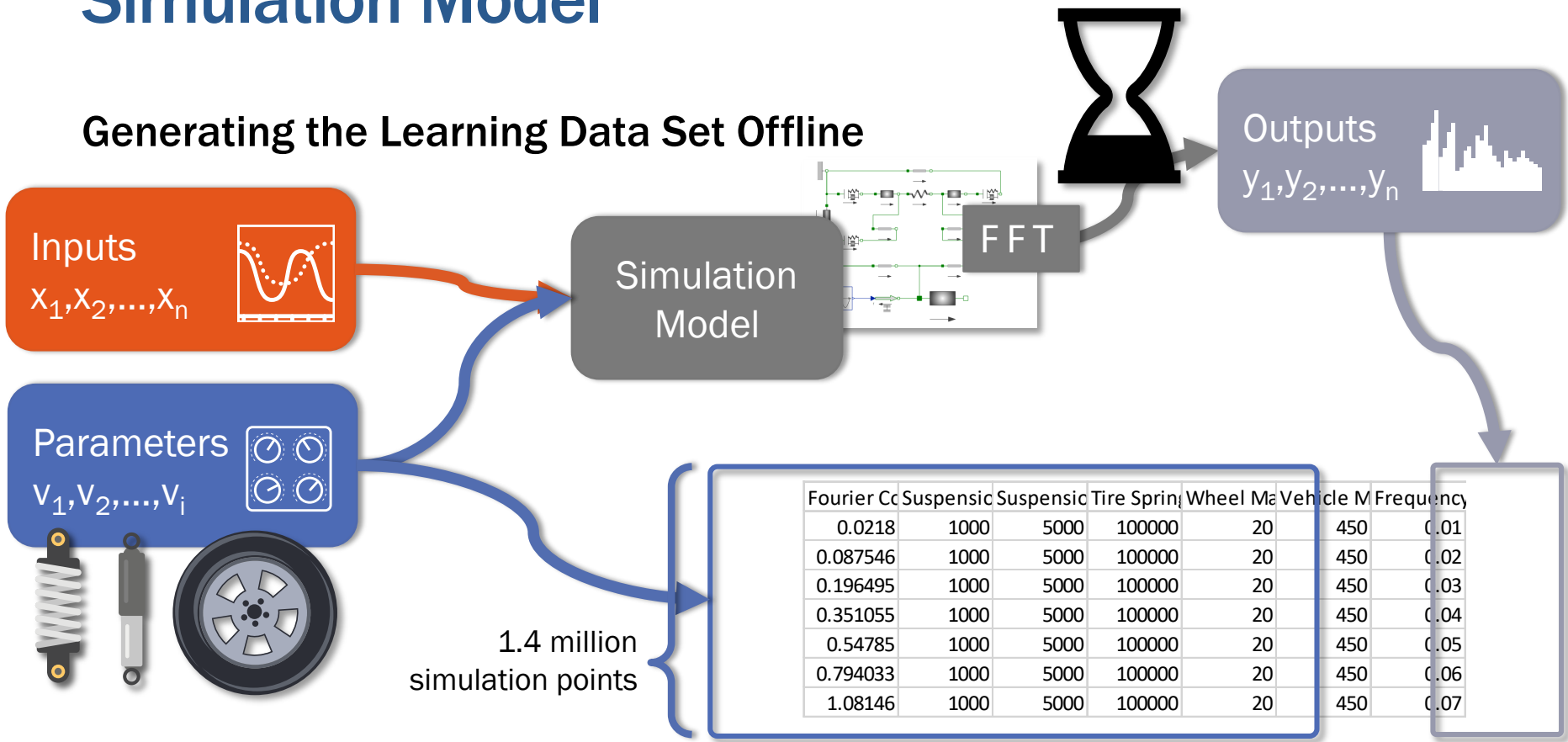
- Partial Body Mass: 400 kg
- Wheel Mass: 40 kg
- Tire Stiffness (Spring Rate): 150,000 N/m
- Tire Damping: 100 Ns/m
- Spring Rate: 21,000 N/m
- Suspension Damping: 1,500 Ns/m



Suspension Damping	Suspension Spring Rate	Tire Spring Rate	Wheel Mass	Vehicle Mass
1,000	5,000	100,000	20	450
1,000	5,000	100,000	20	650
1,000	5,000	100,000	30	450
1,000	5,000	100,000	30	650
1,000	5,000	100,000	40	450
1,000	5,000	100,000	40	650
1,000	5,000	150,000	20	450
1,000	5,000	150,000	20	650
1,000	5,000	150,000	30	450
1,000	5,000	150,000	30	650

Simulation Model

Generating the Learning Data Set Offline

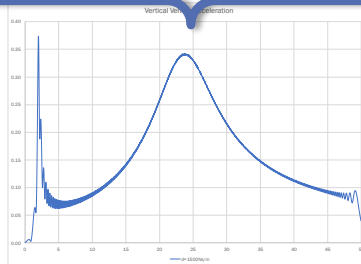


Simulation Model



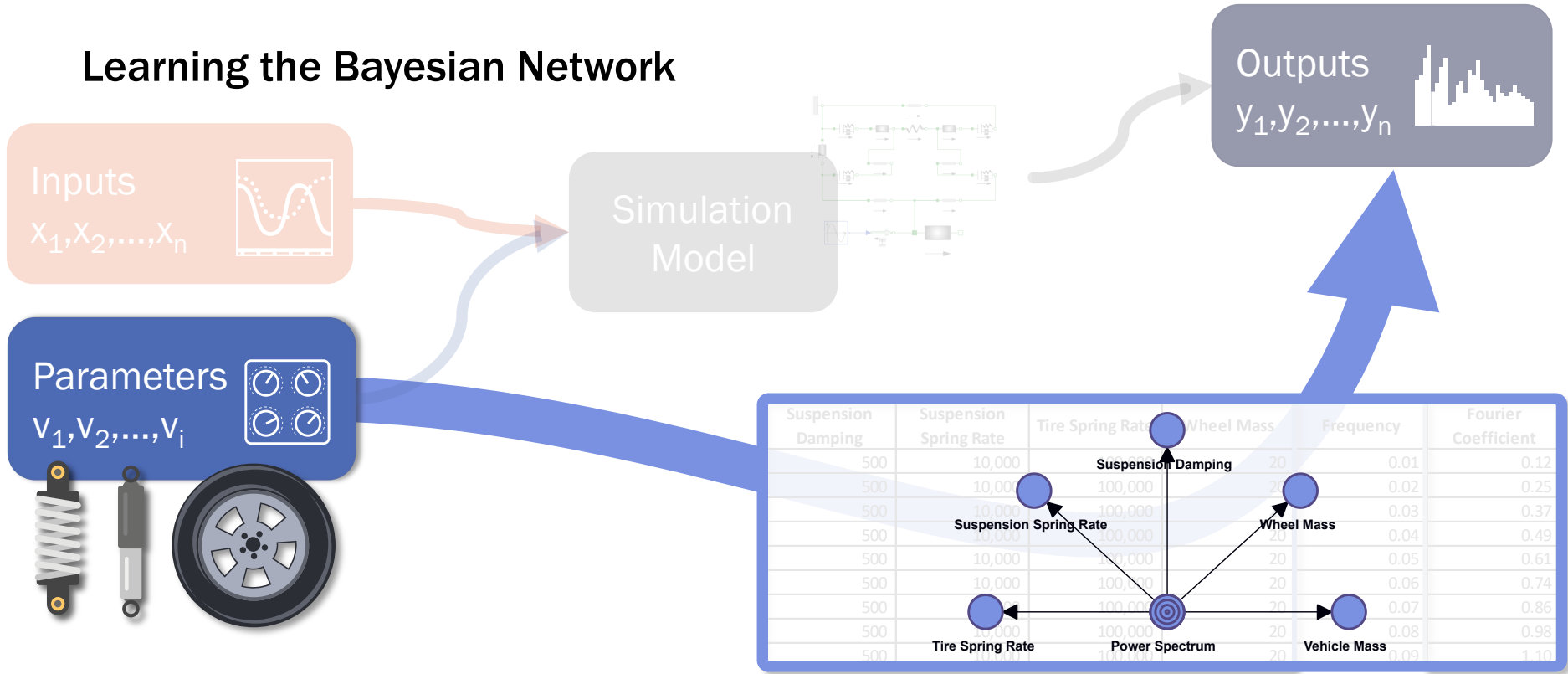
Why not run one billion simulations?

- Querying billions of records quickly is a challenge in and of itself.
- And, we are not looking for a single optimal value, rather we are looking for a distribution of frequencies.



Bayesian Network Model

Learning the Bayesian Network



Bayesian Networks

Conceptual Advantages

- Frequency distribution is a single variable
- Visualization of relationships
- Easy sensitivity analysis
- Simulation of intermediate values
- Simulation of uncertain inputs, i.e., distributions for masses, rates, etc.
- Multiple inputs and multiple outputs
- Representation of nonlinearities
- Mix of categorical and numerical parameters
- Optimization under uncertainty
- Ability to introduce domain knowledge



Data Import

Data Import - C:\Users\StefanConrad\OneDrive - Bayesia USA\Studies\Suspension\SimData12d.csv

Define Data Structure

Separators: Tab Semicolon Comma Space Other

Encoding: UTF-8

Options: Title Line End of Line Character as a Unique One Consider Identical Consecutive separators as a Unique One Consider Different Consecutive Separators as a Unique One Double Quotes Remove as String Delimiters Simple Quotes Remove as String Delimiters Transpose

Missing Values: N/R, NR, NC (Add, Remove)

Filtered Values: VF, FV, N/A (Add, Remove)

Sampling: Define Sample

Learning/Test: Define Learning/Test Sets

Power	Suspension Damping	Suspension Spring Rate	Tire Spring Rate	Wheel Mass	Vehicle Mass	Frequency
0.02179998...	1000.0	5000.0	100000.0	20.0	450.0	0.01
0.08754585...	1000.0	5000.0	100000.0	20.0	450.0	0.02
0.19649542...	1000.0	5000.0	100000.0	20.0	450.0	0.03
0.35105497...	1000.0	5000.0	100000.0	20.0	450.0	0.04
0.54784967...	1000.0	5000.0	100000.0	20.0	450.0	0.05
0.79403262...	1000.0	5000.0	100000.0	20.0	450.0	0.06000000...
1.08146026...	1000.0	5000.0	100000.0	20.0	450.0	0.06999999...
1.42486677...	1000.0	5000.0	100000.0	20.0	450.0	0.08
1.80908483...	1000.0	5000.0	100000.0	20.0	450.0	0.09
2.25928179...	1000.0	5000.0	100000.0	20.0	450.0	0.09999999...
2.75061806...	1000.0	5000.0	100000.0	20.0	450.0	0.11
3.32143904...	1000.0	5000.0	100000.0	20.0	450.0	0.12
3.93391777...	1000.0	5000.0	100000.0	20.0	450.0	0.13

Cancel Previous Next Save Finish



Variable Definition

Data Import - C:\Users\StefanConrad\OneDrive - Bayesia USA\Studies\Suspension\SimData12d.csv

Define Variable Type

Type

Not Distributed

Discrete

Weight

Row Identifier

Action

Columns with Missing Values

All not Distributed

All Discrete

All Continuous

Information

Number of Rows	1444896	100.00%
Not Distributed	0	0.00%
Discrete	5	71.43%
Continuous	1	14.29%
Others	1	14.29%
Missing Values	4925	0.05%
Filtered Values	0	0.00%

Data

Power	Suspension Damping	Suspension Spring Rate	Tire Spring Rate	Wheel Mass	Vehicle Mass	Frequency
0.00179...	1000.0	5000.0	100000.0	20.0	450.0	0.01
0.08754...	1000.0	5000.0	100000.0	20.0	450.0	0.02
0.19649...	1000.0	5000.0	100000.0	20.0	450.0	0.03
0.35105...	1000.0	5000.0	100000.0	20.0	450.0	0.04
0.54784...	1000.0	5000.0	100000.0	20.0	450.0	0.05
0.79403...	1000.0	5000.0	100000.0	20.0	450.0	0.06000000...
1.08146...	1000.0	5000.0	100000.0	20.0	450.0	0.06999999...
1.42486...	1000.0	5000.0	100000.0	20.0	450.0	0.08
1.80908...	1000.0	5000.0	100000.0	20.0	450.0	0.09
2.25928...	1000.0	5000.0	100000.0	20.0	450.0	0.09999999...
2.75061...	1000.0	5000.0	100000.0	20.0	450.0	0.11
3.32143...	1000.0	5000.0	100000.0	20.0	450.0	0.12
3.93391...	1000.0	5000.0	100000.0	20.0	450.0	0.13
4.64210...	1000.0	5000.0	100000.0	20.0	450.0	0.14
5.39096...	1000.0	5000.0	100000.0	20.0	450.0	0.15000000...

Buttons: Cancel Previous Next Save Finish

Power used a observation weight.

Variables with Discrete States

Frequency: Continuous Variable



Missing Values Processing (n/a)

Data Import - C:\Users\StefanConrad\OneDrive - Bayesia USA\Studies\Suspension\SimData12d.csv

Data Selection and Filtering

Missing Value Processing

Filter

OR

AND

Replace by : 1.0

Value

Mean/Modal

Infer

Static Imputation

Dynamic Imputation

Structural EM

Entropy-Based Static Imputation

Entropy-Based Dynamic Imputation

Information

Number of Rows	1444896	100.00%
Not Distributed	0	0.00%
Discrete	5	71.43%
Continuous	1	14.29%
Others	1	14.29%
Missing Values	0	0.00%
Filtered Values	0	0.00%

Select Values

OR

AND

Delete Selections

Display Selections

Data

Power	Suspe...	Suspe...	Tire Sp...	Wheel ...	Vehicle...	Frequ...
3.02179998...	1000.0	5000.0	100000.0	20.0	450.0	0.01
3.08754585...	1000.0	5000.0	100000.0	20.0	450.0	0.02
3.19649542...	1000.0	5000.0	100000.0	20.0	450.0	0.03
3.35105497...	1000.0	5000.0	100000.0	20.0	450.0	0.04
3.54784967...	1000.0	5000.0	100000.0	20.0	450.0	0.05
3.79403262...	1000.0	5000.0	100000.0	20.0	450.0	0.06000000...

Select All Continuous

Select All Discrete

Cancel Previous Next Save Finish

No missing values



Discretization

Data Import - C:\Users\StefanConrad\OneDrive - Bayesia USA\Studies\Suspension\SimData12d.csv

Discretization and Aggregation

Discretization

Type:

Maximum:

Minimum:

Threshold Value:

Create a class for each type of discretization

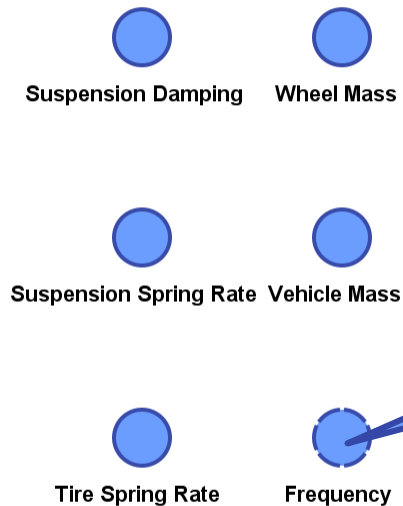
Data

Power	Suspensio...	Suspensio...	Tire Spring...	Wheel Mass	Vehicle Mass	Frequency
0.02179998...	1000.0	5000.0	100000.0	20.0	450.0	0.01
0.08754585...	1000.0	5000.0	100000.0	20.0	450.0	0.02
0.19649542...	1000.0	5000.0	100000.0	20.0	450.0	0.03
0.35105497...	1000.0	5000.0	100000.0	20.0	450.0	0.04
0.54784967...	1000.0	5000.0	100000.0	20.0	450.0	0.05

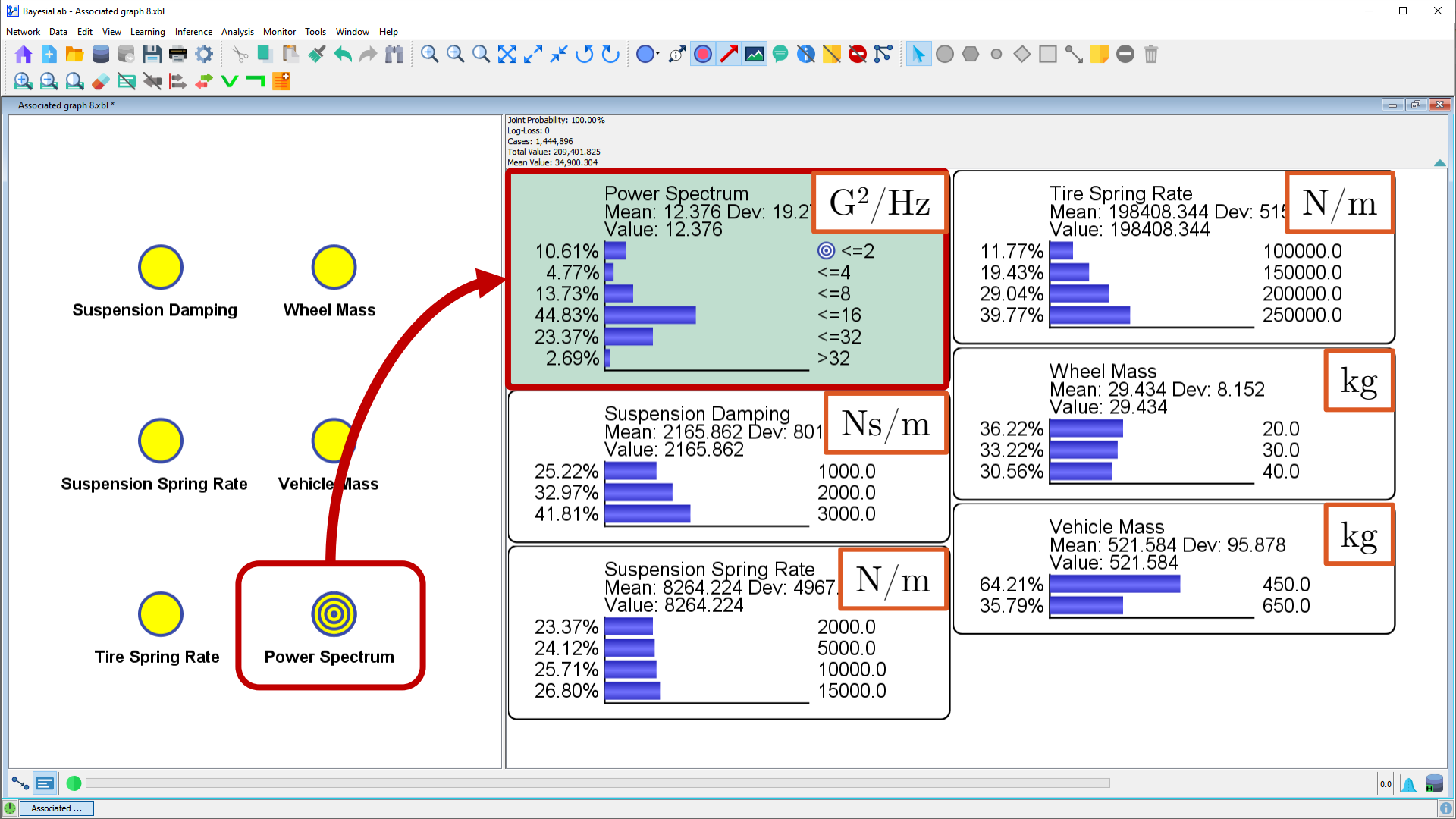
Manual Discretization
in Octave Intervals



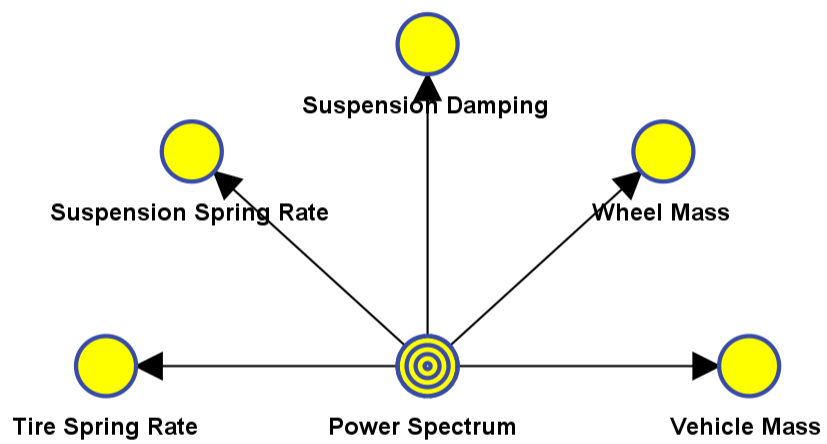
Unconnected Network



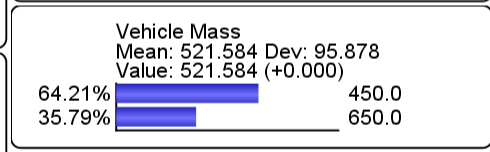
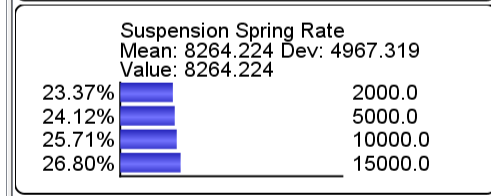
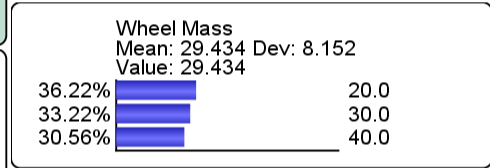
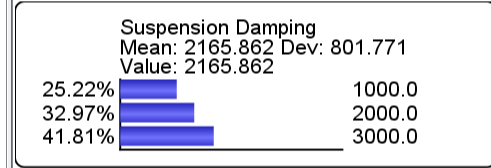
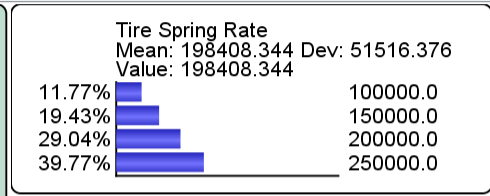
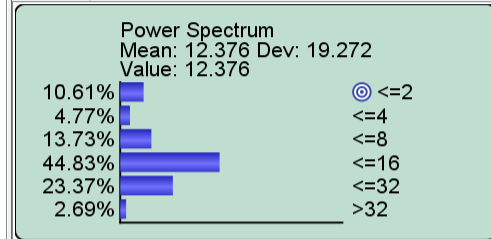
The frequencies, weighted by the squared magnitude, and binned, can be interpreted as the Power Spectrum.

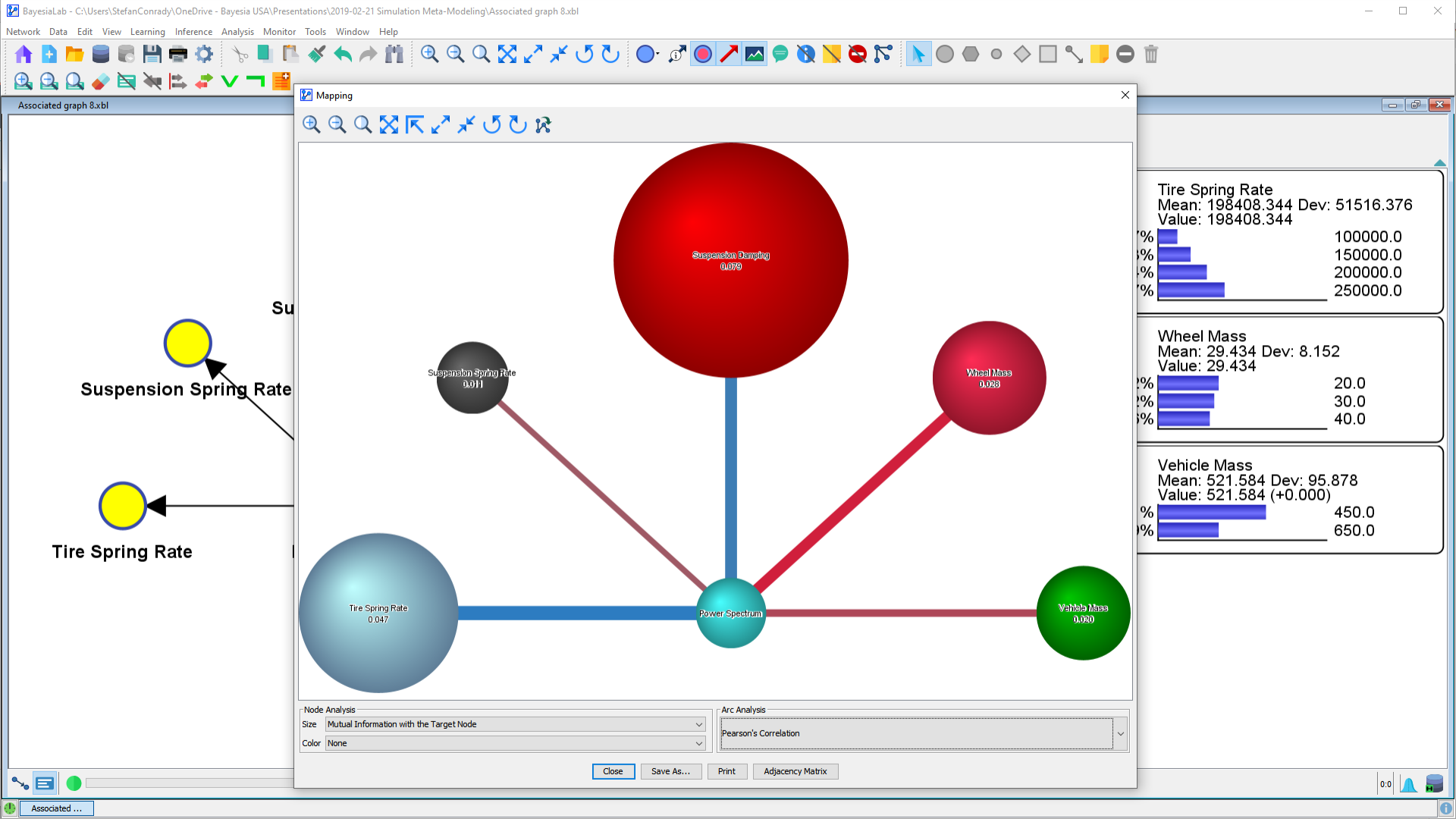


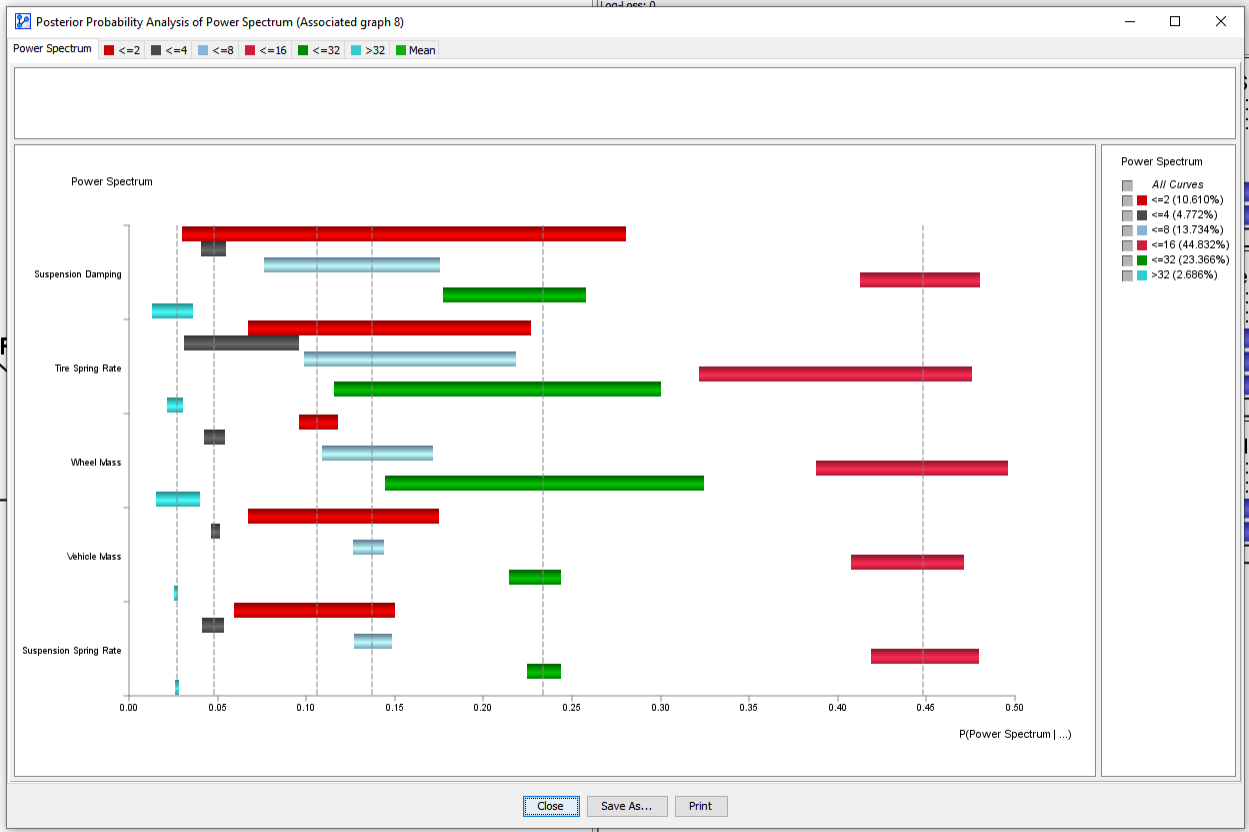
Naïve Bayes Network



Joint Probability: 100.00%
 Log-Loss: 0
 Cases: 1,444,896
 Total Value: 209,401.825
 Mean Value: 34,900.304







Suspension Spring Rate

Tire Spring Rate

Spring Rate
: 198408.344 Dev: 51516.376
: 198408.344

100000.0
150000.0
200000.0
250000.0

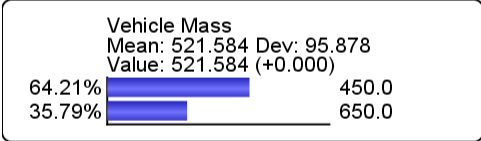
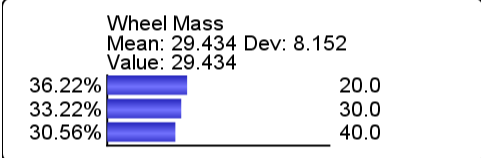
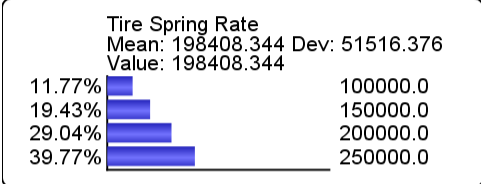
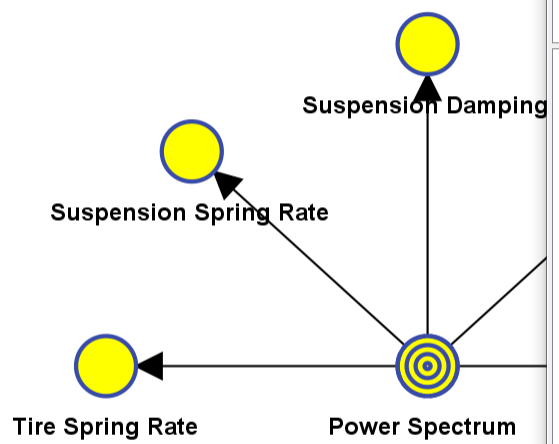
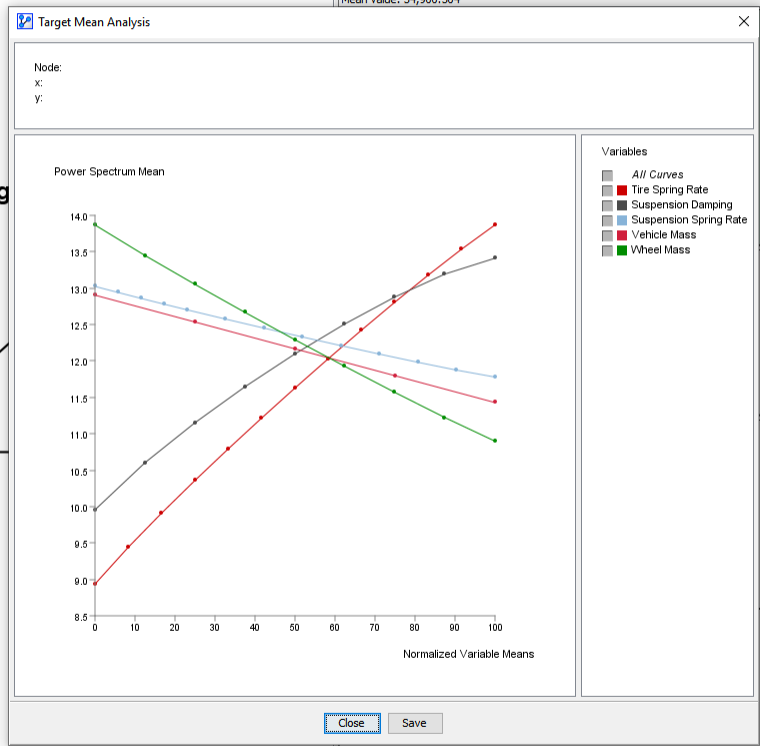
Mass
: 29.434 Dev: 8.152
: 29.434

20.0
30.0
40.0

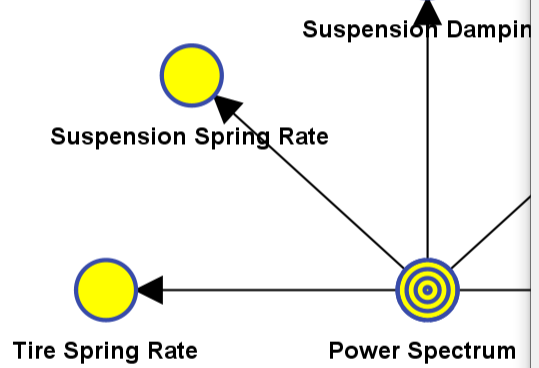
le Mass
: 521.584 Dev: 95.878
: 521.584 (+0.000)

450.0
650.0

Joint Probability: 100.00%
 Log-Loss: 0
 Cases: 1,444,896
 Total Value: 209,401.825
 Mean Value: 34,900.304



Objective: Minimize Power Spectrum ≤ 2 Hz



Joint Probability: 100.00%
 Log-Loss: 0
 Cases: 1,444,896

Target Optimization

Profile Search Criterion

- Probability State ≤ 2
- Mean

Criterion Optimization

- Maximization
- Minimization
- Target Value

Probability: 0.106

Take Into Account the Joint Probability

Weighting

Target Value: 1

Joint Probability: 1

Search Method

- Hard Evidence
- Numerical Evidence Proportional to:
 - Mean
 - Domain
 - Progression Margins

Distribution Estimation Method:

- MinXEnt
- Binary
- Value Shift

Intermediate Points: 100

Direct Effects

Genetic Settings

Number of Kingdoms: 5

Population Size: 10

Crossover Rate (%): 10

Gene Mutation Rate (%): 25

Selection Rate (%): 50

Fixed Seed: 31

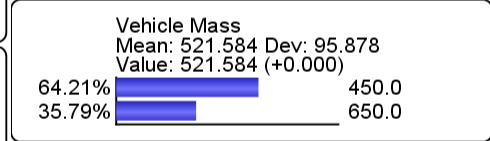
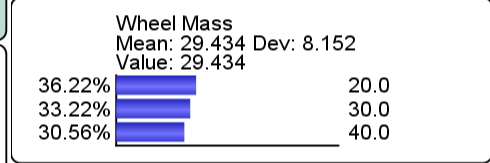
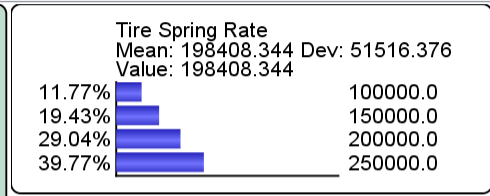
Genetic Stop Criterion

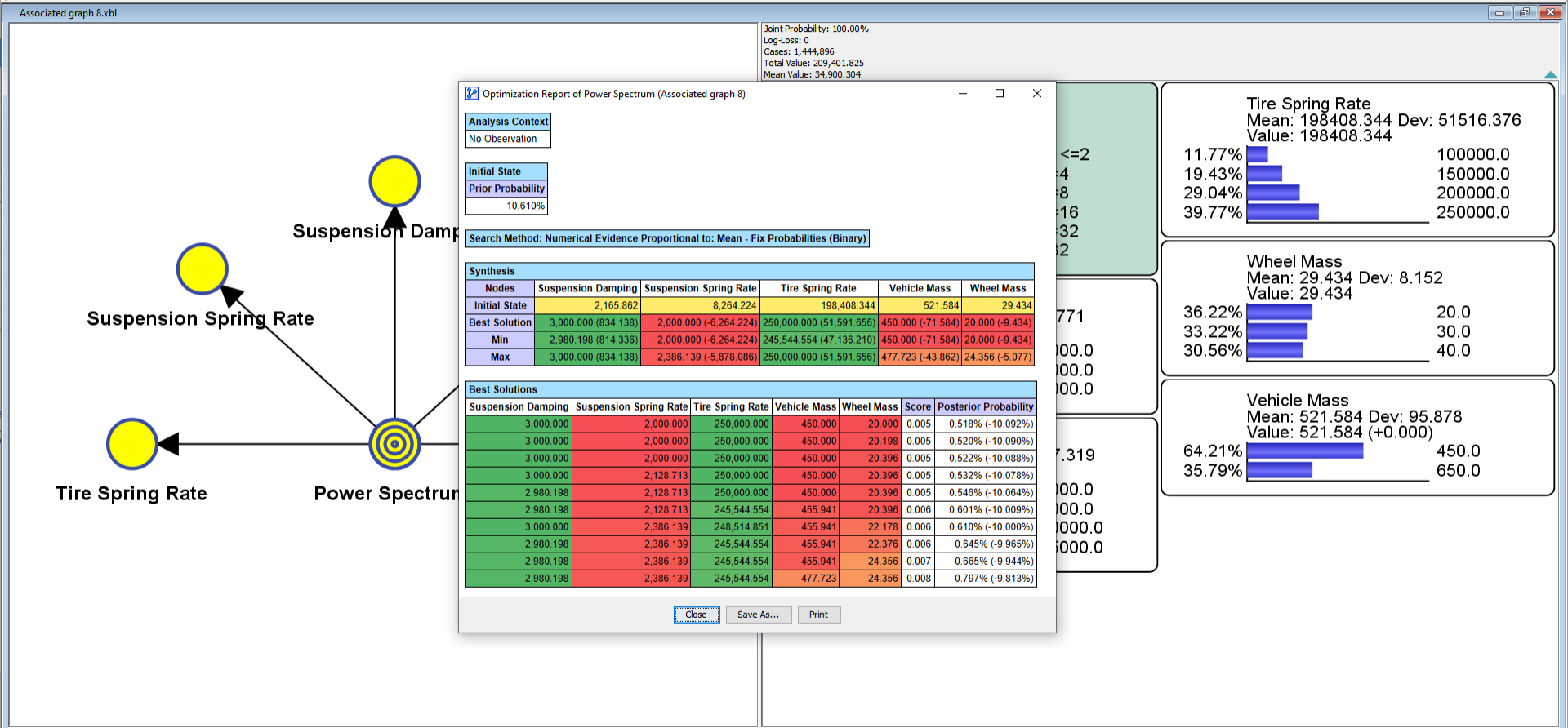
- Consecutive Number of Generations Without Improvement: 5
- For Each Kingdom
- Across all Kingdoms

Output

- Store the n Best Solutions in Evidence Scenarios: 10
- Store All the Solutions in Evidence Scenarios

Save All Generated Solutions:





Joint Probability: 100.00%
 Log-Loss: 0
 Cases: 1,444,896
 Total Value: 209,401.825
 Mean Value: 34,900.304

Optimization Report of Power Spectrum (Associated graph 8)

Analysis Context
No Observation

Initial State
Prior Probability
10.610%

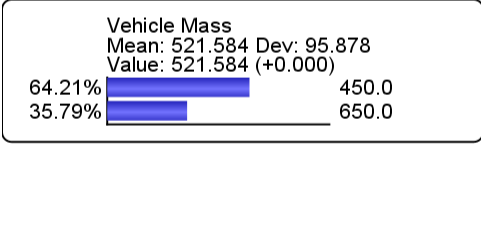
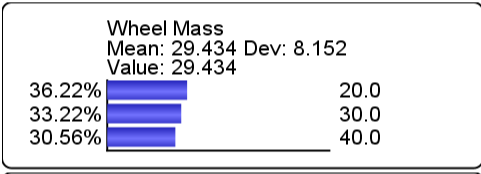
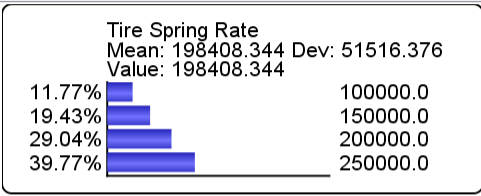
Search Method: Numerical Evidence Proportional to: Mean - Fix Probabilities (Binary)

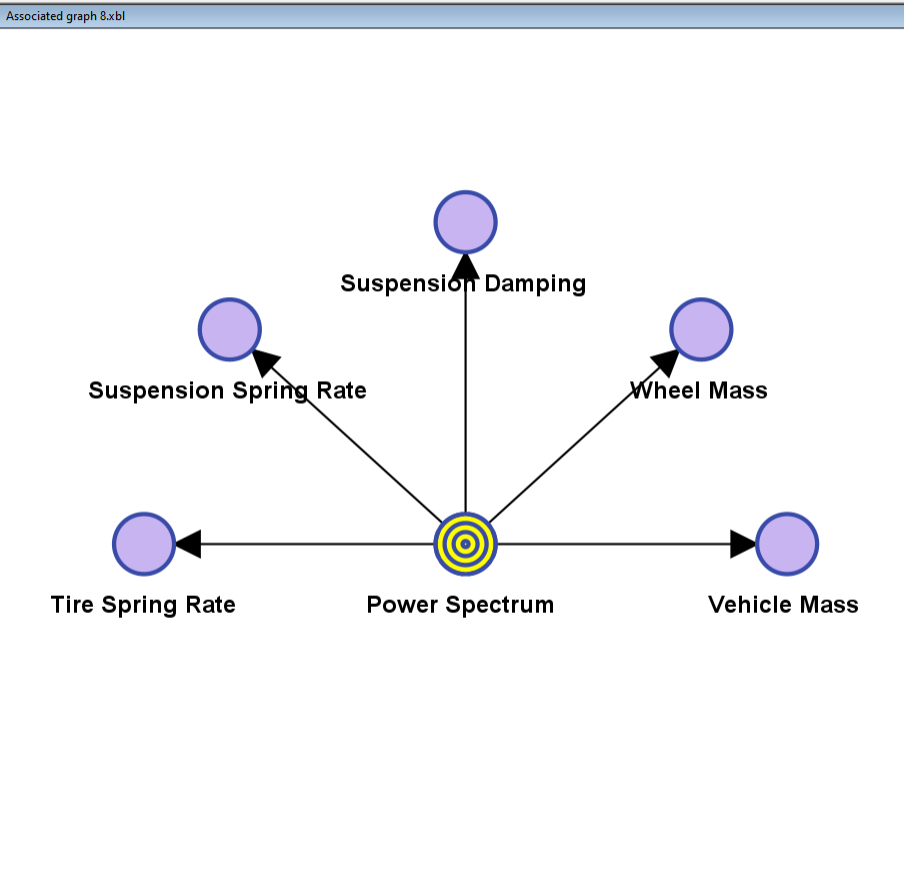
Synthesis						
Nodes	Suspension Damping	Suspension Spring Rate	Tire Spring Rate	Vehicle Mass	Wheel Mass	
Initial State	2,165.862	8,264.224	198,408.344	521.584	29.434	
Best Solution	3,000.000 (834.138)	2,000.000 (-6,264.224)	250,000.000 (51,591.656)	450.000 (-71.584)	20,000 (-9.434)	
Min	2,980.198 (814.336)	2,000.000 (-6,264.224)	245,544.554 (47,136.210)	450.000 (-71.584)	20,000 (-9.434)	
Max	3,000.000 (834.138)	2,386.139 (-5,878.086)	250,000.000 (51,591.656)	477.723 (-43.862)	24.356 (-5.077)	

Best Solutions						
Suspension Damping	Suspension Spring Rate	Tire Spring Rate	Vehicle Mass	Wheel Mass	Score	Posterior Probability
3,000.000	2,000.000	250,000.000	450.000	20.000	0.005	0.518% (-10.092%)
3,000.000	2,000.000	250,000.000	450.000	20.198	0.005	0.520% (-10.090%)
3,000.000	2,000.000	250,000.000	450.000	20.396	0.005	0.522% (-10.088%)
3,000.000	2,128.713	250,000.000	450.000	20.396	0.005	0.532% (-10.078%)
2,980.198	2,128.713	250,000.000	450.000	20.396	0.005	0.546% (-10.064%)
2,980.198	2,128.713	245,544.554	455.941	20.396	0.006	0.601% (-10.009%)
3,000.000	2,386.139	248,514.851	455.941	22.178	0.006	0.610% (-10.000%)
2,980.198	2,386.139	245,544.554	455.941	22.376	0.006	0.645% (-9.965%)
2,980.198	2,386.139	245,544.554	455.941	24.356	0.007	0.665% (-9.944%)
2,980.198	2,386.139	245,544.554	477.723	24.356	0.008	0.797% (-9.813%)

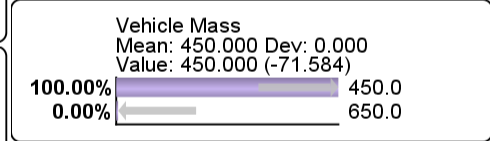
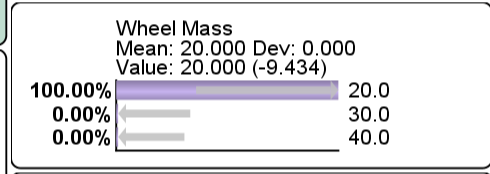
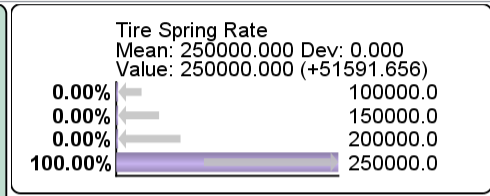
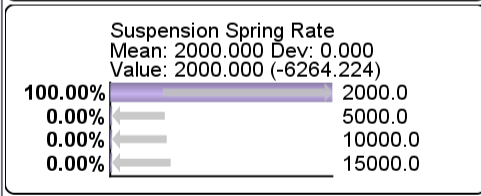
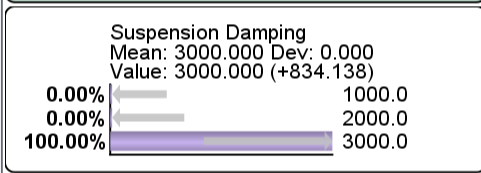
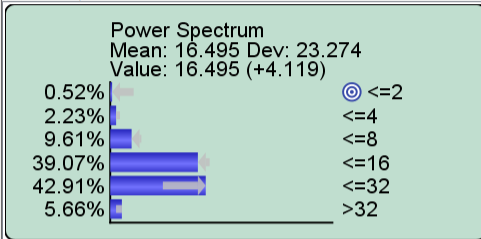
Buttons: Close, Save As..., Print

<=2
 4
 8
 16
 32
 62
 771
 000.0
 000.0
 000.0
 7.319
 000.0
 000.0
 000.0



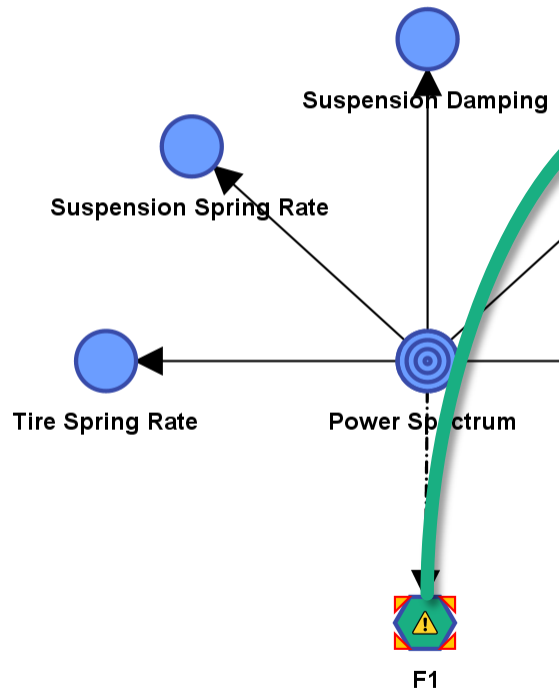


Joint Probability: 1.06%
 Log-Loss: 6.56
 Cases: 15,283.15
 Total Value: 255,486.495
 Mean Value: 42,581.083



Saved Scenario from Optimization

Introducing a Function Node



?F1?=
Entropy(?Power Spectrum?)

Node Editor

Equation Properties Class Rendering Properties

PF1? =
Entropy(?Power Spectrum?)

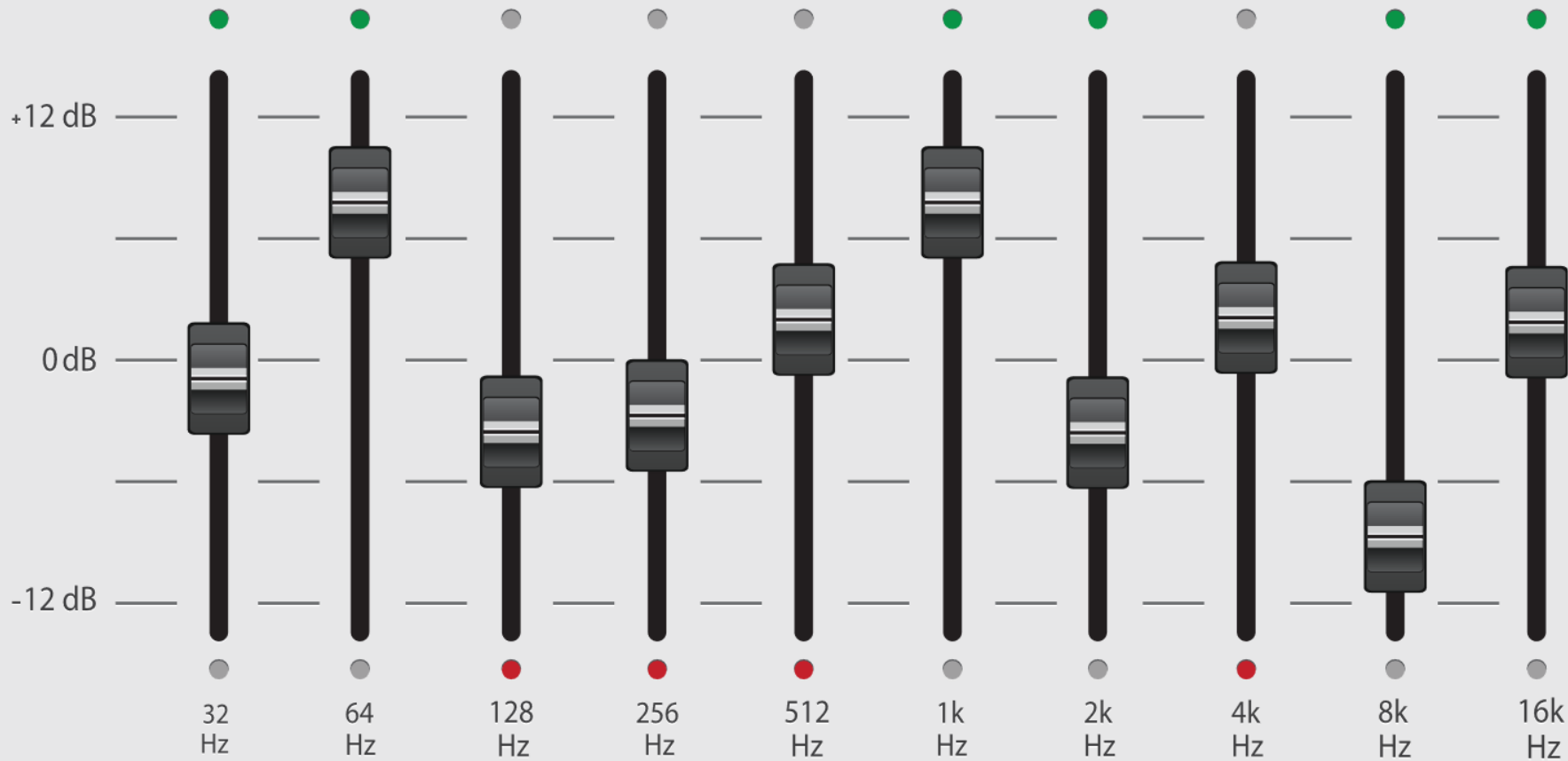
Current value successfully generated: 2.584962500721156

Samples: 1 Fixed Seed: 31

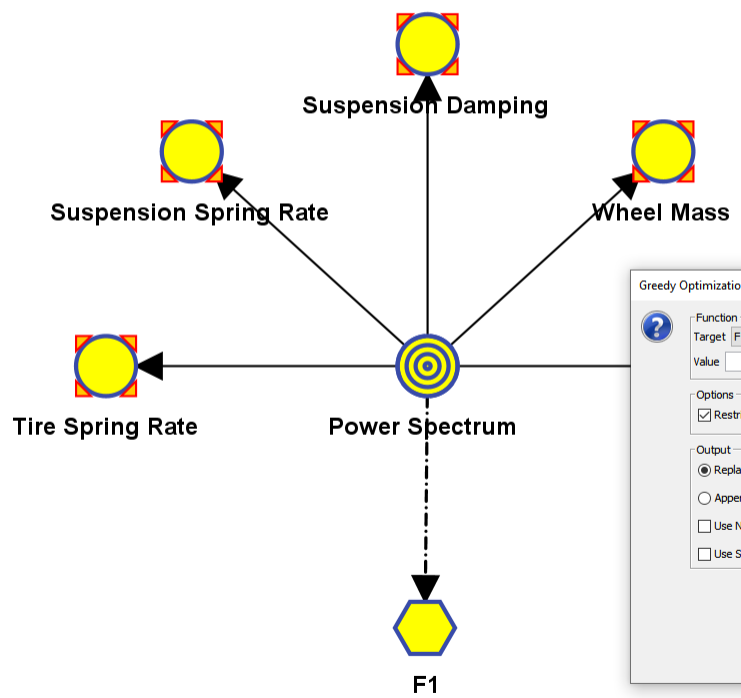
Inference Functions

- JointProb()
- OverallUtility()
- MeanValue(v)
- StdDev(v)
- Entropy(v, [n])
- MaxProbState(v)
- MaxProbIndex(v)
- StateProb(v, s)

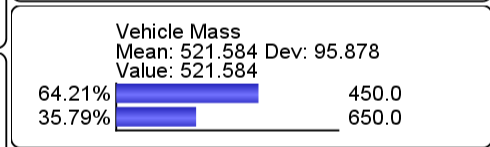
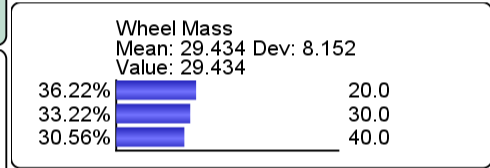
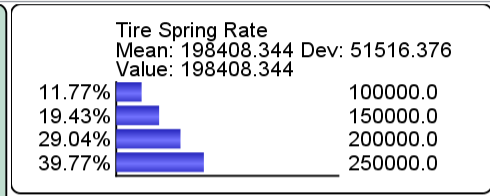
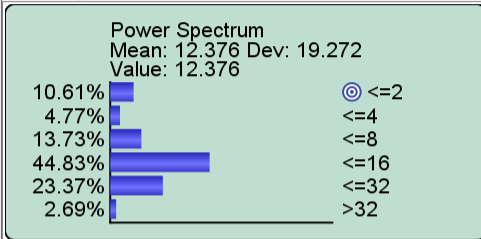
Power Spectrum Domain: [0.01, 50.17]



Maximizing the entropy to equalized the spectrum.



Joint Probability: 100.00%
 Log-Loss: 0
 Cases: 1,444,896
 Total Value: 209,401.825
 Mean Value: 34,900.304



F1
 2.0953790371

Greedy Optimization of Functions

Function: Target F1, Value 10

Options: Restrict Search to the Selected Nodes

Output: Replace Evidence Scenarios

Search Method: Hard Evidence, Numerical Evidence Proportional to: Mean, Domain, Progression Margins

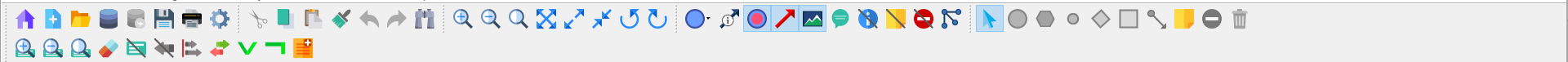
Distribution Estimation Method: Fix Means, MinXEnt, Binary

Fix Probabilities, MinXEnt, Binary, Value Shift

Intermediate Points: 100

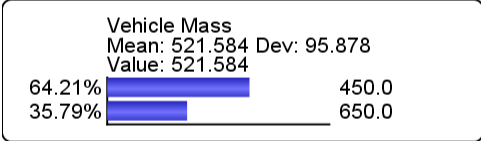
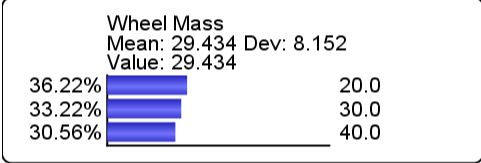
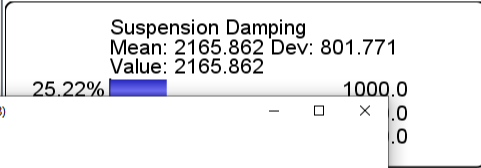
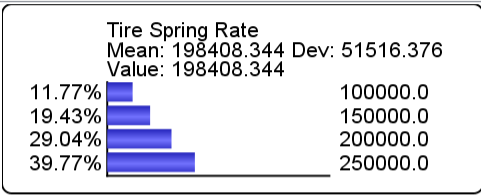
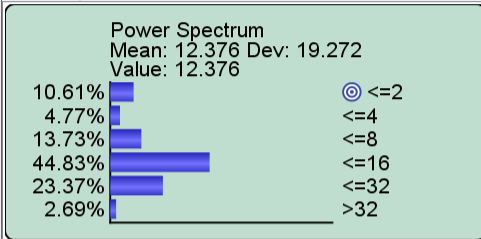
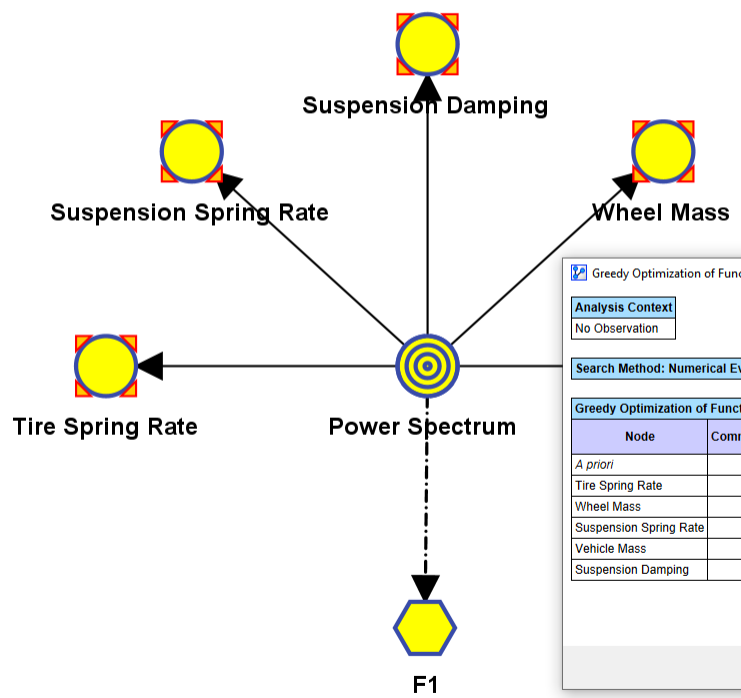
Search Stop Criteria: Maximum Size of Evidence: 3, Minimum Joint Probability: 10, Use the Automatic Stop Criterion

Buttons: OK, Cancel



Associated graph 8.xbl *

Joint Probability: 100.00%
 Log-Loss: 0
 Cases: 1,444,896
 Total Value: 209,401.825
 Mean Value: 34,900.304



Greedy Optimization of Functions (Associated graph 8)

Analysis Context
 No Observation

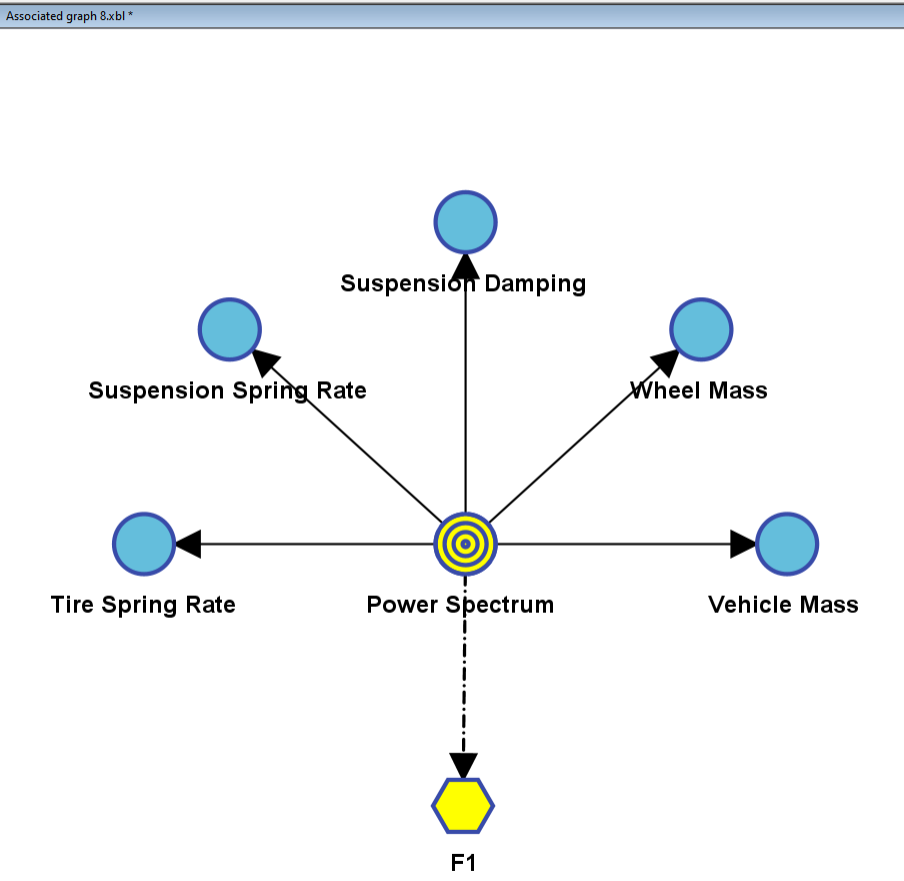
Search Method: Numerical Evidence Proportional to: Mean - Fix Mean (Binary)

Greedy Optimization of Functions: F1

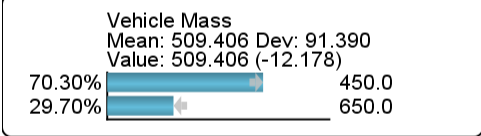
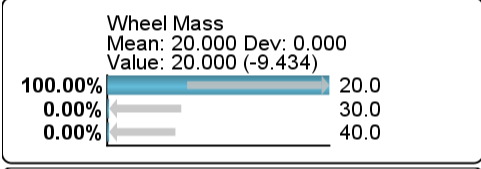
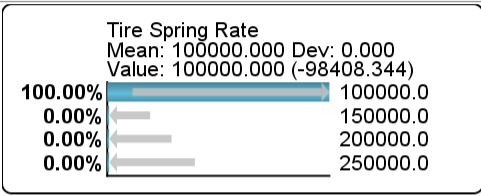
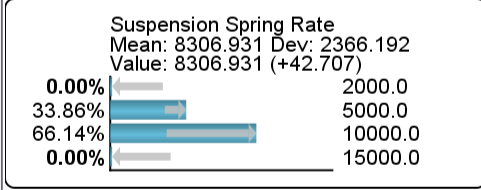
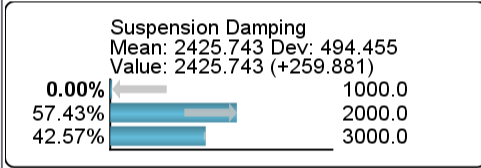
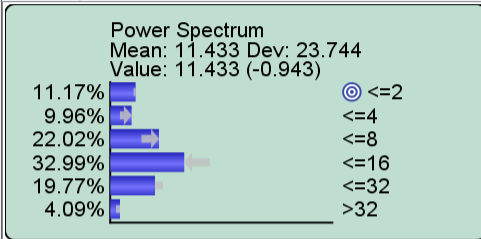
Node	Comment	Prior Value/Mean	Value/Mean at T	Posterior Value/Mean	Function Value	Joint Probability
<i>A priori</i>					2.095	100.000%
Tire Spring Rate		198,408.344	198,408.344	100.000.000	2.294	11.765%
Wheel Mass		29.434	29.897	20.000	2.369	3.982%
Suspension Spring Rate		8,264.224	8,506.708	8,306.931	2.370	1.588%
Vehicle Mass		521.584	528.477	509.406	2.371	1.369%
Suspension Damping		2,165.862	2,102.700	2,425.743	2.344	0.759%

Close Save As... Print Save Scenario

F1
 2.0953790371



Joint Probability: 0.76%
 Log-Loss: 7.04
 Cases: 10,969.06
 Total Value: 111,273.513
 Mean Value: 18,545.585

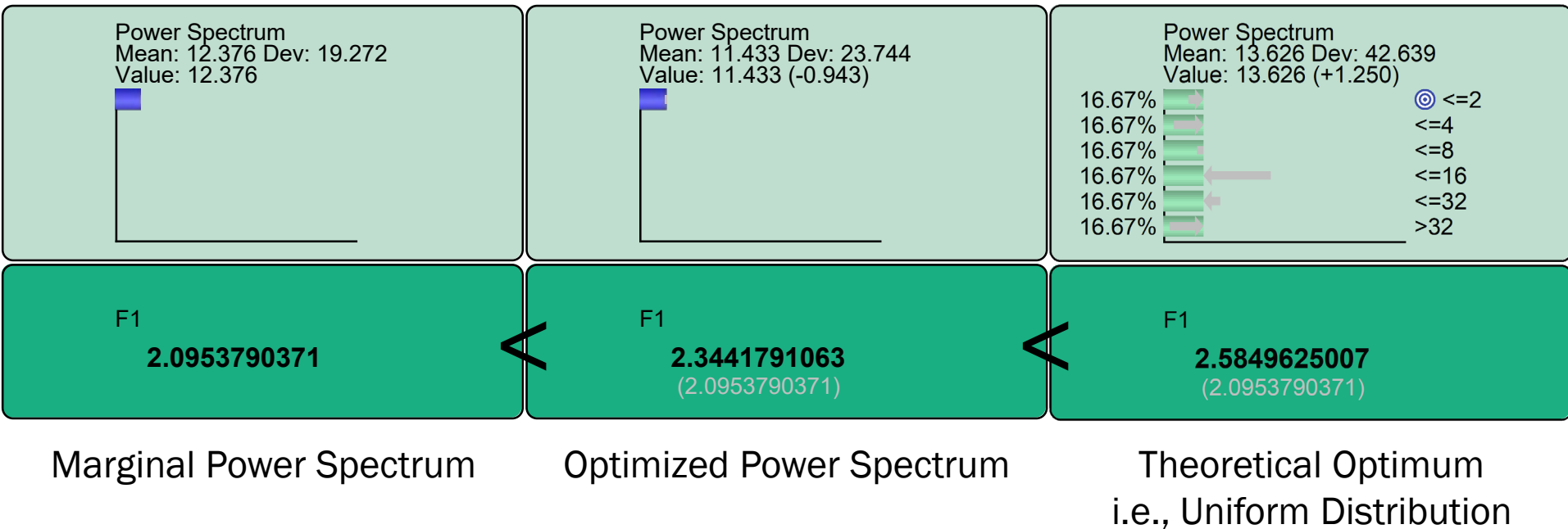


F1
2.3441791063
 (2.0953790371)

Saved Scenario from Optimization

Bayesian Network Simulation

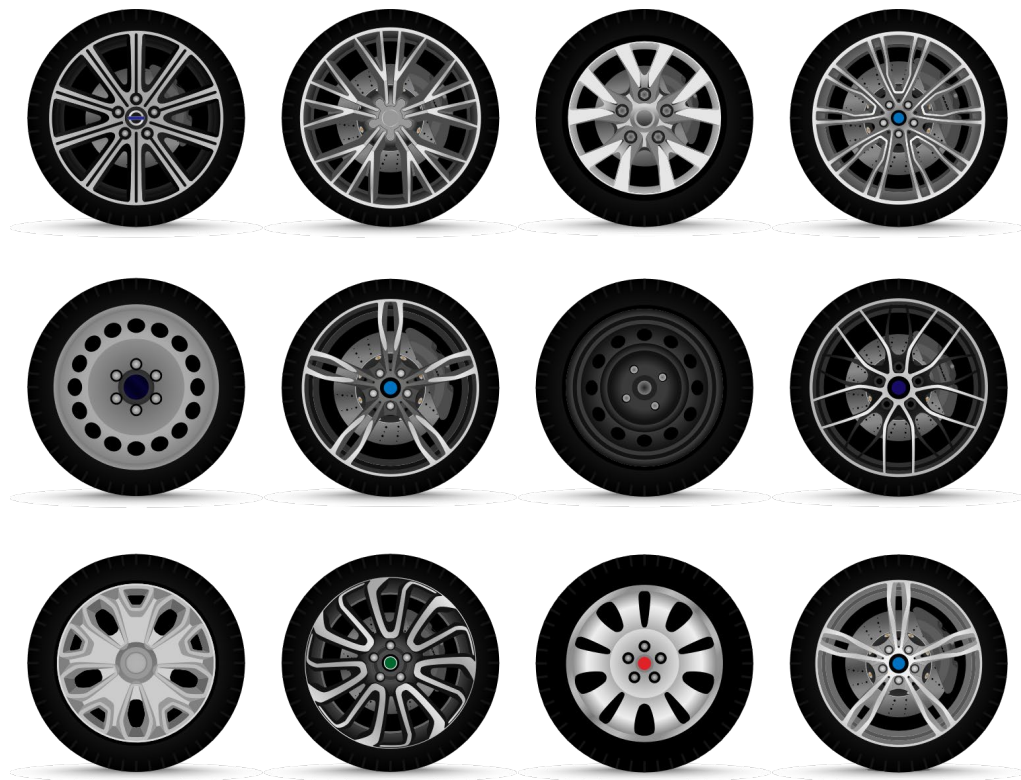
Using Entropy for “Equalization”



Bayesian Network Model

Why Not a Neural Network?

- OK for response surface modeling.
- However, it would be a uninterpretable black box.
- No way to introduce domain knowledge!



Introducing Domain Knowledge

Tire Diameter

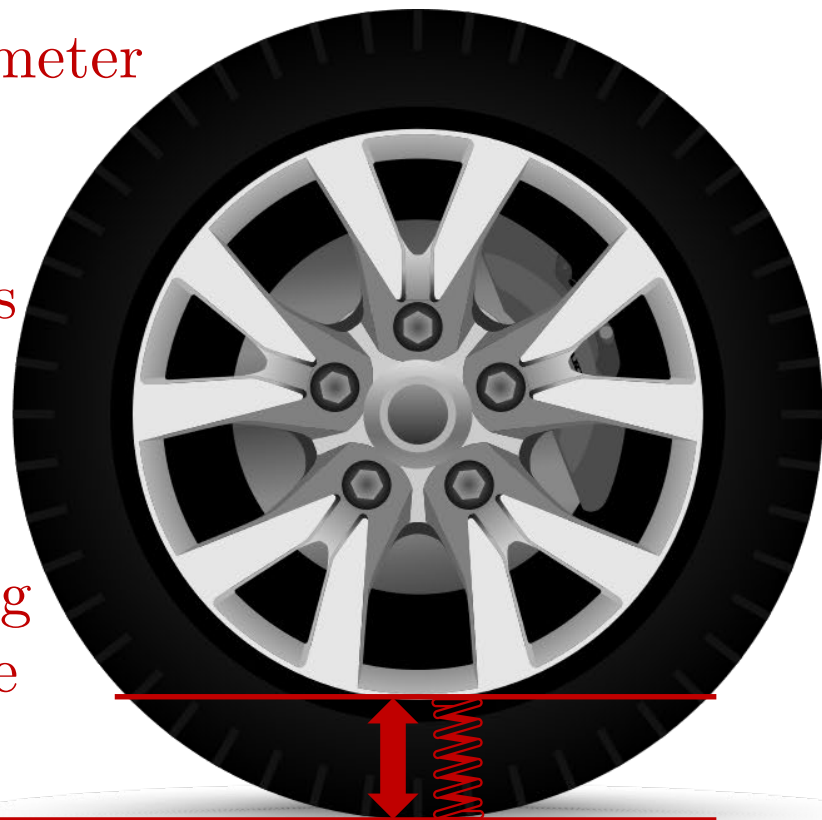
=

Mass

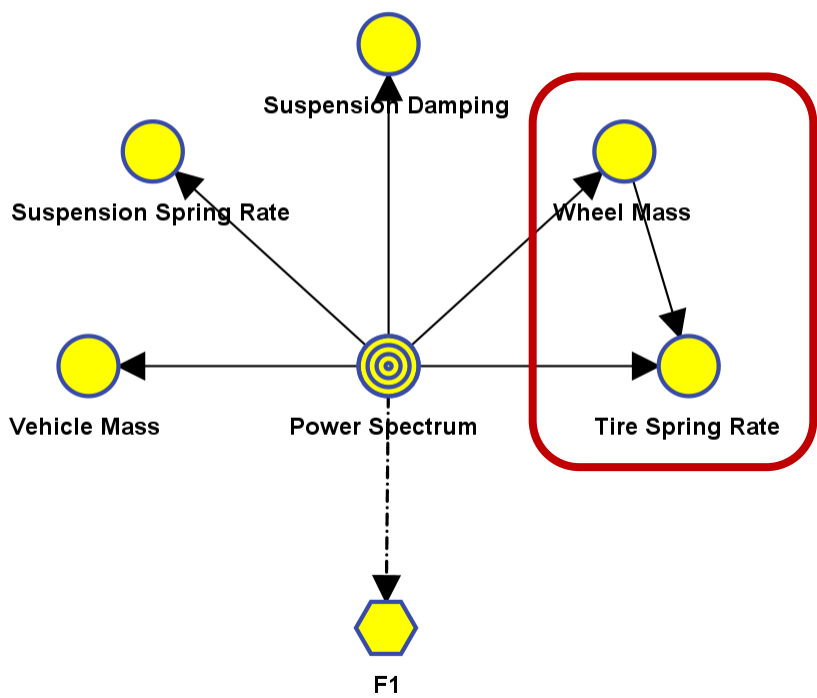
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Spring
Rate

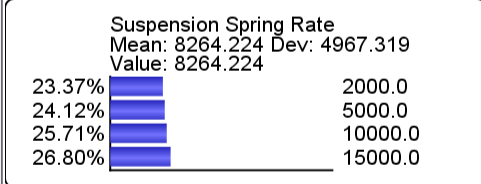
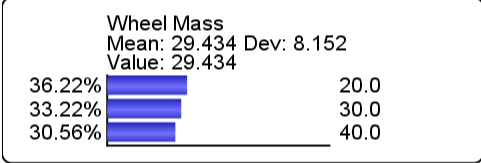
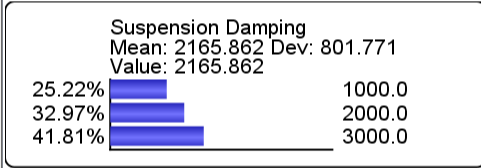
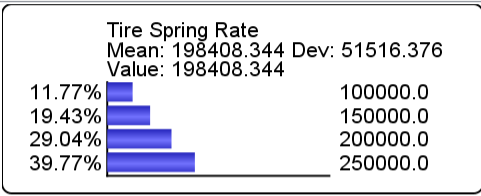
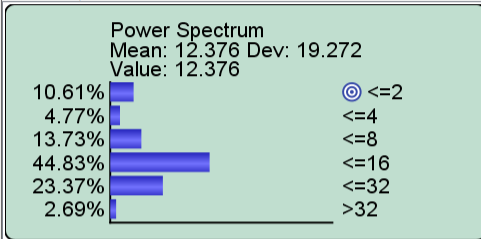
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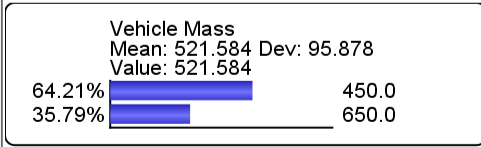
Introducing Domain Knowledge

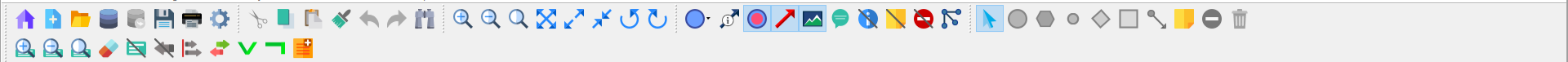


Joint Probability: 100.00%
 Log-Loss: 0
 Cases: 1,444,896
 Total Value: 209,401.825
 Mean Value: 34,900.304

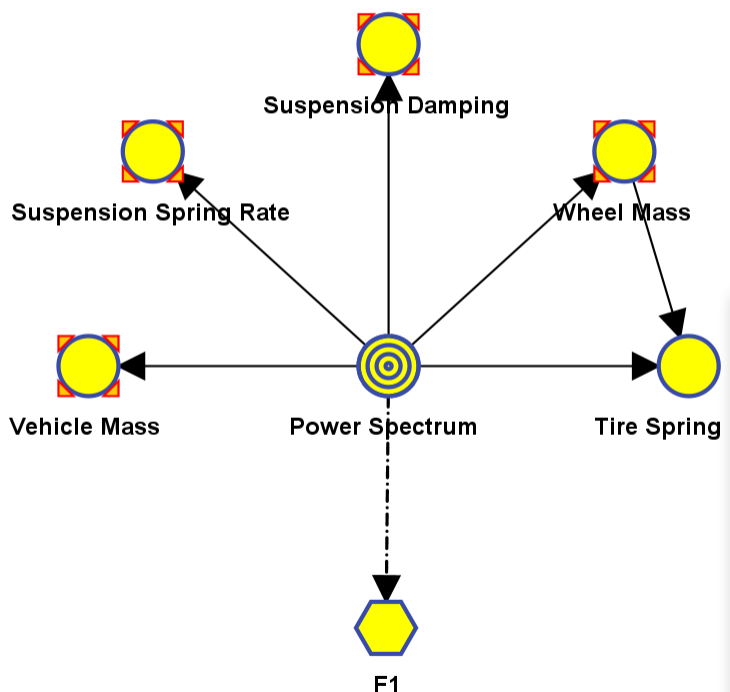


F1
2.0953790371

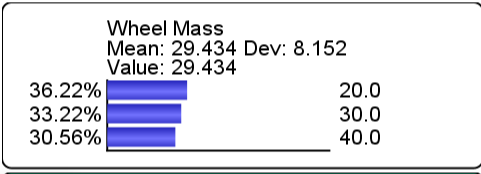
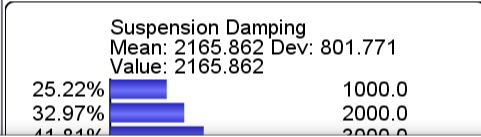
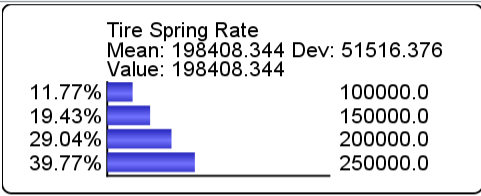
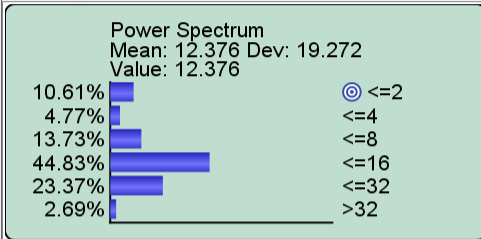




Associated graph 8b.xbl*



Joint Probability: 100.00%
 Log-Loss: 0
 Cases: 1,444,896
 Total Value: 209,401.825
 Mean Value: 34,900.304



F1
2.0953790371

Greedy Optimization of Functions

Function: Target **F1**
 Value:

Options:
 Restrict Search to the Selected Nodes

Output:
 Replace Evidence Scenarios
 Append to Evidence Scenarios
 Use Node Long Name
 Use State Long Name

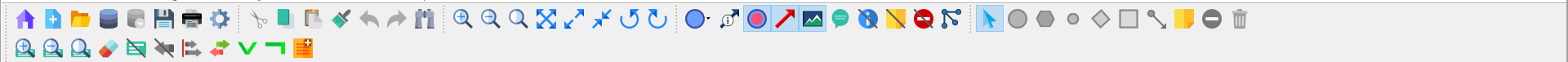
Search Method:
 Hard Evidence
 Numerical Evidence Proportional to:
 Mean Domain Progression Margins

Distribution Estimation Method:
 Fix Means MinXEnt Binary
 Fix Probabilities MinXEnt Binary Value Shift

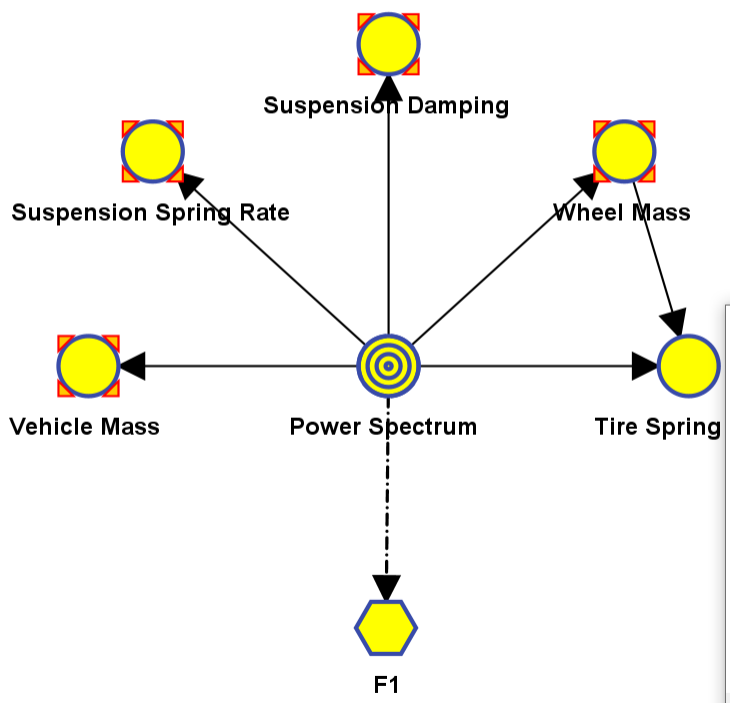
Intermediate Points:

Direct Effects

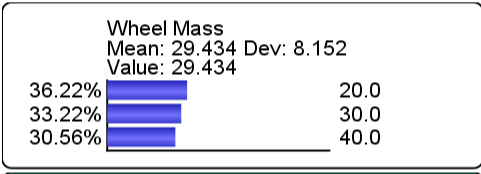
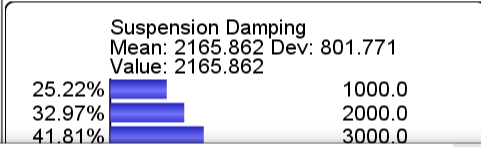
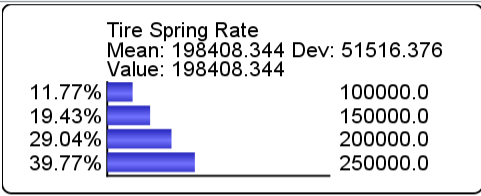
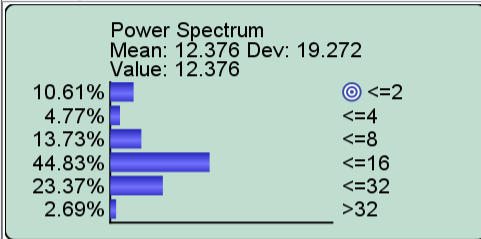
Search Stop Criteria:
 Maximum Size of Evidence:
 Minimum Joint Probability:
 Use the Automatic Stop Criterion



Associated graph 8b.xbl*



Joint Probability: 100.00%
 Log-Loss: 0
 Cases: 1,444,896
 Total Value: 209,401.825
 Mean Value: 34,900.304



Greedy Optimization of Functions: (Associated graph 8b)

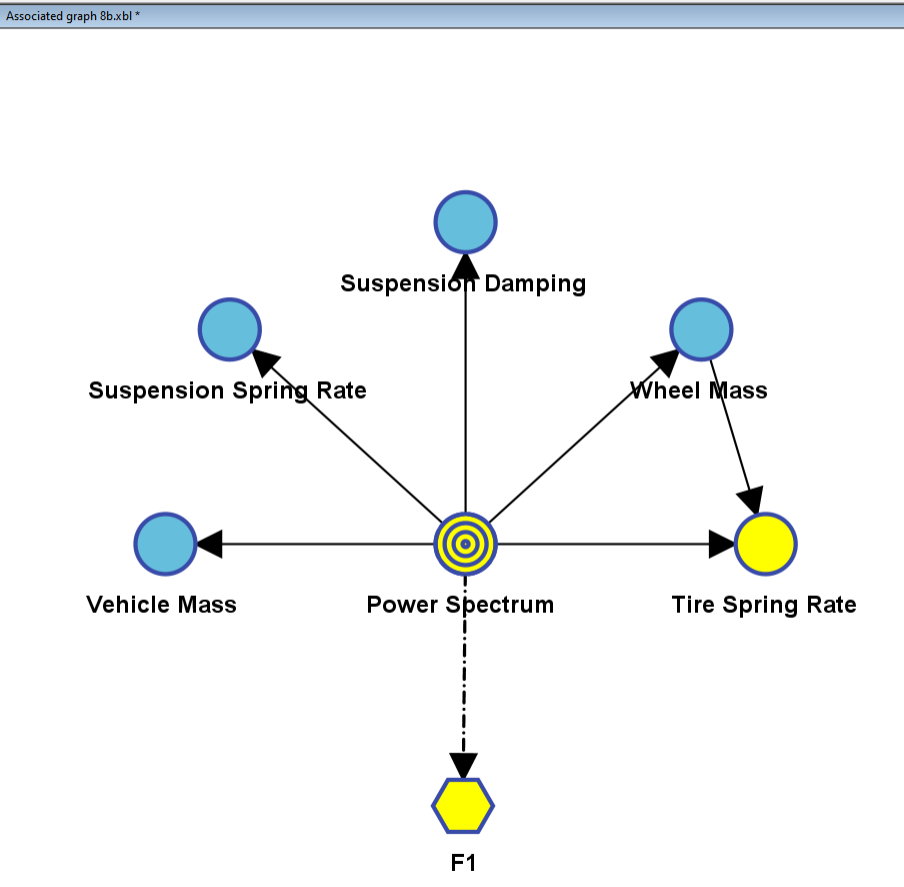
Analysis Context
 No Observation

Search Method: Numerical Evidence Proportional to: Mean - Fix Mean (Binary)

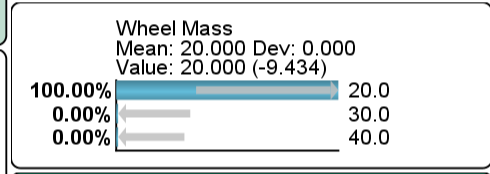
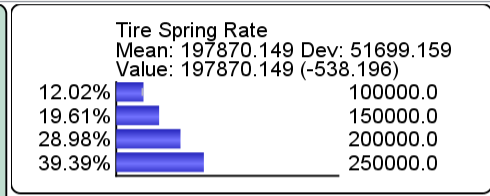
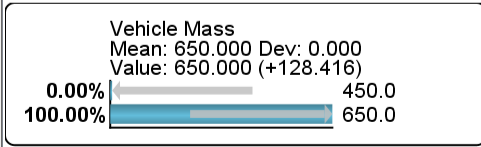
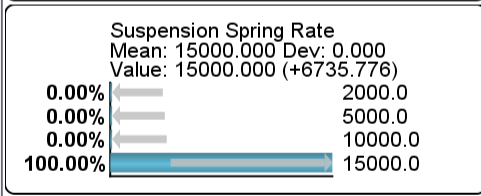
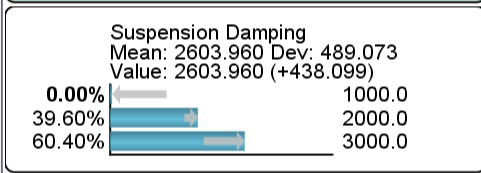
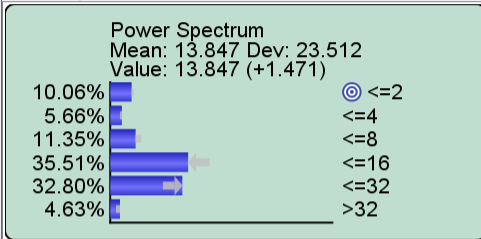
Greedy Optimization of Functions: F1						
Node	Comment	Prior Value/Mean	Value/Mean at T	Posterior Value/Mean	Function Value	Joint Probability
<i>A priori</i>					2.095	100.000%
Vehicle Mass		521.584	521.584	650.000	2.175	35.792%
Suspension Spring Rate		8,264.224	8,396.982	15,000.000	2.203	9.913%
Wheel Mass		29.434	29.527	20.000	2.223	3.545%
Suspension Damping		2,165.862	2,079.270	2,603.960	2.187	2.245%

Close Save As... Print Save Scenario

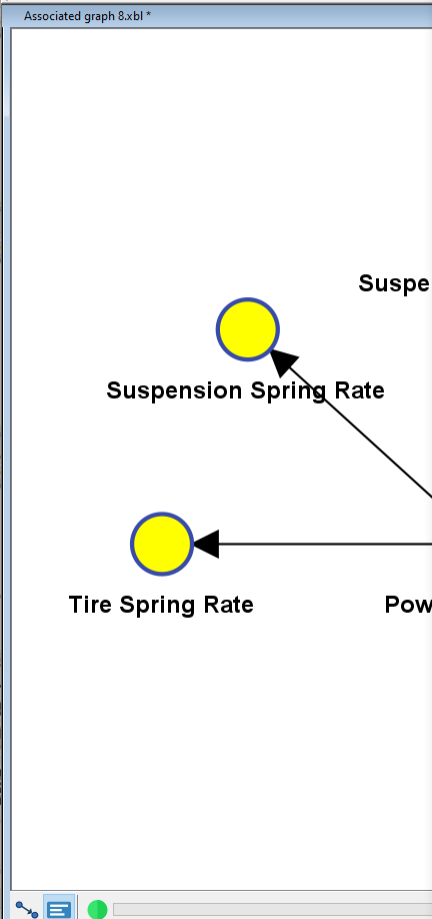
F1
 2.0953790371



Joint Probability: 2.24%
 Log-Loss: 5.48
 Cases: 32,435.59
 Total Value: 216,157.956
 Mean Value: 36,026.326



F1
2.1870928367
 (2.0953790371)



WebSimulator Editor

Available Nodes

- Suspension Damping
- Suspension Spring Rate
- Tire Spring Rate
- Wheel Mass
- Vehicle Mass
- Power Spectrum
- F1

Simulator Inputs Outputs

- Suspension Damping Mean
- Suspension Spring Rate Mean
- Tire Spring Rate Mean**
- Wheel Mass Mean
- Vehicle Mass Mean

Displayed Name: Tire Spring Rate (N/m)

Long Name: [button]

Input Type: Slider Text Both

Mean Mode: Binary MixEnt

Font Color: [button]

Component Image: [button]

Image Size: 225 [button]

Number Output Format: 123,457 [button]

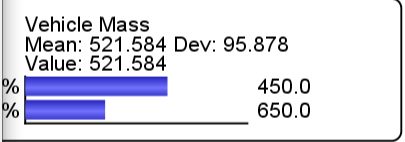
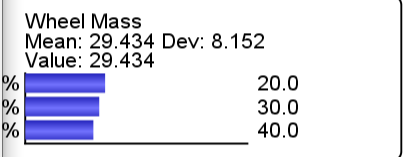
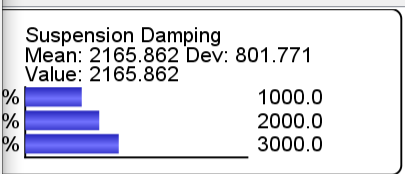
Paragraph 12 pt B I U

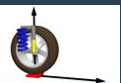
Description

Available Metrics

- Joint Probability
- Log Loss

OK Cancel Preview





Quarter Vehicle Simulator

Bayesia Simulator

Suspension Simul. ▾



Suspension Damping (Ns/m)



Mean



2,000

Observed

Suspension Spring Rate (N/m)



Mean



8,500

Observed

Tire Spring Rate (N/m)



Mean



175,000

Observed

Wheel Mass (kg)



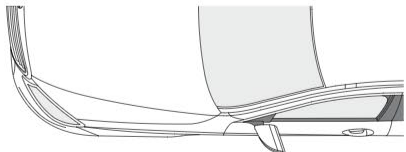
Mean



30

Observed

Quarter Vehicle Mass (kg)

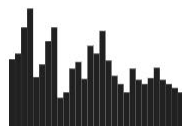


Mean



550

Power Spectrum (G²/Hz)



<=2	16.67 (0.00)
<=4	16.67 (0.00)
<=8	16.67 (0.00)
<=16	16.67 (0.00)
<=32	16.67 (0.00)
>32	16.67 (0.00)

Entropy of Power Spectrum



Models Field of Study Analysis Type Model Type

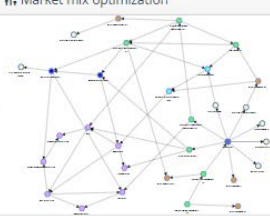
Recent Addition

Conversion Rate Optimization




Conversion Rate Optimization

Market mix optimization



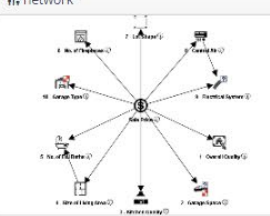
Market mix optimization

network



network

network




network

Marketing Mix Modelling - Sales



Marketing Mix Modelling - Sales

Conversion rate optimization



Ecommerce Simulator

Most Popular

French Personal Traffic Accidents




Car Accidents

Customer Experience model



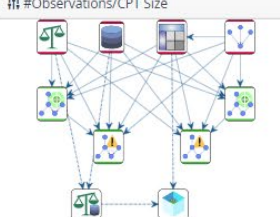
Customer Experience model

World Cup 2018 - Group C Stage Matches



World Cup 2018

#Observations/CPT Size



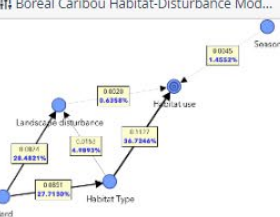
Meta Model: #Observations/CPT Size

Predict your PISA scores



PISA Scores

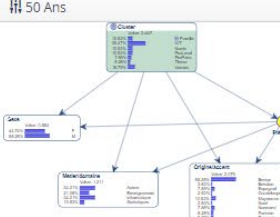
Boreal Caribou Habitat-Disturbance Mod...



Boreal Caribou Habitat-Disturbance

All Models

50 Ans



Associated graph 1



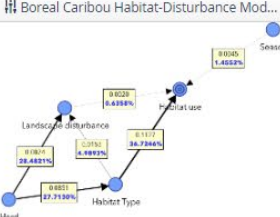
Synovial Sarcoma



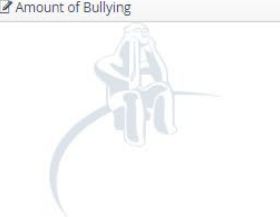
Best Buy Sales Key Drivers Analysis



Boreal Caribou Habitat-Disturbance Mod...

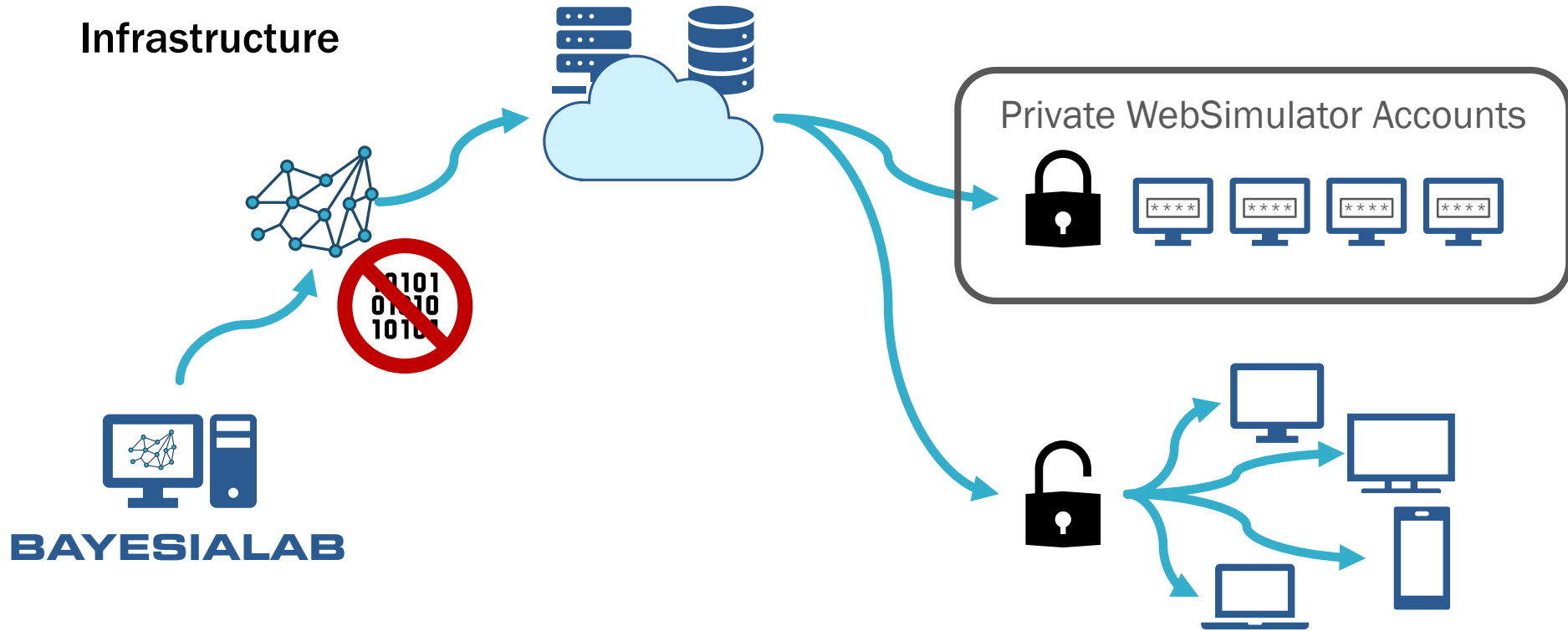


Amount of Bullying



BayesiaLab WebSimulator

Infrastructure



BAYESIALAB



In Conclusion...

BayesiaLab Courses Around the World in 2019

- February 27–28
Dubai, UAE
- March 19–21
Washington, D.C.
- April 2–4
Amsterdam, Netherlands
- May 8–10
Singapore
- May 13–15
Sydney, Australia
- May 21–23
Paris, France
- June 12–14
Seattle, WA



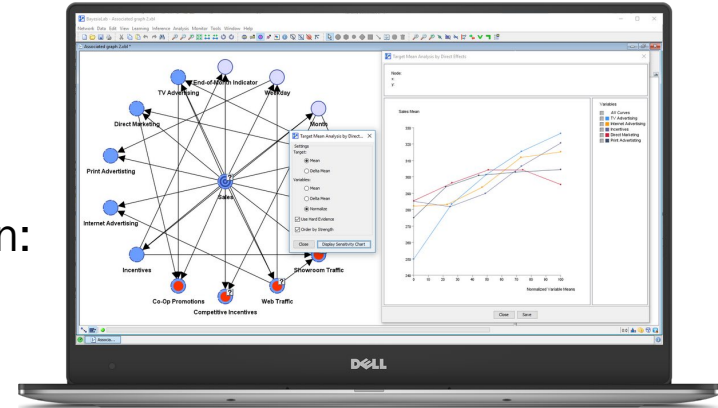
Learn More & Register: bayesia.com/events



BayesiaLab Trial

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User Forum: bayesia.com/community

The screenshot shows the BayesiaLab user forum interface. At the top left is the BayesiaLab logo. A navigation menu includes links for BayesiaLab Software, Bayesian Networks, User Guide & Library, User Forum (which is underlined), BayesiaLab Store, Courses & Events, Learning Resources, News Feed, and About. Below the navigation is a dark blue search bar with a hamburger menu icon on the left, a search input field containing 'This Category' and a search button, and 'Log In' and 'Register' links on the right. The main content area shows a breadcrumb trail 'BayesiaLab Seminars' and a 'START NEW TOPIC' button. A dark blue tab bar contains 'Latest', 'New', and 'Top'. The first forum post is titled 'Webinar on Diagnostic Decision Support with Bayesian Networks', posted 'a minute ago' by 'stefanconrady'. The post content reads: 'The answers to all webinar questions will be posted here.' To the right of the post are icons for replies (0), likes (0), and views (0), with the text 'Started by stefanconrady a minute ago'. At the bottom left, there is a language selector set to 'English'.

7th Annual BayesiaLab Conference
North Carolina Biotechnology Center
October 10–11, 2019, Research Triangle Park, NC



Thank You!



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[BayesianNetwork](#)



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