

"Reducing Risk in 2020"



An Approach for Developing a Knowledge and Analytics-Based Framework and Model To Forecast Program Schedule Performance

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Stevens Institute of Technology

The Problem

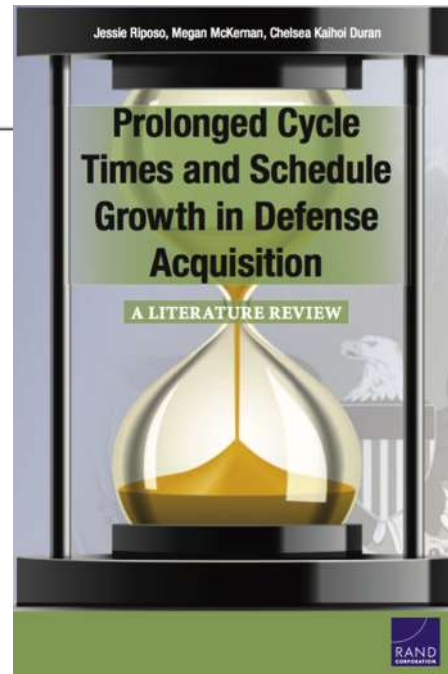


United States Government Accountability Office
Report to Congressional Committees

March 2014

DEFENSE ACQUISITIONS

Assessments of
Selected Weapon
Programs



Sources of Weapon System Cost Growth

Analysis of 35 Major Defense
Acquisition Programs



Joseph G. Bolten, Robert S. Leonard, Mark V. Arena,
Obaid Younossi, Jerry M. Sollinger

RAND Findings



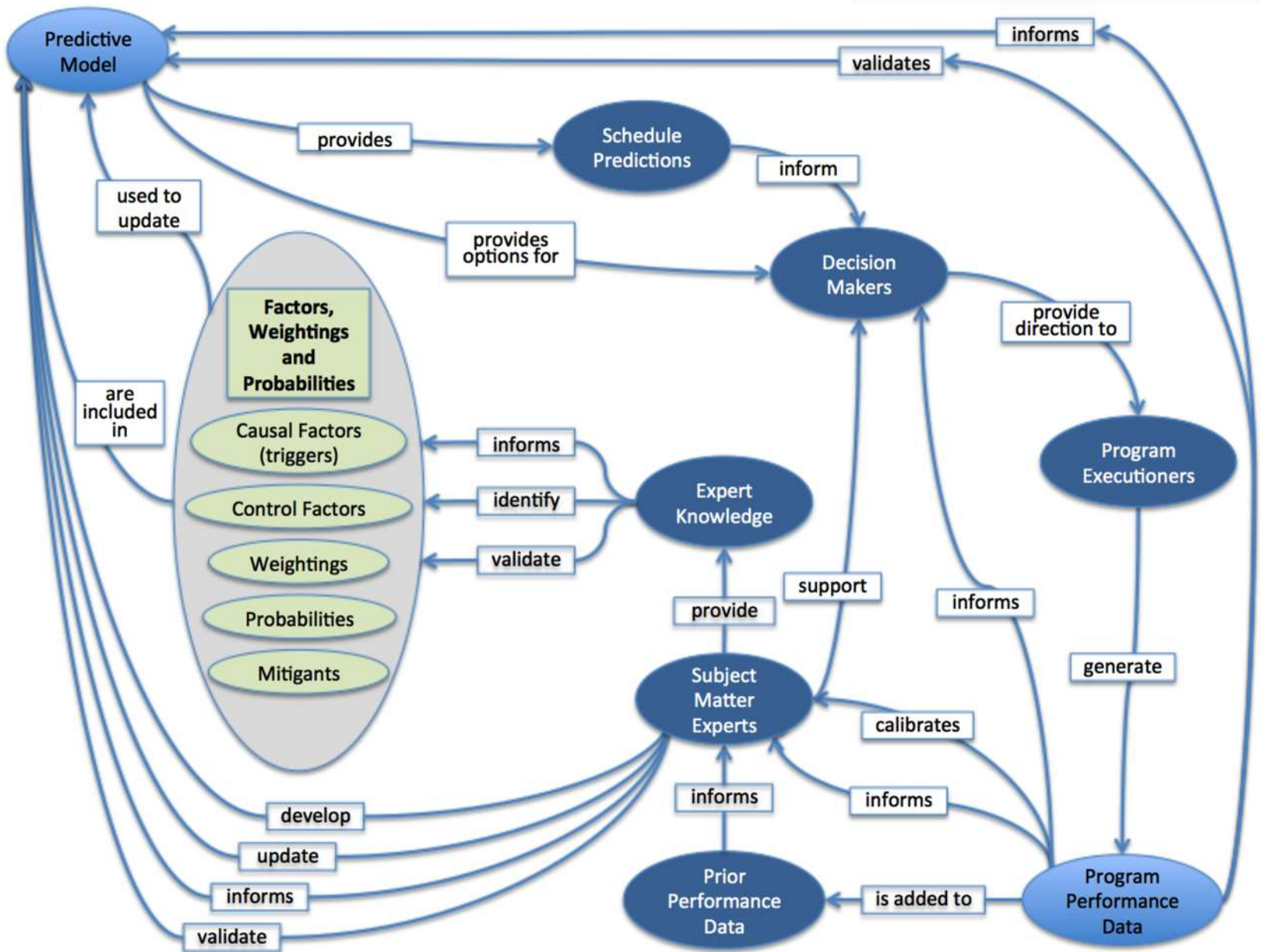
Reasons Cited in the Literature for Prolonged Schedules and Schedule Slippage

Area	Possible Reason
Requirements development, generation, and management	Infeasible or unrealistic requirements
	Unstable requirements (e.g., engineering requirements, readiness requirements, reliability and support requirements)
	Inefficiencies in the process (e.g., serial nature of process and requirements evolution)
Managing technical risk	Excessive technical, manufacturing, or integration risk (general) or program complexity
	Unanticipated design, engineering, manufacturing, technical difficulty, or technology integration issues
	Overly optimistic assumptions/expectations (technical risks, performance goals, system requirements, or design maturity)
	Immature technology
	Concurrency in complicated programs
	Prototyping
	Deficient test planning or testing inefficiencies

Research Approach



- Develop an approach to address cost and schedule delays in large-scale complex weapon systems.
- Identify potential causes or factors for program schedule delays.
- Investigate the feasibility of:
 - Deriving quantitative and qualitative causal factors correlating to schedule performance.
 - Developing a framework and a tailorable predictive model [Bayesian Network (BN) model]
 - Use the framework and BN model, with expert knowledge elicited from subject matter experts (SME), to:
 - Predict schedule performance
 - Inform decision makers on actions needed to manage schedule performance.



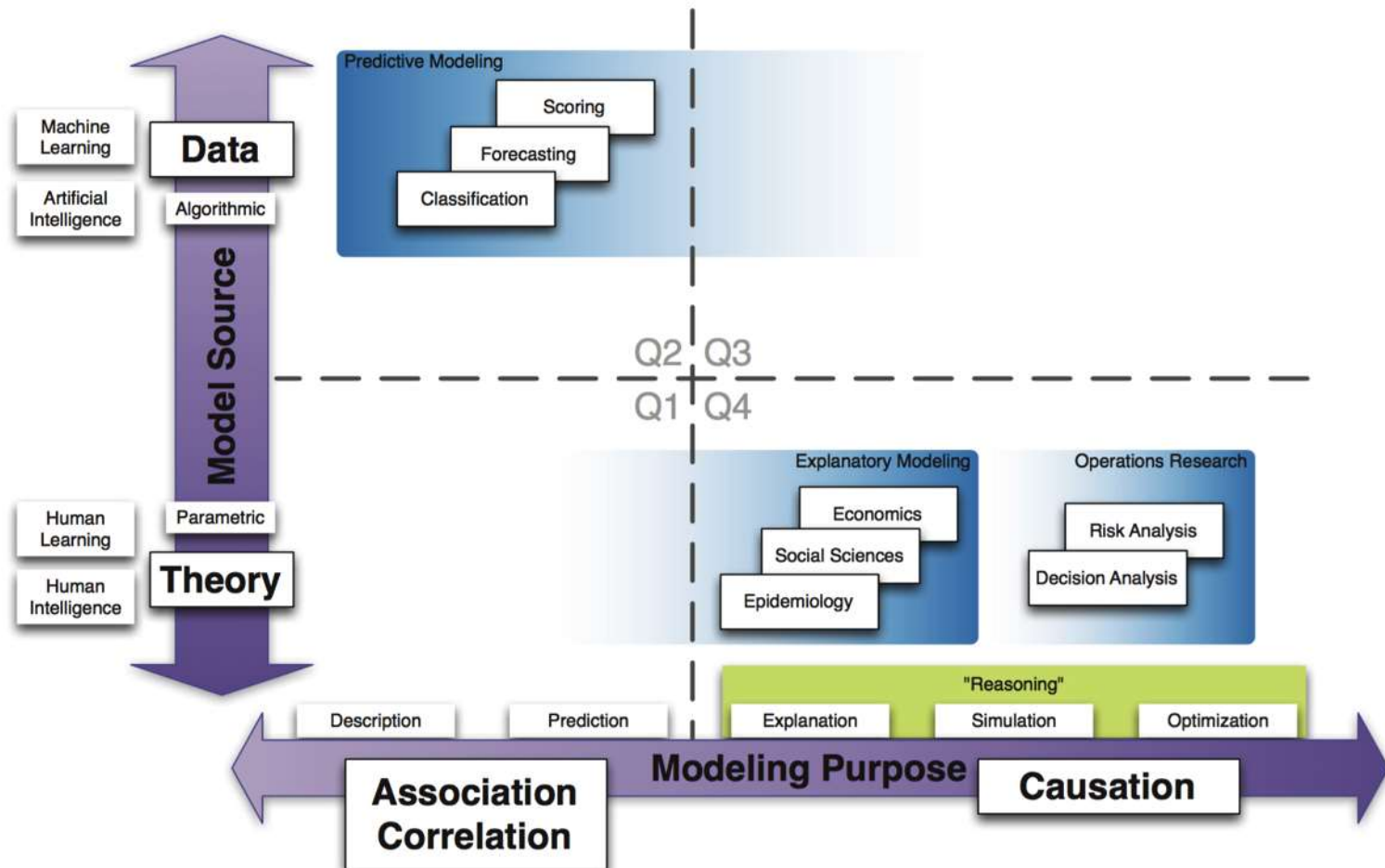
Research Systemigram

Why Bayesian Networks?

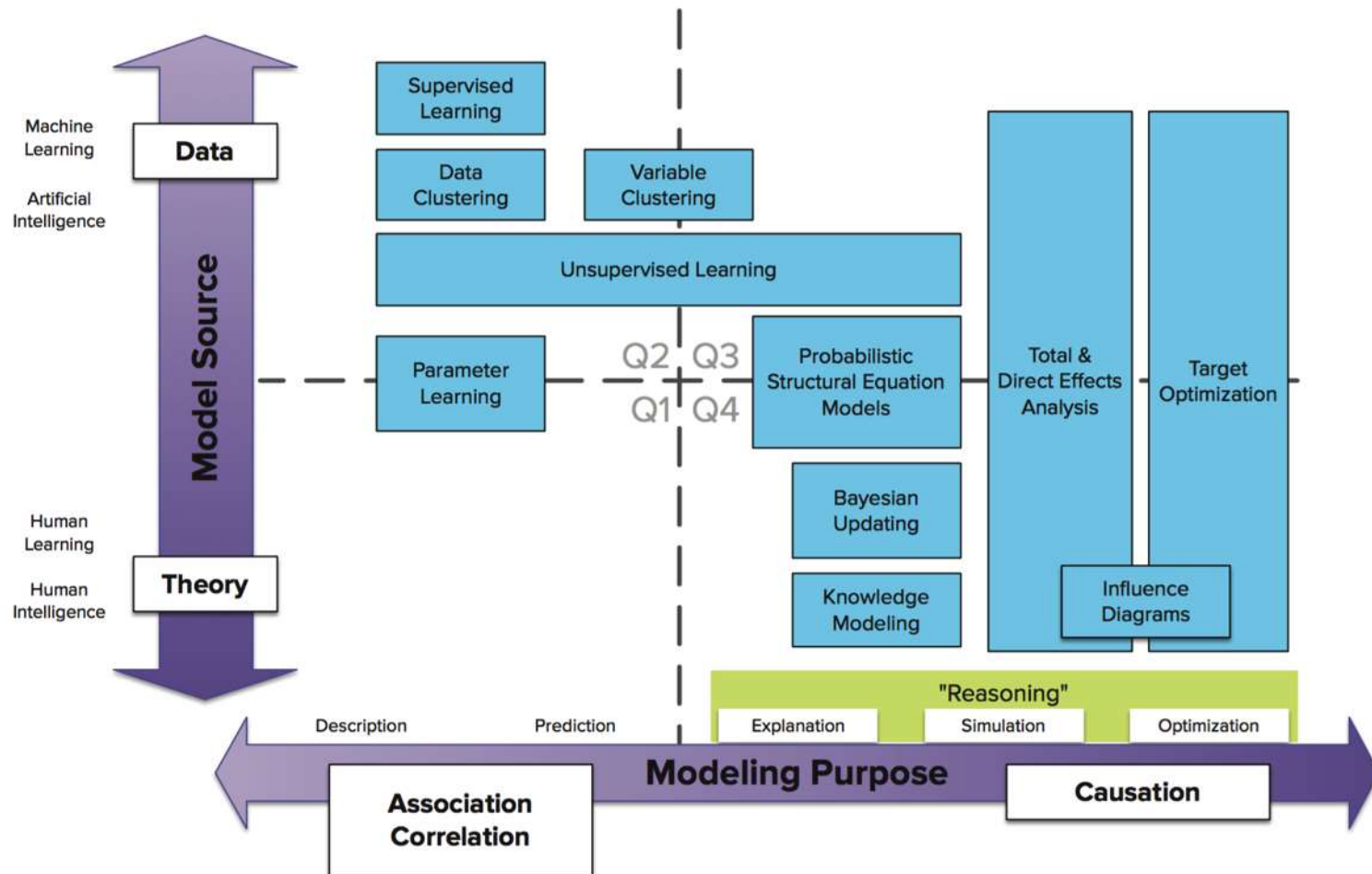


- BNs provide a methodology for combining prior knowledge with real data.
- BNs are equipped to handle contingencies, probabilities, and uncertainties.
- BNs are used to:
 - Graphically model the relationships and dependencies between variables and probabilities.
 - Depict the cause and effect relationships between them.

Conrady Map of Analytic Modeling



Conrady Map of Analytic Modeling with Modeling Methods and Approaches

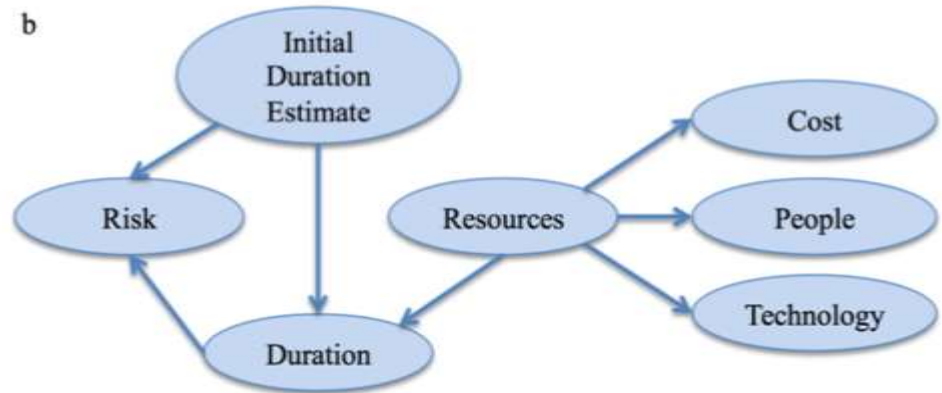
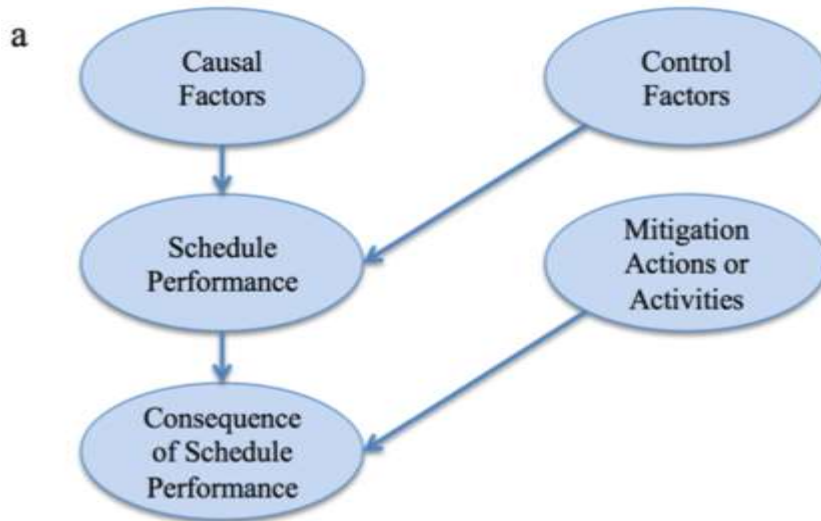


Bayesian Networks



- Building BN models consists of three basic steps.
 1. Identify critical model variables, parameters, or factors and their associated values.
 2. Determine the relationships between the critical model variables, parameters, or factors
 - Create a graphical depiction of the model that reflects the environment being modeled
 3. Obtain the probabilities associated with the model variables.
 - Capturing the required probabilities can be difficult to obtain if actual data is not available.
 - This is especially true for development associated with the implementation of new technologies or capabilities

Bayesian Networks



(a) Fenton's Cause-Consequence Idiom

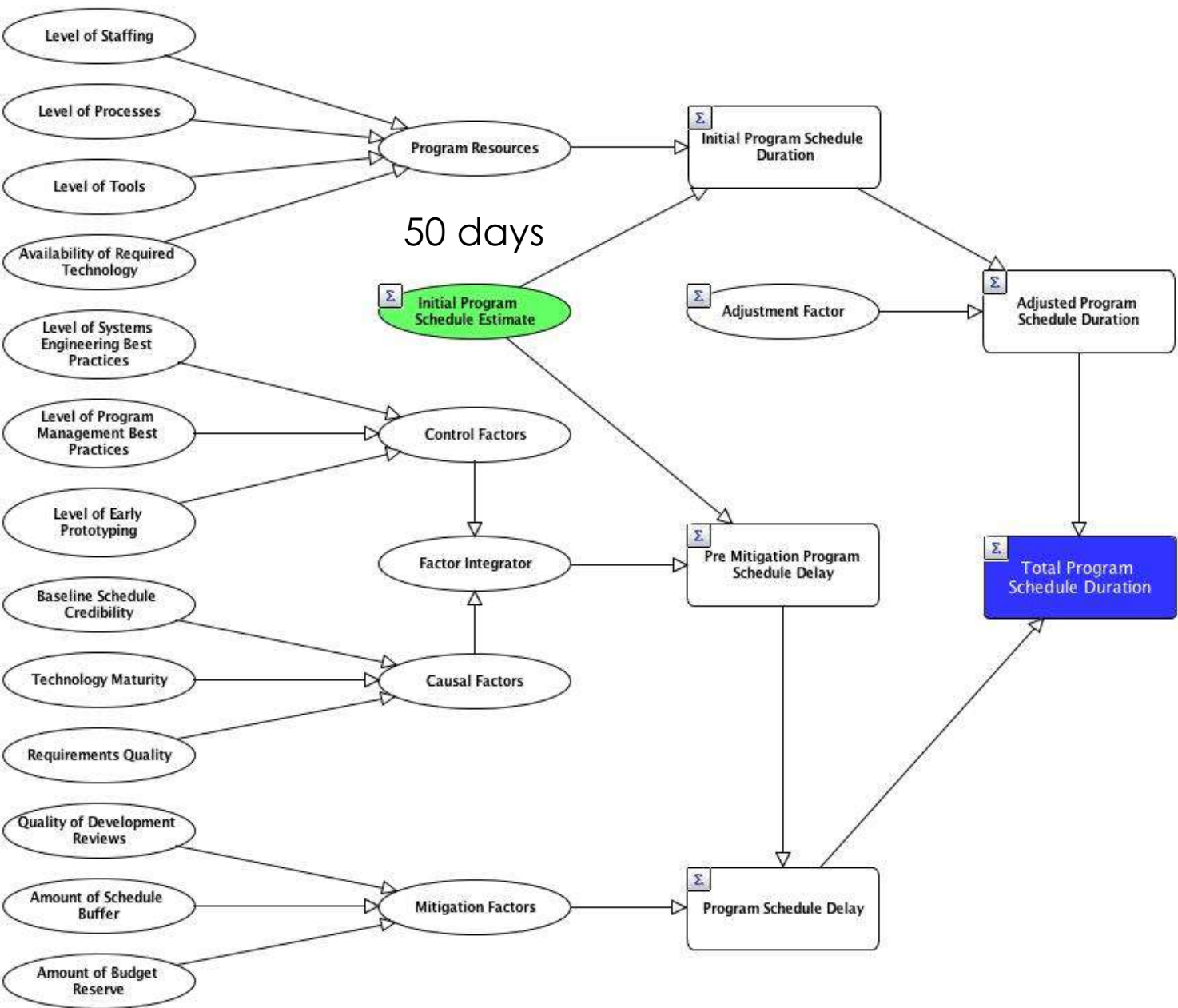
(b) Khodakarami's Bayesian Network Structure For Activity Duration

Probabilities From Expert Knowledge

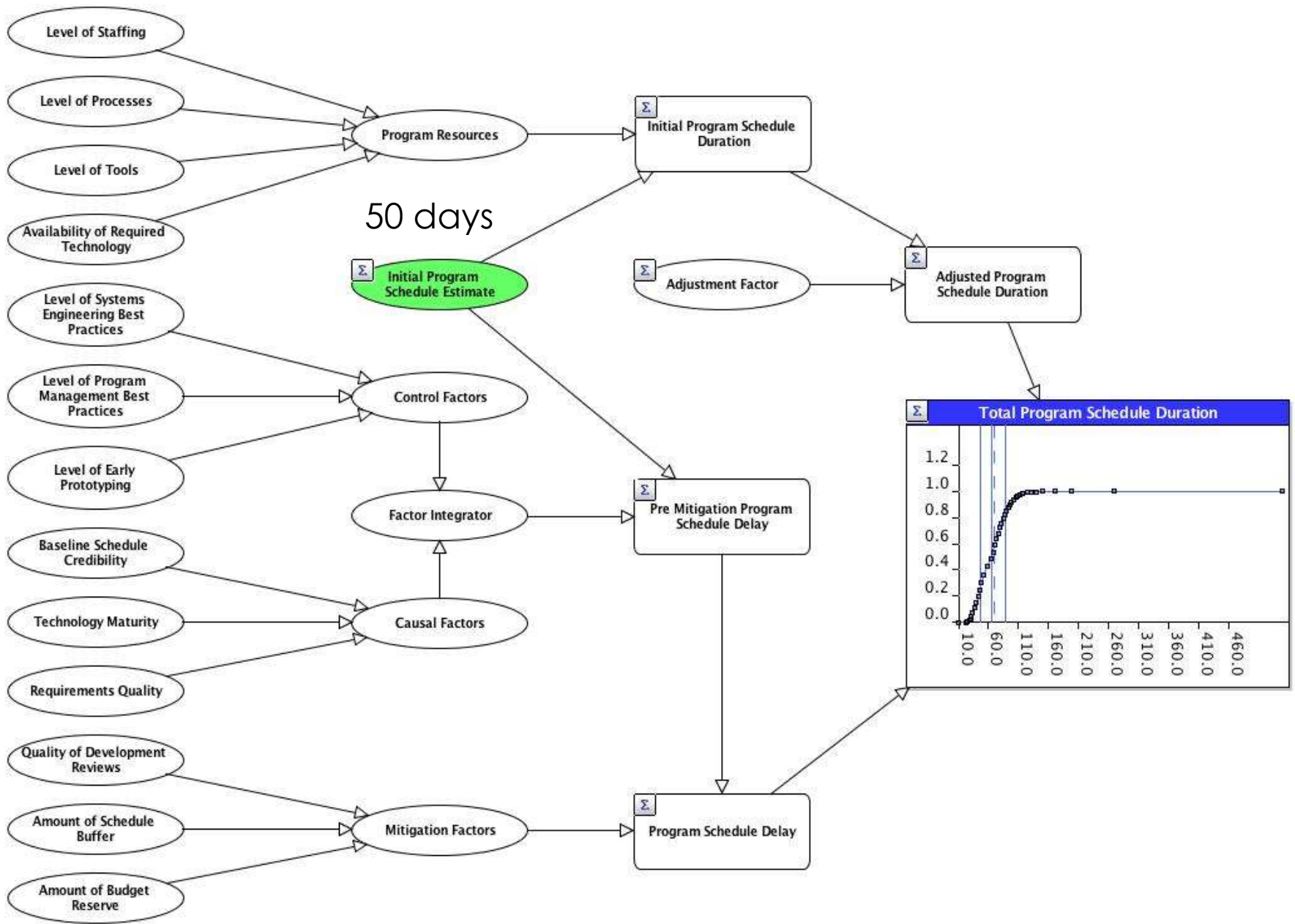


- Obtaining probabilities from sources that do not rely on or require hard data would be very useful.
- SMEs can be used not only to acquire BN model probabilities; they can also be used to refine and interpret BN model results.
- Using SMEs to elicit expert knowledge comes with issues.
- These issues are widely known and primarily focus around the inherent biases of each SME.
- A framework for eliciting expert knowledge from SMEs is being developed to support this research effort.


















Level of Staffing	
Very High	20%
High	20%
Medium	20%
Low	20%
Very Low	20%

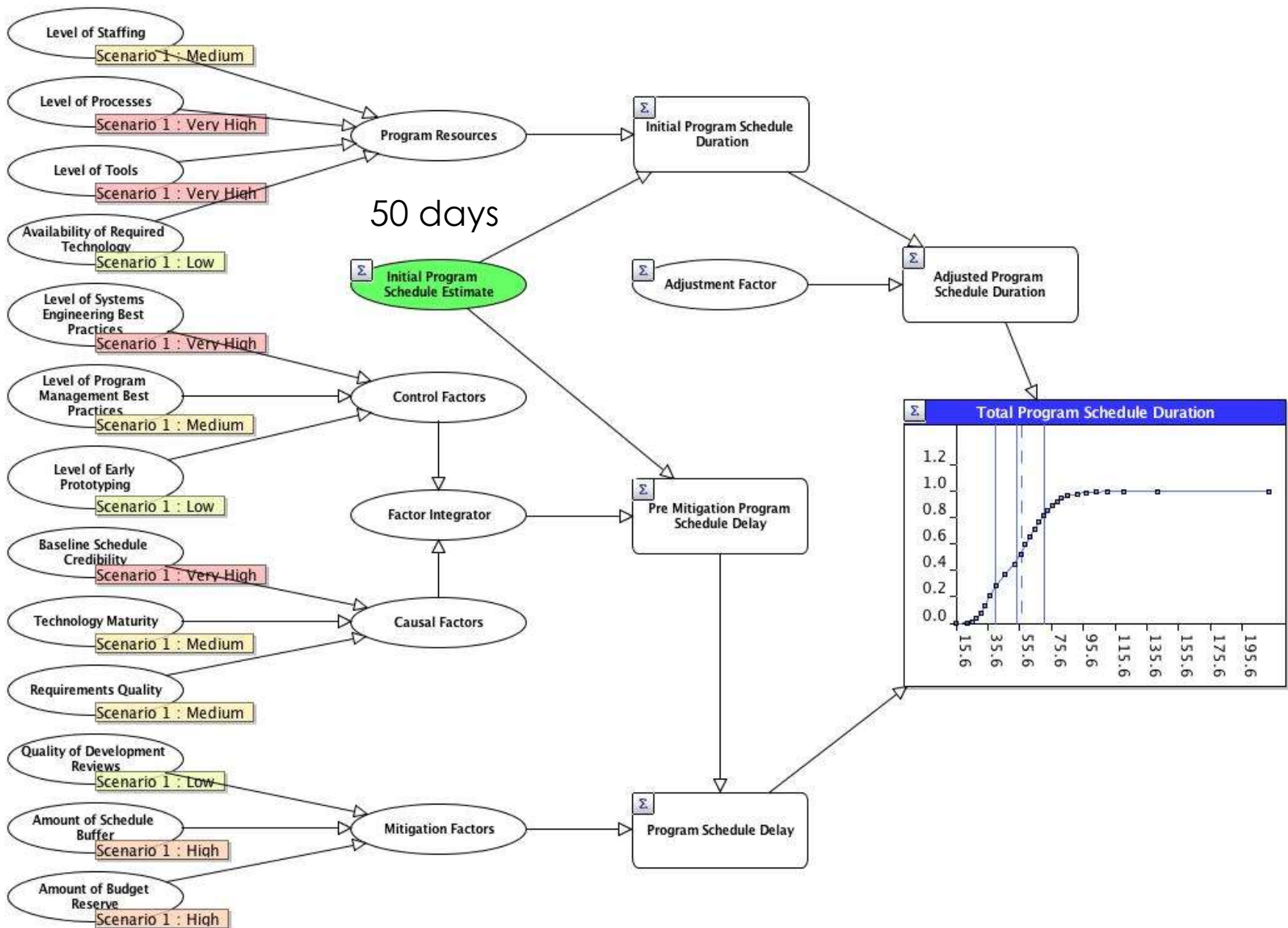


The Model



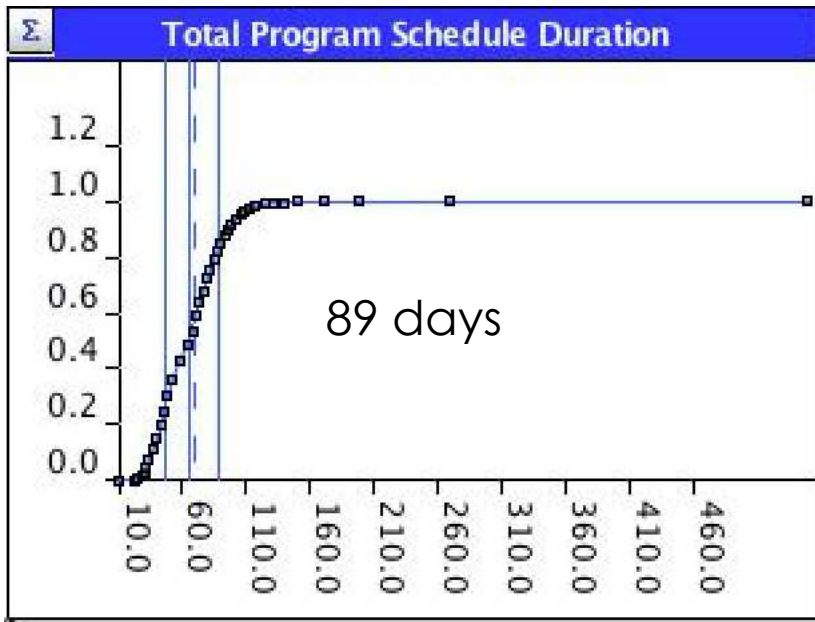
The Model

	Scenario 1
New Risk Object	
Initial Program Schedule Duration	
Program Resources	No Answer 
Adjustment Factor	
Adjusted Program Schedule Duration	
Control Factors	No Answer 
Causal Factors	No Answer 
Mitigation Factors	No Answer 
Pre Mitigation Program Schedule Delay	
Program Schedule Delay	
Total Program Schedule Duration	
Baseline Schedule Credibility	No Answer 
Technology Maturity	No Answer 
Requirements Quality	No Answer 
Level of Systems Engineering Best Practices	No Answer 
Level of Program Management Best Practices	No Answer 
Level of Early Prototyping	No Answer 
Quality of Development Reviews	No Answer 
Amount of Schedule Buffer	No Answer 
Amount of Budget Reserve	No Answer 
Factor Integrator	No Answer 
Level of Staffing	No Answer 
Availability of Required Technology	No Answer 
Level of Tools	No Answer 
Level of Processes	No Answer 
initial_estimate_constant	50

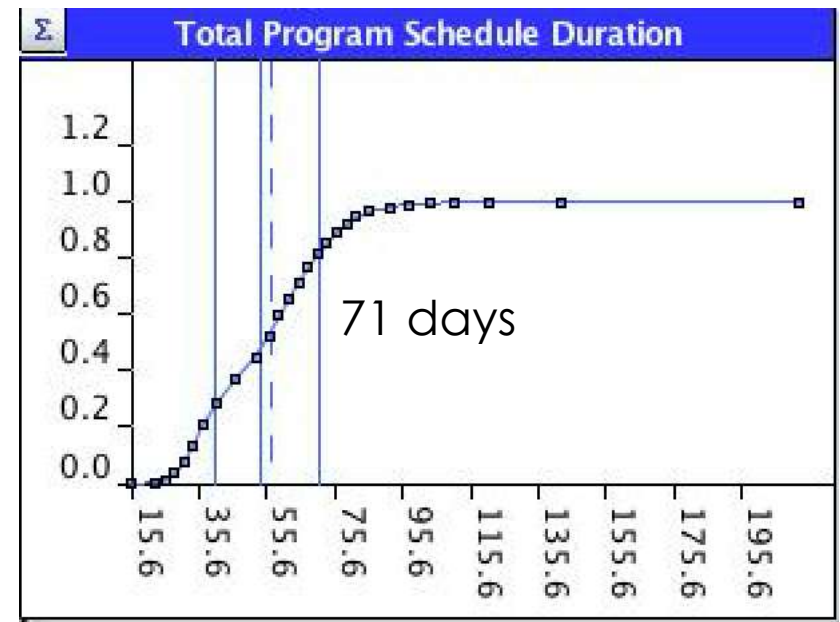


The Model

Sample Results



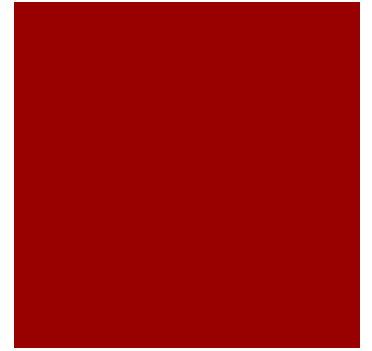
Baseline Probabilities



"SME" Probabilities

Next Steps

- Further research will refine:
 - The causal factor analysis.
 - Mature and assess the BN model.
 - Refine the framework.
 - Develop a framework for eliciting expert knowledge from SMEs.
 - Validate on real programs.



Questions?

