Managing Uncertainty in Socio-Technical Enterprises using a Real Options Framework

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System design is necessary, but not sufficient for success

Challenger and Columbia accidents:

→ Revealed flaws in the decision making processes at NASA

→ Highlighted need for organizational change

Failures may be rooted at the organizational level, not necessarily at the engineering design level

How to manage uncertainties facing complex enterprises?

Flexibility and Real Options

Flexibility is a means of managing uncertainties

Flexibility: ability to undergo change with relative ease

Real options analysis is a means of modeling and valuation of flexibility

Real option: refers to the right, but not the obligation, to take an action at a later time

Problem and Challenges

Problem:

How can real options be used for holistic decision making and architecting of socio-technical enterprises under uncertainty?

1. Although real options analysis has been applied to different domains relevant to an enterprise, such as strategic investments and product design, there is no integrated framework that enables systematic exploration of what type of flexibility is desirable, how to enable flexibility and where to implement flexibility in an enterprise.

2. Enterprises exhibit the emergence of silos that become isolated over time as complexity grows. This constitutes a barrier to effectively communicating information across the silos, which may lead to suboptimal decisions within the isolated silos.

Research Questions

Problem:

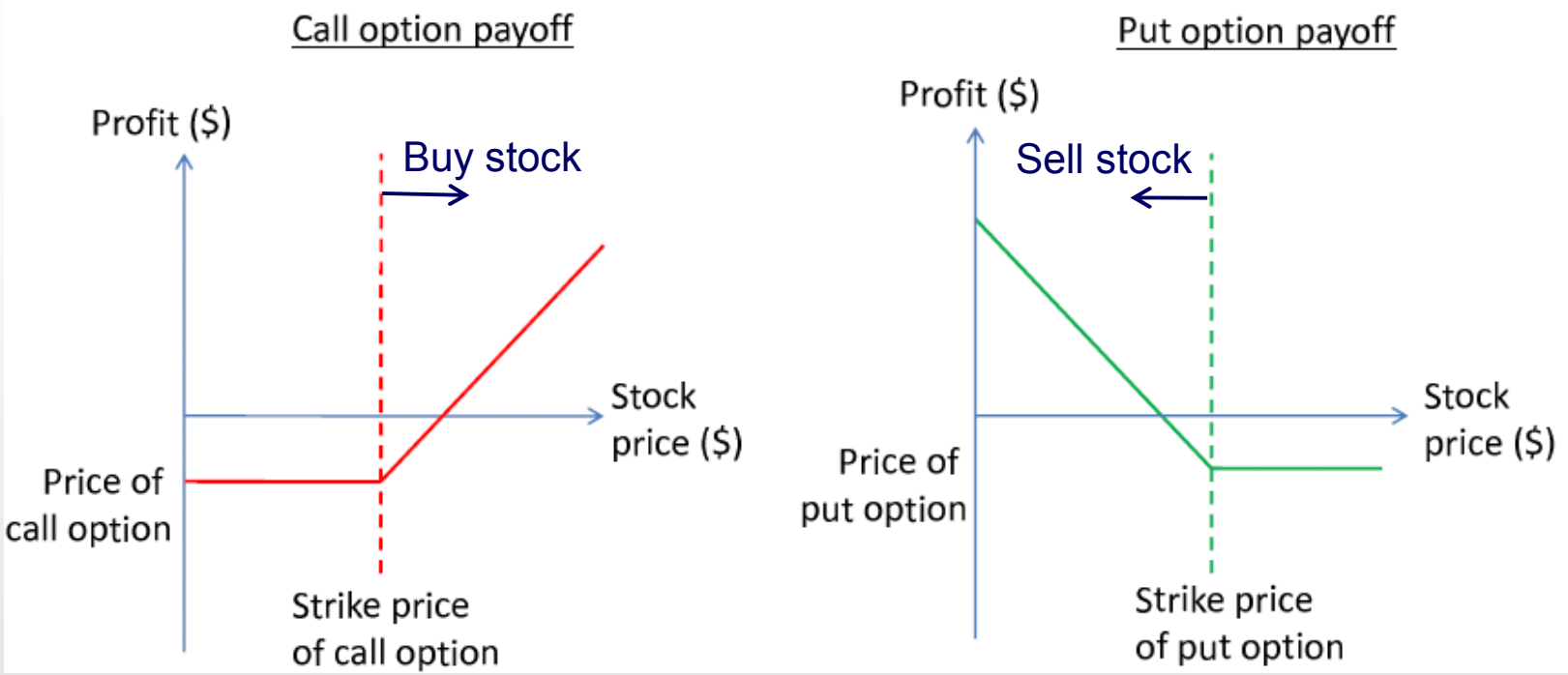
How can real options be used for holistic decision making and architecting of socio-technical enterprises under uncertainty?

1. What type of flexibility, if any, is desirable?
2. How to enable flexibility?
3. Where to enable flexibility in an enterprise?
4. How to enable holistic thinking to systematically identify and evaluate all of the above?

Outline

- Real option characterization
- Enterprise architecture framework
- Real options in enterprise architecture
- Future work

Simple Financial Options

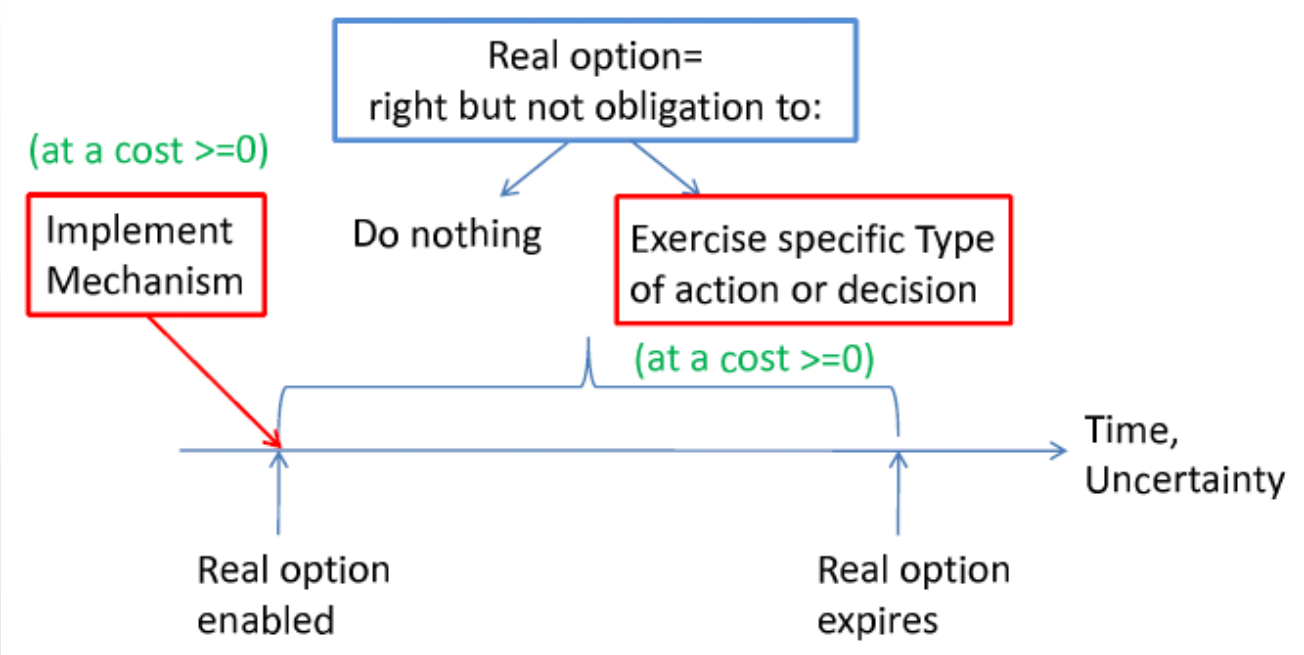


Financial option: right, but not the obligation, to buy or sell an underlying security at a specified price, on or before expiration date of the option

Real option: right, but not the obligation, to take an action/decision at a later time

Methods for valuation of financial options: Black-Scholes, binomial pricing, Monte Carlo

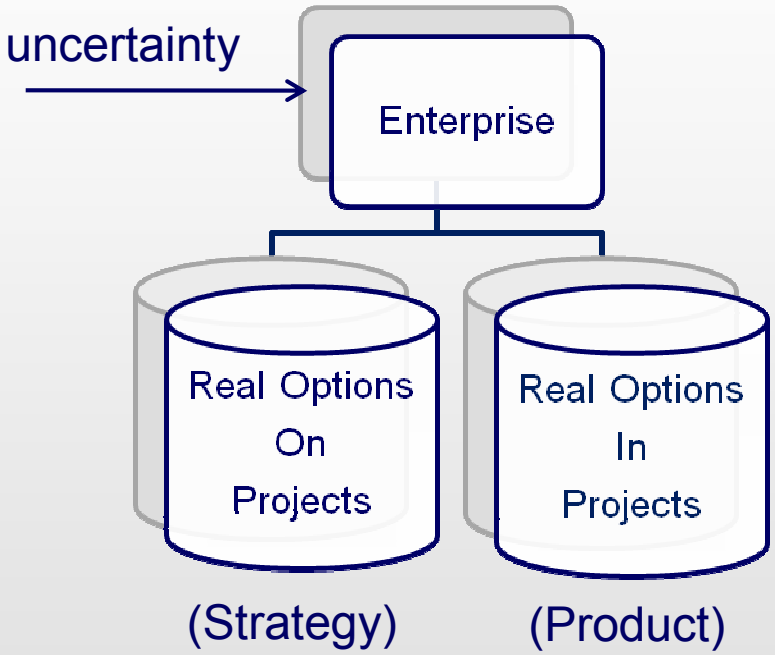
Real Option Characterization



1. Real Option Mechanism:
   actions/decisions that enable a real option

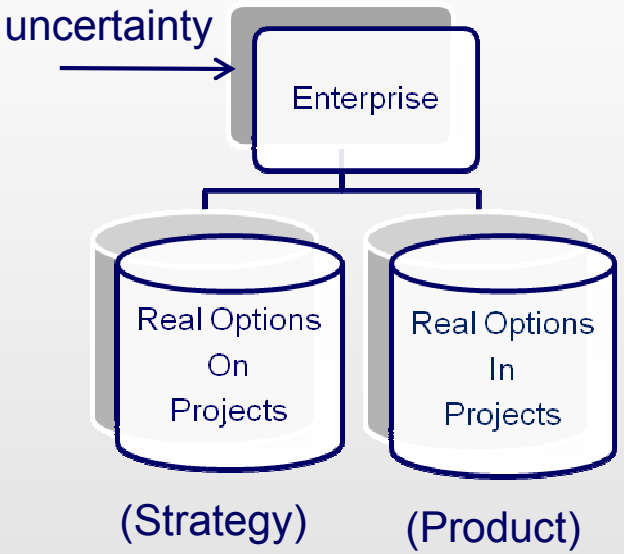
2. Real Option Type:
   actions/decisions that may be exercised by the owner of the real option

Real Options Silos



→Explore interactions between “real option silos”

Integrating the Real Options Silos



Real Option Mechanism \ Real Option Type	In Design	In Strategy
In Design	MAV design enables a reuse option in future design	MAV design enables future market expansion
In Strategy	MAV development partnership enables option to use new type of technology in design	Investment in MAV project enables option to expand development to swarm in future

MAV = Mini Air Vehicle

May "classify" the location of both the mechanism and type of real option

Enterprise Architecting

Definition (Nightingale and Rhodes, 2007):

Applying holistic thinking to design, evaluate and select a preferred structure for a future state enterprise to realize its value proposition and desired behaviors

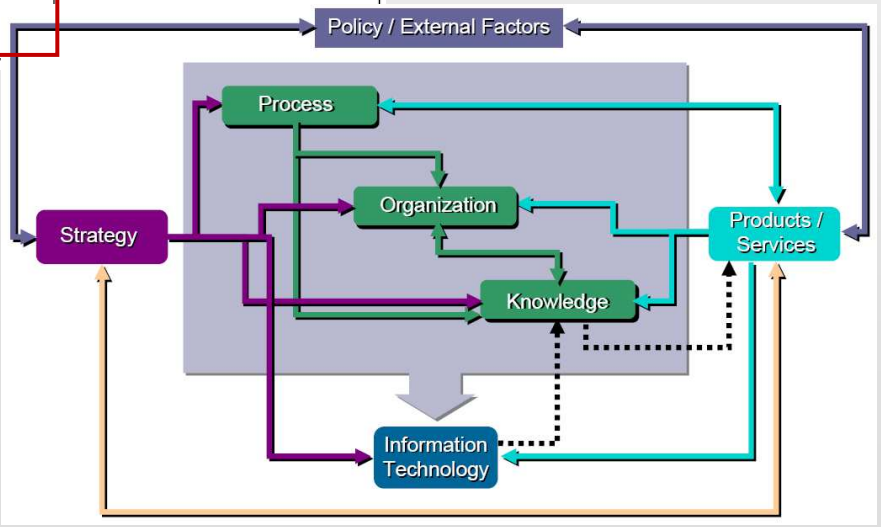
Eight Enterprise Views

Strategy View	Policy View	Process View	Organizational View
Business model, business strategies and internal/external strategic drivers; enterprise metrics and objectives	Policies that impact the enterprise as well as policies internal to the enterprise that affect performance	Key business processes, and activities that capture, manipulate, and manage the business information to support business operations.	The organizational structure of the enterprise, major operations performed by organizations, types of workers, work location, and distribution of organizations to locations

Knowledge View	Information Tech. View	Product View	Service View
All information and knowledge needed to perform the enterprise business operations and relationships among that information	Key IT infrastructure (both hardware and software) that supports the enterprise.	Product(s) developed by the enterprise; key platforms; modular vs integral architectures, etc.	Services(s) delivered and or supplied by the enterprise.

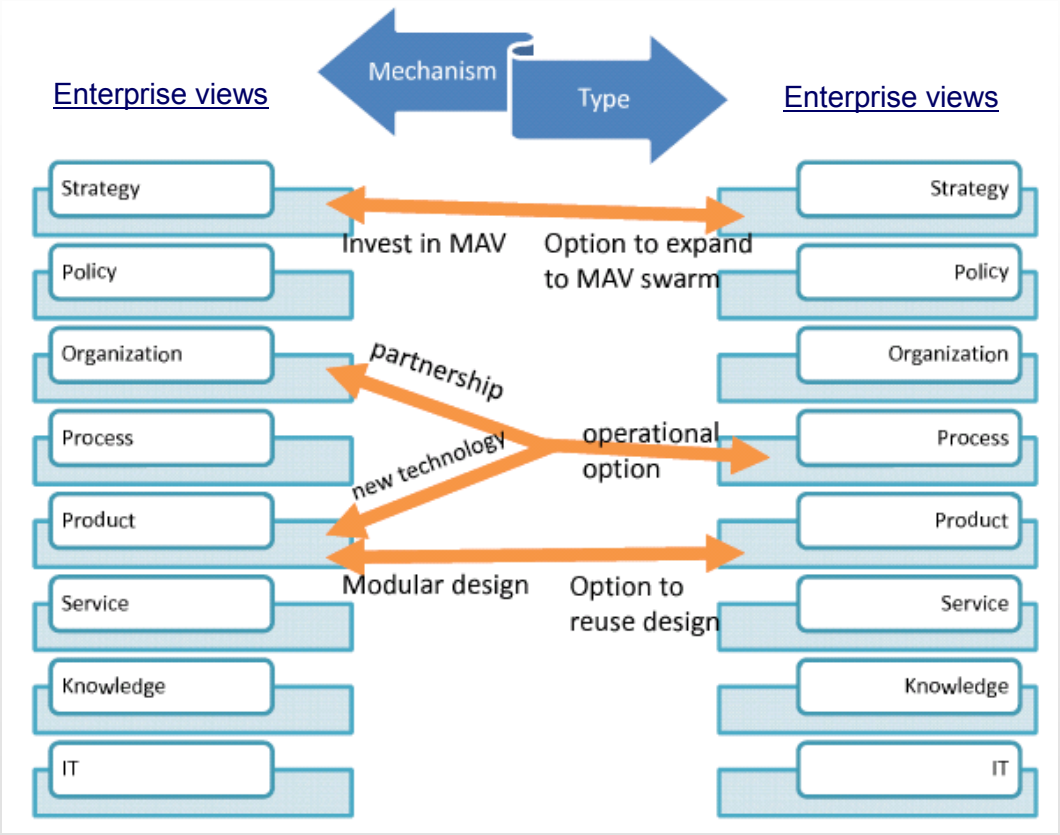
Traditional "enterprise architecture"

Traditional system architecture



(Nightingale and Rhodes, 2007)

Real options in enterprise architecture



→ Mechanisms, types may exist within any of the enterprise views
→ Extend the real options approach to encompass all views of an enterprise

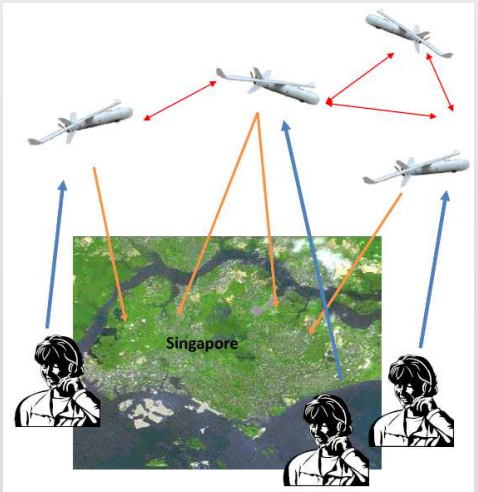
Managing Operational Uncertainties using Real Options

(CSER'07 paper - Mikaelian, Bartolomei, Hastings)

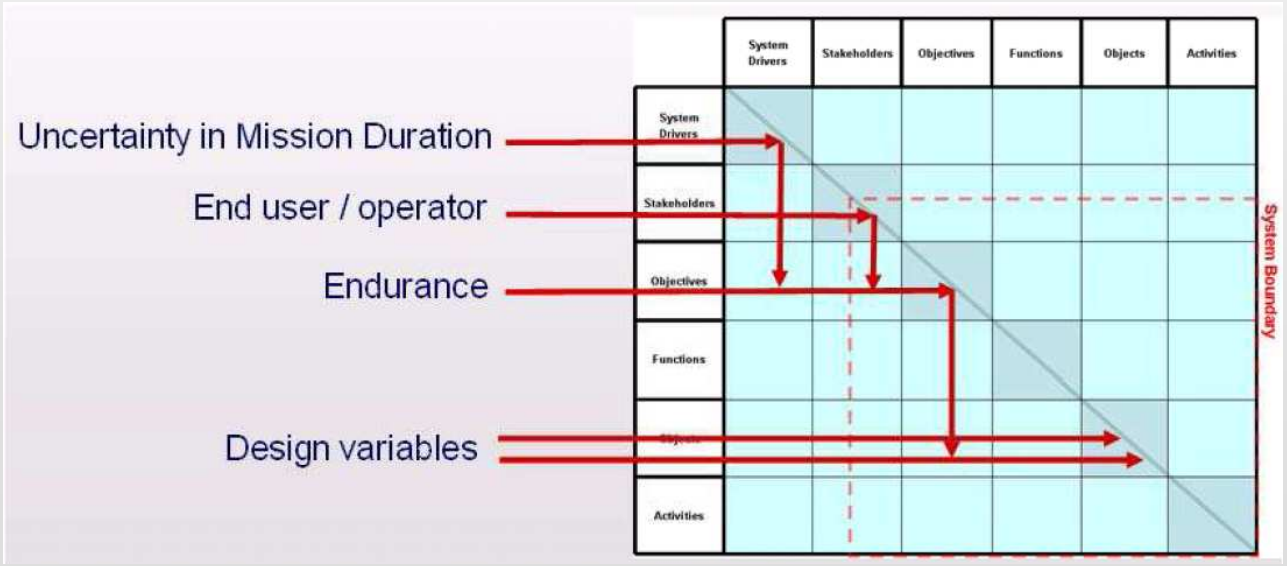
Operational uncertainty:
- required flight duration of MAV:
  short (< 1 hr), long (1-2 hrs)

Type of real option:
- operational option to insert extra battery

Mechanism:
- modular design to accommodate extra battery



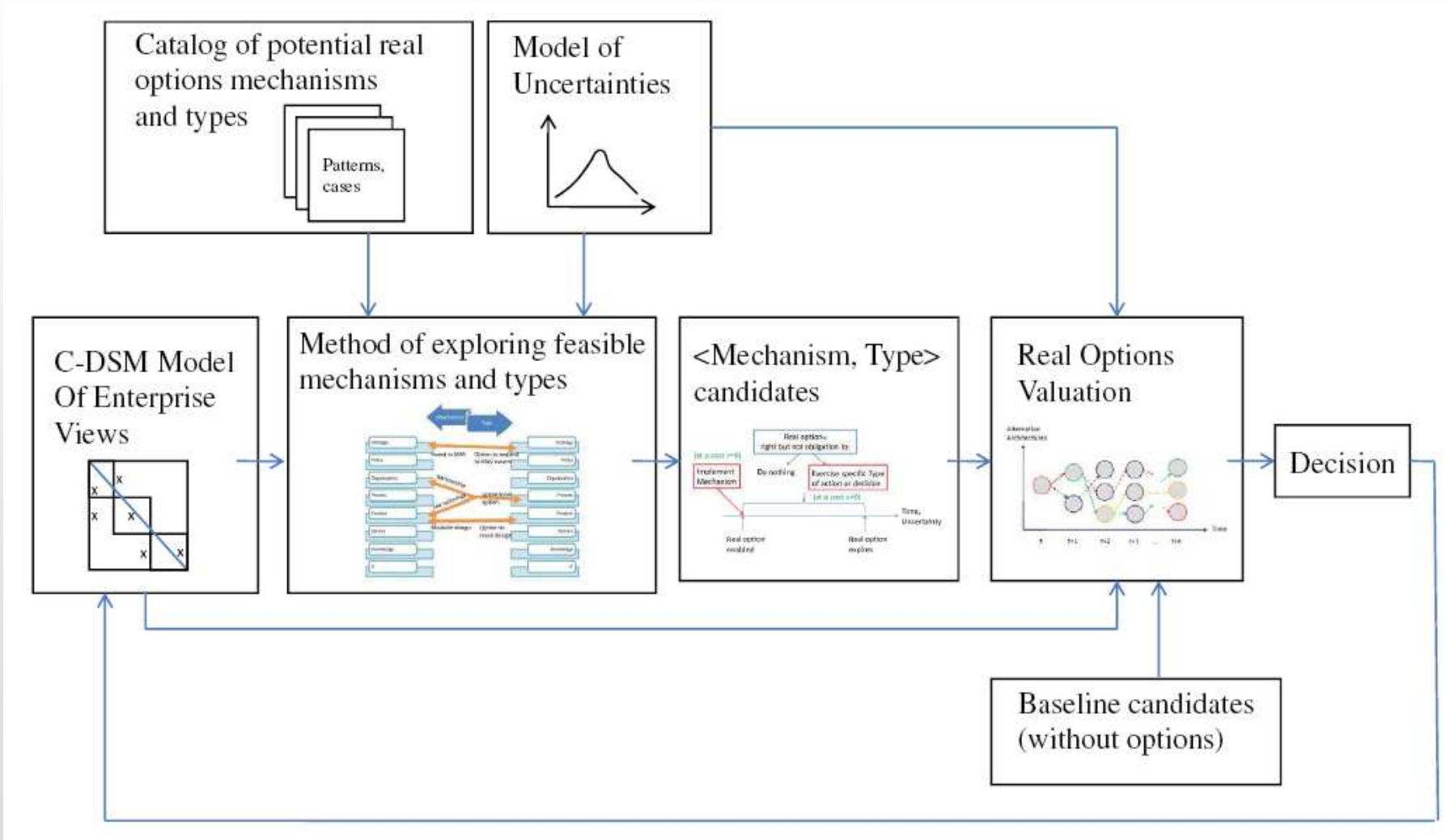
Coupled Dependency Structure Matrix (C-DSM)



Real Option Examples

Challenge	Examples of uncertainties	Examples of real options (mechanism → type) across enterprise views
Dealing with operational uncertainties	- Future mission demands - System failures	Design mechanism: flexible payload bay *(Product View)* → Operational option to add extra battery *(Process View)*
		Train more operators *(Process View)* → Deployment of larger swarm *(Strategy View)*
Investments in research and new technologies	- Future customer demands - Uncertain outcome of the investment	Investment in autonomy *(Strategy, Organization, Knowledge, Product Views)* → Potential for patents *(Knowledge View)*, competitive advantage *(Strategy, Product Views)*, Deployment of larger swarm *(Process View)*, hiring less operators *(Organization View)*, abandoning the investment if low prospects *(Strategy View)*
		Deferral of decision to invest *(Strategy View)* → Option to invest later *(Strategy View)*
Technology make-buy decisions	- Technology demands for future products - Future availability and performance of COTS components	Develop own components *(Strategy, Organization, Knowledge, Product Views)* → Flexibility to modify, customize components *(Product View)*, may leverage organizational expertise later *(Knowledge View)*
Organizational structure	- Organizational competencies - Types of future projects	Development partnership *(Strategy, Organization Views)* → Option to expand/abandon collaboration in future *(Strategy, Organization Views)*, option to leverage organization's competencies/resources *(Strategy, Organization, Knowledge Views)*

The Framework



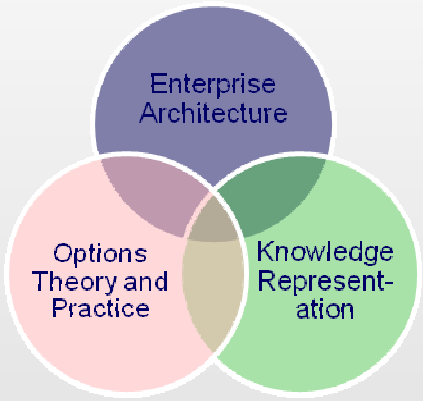
Summary

Objective

- Explore how can real options be used for holistic decision making and architecting of enterprises under uncertainty
- Paper presents conceptual foundation for this work

Method

- Model enterprise views, uncertainties
- Explore potential mechanisms and types of options that encompass enterprise views
- Use real options valuation toolbox



Anticipated Contribution

- Framework for systematic exploration and valuation of mechanisms and types of real options that deal with enterprise level uncertainties, enabled through holistic modeling of enterprise dependencies.