Identifying best EVM-based Risk Management policies through Dynamic Simulation

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PMI® Risk Management Specific Interest Group

Agenda

- Overview of Earned Value Management
- System Dynamics Modeling
- Developing an SD project model
- Modeling EVM-based control policies
- Practical Example: EVM vs. Traditional Control
  - Managing the impacts of risks
  - Exploring opportunities
  - Managing the project objectives
- Conclusions

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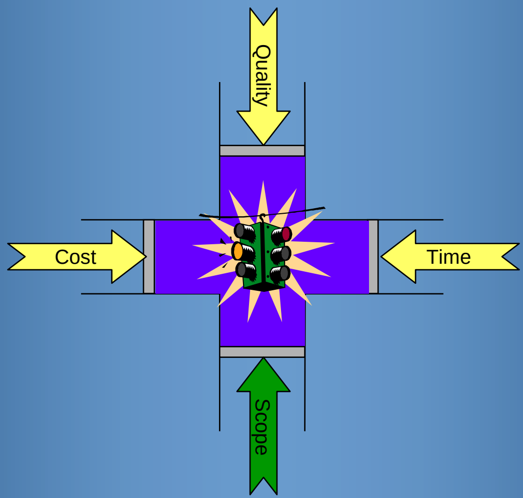
Earned Value Management
Overview

- The Challenge of Control
- Basic Metrics
- Variance and Performance Indices
- “At Completion” forecasts

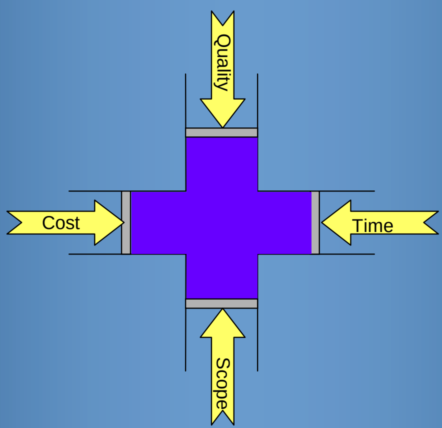
Earned Value Management

The Challenge of Control

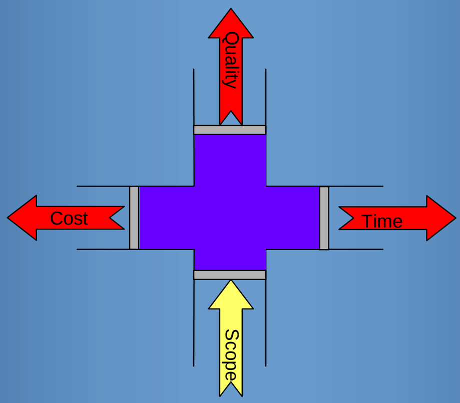


Earned Value Management

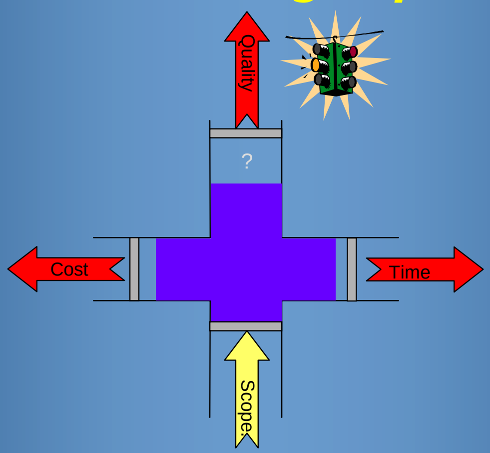
The Challenge of Control



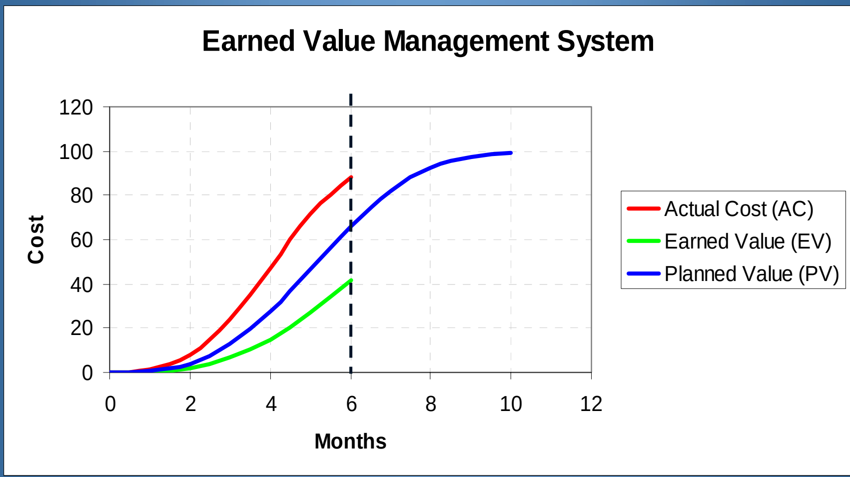
Earned Value Management
The Challenge of Control



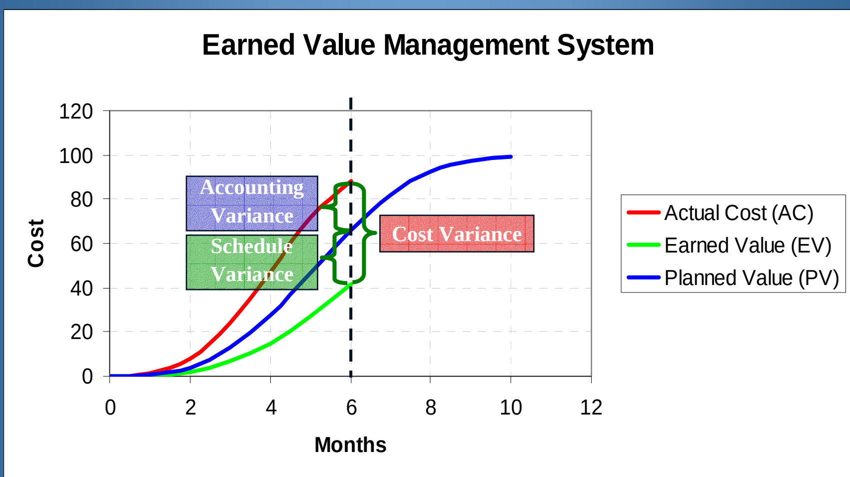
Earned Value Management
The Challenge of Control

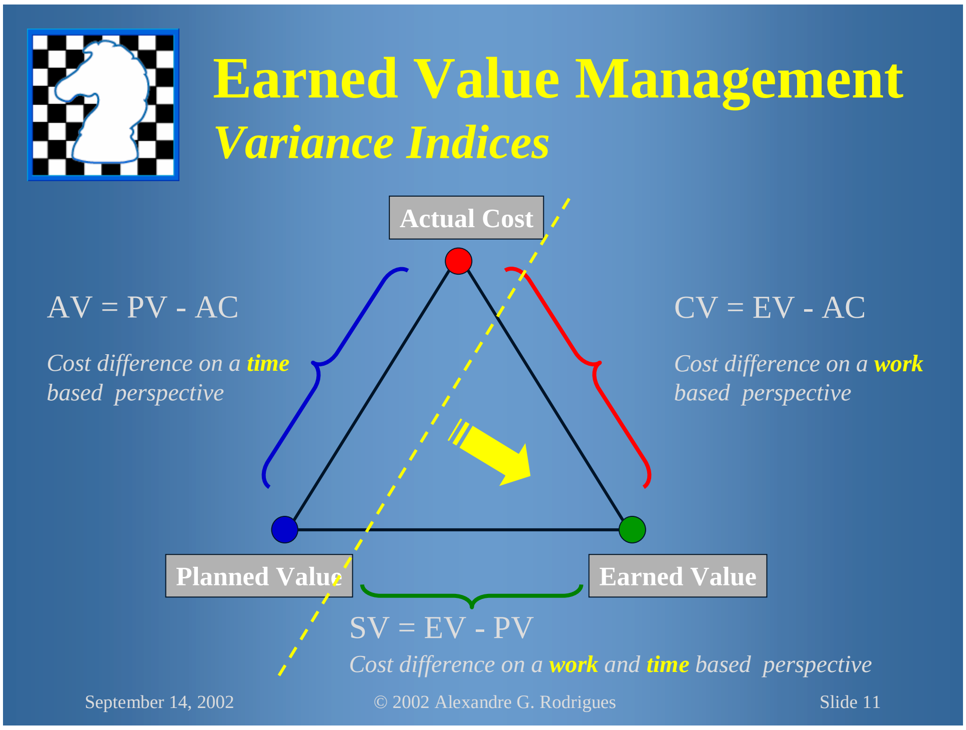


Earned Value Management
Basic Metrics



Earned Value Management
Variance Indices




Earned Value Management
Variance Indices
Actual Cost
AV = PV - AC
Cost difference on a time based perspective
CV = EV - AC
Cost difference on a work based perspective
Planned Value
Earned Value
SV = EV - PV
Cost difference on a work and time based perspective
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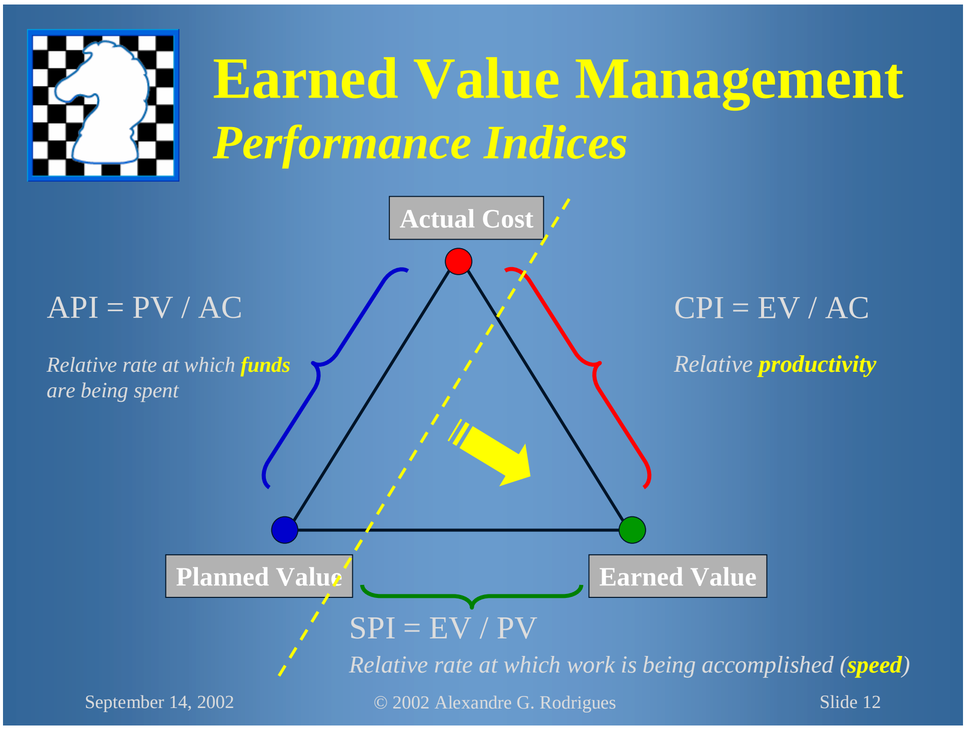
Earned Value Management
Performance Indices
Actual Cost
API = PV / AC
Relative rate at which funds are being spent
CPI = EV / AC
Relative productivity
Planned Value
Earned Value
SPI = EV / PV
Relative rate at which work is being accomplished (speed)
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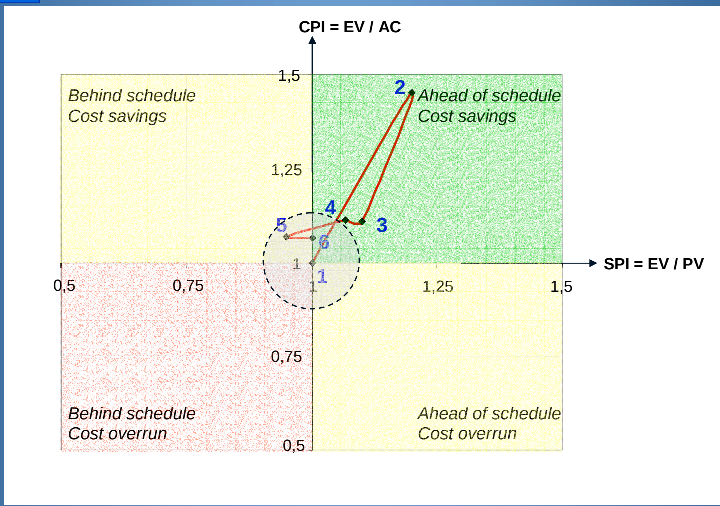
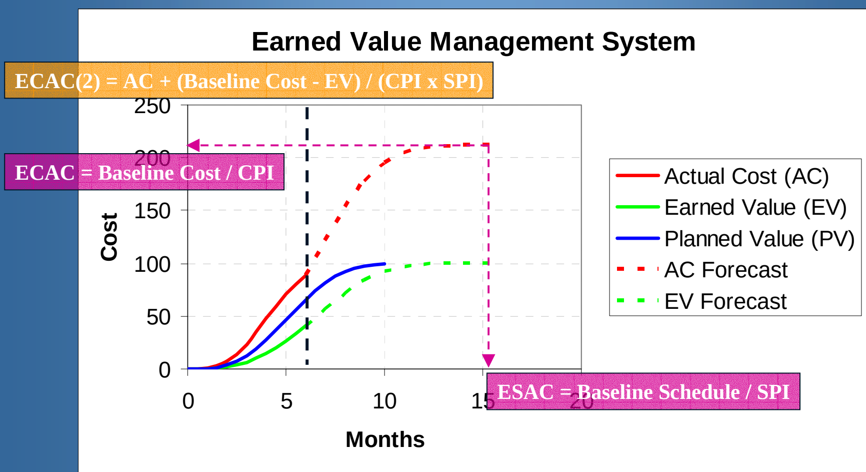
Earned Value Management

Performance Indices



Earned Value Management

“At Completion” Forecasts



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- **System Dynamics Modeling**
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- Modeling EVM-based control policies
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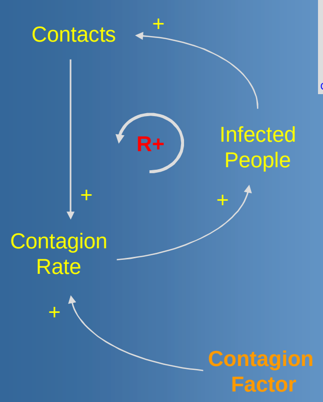
System Dynamics Modeling
Overview

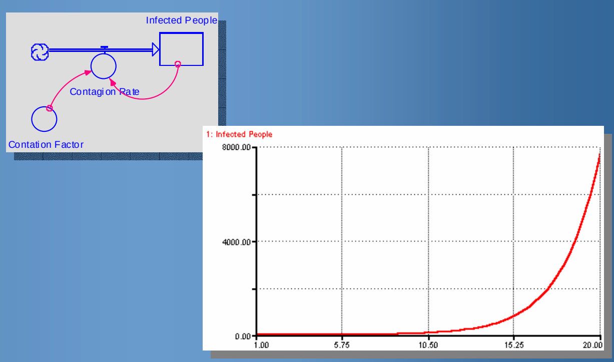
- Introduction
- Modeling Feedback Dynamics
  - Positive Feedback
  - Negative and Positive Feedback
  - Complex Dynamics
- Feedback Dynamics in Business Systems
- Feedback Dynamics in Projects

System Dynamics Modeling
Introduction

- Developed in the late 50s by Forrester (MIT):
  - A simulation based modelling approach
  - Aimed at analysing the behaviour of complex social systems
  - Feedback structure as the primary responsible for behaviour
  - Management laboratory:
    - Models supports policy improvement through "what-if" scenario analyses
- A two-phase modelling process:
  - Qualitative Influence Diagrams
  - Quantitative Simulation Models
- Growing application to real life business problems and to Project Management

System Dynamics Modeling
Positive Feedback

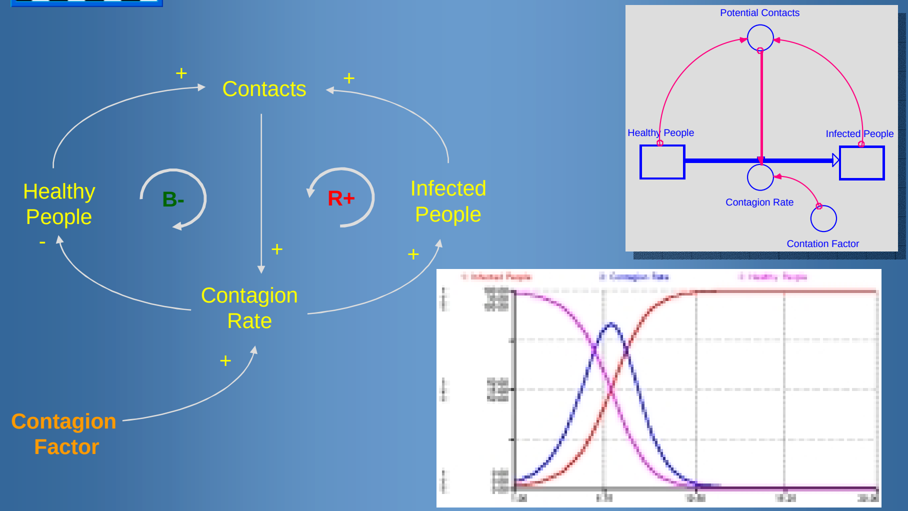




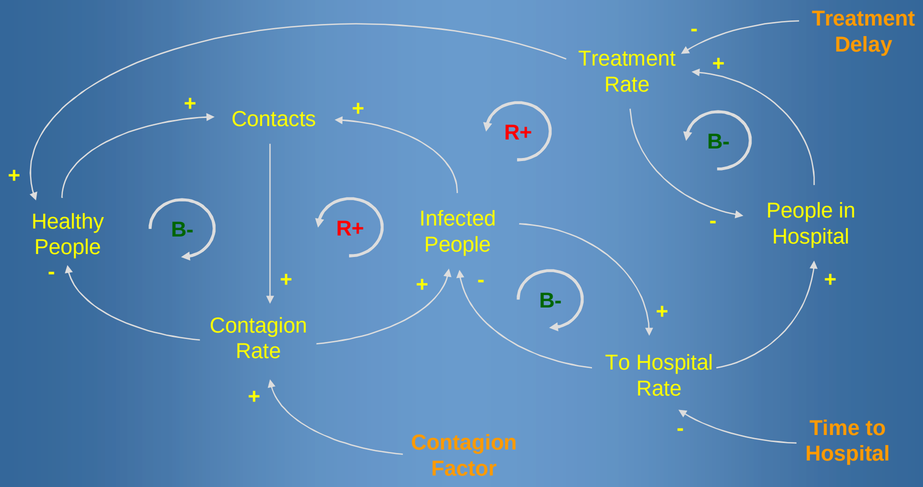
Infected_People(t) = Infected_People(t - dt) + (Contagion_Rate) * dt
INIT Infected_People = 1

INFLOWS:
Contagion_Rate = Infected_People*Contation_Factor
Contation_Factor = .5

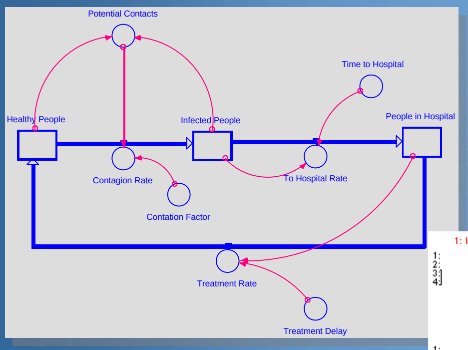
System Dynamics Modeling
Negative and Positive Feedback

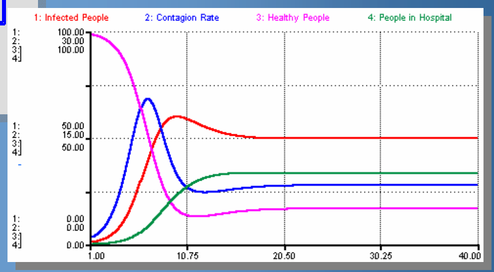


System Dynamics Modeling
Complex Feedback

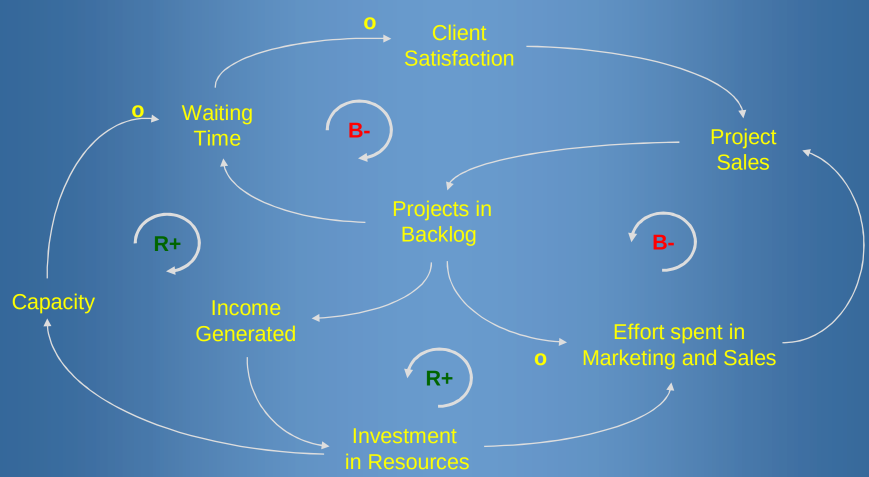


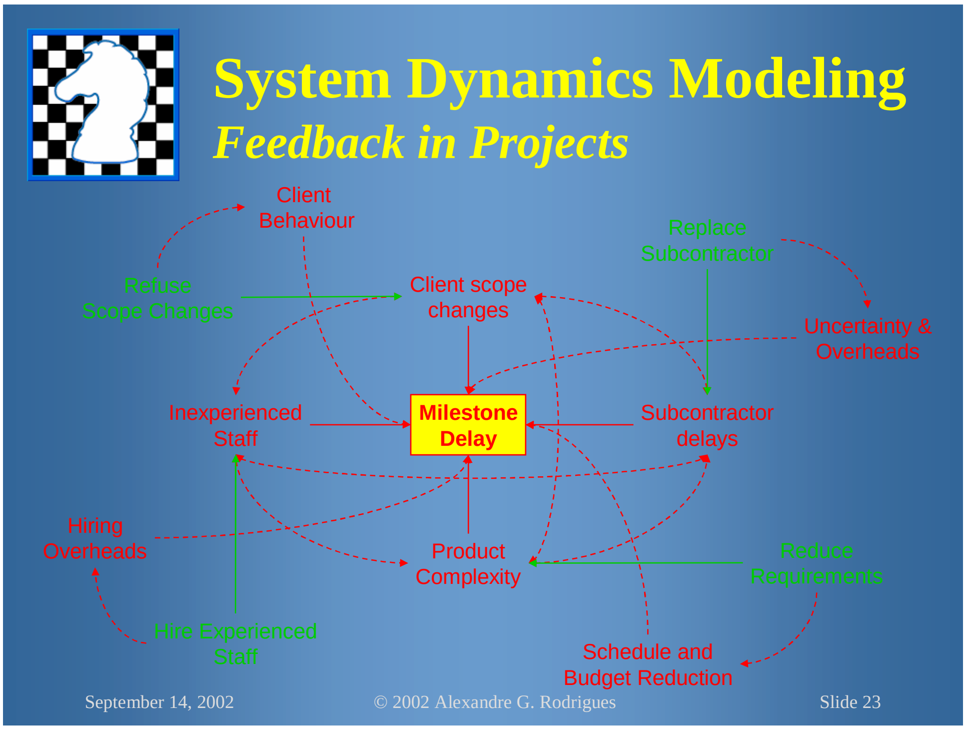
System Dynamics Modeling
Complex Feedback





System Dynamics Modeling
Feedback in Business Systems




System Dynamics Modeling
Feedback in Projects
Client Behaviour
Replace Subcontractor
Refuse Scope Changes
Client scope changes
Uncertainty & Overheads
Inexperienced Staff
Milestone Delay
Subcontractor delays
Hiring Overheads
Product Complexity
Reduce Requirements
Hire Experienced Staff
Schedule and Budget Reduction
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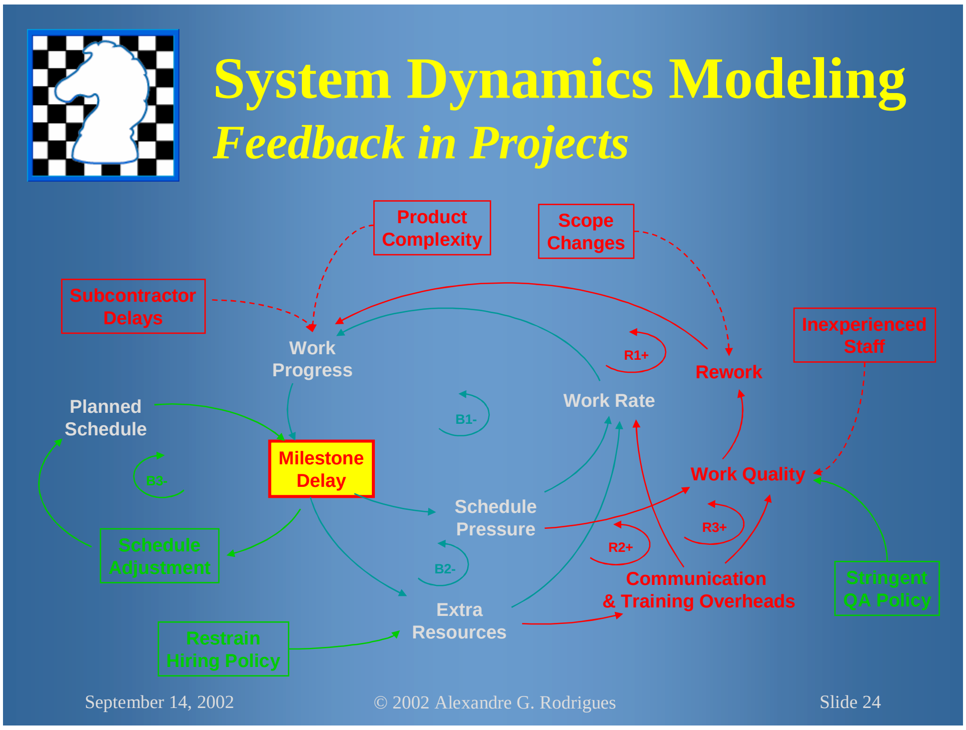
System Dynamics Modeling
Feedback in Projects
Product Complexity
Scope Changes
Subcontractor Delays
Work Progress
R1+
Rework
Inexperienced Staff
Planned Schedule
B1-
Work Rate
B3-
Milestone Delay
Work Quality
Schedule Pressure
R3+
Schedule Adjustment
R2+
B2-
Communication & Training Overheads
Stringent QA Policy
Extra Resources
Restrain Hiring Policy
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System Dynamics Modeling
Complexity in Social Systems

- **Systemic:**
  - Everything affects everything, directly or indirectly
- **Dynamic:**
  - They do not take place at one point in time. They unfold over-time.
- **Feedback effects:**
  - Causes lead to effects, which over-time will affect the causes
- **Long-term effects (delayed):**
  - The impacts of actions and events remain unperceived in the short-term
- **Non-linear:**
  - Relationships between causes and effects are rarely linear
- **Subjective, intangible, secondary, undesired effects:**
  - Many factors involved are of social human nature and difficult to anticipate

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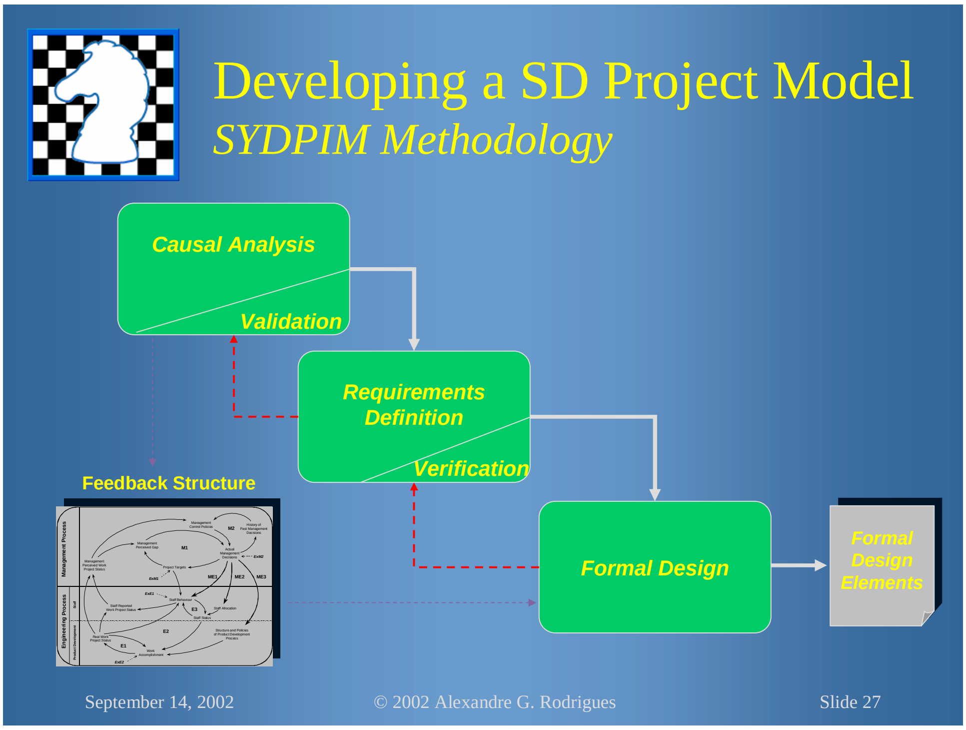
Developing a SD Project Model
SYDPIM Methodology
Causal Analysis
Validation
Requirements Definition
Verification
Feedback Structure
Formal Design
Formal Design Elements
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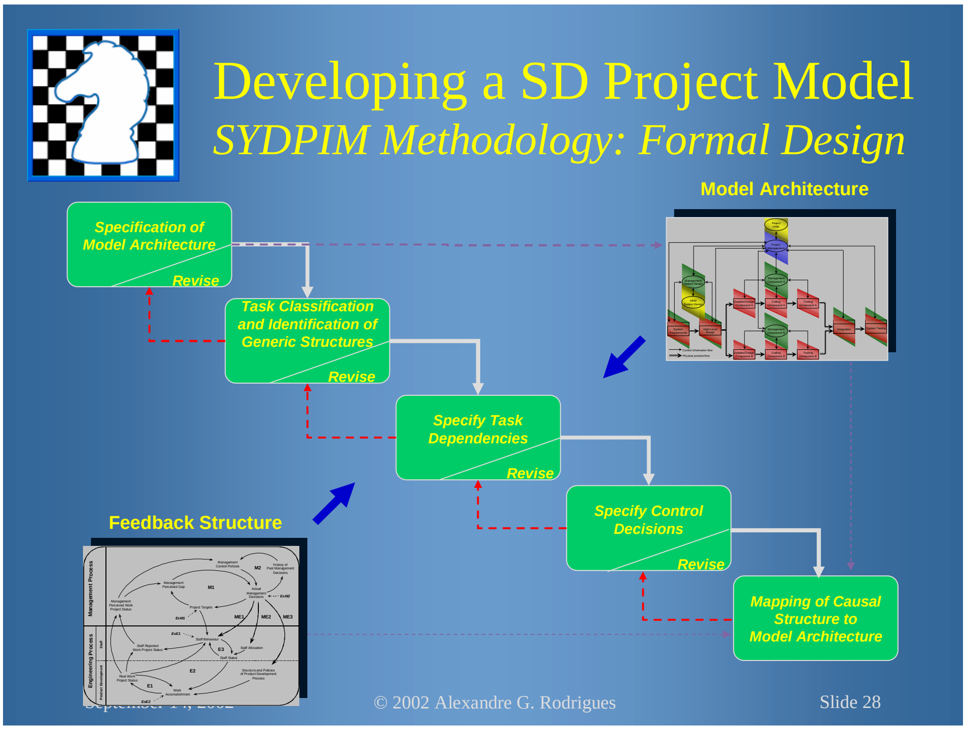
Developing a SD Project Model
SYDPIM Methodology: Formal Design
Model Architecture
Specification of Model Architecture
Revise
Task Classification and Identification of Generic Structures
Revise
Specify Task Dependencies
Revise
Specify Control Decisions
Revise
Mapping of Causal Structure to Model Architecture
Feedback Structure
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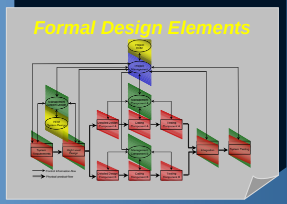
Developing a SD Project Model
SYDPIM Methodology: Implementation

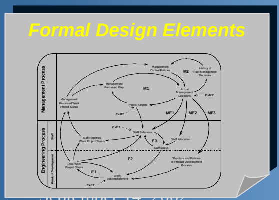
Development of super-structures — Validation

Tailoring of super-structures to project tasks — Validation

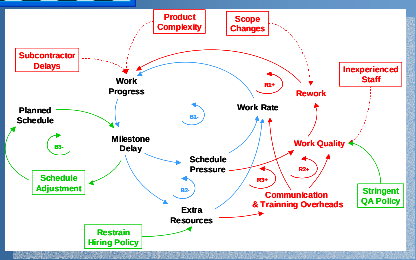
Integration of project tasks — Validation

Final Model Validation

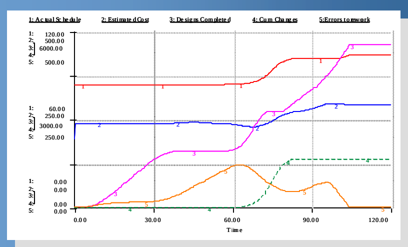




Developing a SD Project Model
Using the Model



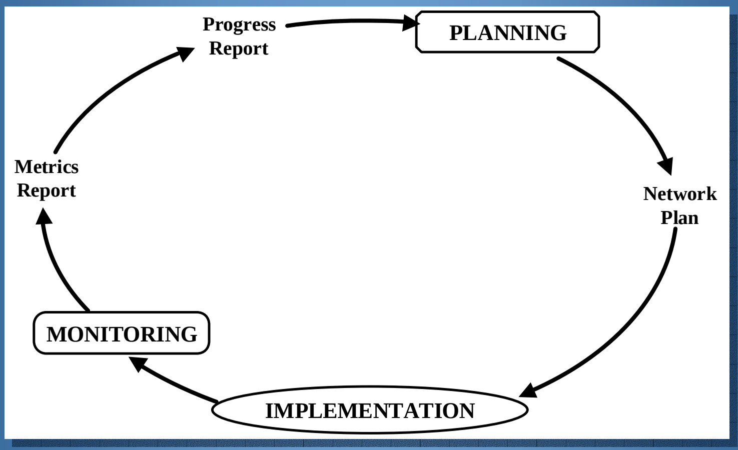
1. Project **feedback structure** is identified and is captured in the simulation model
2. Project is simulated and its **behaviour over-time** is produced



3. Project **behaviour** is analysed under a **feedback** perspective
4. Solutions are devised and the SD model is re-calibrated for **testing** them

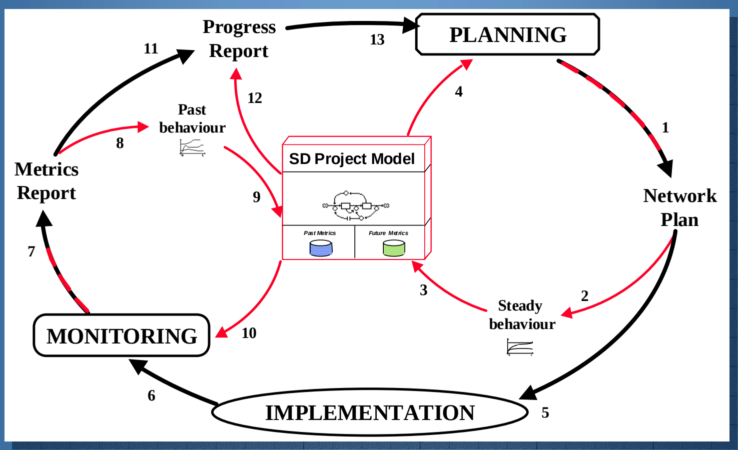
Developing a SD Project Model

Using the Model (SYDPIM)



Developing a SD Project Model

Using the Model (SYDPIM)



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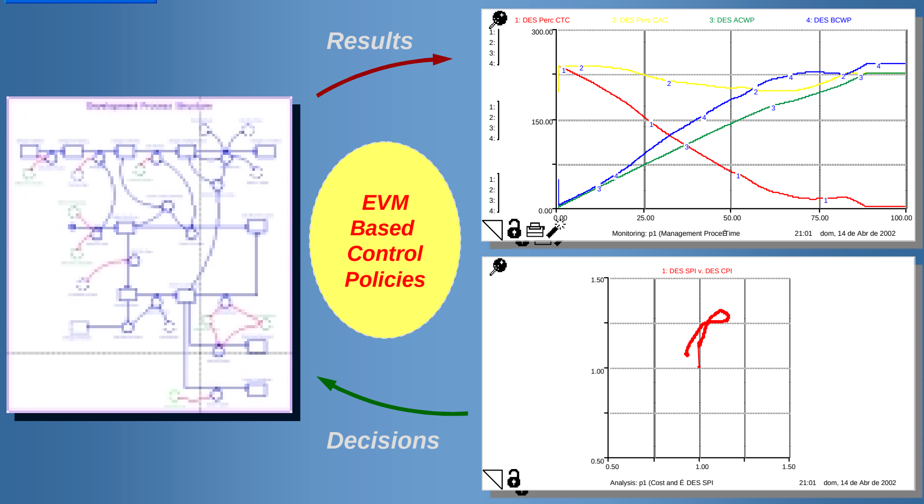
Modeling EVM-based control policies

- Concept
- Overview of the SD model used
  - Process Structure
  - Key feedback effects
  - The Project Plan
  - Base Control Policies
- Modeling of EVM Control
  - EVM metrics and indices
  - EVM in the control policies

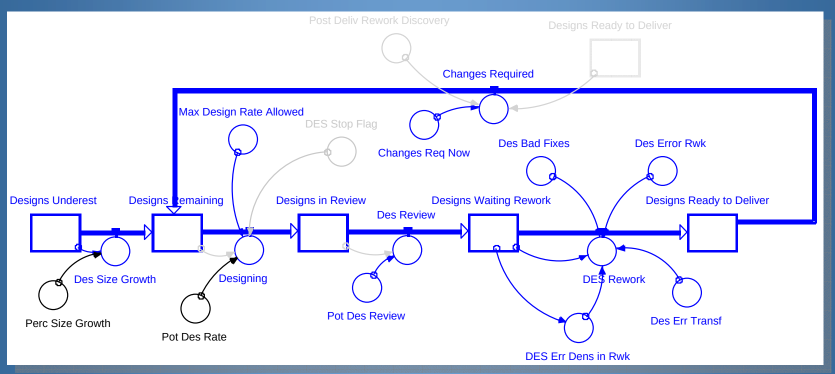
Modeling EVM policies

Concept



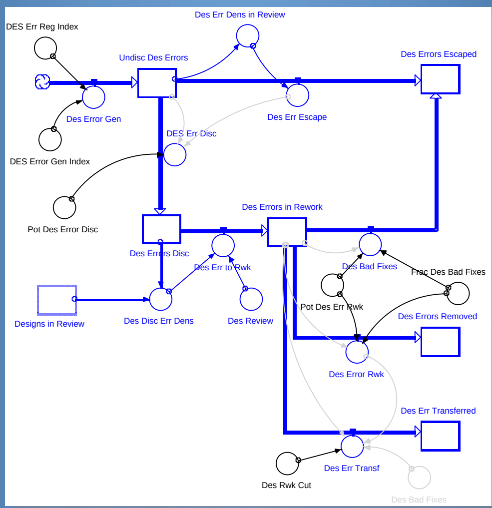
The SD Project Model

Process Structure: work-flow



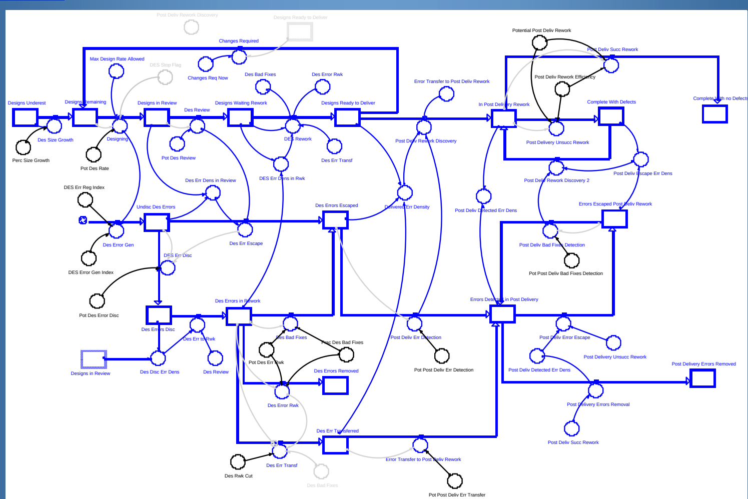
The SD Project Model

Process Structure: defects-flow



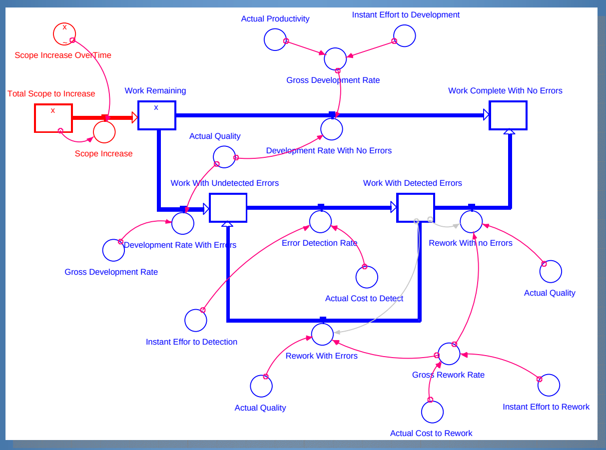
The SD Project Model

Process Structure (complex)



The SD Project Model

Process Structure (simpler)



The SD Project Model

Key Feedback Effects

- Schedule pressure:
  - ↓ Productivity, Cost to Rework
  - ↓ Quality
- Communication Overheads (team size)
  - ↓ Productivity, Cost to Rework
- Work Progress
  - ↓ Productivity, Quality, Cost to Detect, Cost to Rework
- Error Density
  - ↓ Quality
  - ↓ Cost to Detect
- Managerial
  - ↓ Schedule Adjustment
  - ↓ Staff Adjustment
  - ↓ QA Level Adjustment

The SD Project Model
The Project Plan

- Objectives:
  - Scope, Cost, Schedule, Quality
  - Priority and importance of each objective
- Staff Profile
  - Planned Allocation Over-Time
- Planned QA Effort
  - As fraction of total effort
  - Over-time
- Planned Rework Fraction
  - As fraction of total effort
- Expected Productivity Variation Over Progress
  - This the expected learning curve, which should have an impact on the Earned Value estimation based on % progress

The SD Project Model
Base Control Policies

- Schedule Adjustment. Depends on:
  - Progress
  - Perceived slippage
  - Schedule priority
  - Delay to adjust
- Staff Adjustment. Depends on:
  - Progress
  - Perceived Staff Gap
  - Budget Priority
  - Delay to adjust (increase / decrease)
- QA Level Adjustment. Depends on:
  - Schedule Pressure
  - Quality Priority
- Weight Given to Baseline. Depends on:
  - Progress

The SD Project Model
Modeling of EVM Control

- The model calculates at any point in time:
  - AC, EV, and PV
  - CPI, SPI, TCPI, TSPI, CPI Modified, SPI Modified
  - ECAC, ESAC, ECTC
  - Average Staff Level Currently Available
- Based on these EVM indices, it calculates:
  - Average Staff Level Needed to Complete on Planned Schedule
  - Staff Gap = Staff Needed – Staff Available
  - Schedule Pressure = Staff Gap / Staff Currently Working
- These metrics drive management decisions, along with the Base Policies:
  - Staff Gap drives Staff Adjustment
  - Schedule Pressure Drives Schedule Adjustment
  - Schedule Pressure Drives QA Level Adjustment

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Practical Example

EVM vs. Traditional Control

- The SD model was calibrated to reproduce a set of scenarios, aimed at:
  - Comparing the performance of EVM-based control vs. traditional operational control
  - Analyzing how the project objectives (schedule, budget quality) should be managed in terms of priority throughout the project, in order to maximize the overall project performance (which depends on the importance of the objectives)

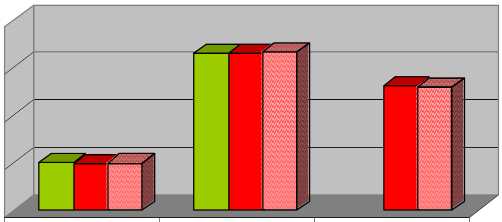
EVM vs. Traditional Control

Scenarios Analyzed

- Base Case:
  - Project implemented as planned
- Scope Risk:
  - 30% addition of new scope, over a period of time
- Scope Risk + Staff Risk:
  - Scope Risk
  - Staff leaving the project at certain moments in time
- Productivity Opportunity:
  - Constant productivity increase
  - Varying productivity increase

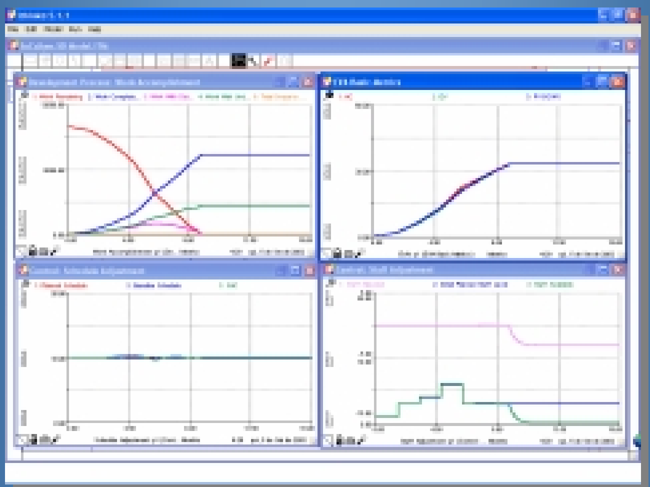
EVM vs. Traditional Control
Base Case

Project Outcome vs. Plan



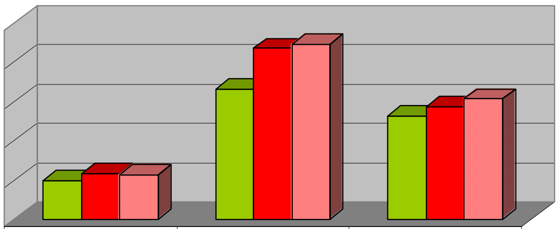
	Schedule (month)	Budget (person-month)	Quality (% Def. Work)
Planned	10.00	33.20	
Base w / EV	9.92	33.18	26.30
Base w / OC	9.95	33.30	26.00

EVM vs. Traditional Control
Base Case With EVM Control



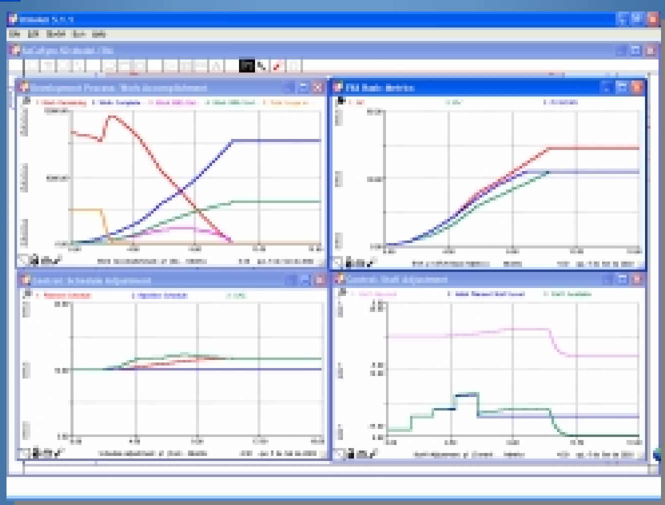
EVM vs. Traditional Control
Scope Risk

Project Outcome vs. Plan: With Scope Addition



	Schedule (month)	Budget (person-month)	Quality (% Def. Work)
Base w / EV	9.92	33.18	26.30
Scope Addition w / EV	11.65	43.58	28.70
Scope Addition w / OC	11.38	44.56	30.70

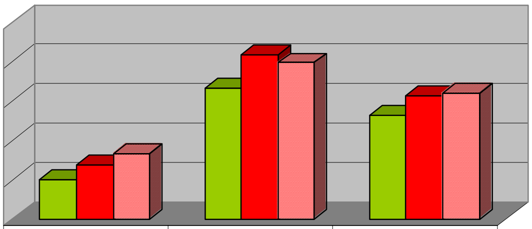
EVM vs. Traditional Control
Scope Risk With EVM Control



EVM vs. Traditional Control

Scope Risk + Staff Risk

Project Outcome vs. Plan: With Scope and Staff Risk



	Schedule (month)	Budget (person-month)	Quality (% Def. Work)
Base w / EV	9.92	33.18	26.30
Staff+Scope Risk w / EV	13.64	41.60	31.20
Staff+Scope Risk w / OC	16.50	39.57	31.80

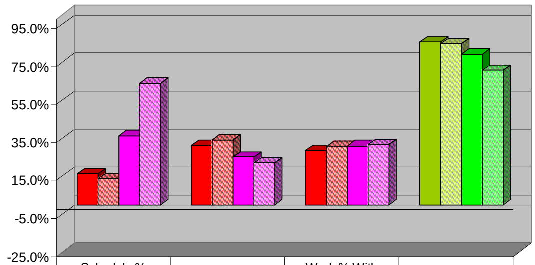
EVM vs. Traditional Control

Scope Risk + Staff Risk With EVM

EVM vs. Traditional Control

Scope Risk + Staff Risk

Project Performance: Sope and Staff Risk Scenarios



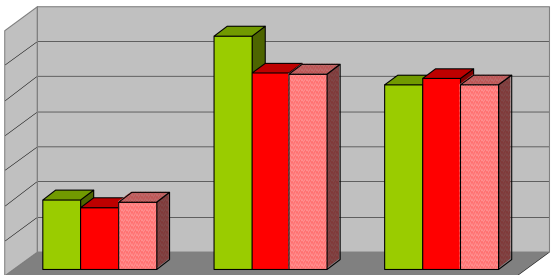
	Schedule % Deviation	Budget % Deviation	Work % With Defects	Performance
Scope Addition w/ EV	16.5%	31.3%	28.7%	85.7%
Scope Addition w/ OC	13.8%	34.2%	30.7%	85.0%
Staff+Scope Risk w/ EV	36.40%	25.30%	31.20%	79.50%
Staff+Scope Risk w/ OC	64.10%	22.10%	31.80%	70.80%

Project Objectives

EVM vs. Traditional Control

Productivity Opportunity: Constant

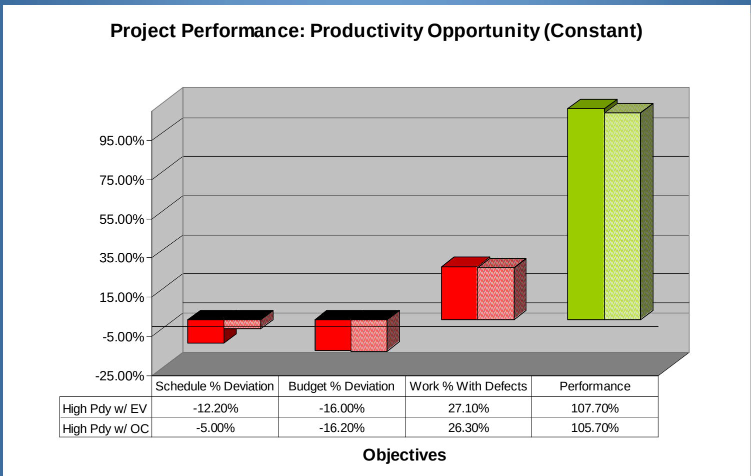
Project Outcome vs. Plan: Higher Productivity (Constant)



	Schedule (month)	Budget (person-month)	Quality (% Def. Work)
Base w/ EV	9.92	33.18	26.30
High Pdy w/ EV	8.78	27.88	27.10
High Pdy w/ OC	9.50	27.83	26.30

EVM vs. Traditional Control

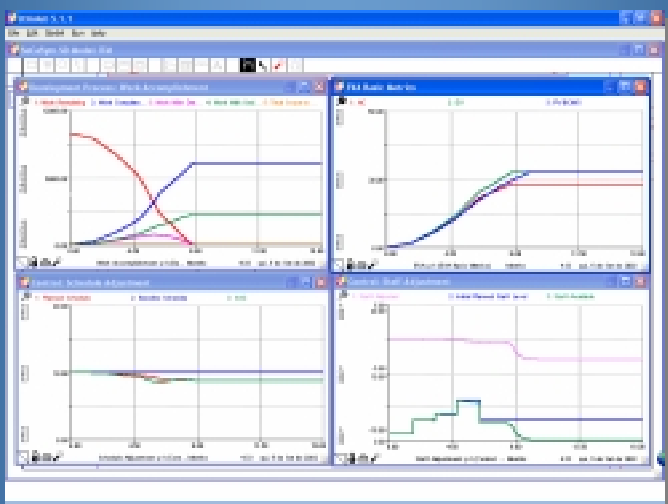
Productivity Opportunity: Constant



	Schedule % Deviation	Budget % Deviation	Work % With Defects	Performance
High Pdy w/ EV	-12.20%	-16.00%	27.10%	107.70%
High Pdy w/ OC	-5.00%	-16.20%	26.30%	105.70%

EVM vs. Traditional Control

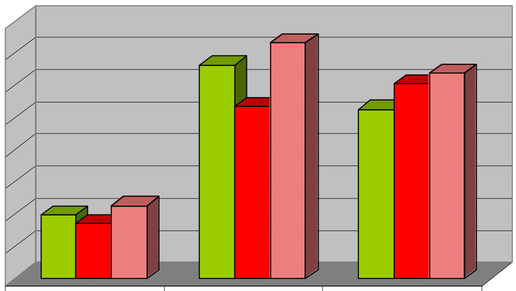
Productivity Opportunity: Constant



EVM vs. Traditional Control

Productivity Opportunity: Varying

Project Outcome vs. Plan: Varying Productivity

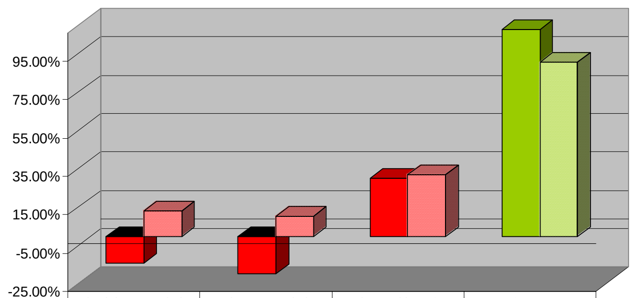


	Schedule (month)	Budget (person-month)	Quality (% Def. Work)
Base w/ EV	9.92	33.18	26.30
Varying Pdy w/ EV	8.60	26.73	30.30
Varying Pdy w/ OC	11.31	36.69	31.90

EVM vs. Traditional Control

Productivity Opportunity: Varying

Project Performance: Productivity Opportunities (Varying)

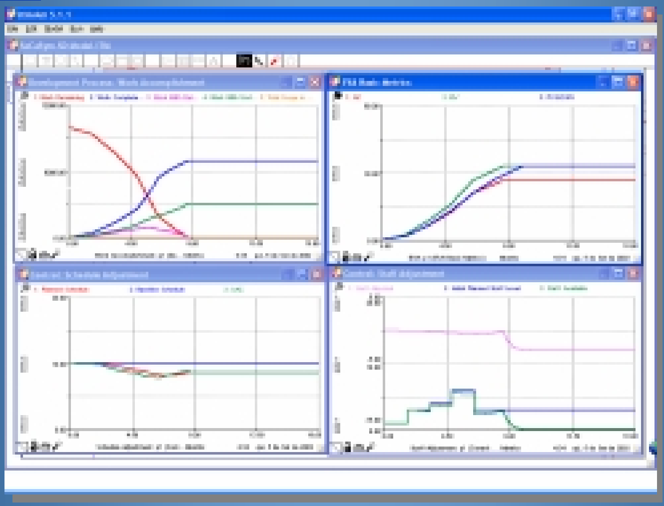


	Schedule % Deviation	Budget % Deviation	Work % With Defects	Performance
Varying Pdy w/ EV	-14.00%	-19.50%	30.30%	107.90%
Varying Pdy w/ OC	13.10%	10.50%	31.90%	90.70%

Objectives

EVM vs. Traditional Control

Productivity Opportunity: Varying



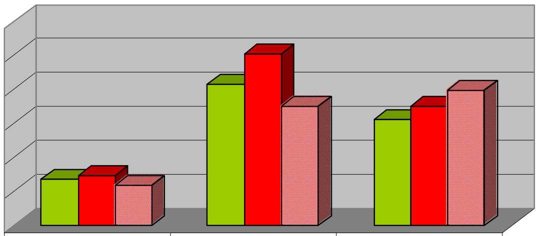
EVM vs. Traditional Control

Managing the Objectives Priority

- The base scenario considered:
  - EVM-based control
  - Previous Scope and Staff Risks
  - Priority of the objectives equals to their importance
- The priorities were than changed
  - All "Very High" – full pressure to minimize impacts
  - Budget, Schedule and Quality priorities were progressively relaxed to search for an "optimal" solution

EVM vs. Traditional Control
Managing the Objectives Priority

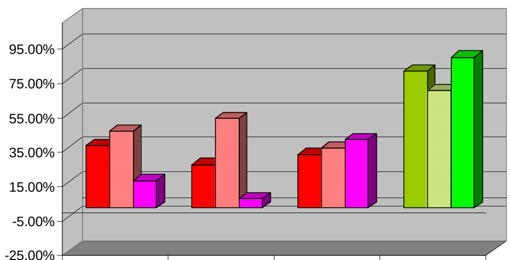
Project Outcome: Managing Objectives Priority



	Schedule (month)	Budget (person-month)	Quality (% Def. Work)
Staff+Scope Risk w / EV	13.64	41.60	31.20
Full Pressure	14.49	50.45	35.00
Optimal	11.60	35.02	39.80

EVM vs. Traditional Control
Managing the Objectives Priority

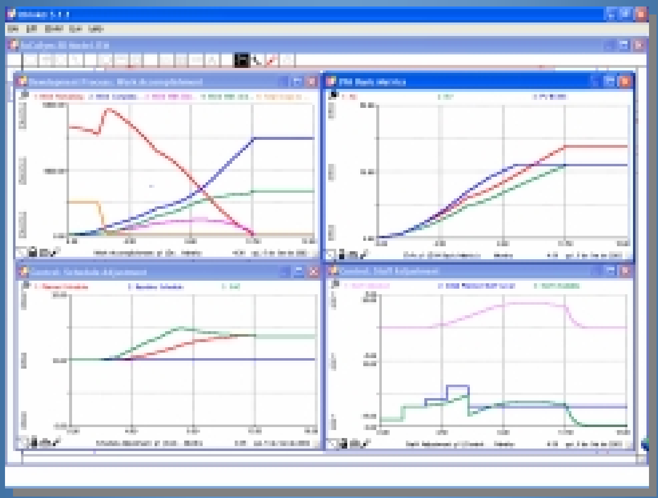
Project Performance: Managing Objectives



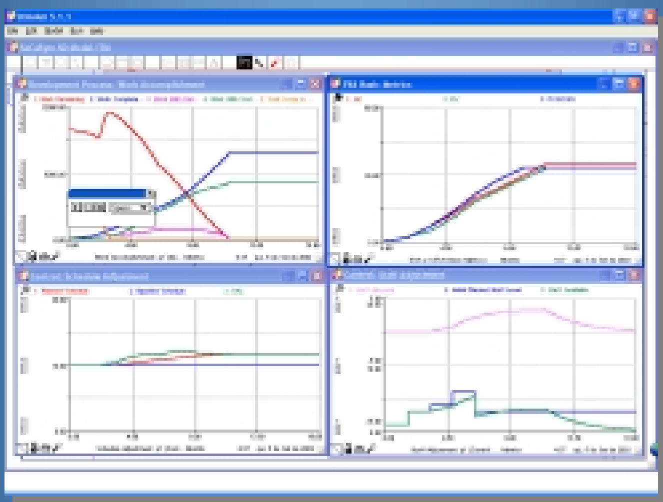
	Schedule % Deviation	Budget % Deviation	Work % With Defects	Performance
Staff+Scope Risk w/ EV	36.40%	25.30%	31.20%	79.50%
Full Pressure	44.90%	52.00%	35.00%	68.40%
Optimal	16.00%	5.50%	39.80%	87.70%

Objectives

EVM vs. Traditional Control
Managing the Objectives Priority



EVM vs. Traditional Control
Managing the Objectives Priority



Agenda

- *Overview of Earned Value Management*
- *System Dynamics Modeling*
- *Developing an SD project model*
- *Modeling EVM-based control policies*
- *Practical Example: EVM vs. Traditional Control*
  - *Managing the impacts of risks*
  - *Exploring opportunities*
  - *Managing the project objectives*
- Conclusions

Conclusions

- When compared with more traditional operational control, in general EVM-based control policies perform better
- In scenarios of uncertainty, EVM appears to provide robust indicators of performance on the basis of which good “at completion” estimates can be produced
- EVM provides indices of status and estimates of “at completion”, but it does not tell what you should do in face of deviations
- Simulation is essential for testing, improving and exploring control policies (it’s too expensive and slow to do it in the real world). System Dynamics modeling provides an excellent means to do this

Identifying best EVM-based Risk Management policies through Dynamic Simulation

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PMI® Risk Management Specific Interest Group

Thank you!!

Any Questions ?

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