# Integrated model for reliability assessment by applying Non parametric Bayesian Networks

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# Goals

- Improve system reliability assessment by using Bayesian network to integrate data from three sources: new designs risk assessment, complexity evaluated for new designs, reliability data accepted from suppliers and reliability tests done during development.
- Update the model with posterior reliability data from field.
- Provide an integrated view to help achieve balanced decisions.

# Motivation

- Reliability assessment is surrounded with high uncertainty which comes from two major different sources: lack of knowledge (engineering, marketing requirement etc`), variation between systems, small samples and variations in processes etc`.
- By applying this integrated model, we try to treat uncertainty stems from lack of knowledge.
- In addition, reliability will be treated in context of risks, complexity and customer behavior.

# Content

- Basic terms in the integrated approach
  - Non-parametric Bayesian Networks
  - Calibration via conditionalization
  - Technical risk management
  - Reliability data used from sub-suppliers
  - Product complexity
- Case study
- Summary

# General

- Non-parametric Bayesian Networks
  - NPBNs originate from probabilistic graphical models, which represent multivariate densities via a combination of qualitative graph structure that encodes independencies and local quantitative parameters.
  - Bayesian networks (BNs) are directed acyclic graphs (DAGs) whose nodes represent variables and the edges represent causal relationships between the variables. These variables are associated to conditional probability functions that, together with the DAG, are able to provide a compact representation of high-dimensional distributions.
- Calibration via conditionalization
  - Step 1 -Apply PC Algorithm to model Non-Bayesian network
  - Step 2 -Identification of the calibration link.
  - Step 3 -Performing calibration for each BN, and infer the characteristics changed in each BN.

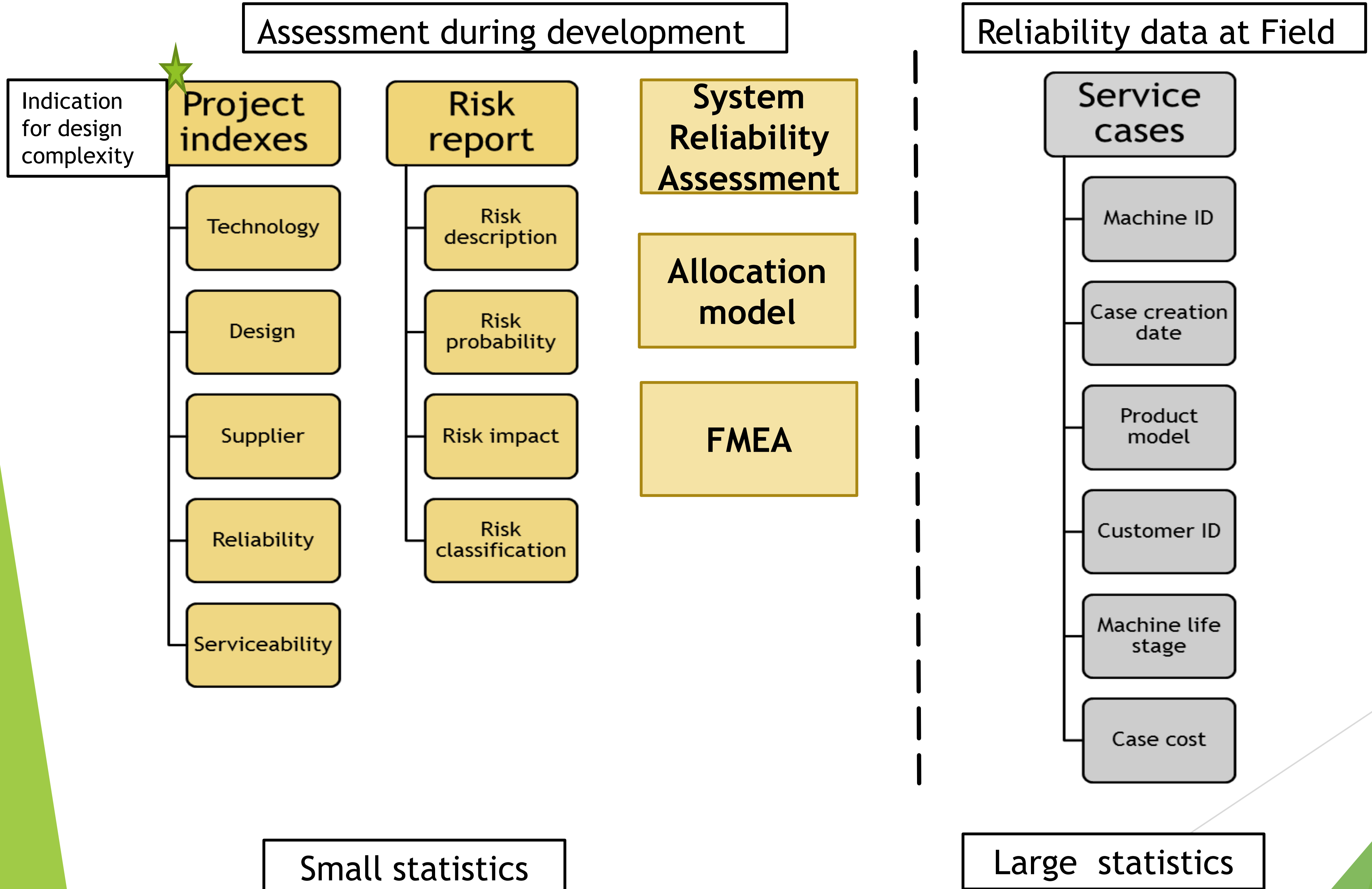
# General

- Technical risk management- definitions
  - Frank H. Knight : “risk is present where **future events** occur with measured **probability**”
  - Risk management includes four phases: Identification, Analysis, Control and Feedback. (Kenett, 2010)
  - Two main concepts in technical risk assessment: Risk impact to system and risk probability.
- Product reliability
  - Definition of Reliability: The probability that a product will perform its intended function until a given point in time, under specified use conditions.
  - Frequent reliability metric used in industry is MTBF. Usually, vendors supply this metric without reporting the conditions it measured or its basic assumptions.

# General

- Product complexity
  - Product complexity has three main elements:
    - The number of product components to specify and produce
    - The extent of interactions to manage between these components (parts coupling)
    - The degree of product novelty
  - Product complexity is driven by number of factors such as: performance targets, technology and product architecture.

# Data Sources for Complexity, Risk and Reliability



# Complexity Data structure - **Example**

Project A

| | Indexes | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Cost of Part Significant | New Technology | New Design | New Supplier | Existing Design has | MTBF consideration | MTTR consideration | Cost of Service | Cost of Part Significant |
| Design A | Y | N | N | | | | | | |
| Design B | N | N | N | | | | | | |
| Design C | Y | Y | Y | | | | | | |
| Design D | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| Design N | | | | | | | | | |

# Risk Data structure - **Example**

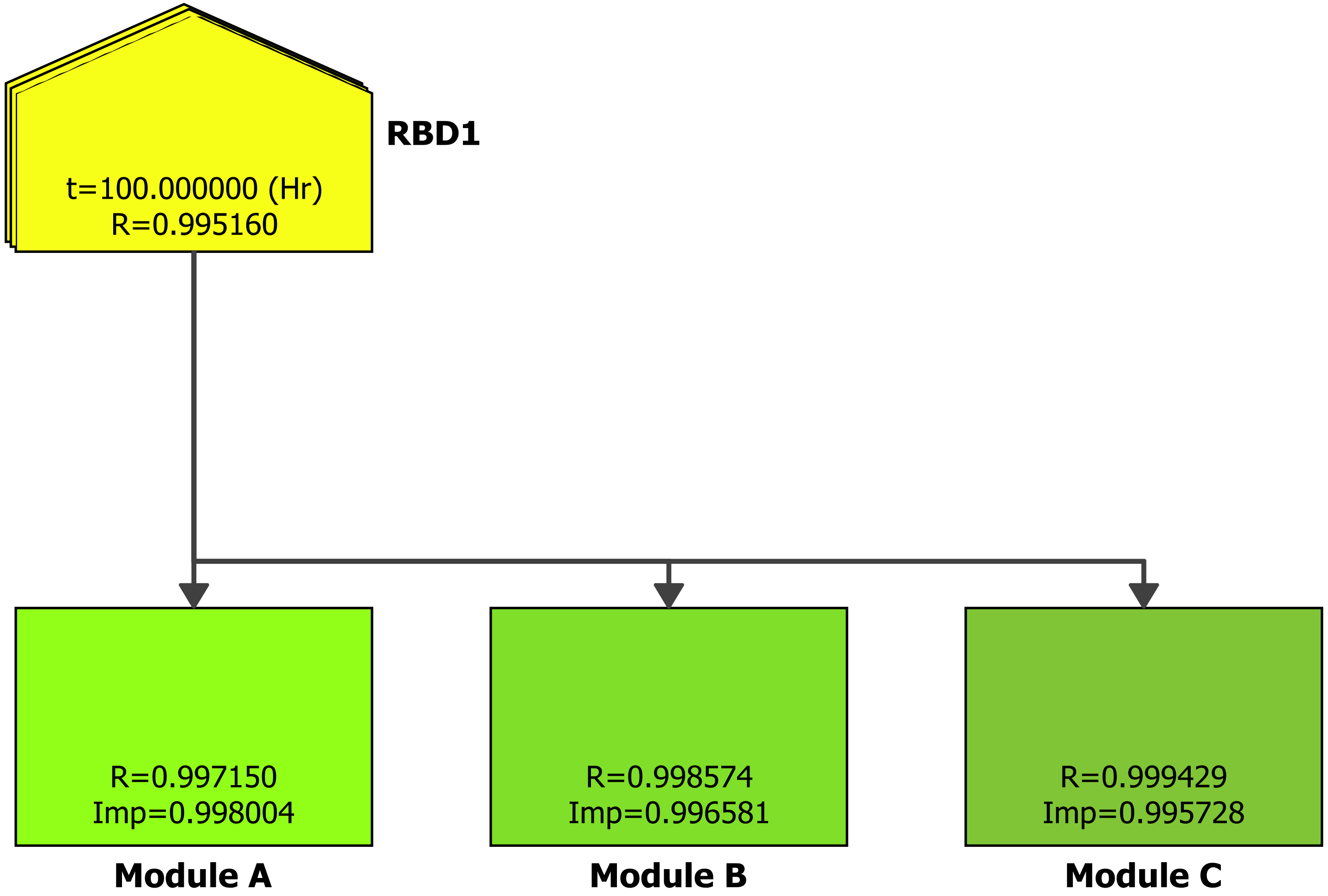
Project A

| | Probability | Impact | Mitigation plan | month | year |
|---|---|---|---|---|---|
| Risk A | H | N | | | |
| Risk B | N | N | | | |
| Risk C | H | H | | | |
| Risk D | | | | | |
| | | | | | |
| | | | | | |
| Risk N | | | | | |

Probability
High- likely or almost likely that the risk will occur
Normal - somewhat probable or improbable or unlikely that the risk will occur.

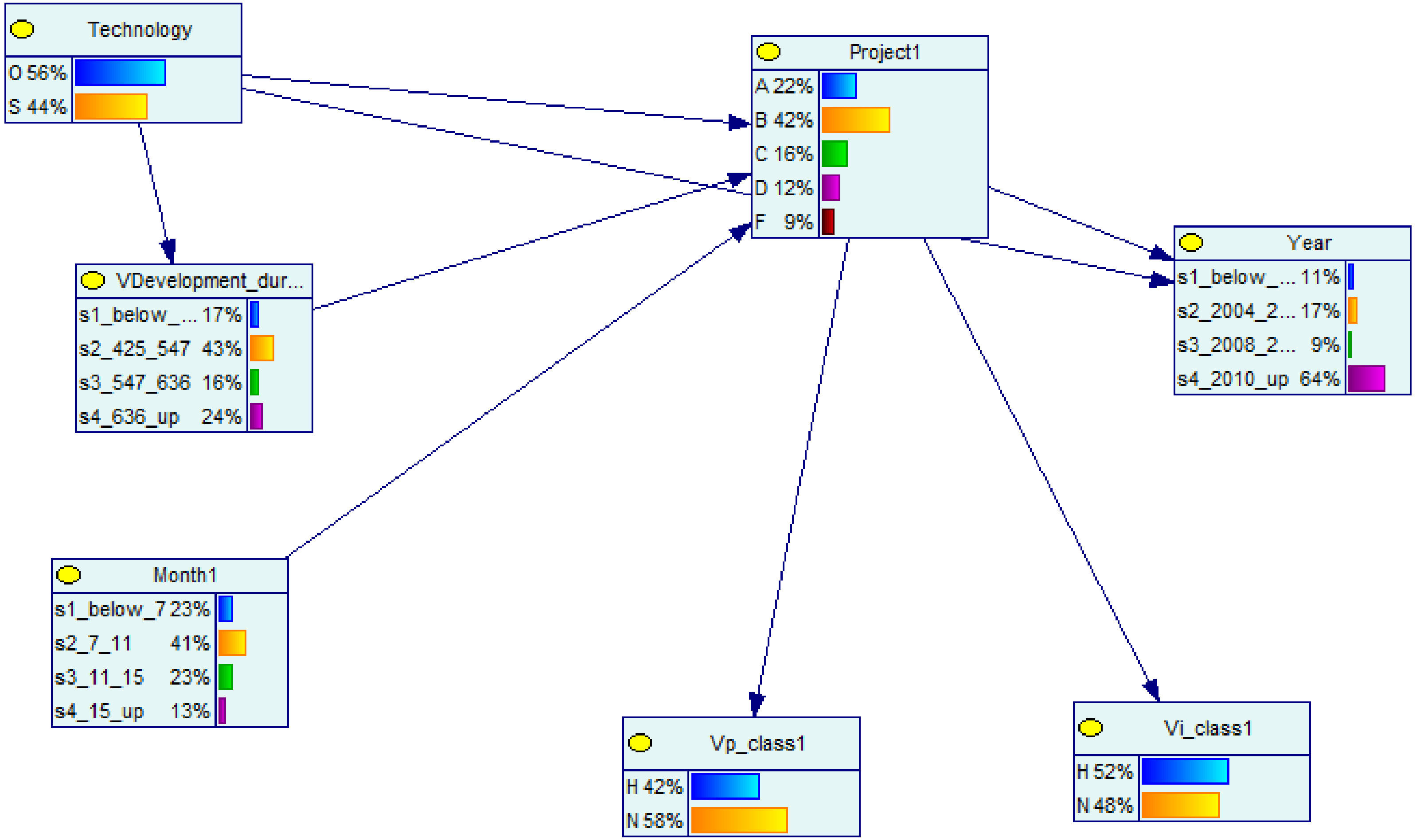
Impact
High- high or very high impact in product performance
Normal – some or little or very little impact.

# Allocation Model- **Example**



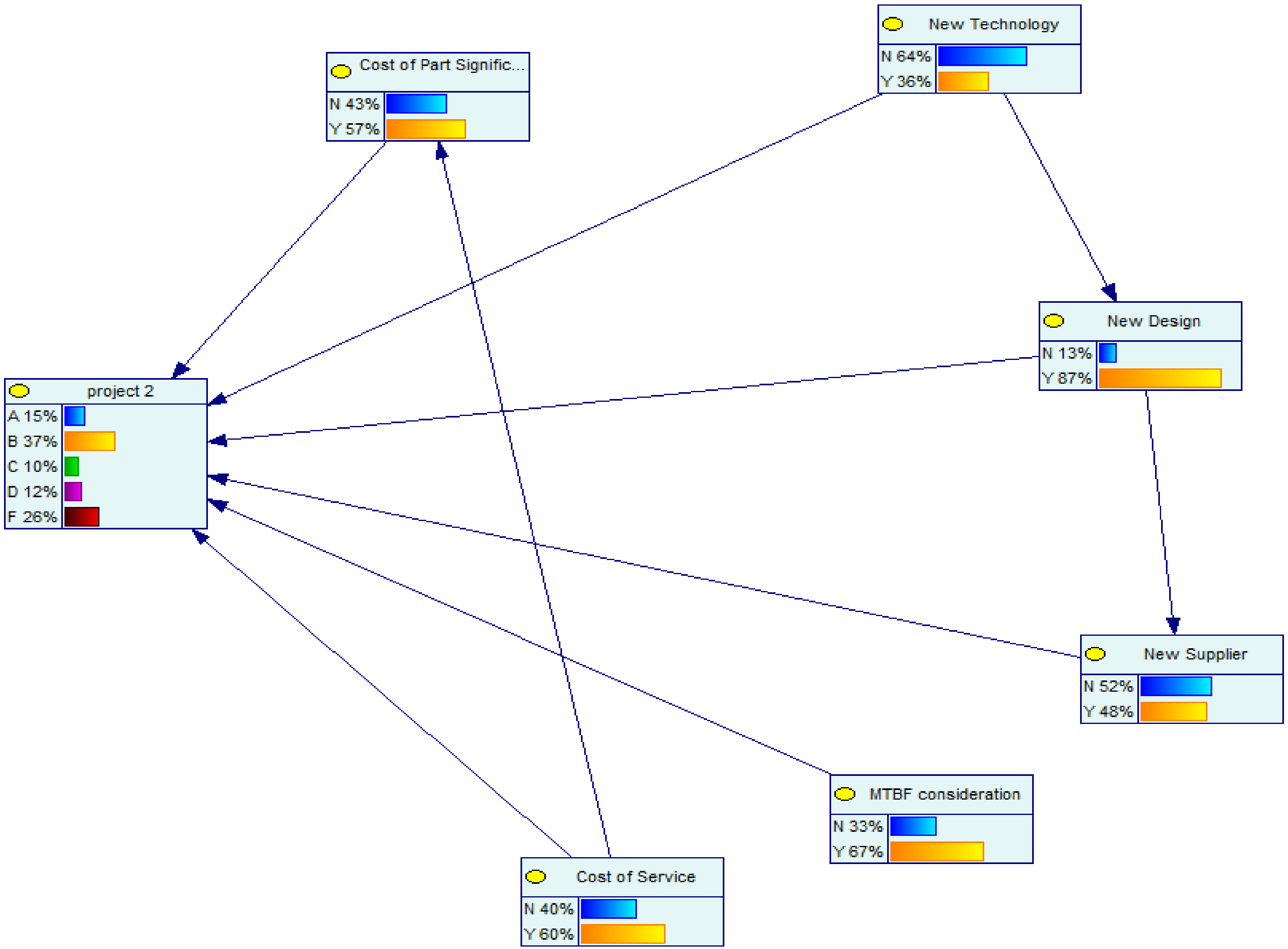
# BN Applied for Product Risk Management

Step 1- build BN for Risk



# BN Applied for project Complexity

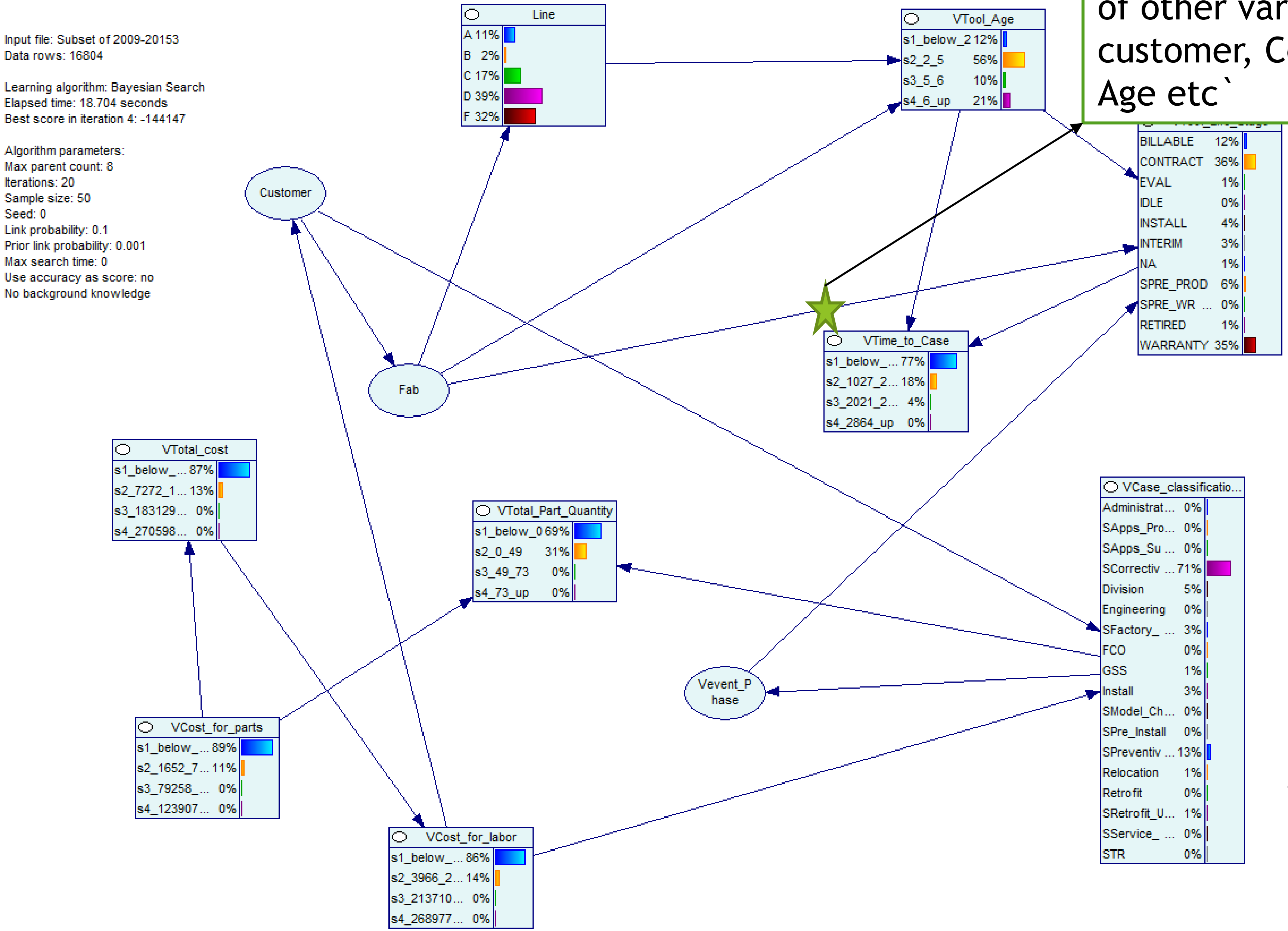
Step 1- build BN for product complexity



# BN Applied for reliability

Time to Failure is learned in context of other variables: customer, Cost, Tool Age etc`

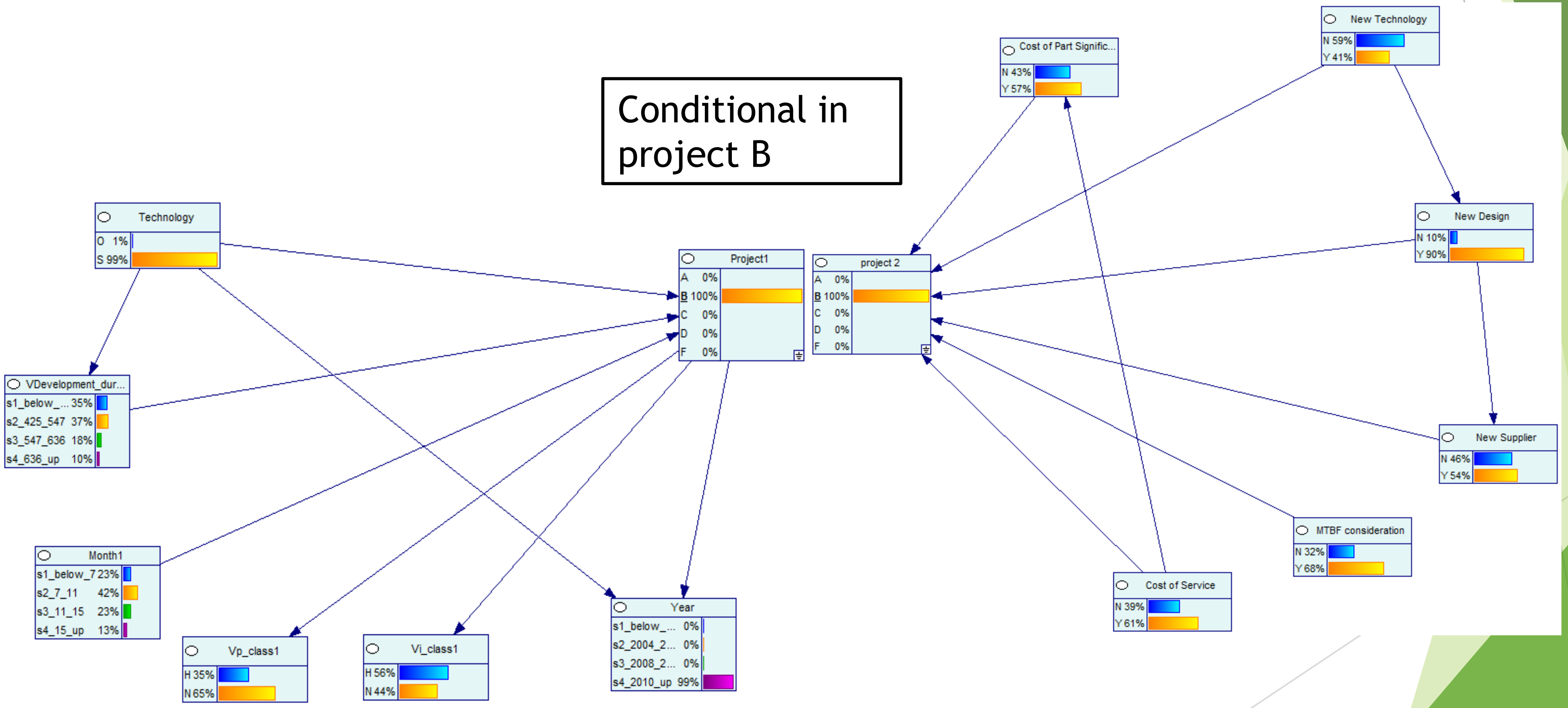
Step 1- build BN for product Reliability



Step 2- Calibration via conditionalization

# Integration by calibrating on project variable: of Risk BBN and Project characteristics BBN

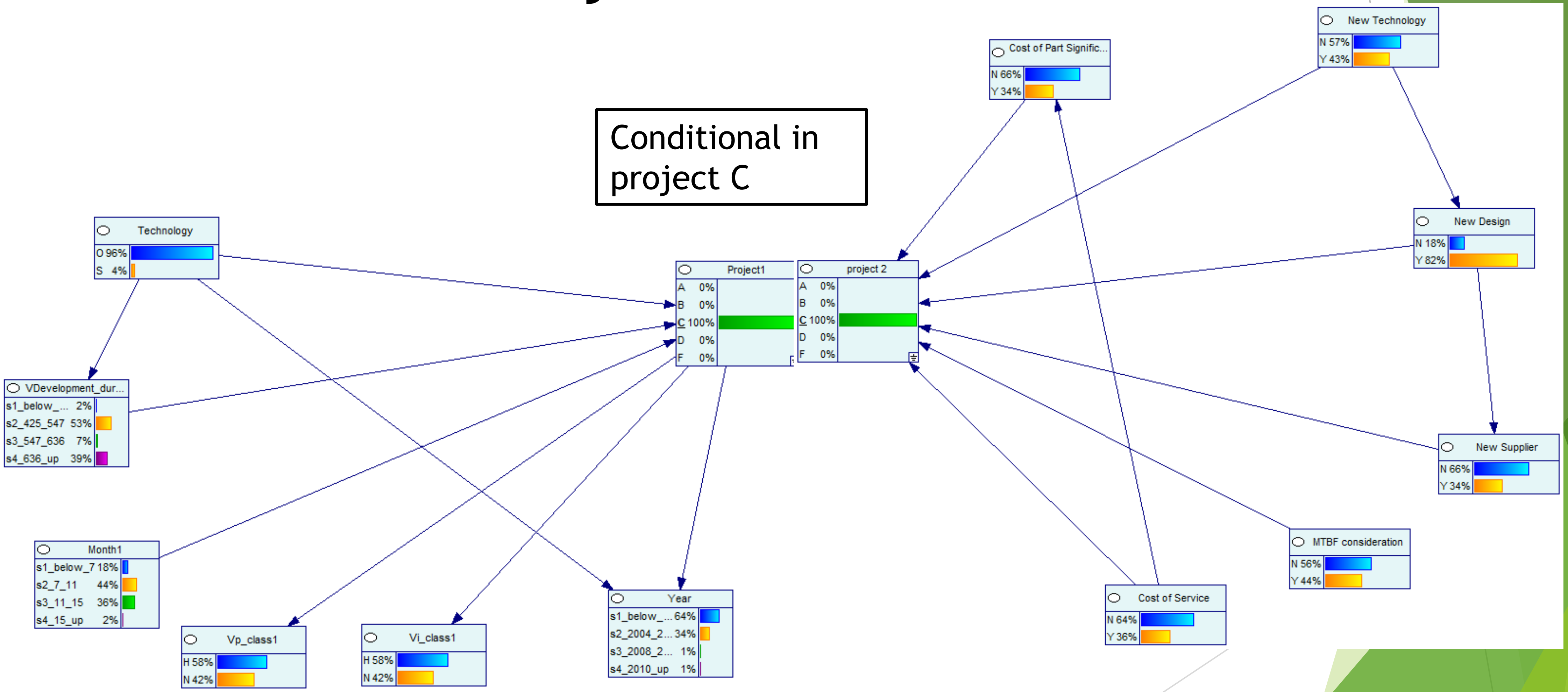
Conditional in project B



Step 2- Calibration via conditionalization

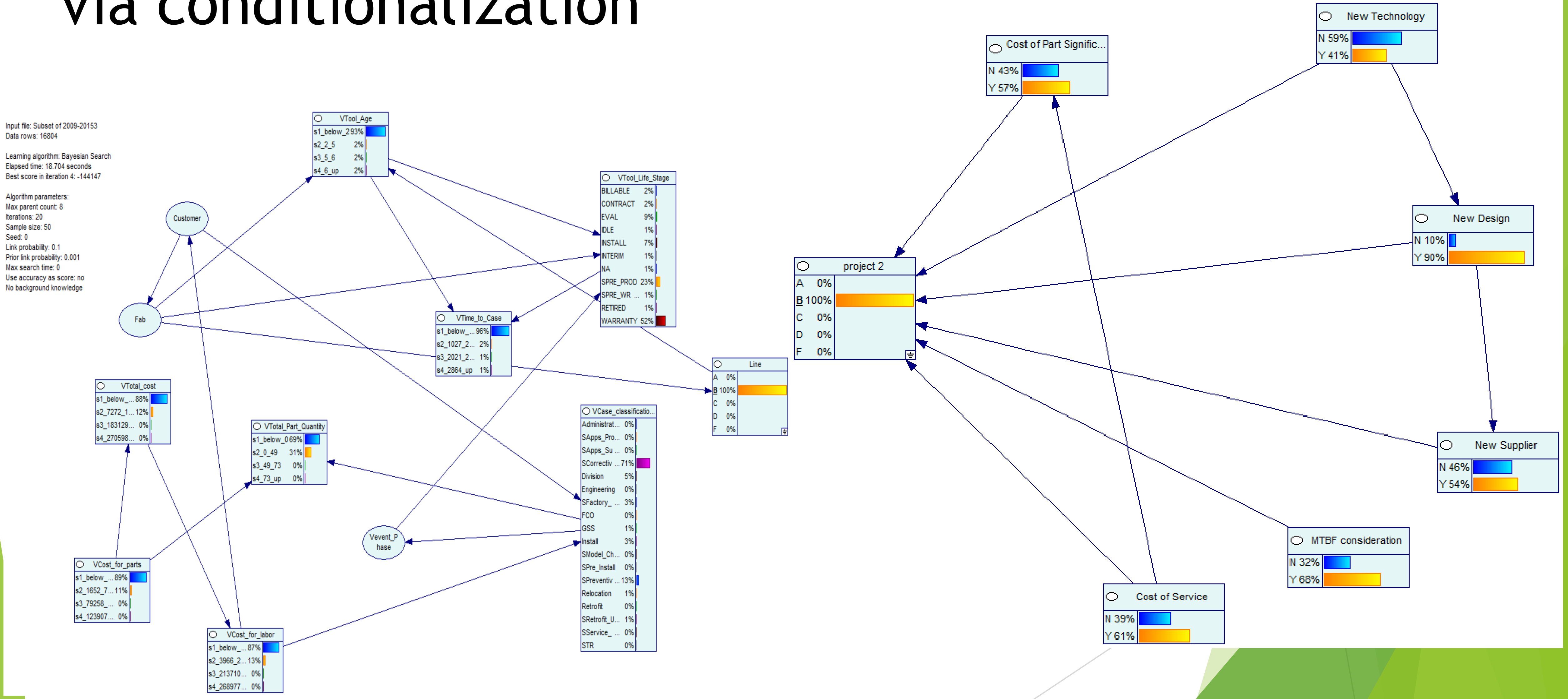
# Integration by calibrating on project variable: of Risk BBN and Project characteristics BBN

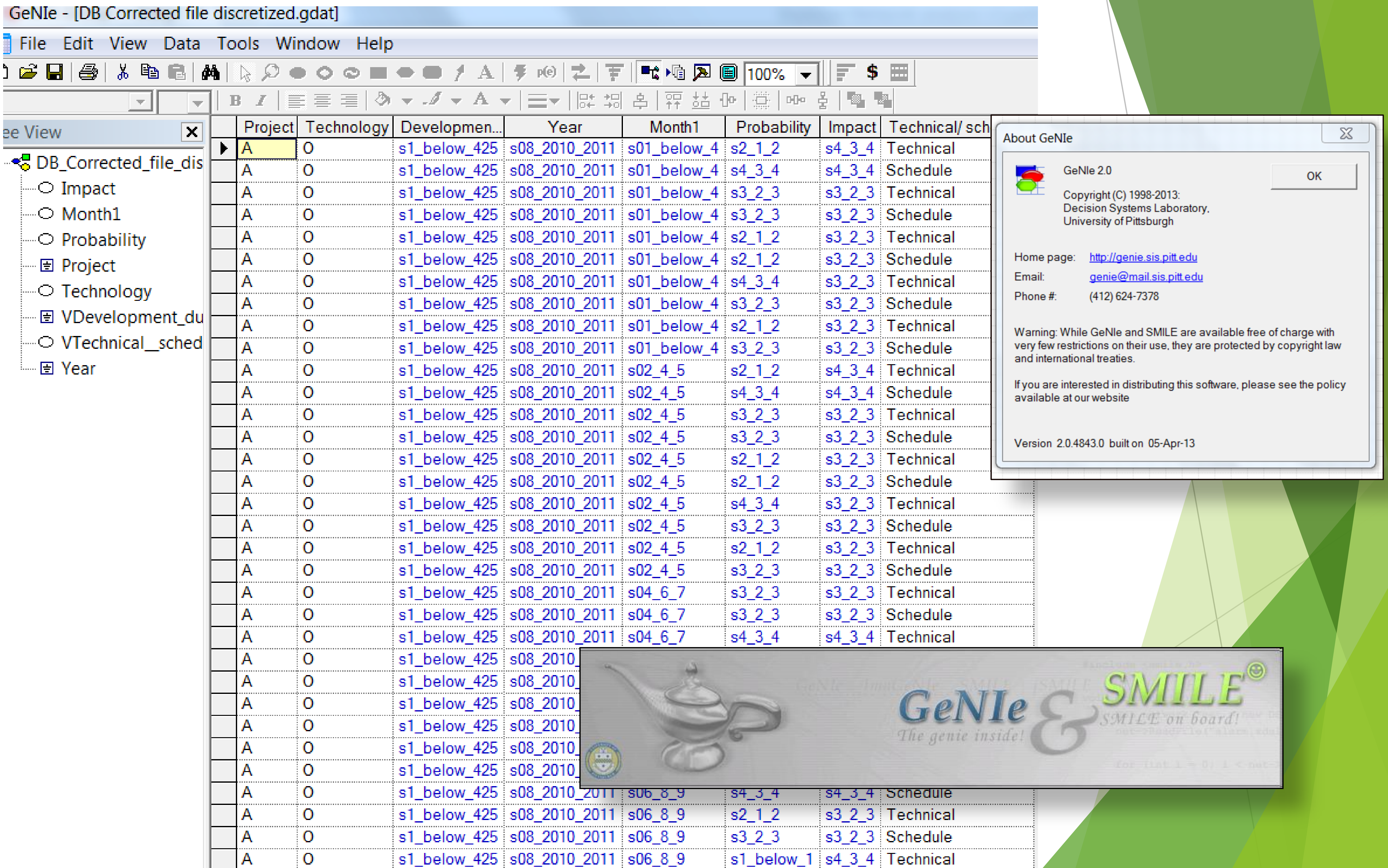
Conditional in project C



# Integrated Risk and Reliability at Field via conditionalization

Step 2- Calibration via conditionalization

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# Summary

- We learned how to integrate data from different domains. In addition, we assess reliability and risks in context of products complexity, service costs, and customer behavior.
- Probability assessment is common for risks and reliability domains as in both we give assessment of probability for future event. Usually these two activities runs separately In the industry. more than once, we notice difference in assessment for the same design/inherent risk in these two activities.
- In risk assessment, probability is valued by categorical variable, while in reliability probability is expressed by MTBF.
- MTBF allocation Models contains sub-modules without treating interfaces. risk assessment may supply additional risks which are beyond modules boundary. And it can be added to MTBF assessment.
- Further steps:
- Model Time to failure as continues variable in the BN.
- Modeling uncertainty relating the parameters to see how it will effect the method of integration.

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