Risk Aggregation Methodology for Joint Fires Coordination

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Outline

- Motivation
- Introduction
- Where aggregation is required?
- Our methodology
- Applications

Motivation

- Research on risk aggregation is scarce
- Risk aggregation methodologies for joint operations
  - mission planning and
  - plan execution

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What is Risk?

Risk is the expression of the likelihood and impact of an event with the potential to influence the achievement of an organization's objectives [Treasury Board Canada Secretariat 2001]

Thick Snow Cover
and
Construction Work Requiring Explosives

Risk Evaluation Matrix						
		Probability				
Severity		Frequent **A**	Probable **B**	Occasional **C**	Rare **D**	Improbable **E**
Catastrophic	**I**	**EH**	**EH**	**H**	**H**	**M**
Critical	**II**	**EH**	**H**	**H**	**M**	**L**
Marginal	**III**	**H**	**M**	**M**	**L**	**L**
Negligible	**IV**	**M**	**L**	**L**	**L**	**L**

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Marginal	**III**	**H**	**M**	**M**	**L**	**L**
Negligible	**IV**	**M**	**L**	**L**	**L**	**L**

What is Risk Management?

- Risk management is a systematic approach to setting the best course of action under uncertainty by identifying, assessing, understanding, acting on, and communicating risk issues [Treasury Board Canada Secretariat 2001]

- Risk management is crucial for effective joint decision making to enhance operational capabilities and mission accomplishment, with minimal acceptable loss

Risk Management

Principles:

- Accept No Unnecessary Risk
- Make Risk Decisions at the Appropriate Level
- Anticipate and Manage Risk by Planning

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- Proper communication of risk information

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➔ **Risk aggregation**

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In Joint Operations, Risk Aggregation is Needed Due to:

- Risk-related information is collected from diverse sources

- Different risk categories

- Aggregation of risk through command structure because:

  Risk information are collected at lower level of command and decisions are made at higher level of command

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Our methodology

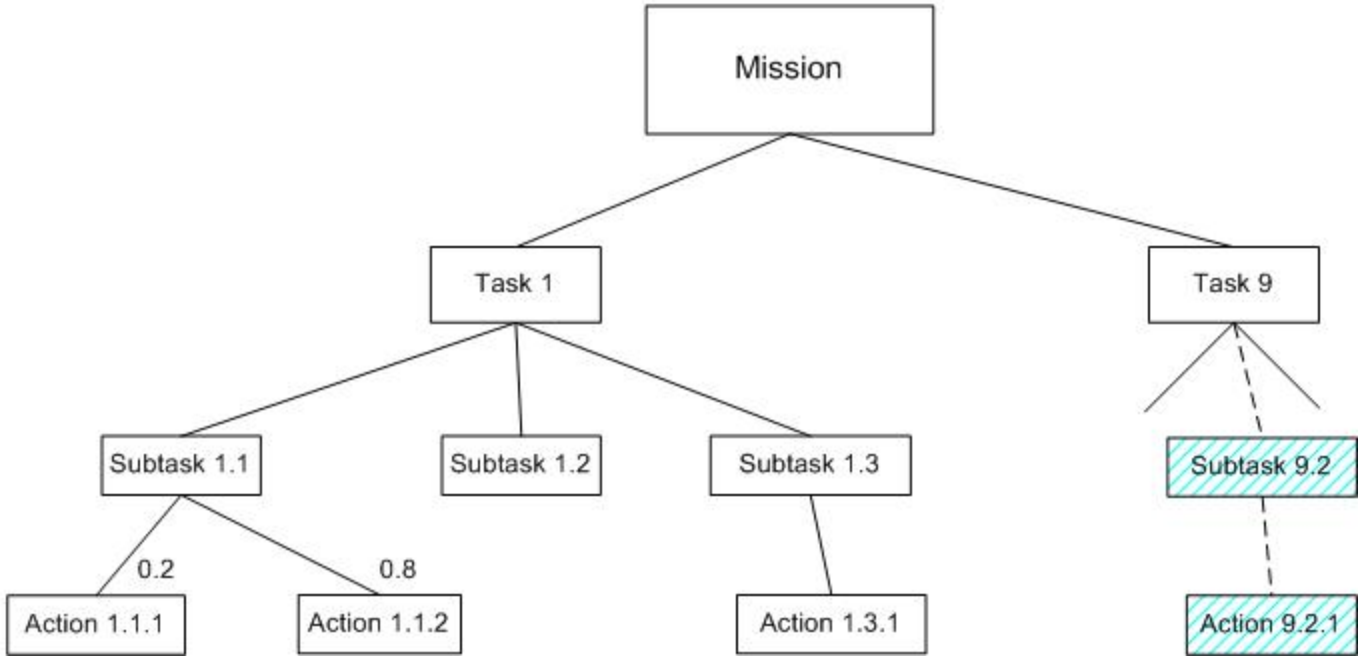
(S1) Generate a tree-like graph representing a Mission Decomposition Structure (MDS) dividing the mission in tasks, subtasks, and actions;

(S2) Determine the importance weights for the edges of the MDS (representing importance of a success of a child node to a success of the parent node);

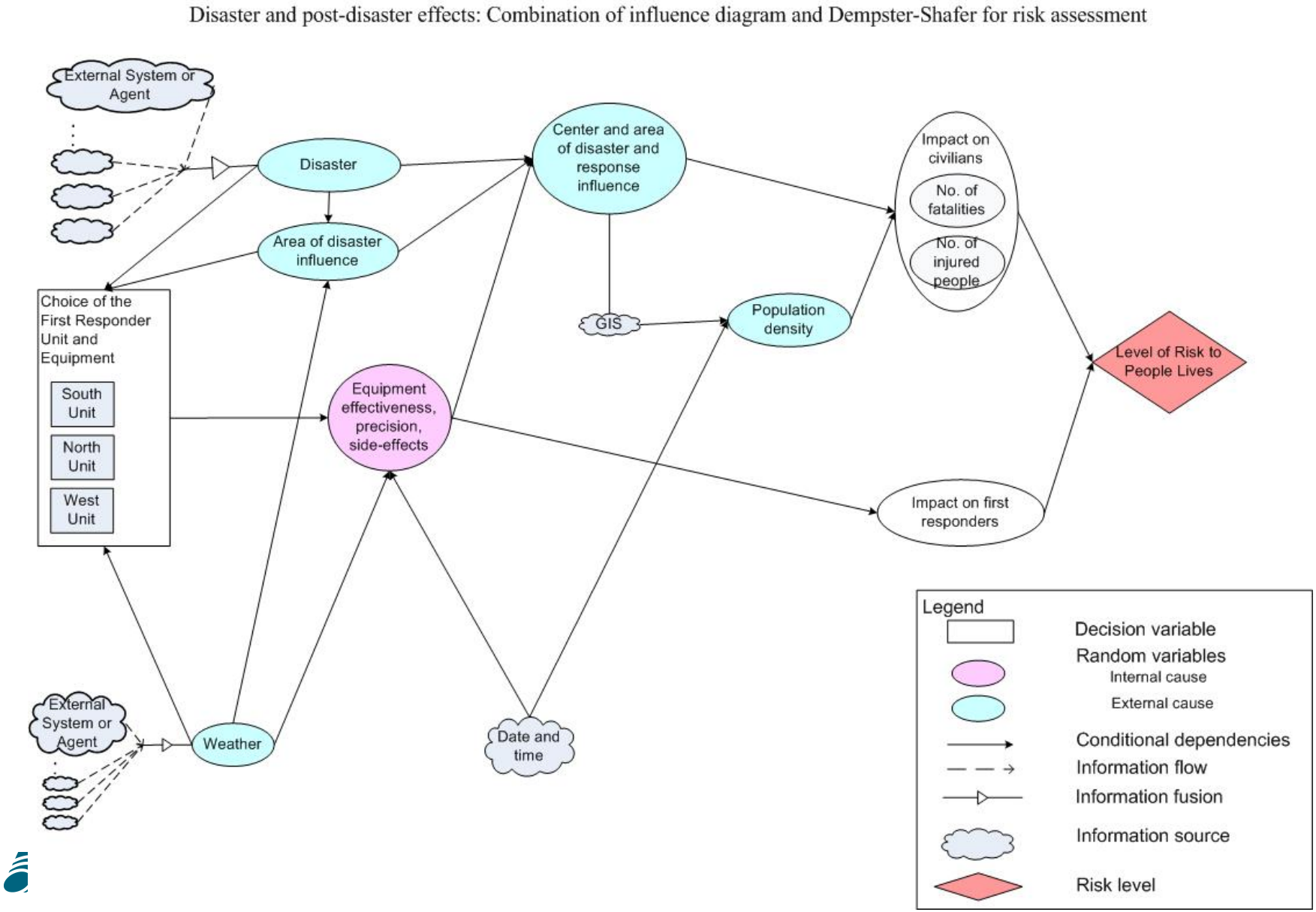
(S3) For each action/task, identify associated risks; and

(S4) For each risk, identify its core factors and generate corresponding Bayesian network, influence diagram, Expanded Bayesian Network (EBN) or Expended Influence Diagram (EID) combining Dempster-Shaffer methodology and influence diagram

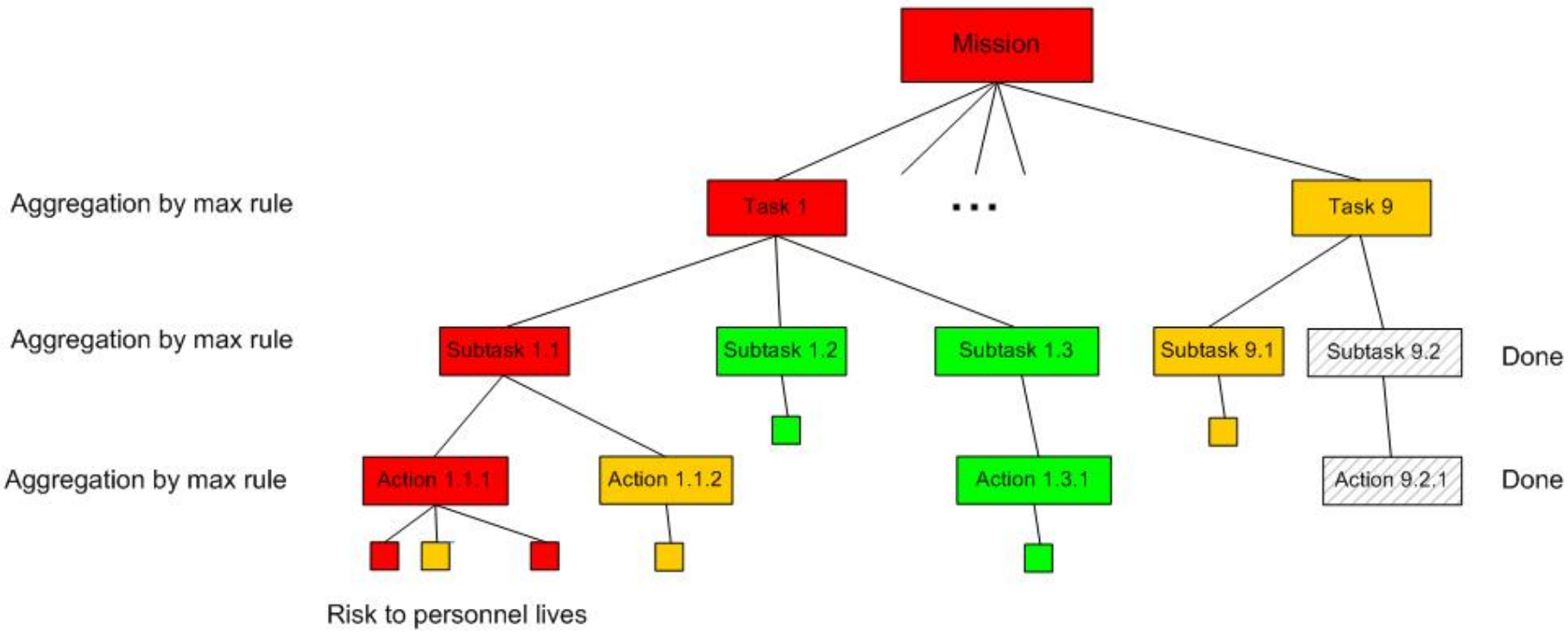
Mission Decomposition Structure (MDS)



Expanded Influence Diagram



Mission Decomposition Structure (MDS) and Risk to Personnel Lives



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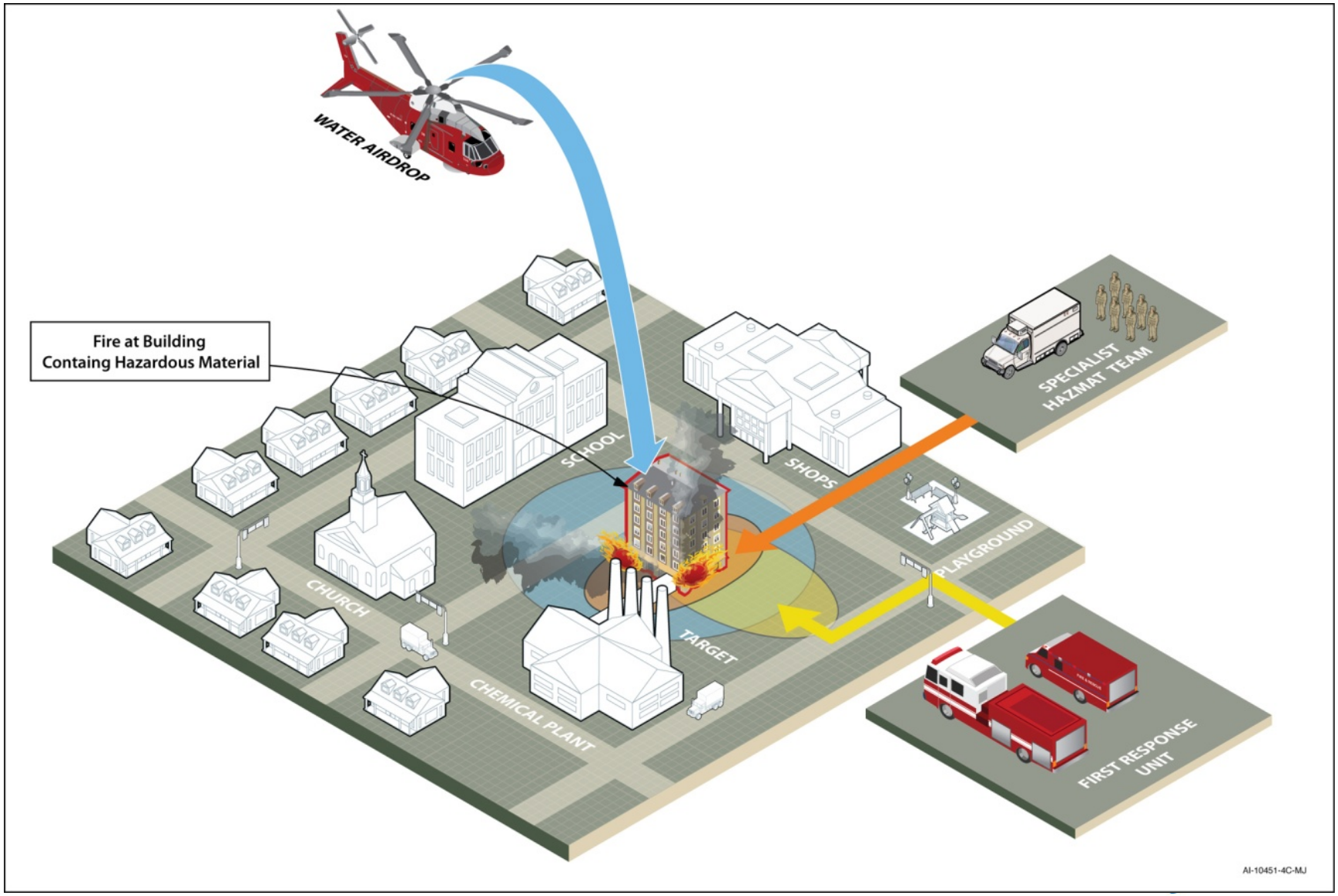
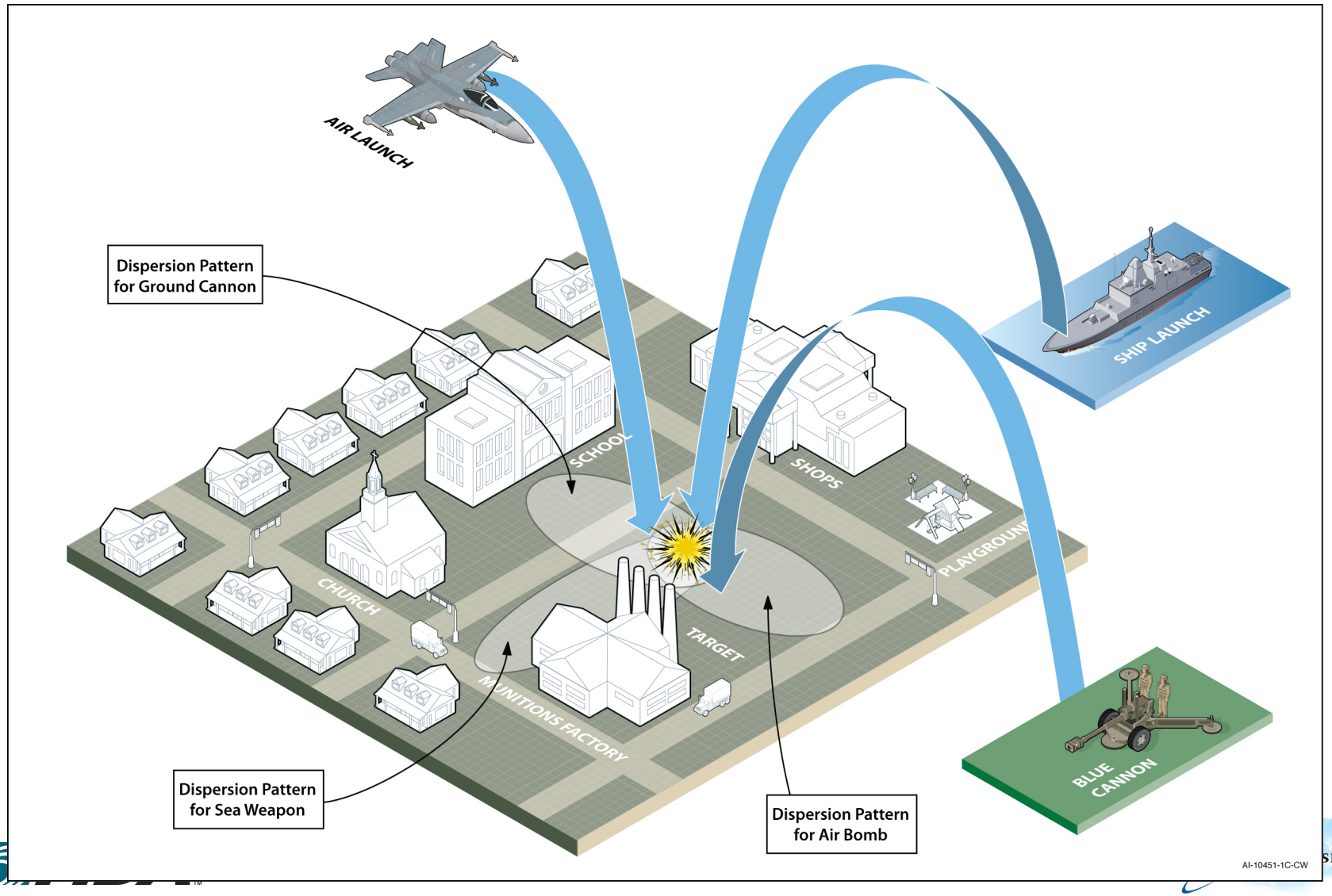
- Problems requiring aggregation
- Potential solutions
- Application

The Intervention Plan for Fire Scenario



Joint Fires Coordination in Urban Environment



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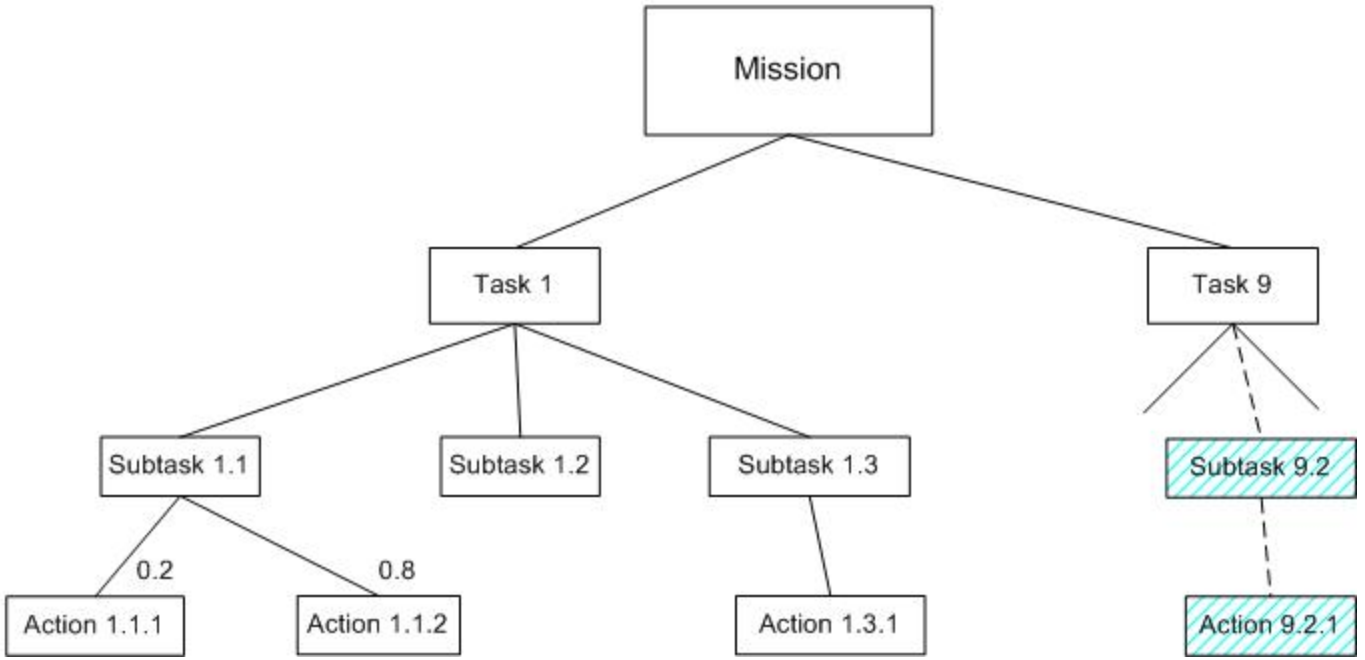
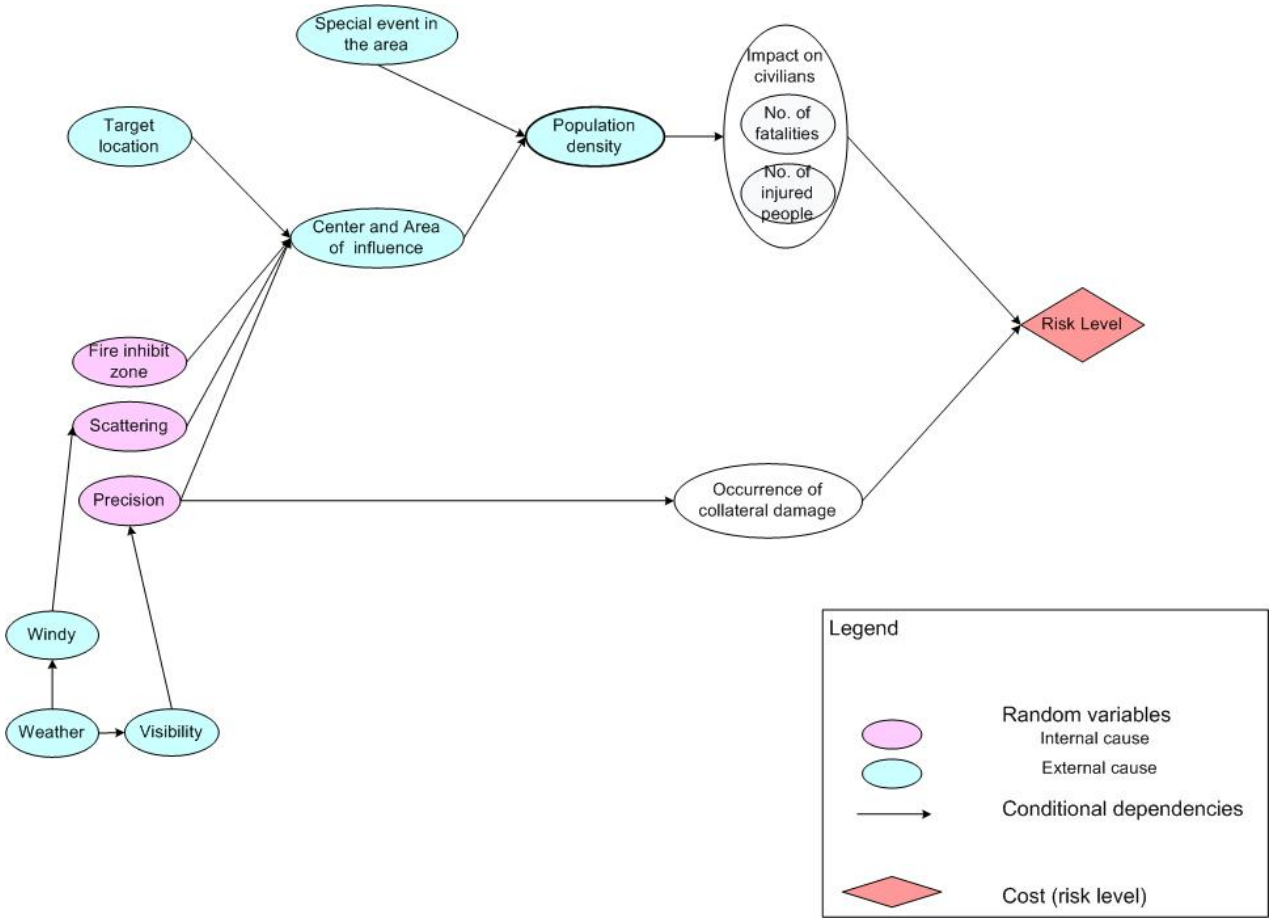


Risk Categories

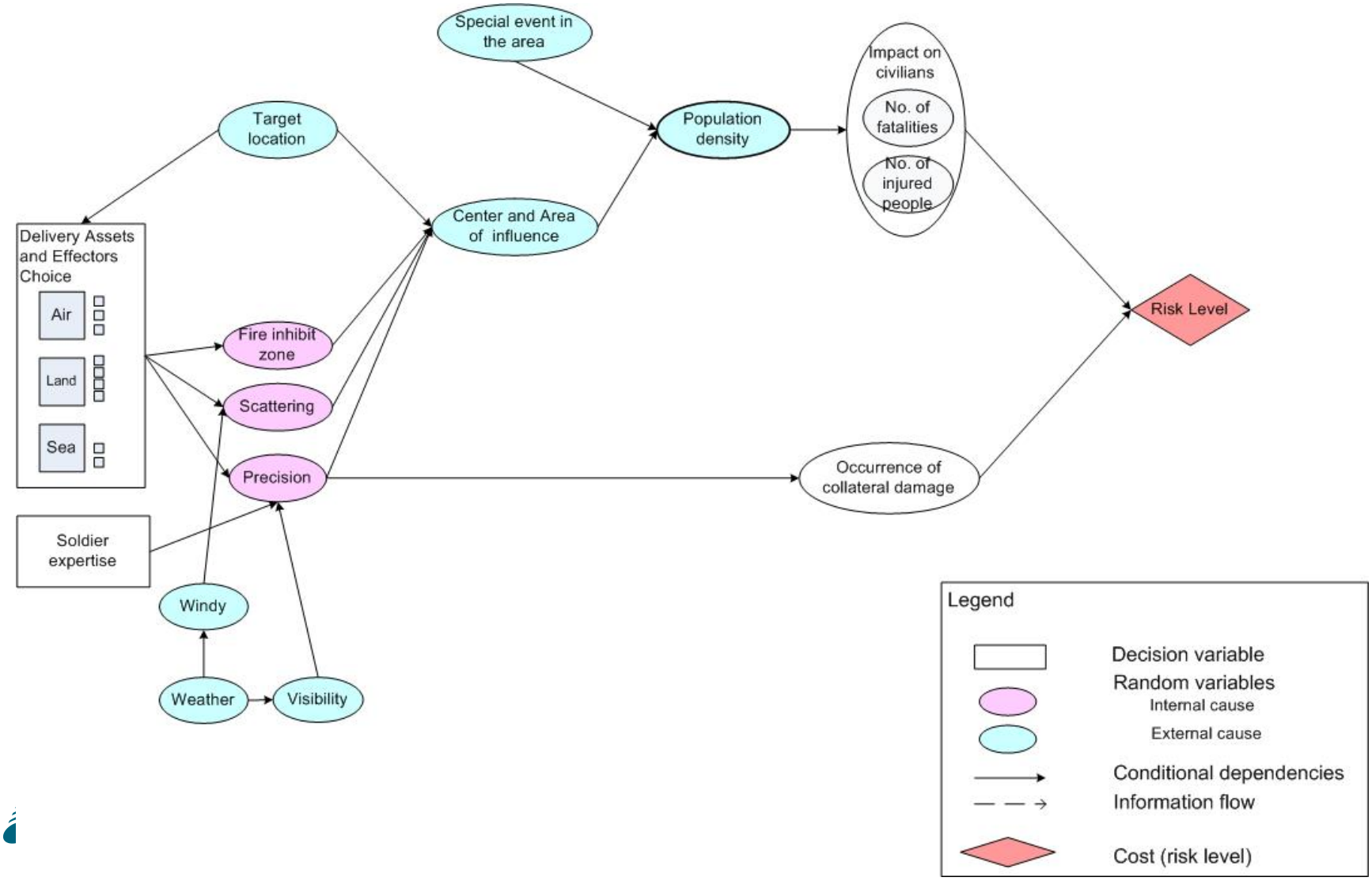
Relevant to joint operations:

- Personnel (health and life)
- Population (health and life)
- Mission success
- Resources and equipment
- Important buildings (schools, hospitals)

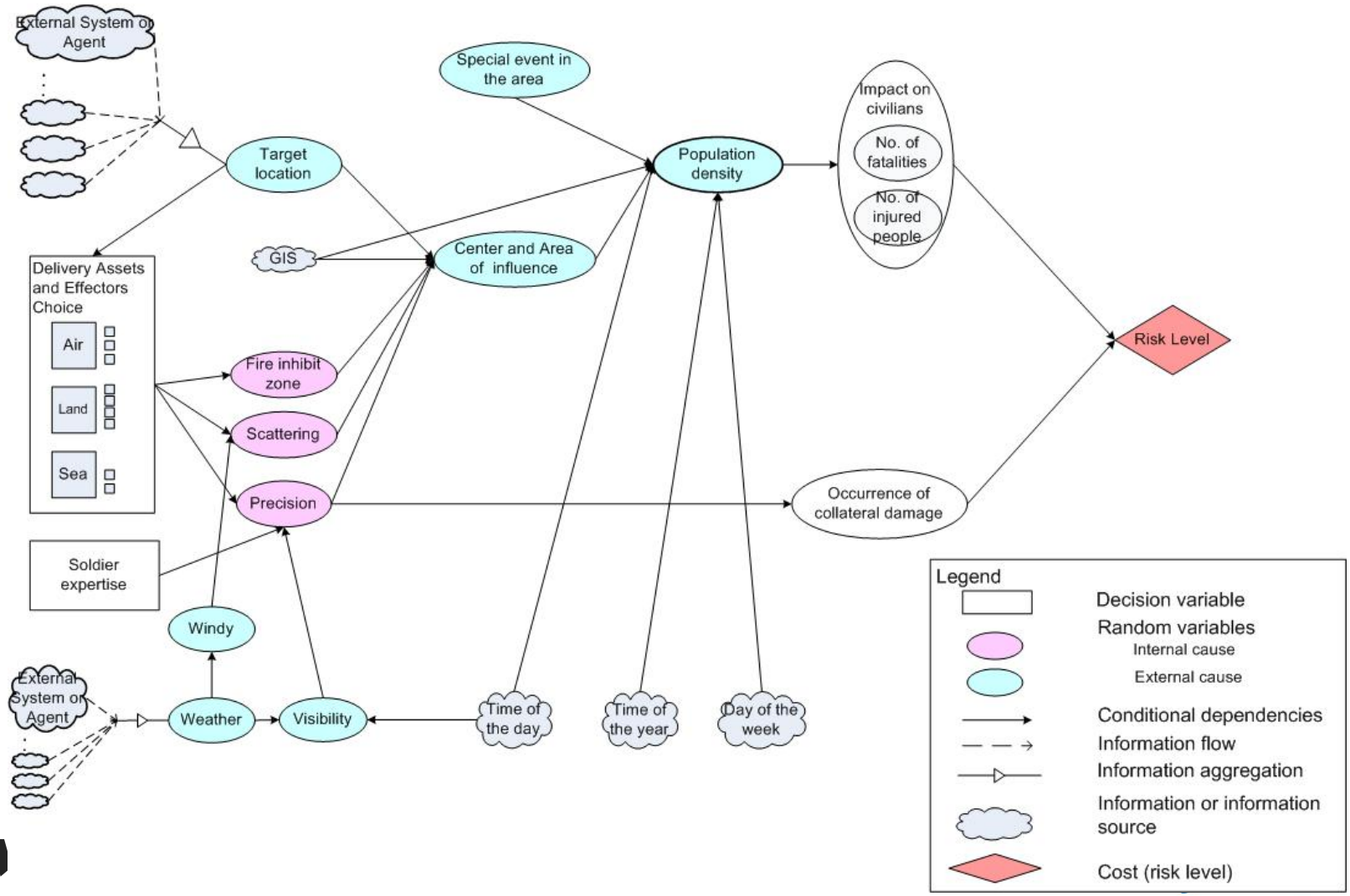
Risk assessment:
Risk of collateral damage using Bayesian network



Decision making and Risk assessment: Risk of collateral damage vs. choice of delivery assets using Influence diagram



Aggregation of risk related information: Decision making and Risk assessment
Risk of collateral damage vs. choice of delivery assets using Expanded Influence Diagram



Bottom-Up Aggregation of Risks along the Mission Decomposition Structure

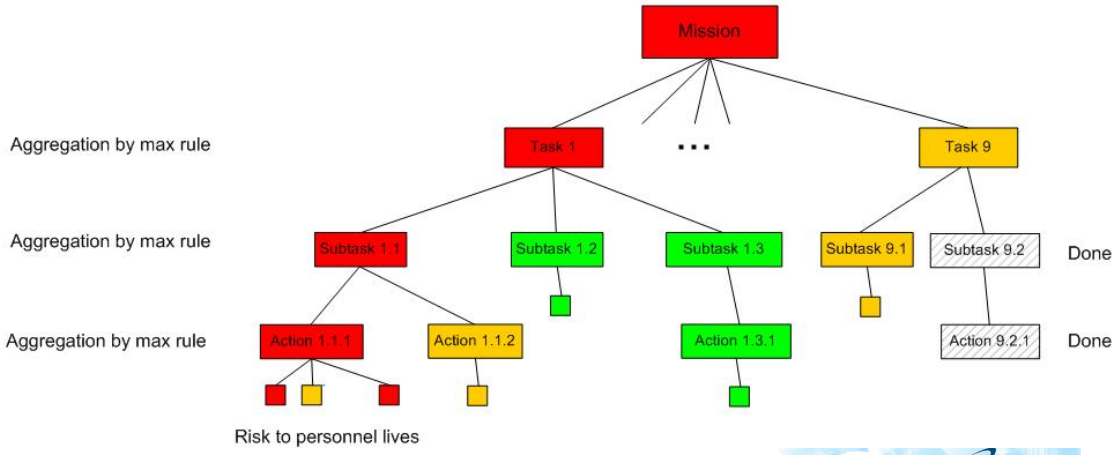
Aggregation strategy depends on risk type:

- Max rule
- By importance
- Weighted sum

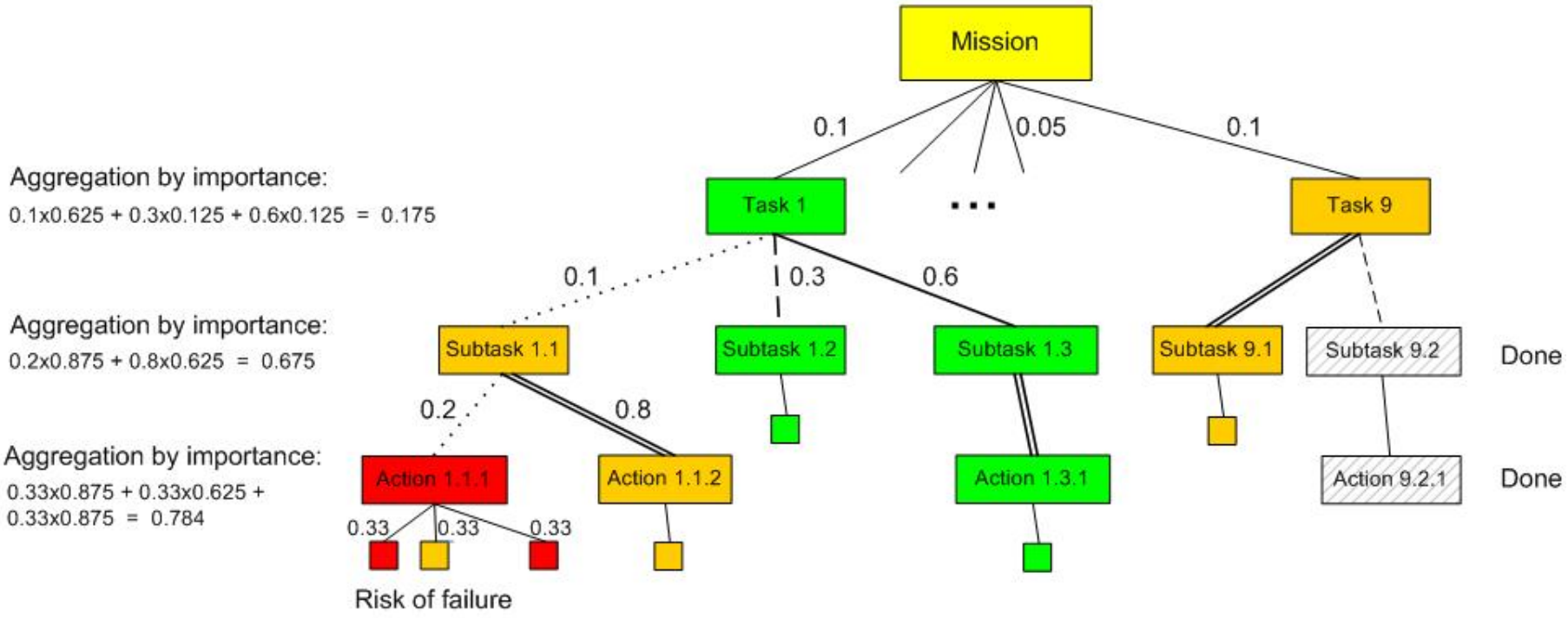
In each leaf node:

- (Expanded) Influence Diagram or
- (Expanded) Bayesian Network

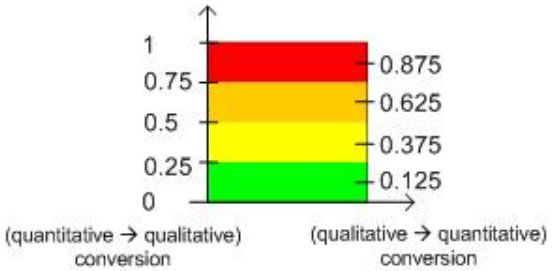
Mission Decomposition Structure (MDS) and Risk to Personnel Lives



Mission Decomposition Structure (MDS) and Risk of Mission Failure



Risk levels and (qualitative, quantitative) conversion rules



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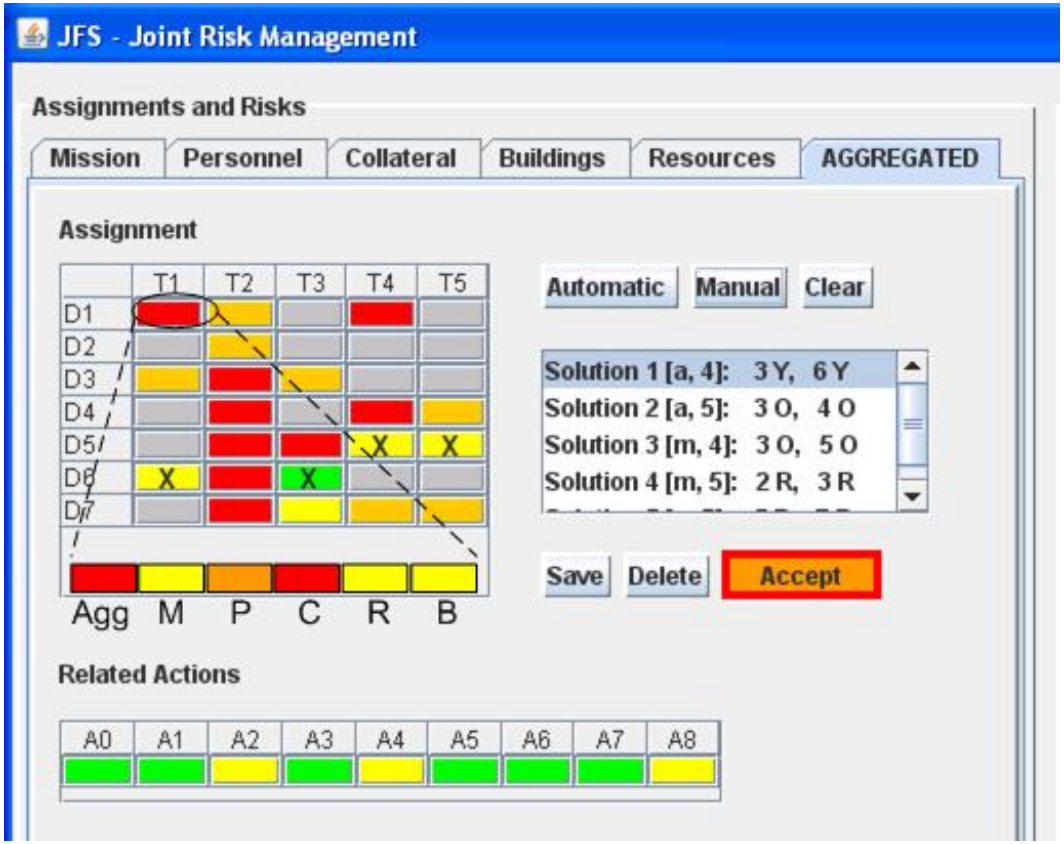
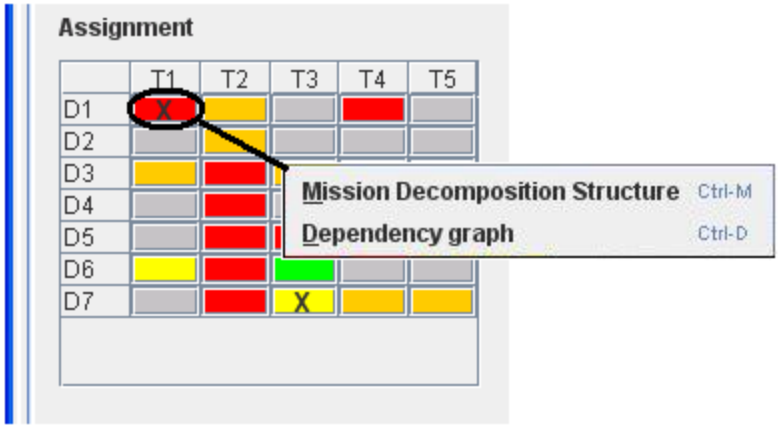
Aggregation/Disaggregation of Risk

Aggregation of different risk types is usually not recommended

But if aggregation of different risk types is done, it has to be transparent



Decision-making support



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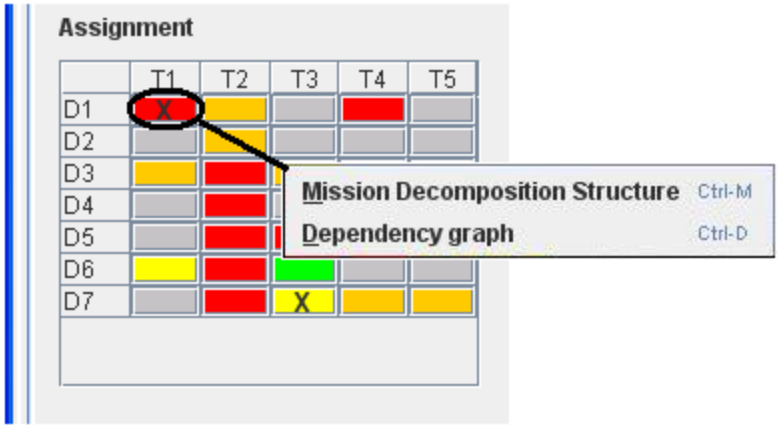

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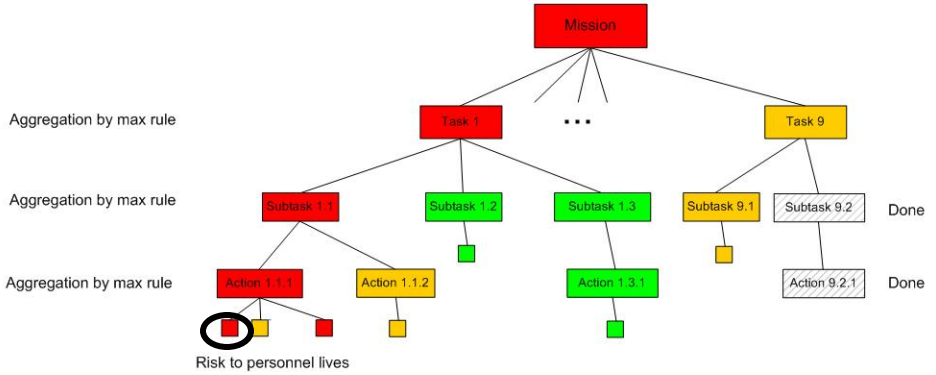

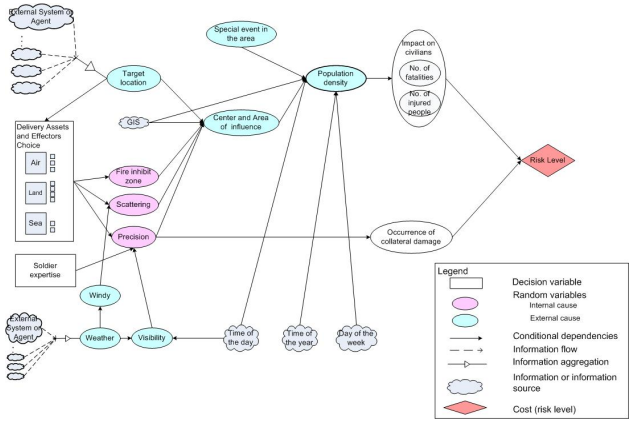

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JFS - Joint Risk Management

Assignments and Risks

Mission | Personnel | Collateral | Buildings | Resources | AGGREGATED

Assignment

	T1	T2	T3	T4	T5
D1					
D2					
D3					
D4					
D5		X	X		
D6	X				
D7				X	X

Automatic | Manual | Clear

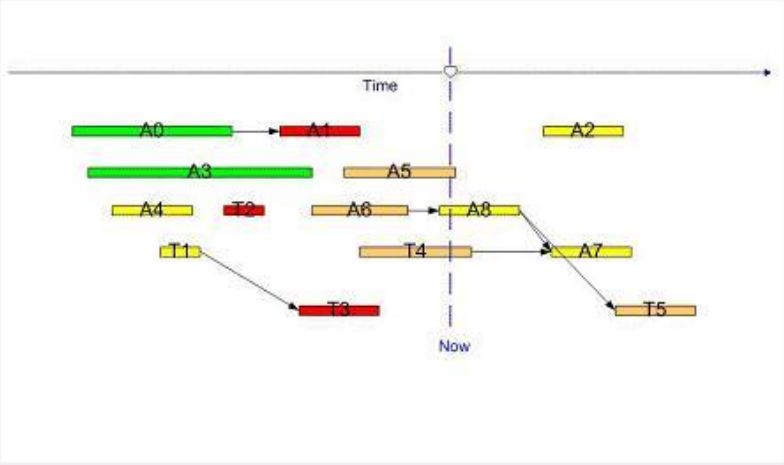
Solution 1 [a, 4]: 3 Y, 6 Y
Solution 2 [a, 5]: 3 O, 4 O
Solution 3 [m, 4]: 3 O, 5 O
Solution 4 [m, 5]: 2 R, 3 R

Save | Delete | Accept

Related Actions

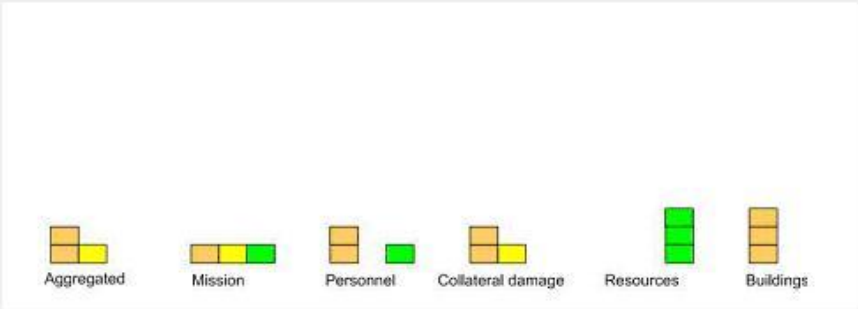
A0	A1	A2	A3	A4	A5	A6	A7	A8

Gantt Chart

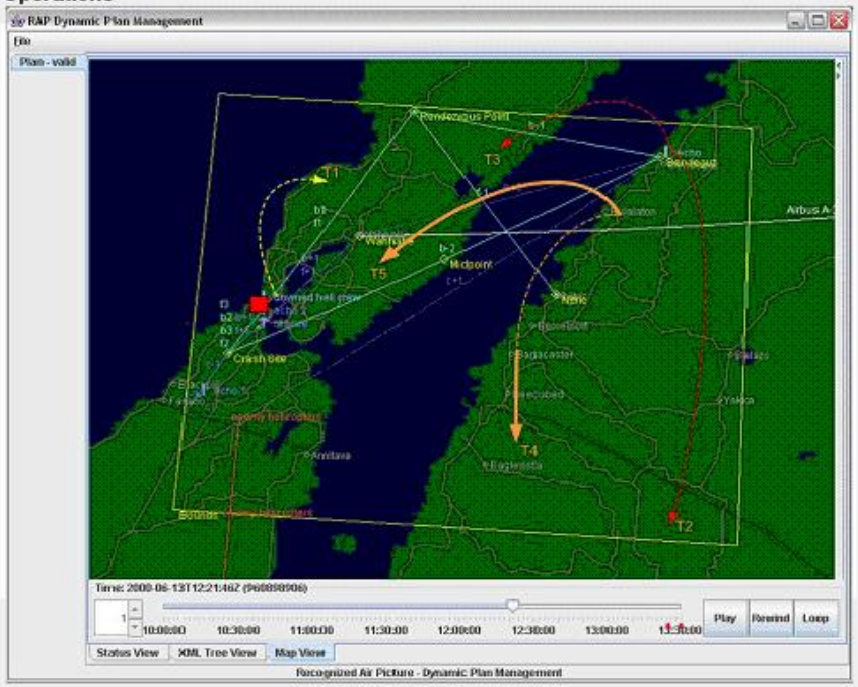


Simulation

Risks: Total | Only Assignments | Only Related Actions



Operations



All Assignments (Static) | Play | Pause | Stop

start | Inbox - ... | 4 Inter... | 3 Java... | Rap_sim... | My Docu... | MUScree... | JFS_full... | EN | 3:03 PM

Real-time risk assessment and aggregation

Do regularly (iteratively or triggered by events):

(D1) For each risk, assess its level, using EID;

(D2) For each risk type, aggregate risks over tasks, going upwards along the MDS, and

(D3) If needed, at each level of command and MDS, aggregate different risk types.

Conclusion (1/2)

- Proposed Aggregation/disaggregation methodology includes:
  - Aggregation of risk related information from different sources: Expanded Bayesian network (by using Dempster-Shafer theory of evidence)
  - Aggregation of decision making and risk related information from different sources: Expanded Influence Diagram (by using Dempster-Shafer theory of evidence)
  - Risk aggregation through command structure: Mission Decomposition Structure and different risk aggregation strategies for different risk types
  - Each leaf of the Mission Decomposition Structure has corresponding influence diagrams

Conclusion (2/2)

Presented methodologies support:

- Risk aggregation and disaggregation
- Comprehensive view for easier decision making
- Real-time monitoring of causes, risks, and controls
- Proper communication and visualization of risk related data
- Risk management at different levels of command structure
- Collaboration in joint multi-agency operations

Questions?