A software database on VoI & UQ

WG3: COST Action TU1402

tools focusing on UQ

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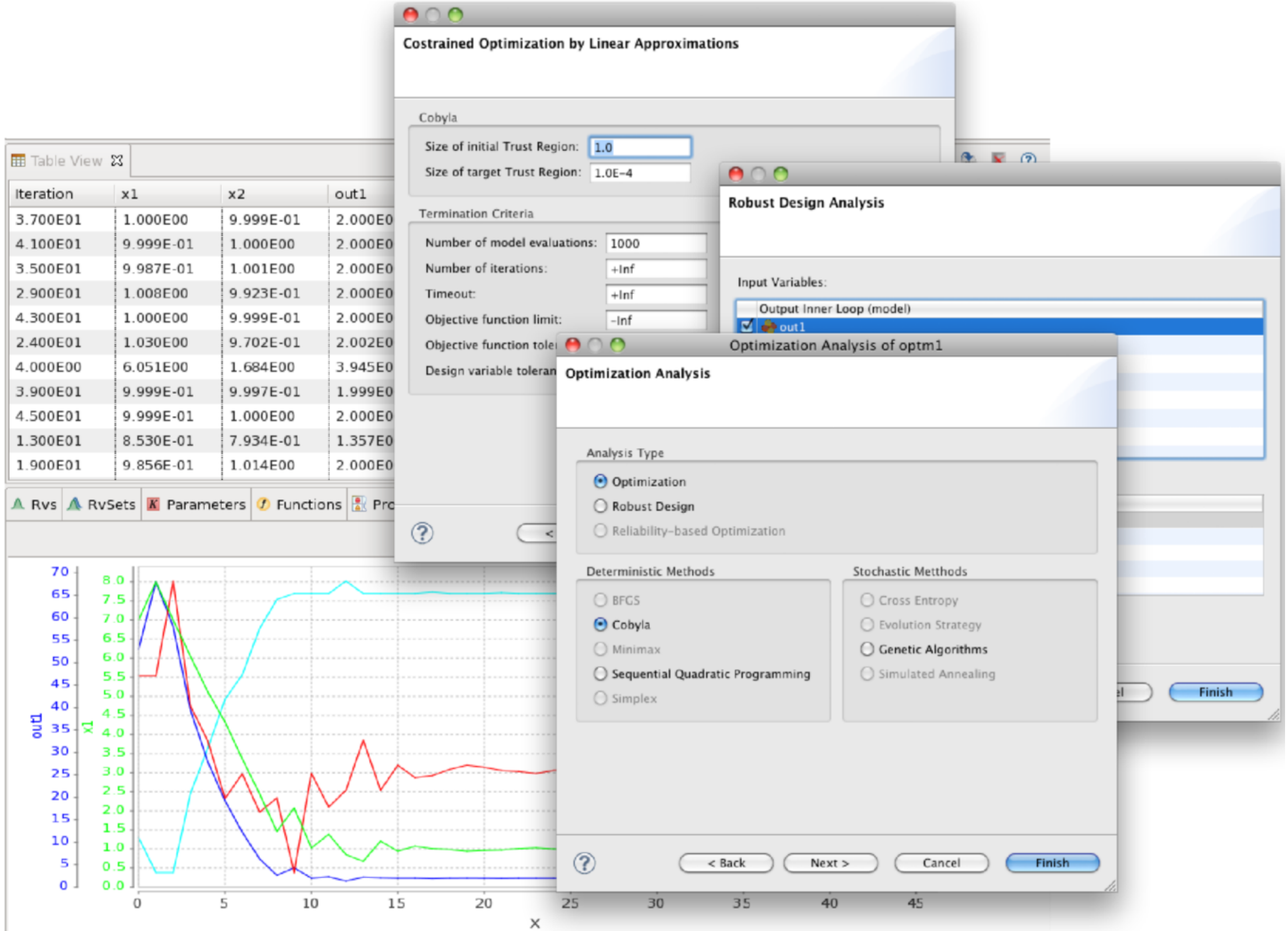
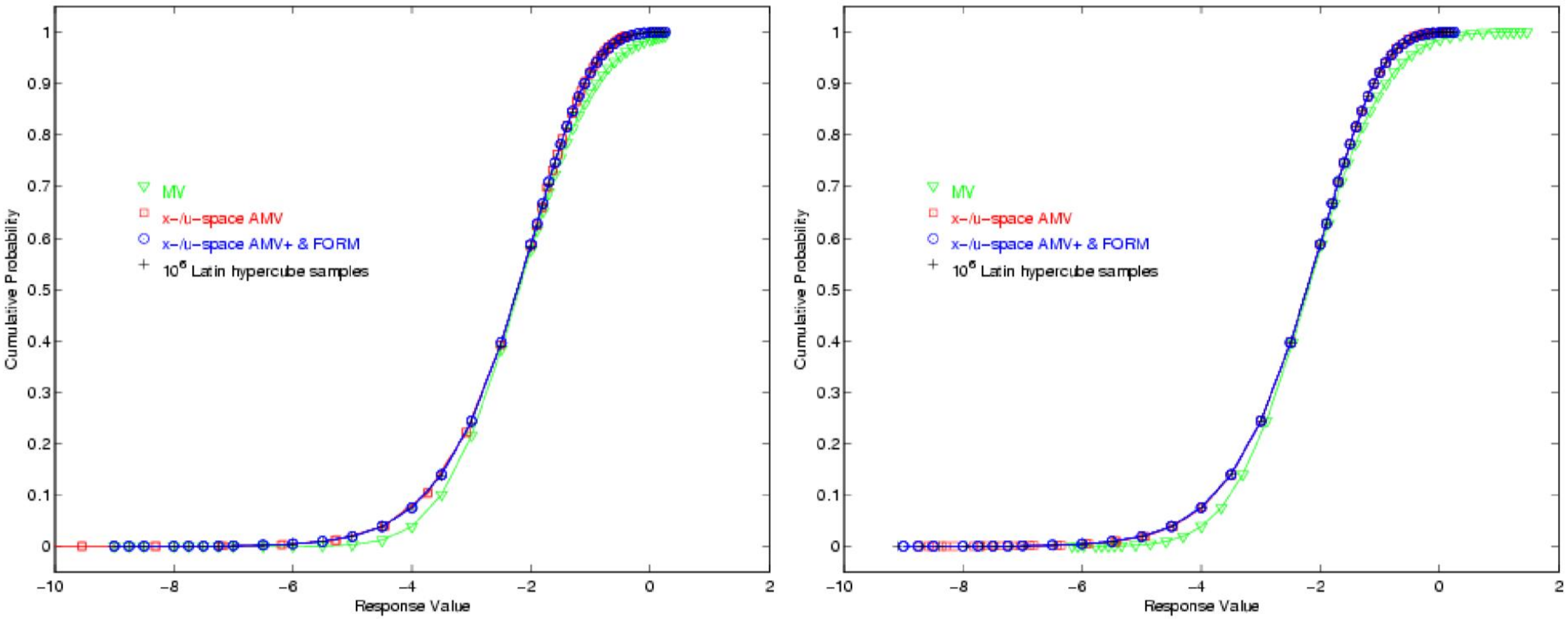
Name	Short Description
COSSAN-X Institute for Risk and Uncertainty, University of Liverpool	COSSAN is a general purpose software package for Uncertainty Quantification (UQ), Simulationbased Reliability Analysis, Sensitivity Analysis, Meta-Modelling, Stochastic Finite Elements Analysis (SFEM), and Reliability-Based Optimization (RBO)



WG3: Methods & Tools

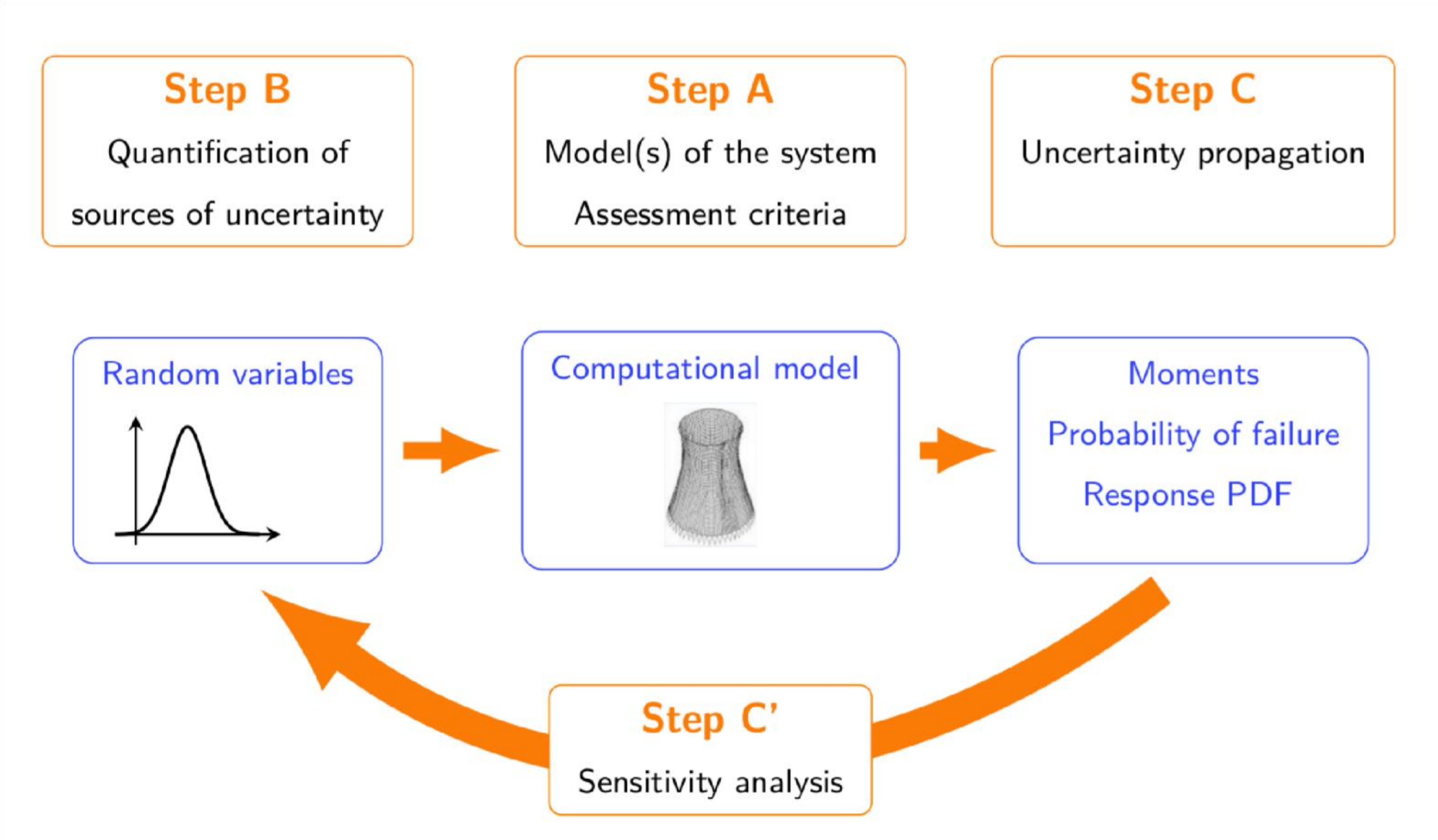
Name	Short Description
DAKOTA SANDIA National Laboratories	The Dakota toolkit provides a flexible, extensible interface between analysis codes and iterative systems analysis methods. Dakota contains algorithms for: optimization with gradient and nongradient-based methods; uncertainty quantification with sampling, reliability, stochastic expansion, and epistemic methods; parameter estimation with nonlinear least squares methods; and sensitivity/variance analysis with design of experiments and parameter study methods.



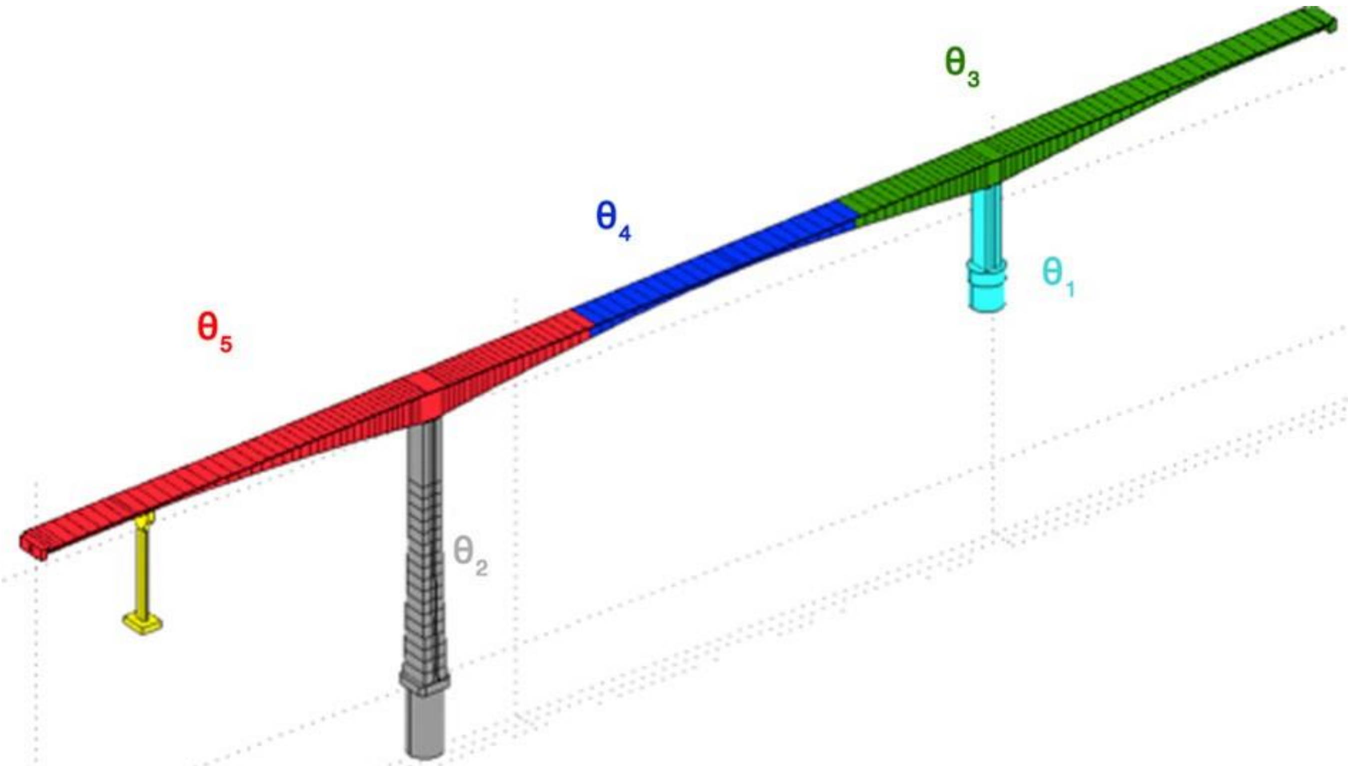
(a) RIA methods

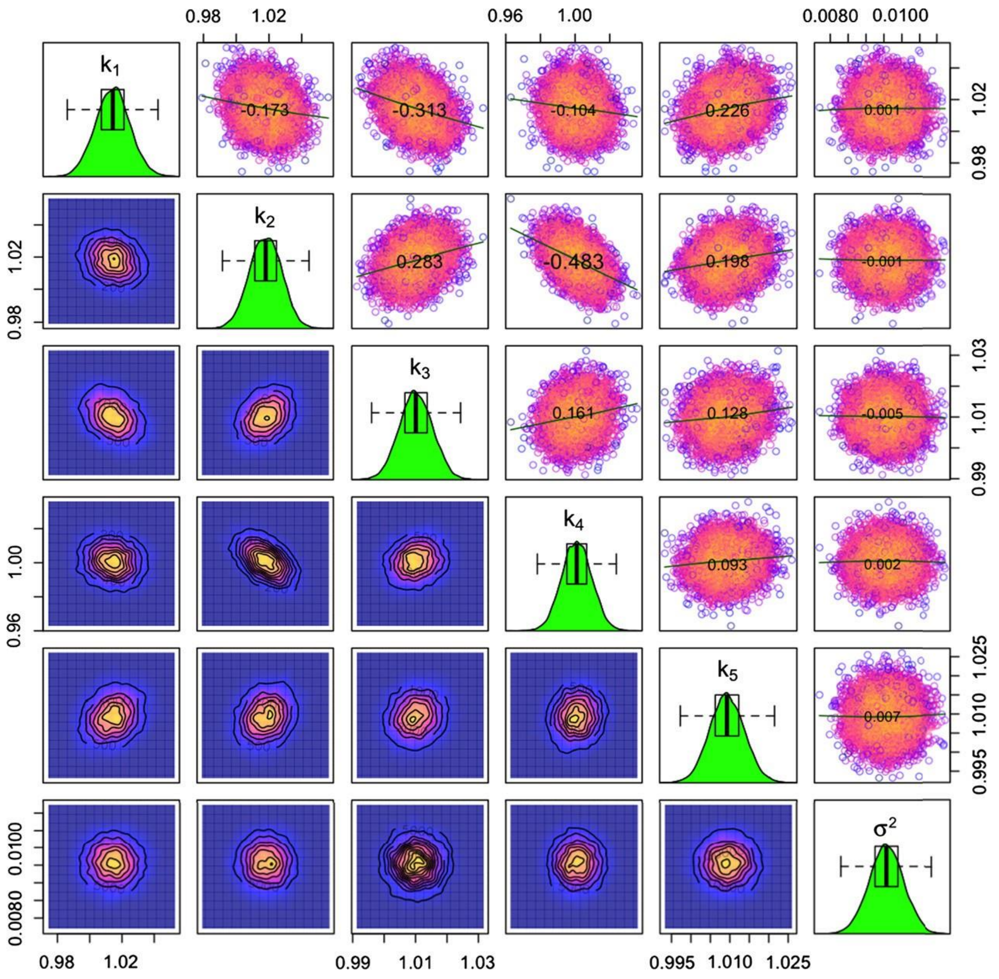
(b) PMA methods

Name	Short Description
UQLab Chair of Risk, Safety and Uncertainty Quantification, ETH ZUrich	UQLab is a general purpose Uncertainty Quantification framework developed at ETH Zurich (Switzerland). It is made of open-source scientific modules which are smoothly connected through UQLabCore to carry out uncertainty propagation through Monte Carlo sampling, sensitivity analysis, reliability analysis (computation of rare event probabilities), build surrogate models (polynomial chaos expansions, Kriging, low-rank tensor approximations, etc.) and more.

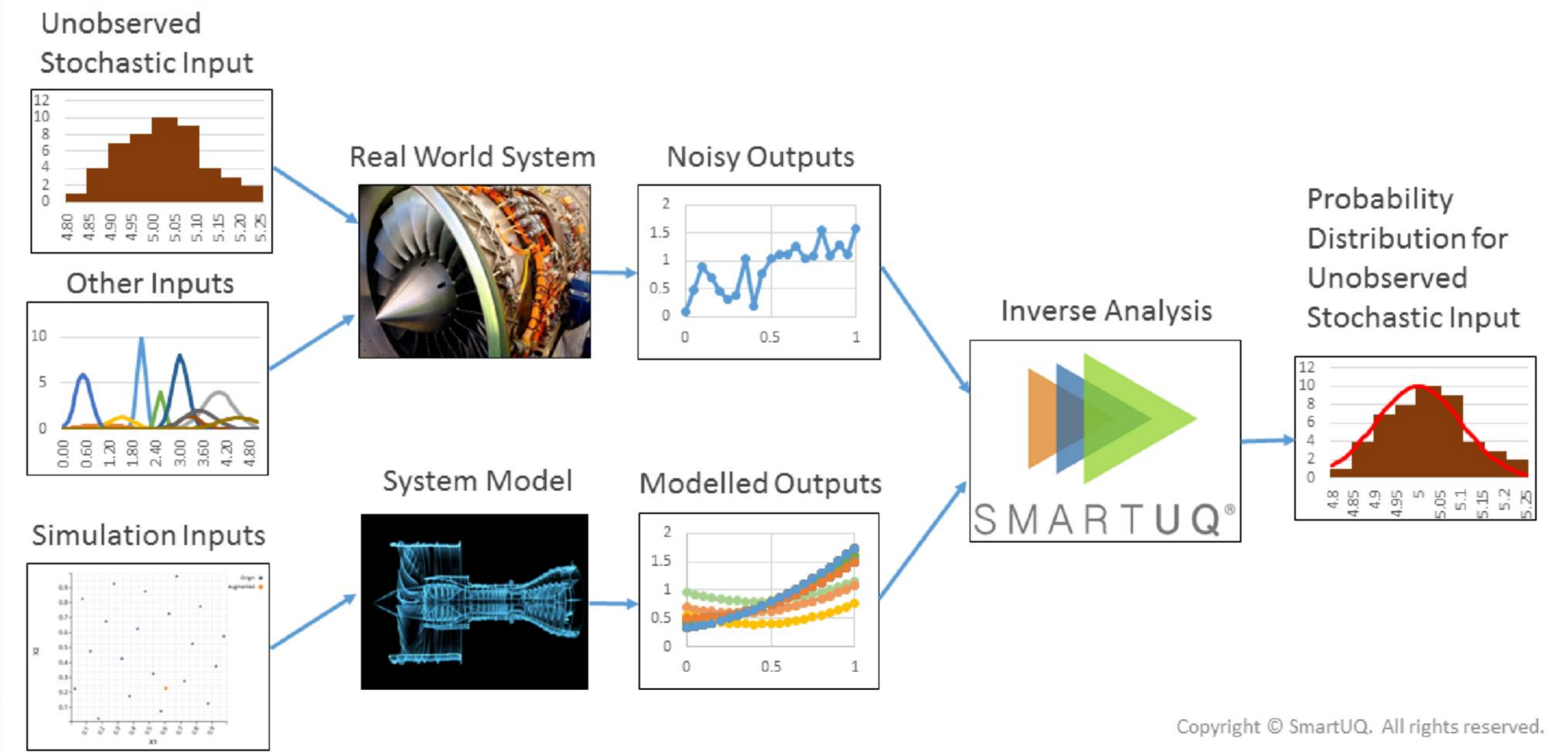

Step B
Quantification of
sources of uncertainty
Step A
Model(s) of the system
Assessment criteria
Step C
Uncertainty propagation
Random variables
Computational model
Moments
Probability of failure
Response PDF
Step C'
Sensitivity analysis

Name	Driving Principles	Short Description
Pi4U Chair of Computational Science, ETHZ System Dynamics Laboratory, University of Thessaly	TMCMC (for exact Bayesian inference) - CMA-ES (for optimization) - Subset Simulation (for rare event sampling) - ABC-SubSim (for approximate Bayesian inference) - A-PNDL (for parallel numerical differentiation)	Π4U (Pi4U) is an HPC framework for Bayesian uncertainty quantification of large scale computational models.

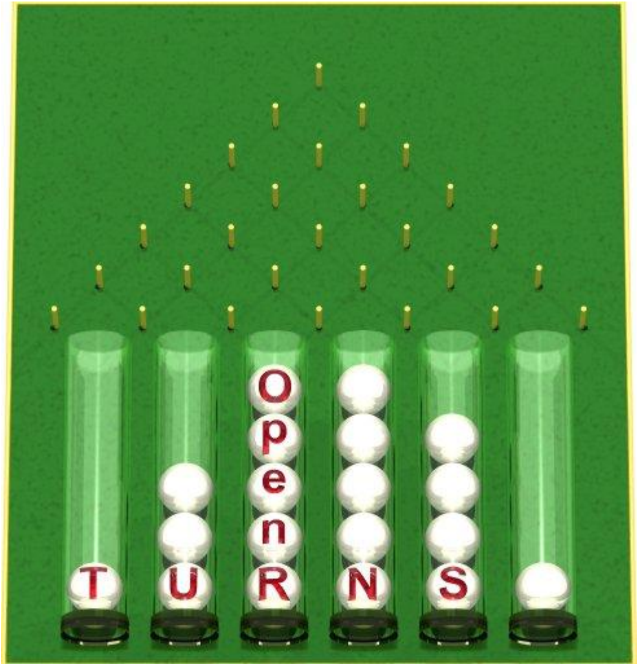

θ3
θ4
θ1
θ5
θ2

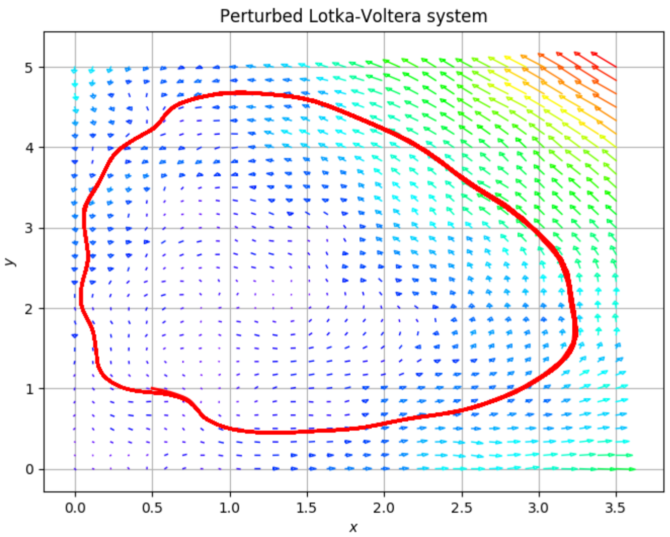

k1
k2
k3
k4
k5
σ2
-0.173
-0.313
-0.104
0.226
0.001
0.283
-0.483
0.198
-0.001
0.161
0.128
-0.005
0.093
0.002
0.007
0.98
1.02
0.96
1.00
0.0080
0.0100
0.99
1.01
1.03
0.995
1.010
1.025

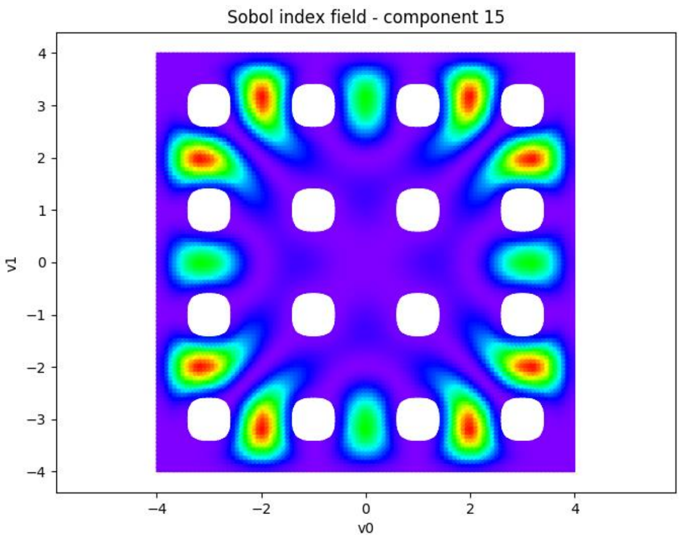
Name	Short Description
SMART UQ Chair of Computational Science ETH Zurich	SmartUQ: a powerful uncertainty quantification and analytics software platform for Design of Experiments, Emulation, Sensitivity Analysis, Statistical Calibration/Optimization, Propagation of Uncertainty, Inverse Analysis

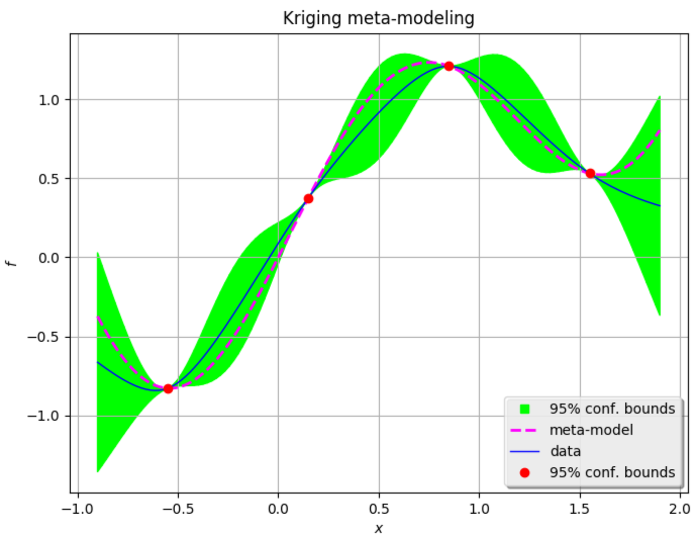

Unobserved
Stochastic Input
Other Inputs
Simulation Inputs
Real World System
System Model
Noisy Outputs
Modelled Outputs
Inverse Analysis
SMARTUQ
Probability
Distribution for
Unobserved
Stochastic Input
Copyright © SmartUQ. All rights reserved.

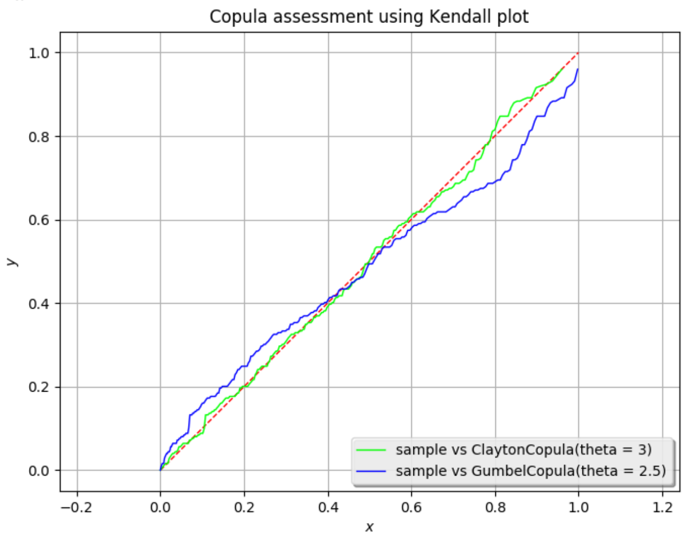
OpenTURNS Airbus, EDF, IMACS, ONERA, PHIMECA	• Multivariate probabilistic modelling including dependence • Numerical tools dedicated to the treatment of uncertainties • Generic coupling to any type of physical model • Open source, LGPL licensed, C++/Python library

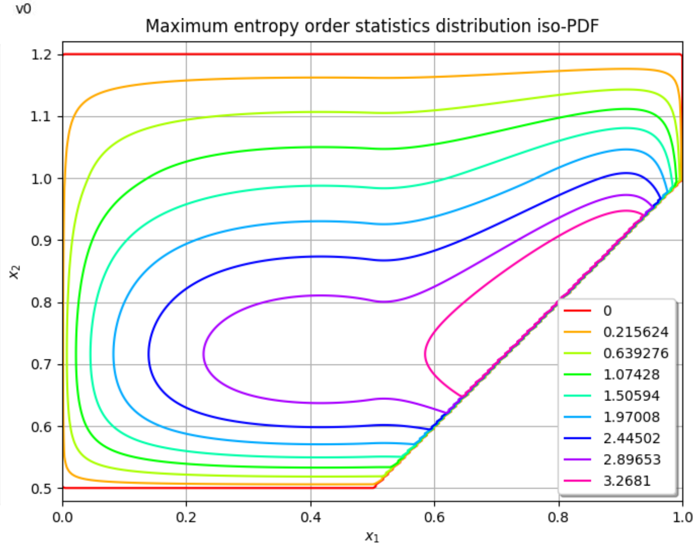



Perturbed Lotka-Voltera system
x
y


Sobol index field - component 15
v0
v1


Kriging meta-modeling
x
f
95% conf. bounds
meta-model
data
95% conf. bounds


Copula assessment using Kendall plot
x
y
sample vs ClaytonCopula(theta = 3)
sample vs GumbelCopula(theta = 2.5)


Maximum entropy order statistics distribution iso-PDF
x1
x2
0
0.215624
0.639276
1.07428
1.50594
1.97008
2.44502
2.89653
3.2681

tools focusing on Decision support/policy planning

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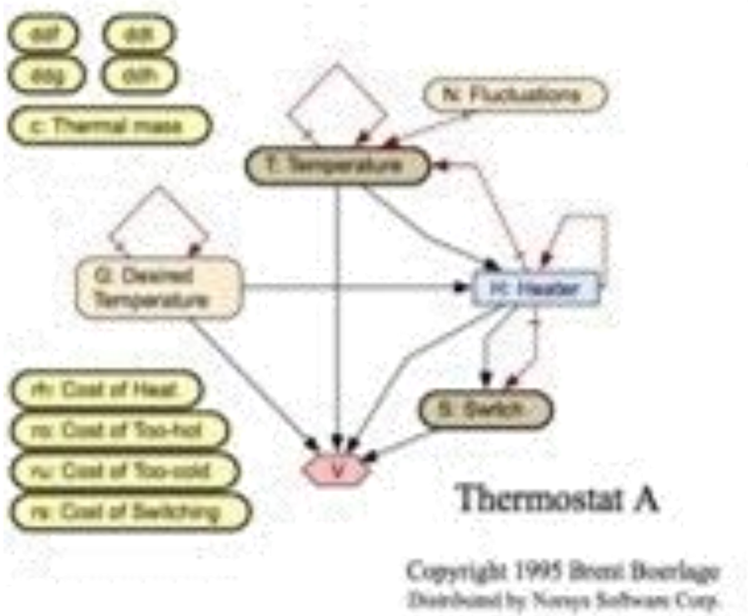
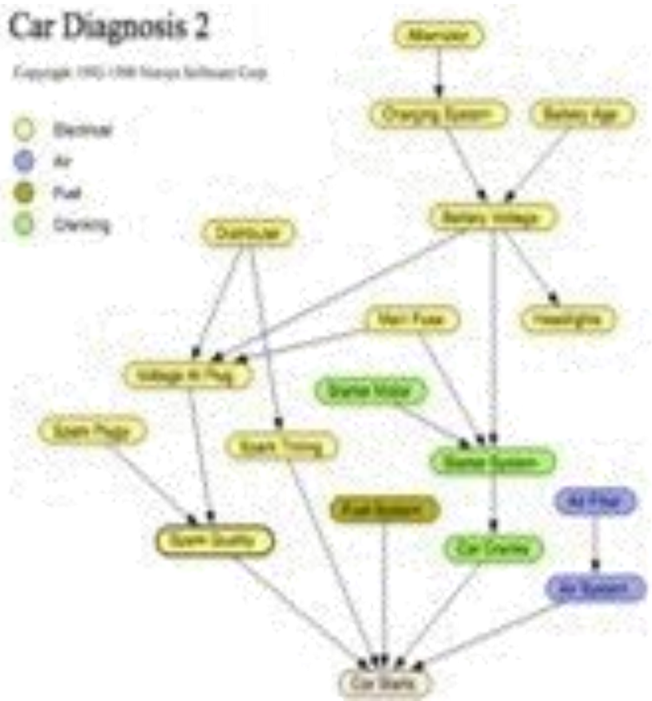
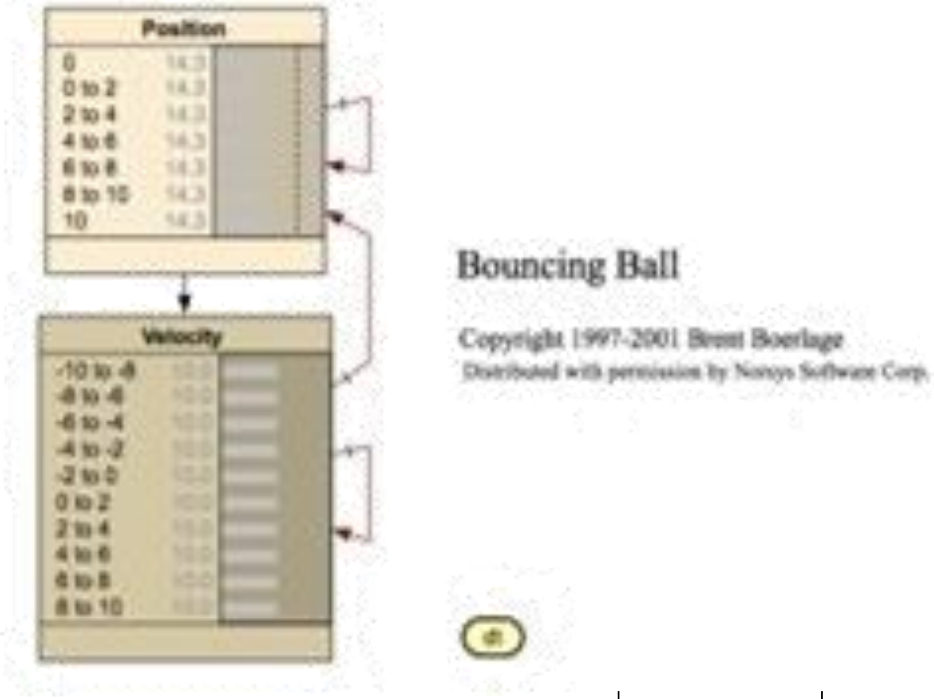
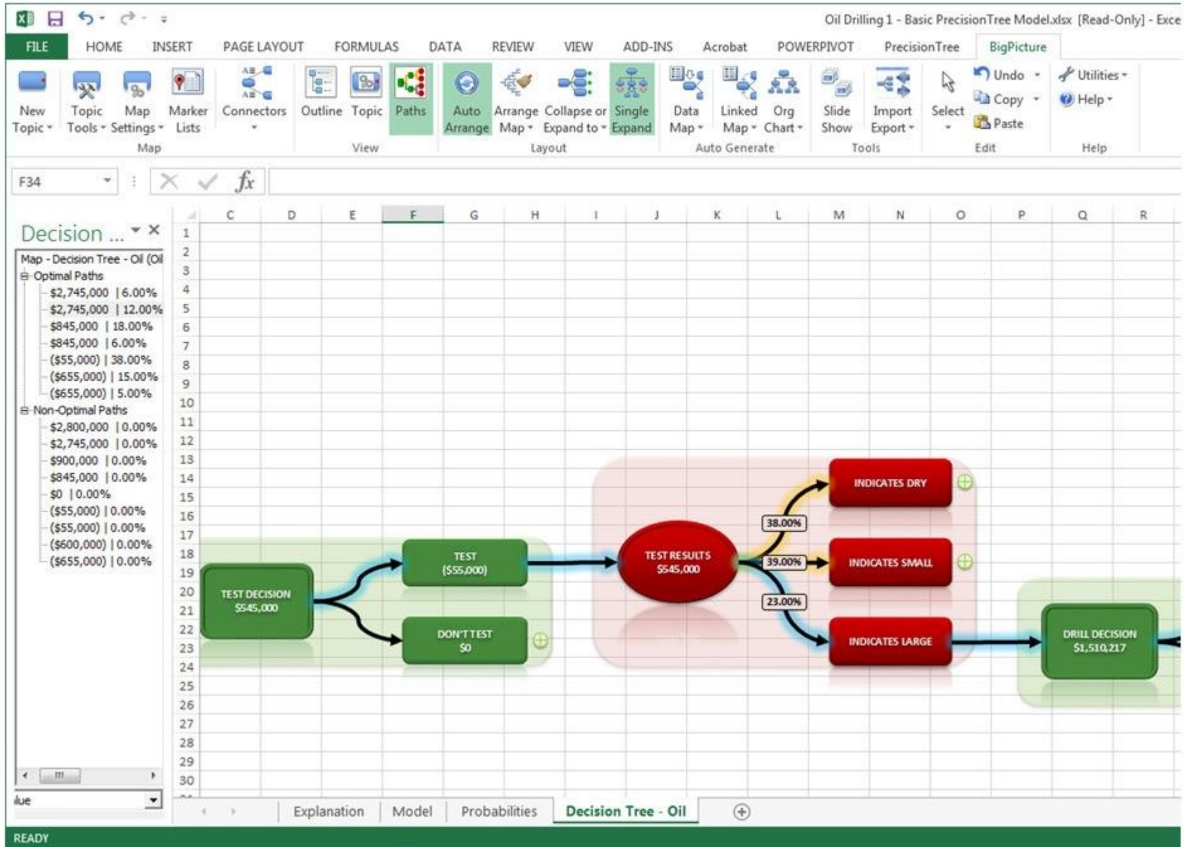
Name	Driving Principle	Short Description
Netica NORSYS Software Corp.	Bayes Nets	Netica works with belief networks and influence diagrams. It can use influence diagrams to find optimal decisions which maximize the expected values of specified variables. Netica can construct conditional plans, since decisions in the future can depend on observations yet to be made, and the timings and inter-relationships between decisions are considered



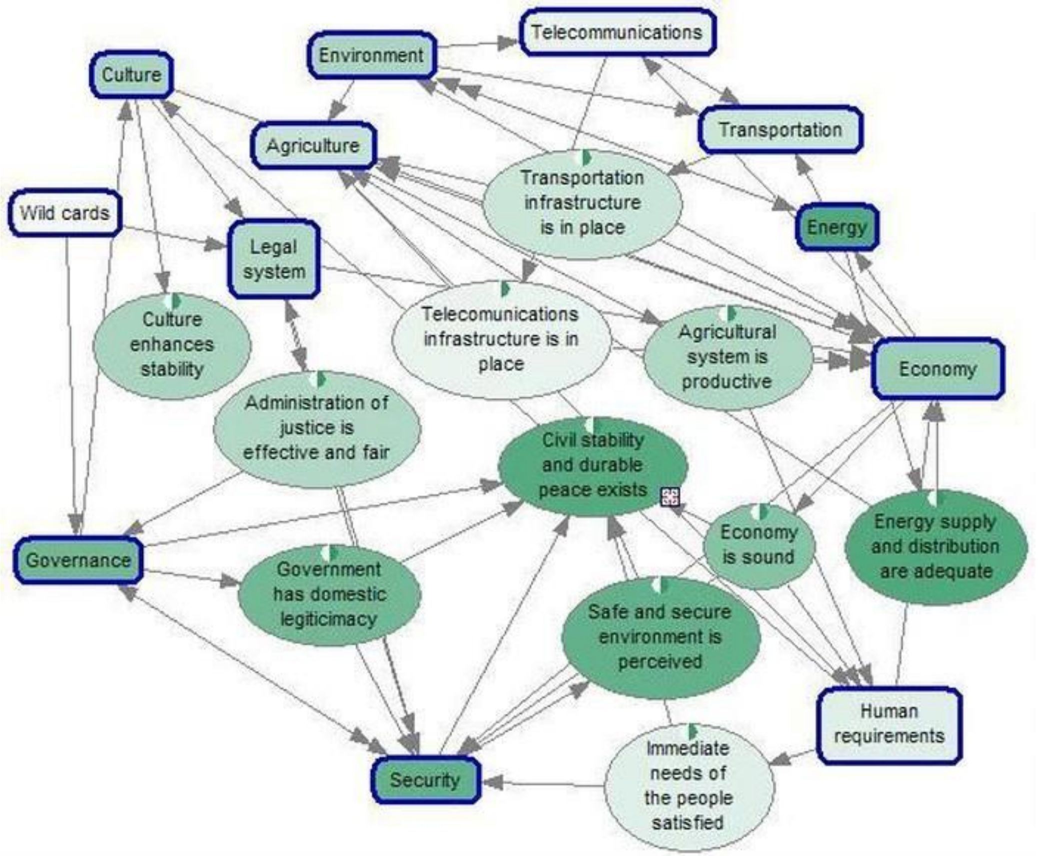


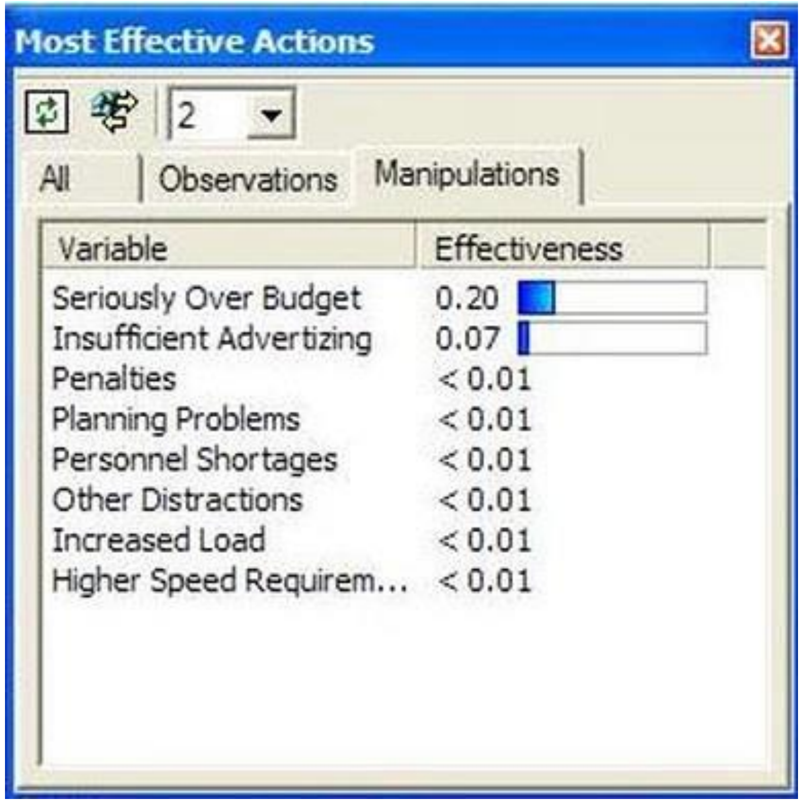


Name	Driving Principle	Short Description
Precision Tree Palisade	Decision Trees	PrecisionTree, visually maps out, organizes, and analyzes decisions using decision trees, in Microsoft Excel. Decision trees are quantitative diagrams with nodes and branches representing different possible decision paths and chance events.

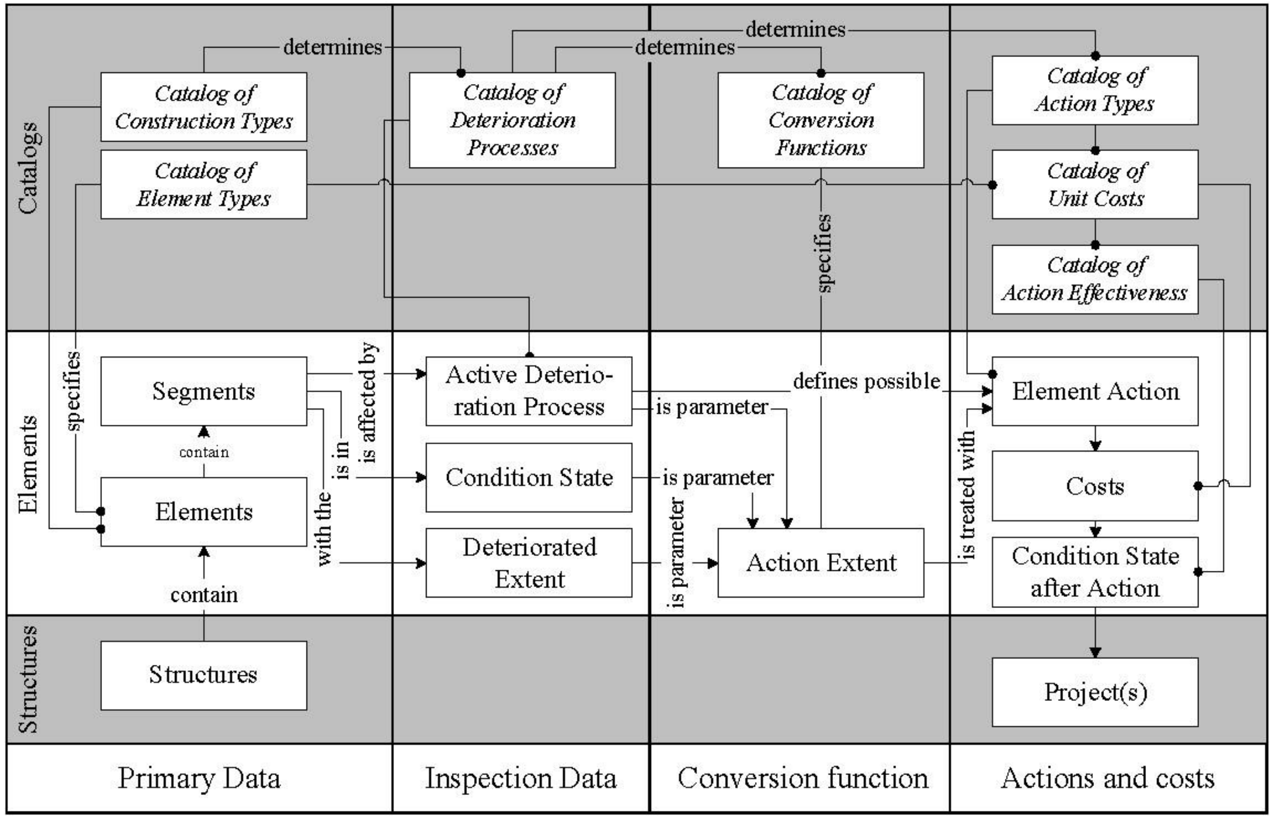


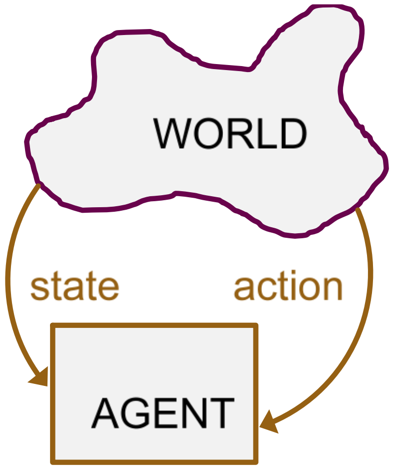
Name	Driving Principle	Short Description
GeNIe BAYES FUSION	Bayesian networks, influence diagrams, and structural equation models	GeNIe is a graphical user interface (GUI) to SMILE and allows for interactive model building and learning.
QGeNIe Modeler BAYES FUSION		QGeNIe is a rapid model development interface that allows for fast prototyping of decision models, useful especially in applications such as strategic planning.


Telecommunications
Environment
Culture
Transportation
Agriculture
Transportation infrastructure is in place
Wild cards
Legal system
Energy
Culture enhances stability
Telecomunications infrastructure is in place
Agricultural system is productive
Economy
Administration of justice is effective and fair
Civil stability and durable peace exists
Economy is sound
Energy supply and distribution are adequate
Governance
Government has domestic legiticimacy
Safe and secure environment is perceived
Human requirements
Immediate needs of the people satisfied
Security

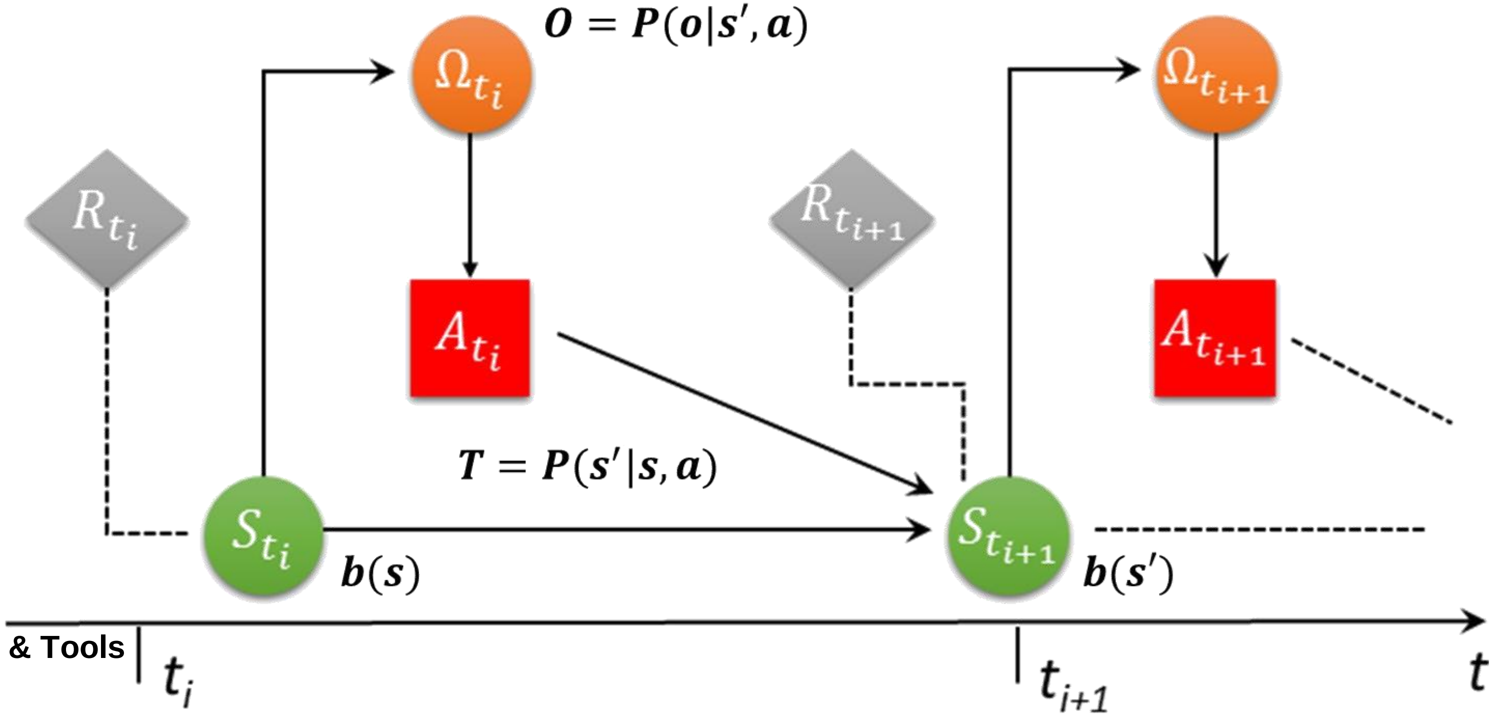

Most Effective Actions
2
All
Observations
Manipulations
Variable
Effectiveness
Seriously Over Budget
0.20
Insufficient Advertizing
0.07
Penalties
< 0.01
Planning Problems
< 0.01
Personnel Shortages
< 0.01
Other Distractions
< 0.01
Increased Load
< 0.01
Higher Speed Requirem...
< 0.01

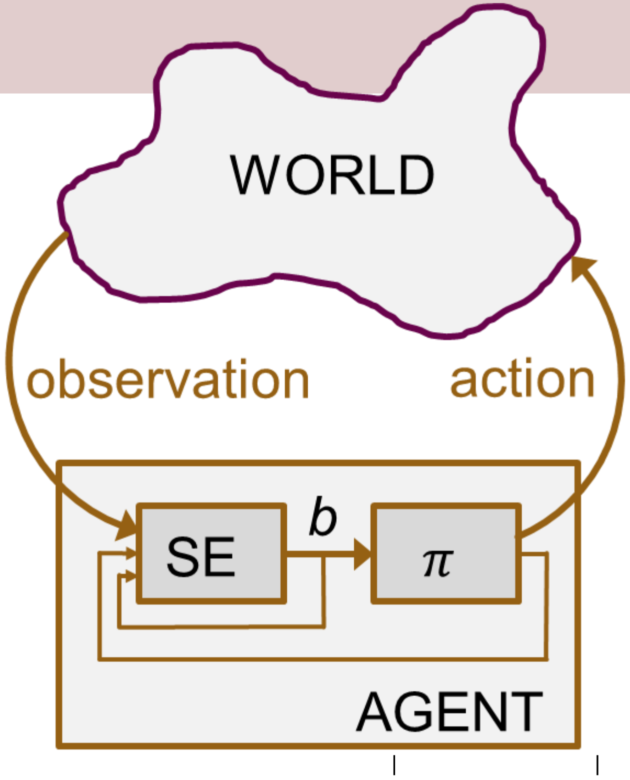
Name	Driving Principle	Short Description
KUBA Infrastructure Management Consultants GmbH (IMC)	Markov-Decision Processes	KUBA facilitates management of engineering structures such as bridges, galleries, retaining walls and tunnels. The individual modules of KUBA support: • administration and documentation of the structure, inspections and maintenance measures • identification of optimal conservation strategies, calculation of associated state forecasts and their financial requirements as well as identification of proposed measures (CUBA-MS),





Name	Driving Principle	Short Description
Perseus POMDP Matthijs Spaan, TU DELFT, Frans Oliehoek	Partially Observable Markov Decision Processes (POMDPs)	The Multiagent decision process (MADP) Toolbox is a free C++ software toolbox for scientific research in decisiontheoretic planning and learning in multiagent systems (MASs). This solves an infinite horizon deicion making problem
Finite Horizon POMDP ETH Zurich		A beta version is to be released soon.





Next Steps

- Create a common case study for sequential decision making, e.g. the Ellis bridge inspection problem.
- Use the same case studies, across the different platforms to demonstrate capabilities and potential.
- Gather further inputs from Action participants