TOWARDS A SAR KNOWLEDGE SYSTEM OF THE FUTURE

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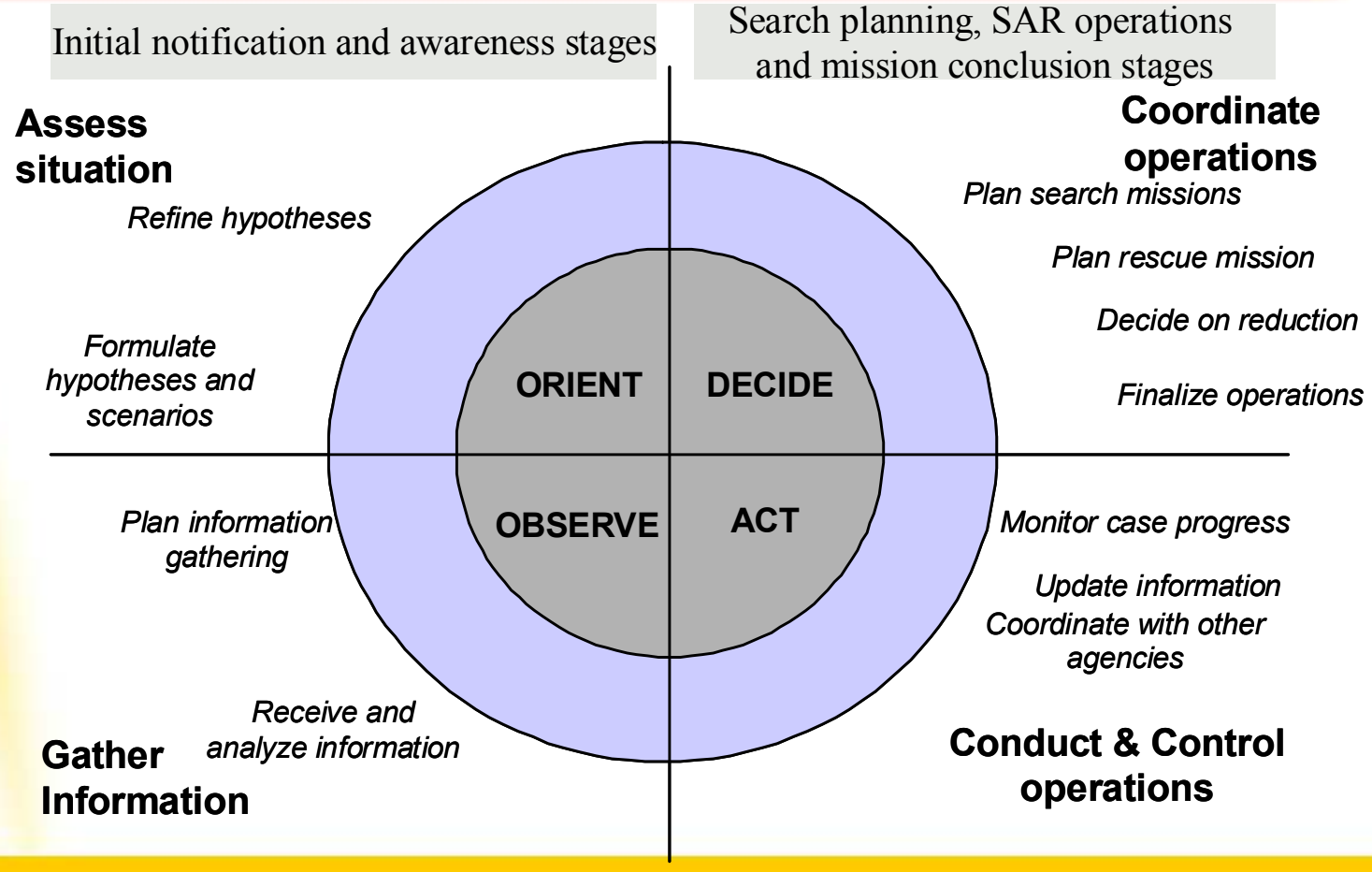
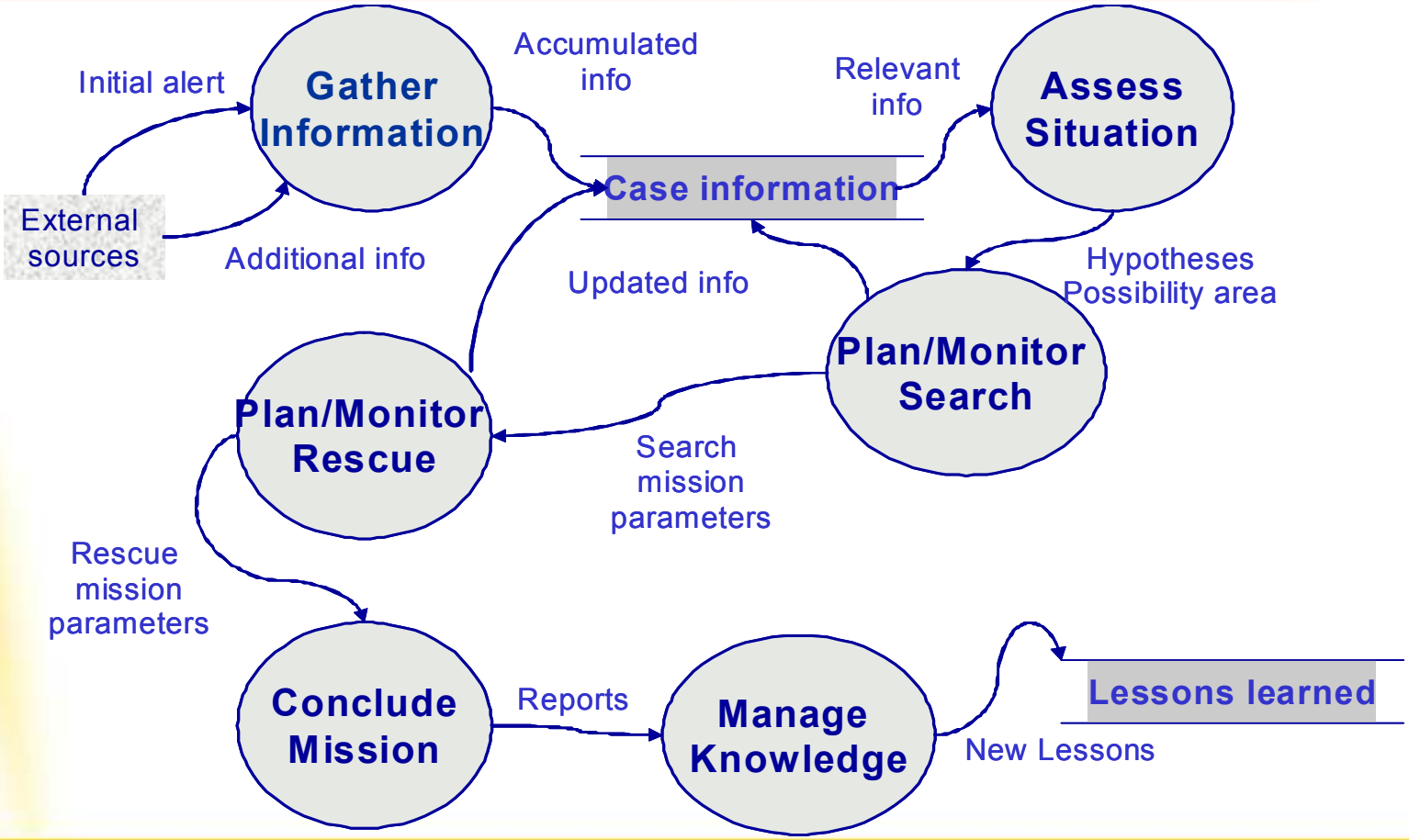
Outline

- Models of case prosecution in a JRCC
- Modules of a SAR knowledge system
- How?
- Overview of some projects
  - Search planning: SARPlan
  - Multi-Criteria Path Planning with Terrain Visibility Constraints
  - Rule-based system - SARSim

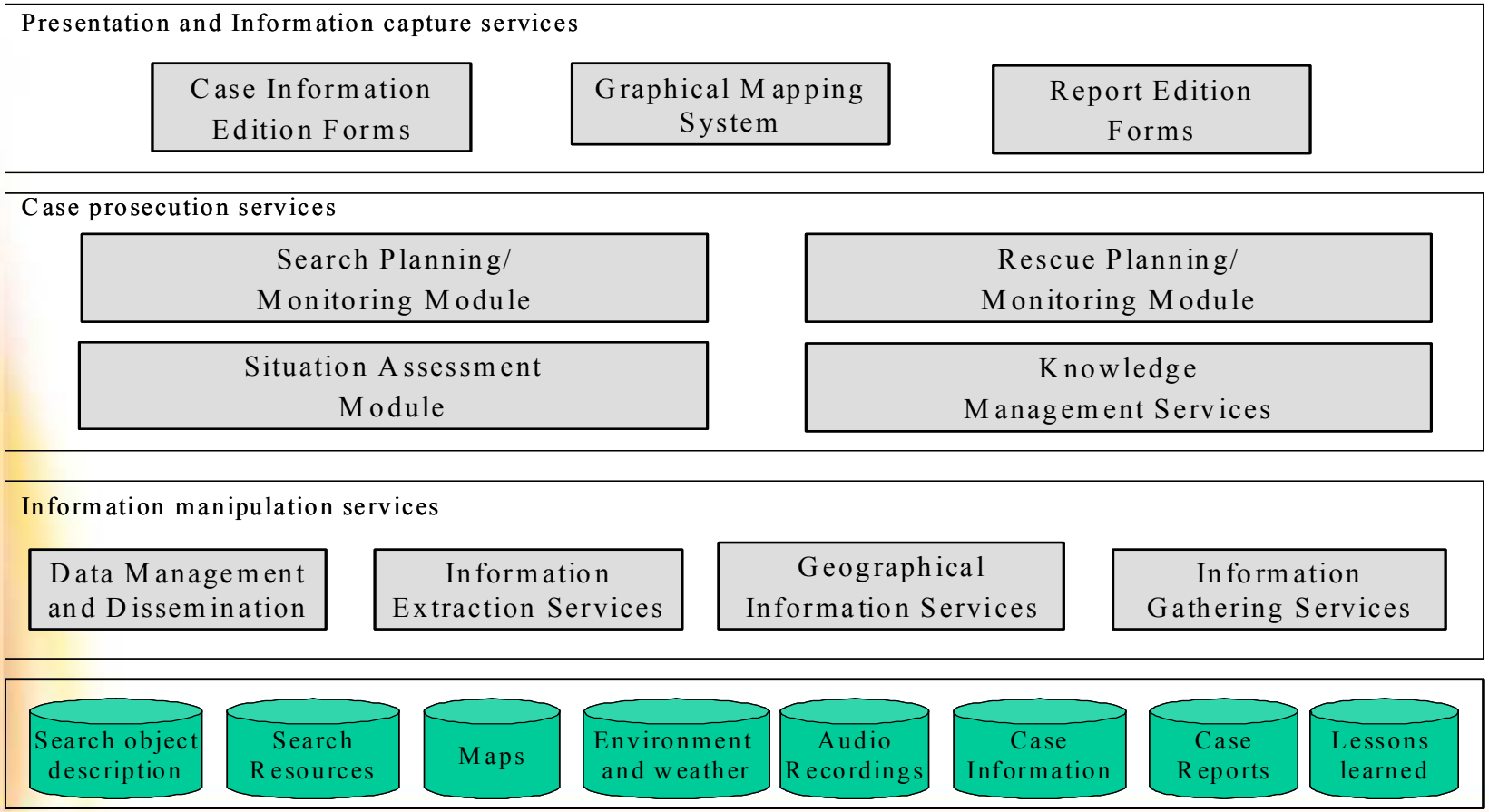
OODA loop model for SAR case prosecution in a JRCC



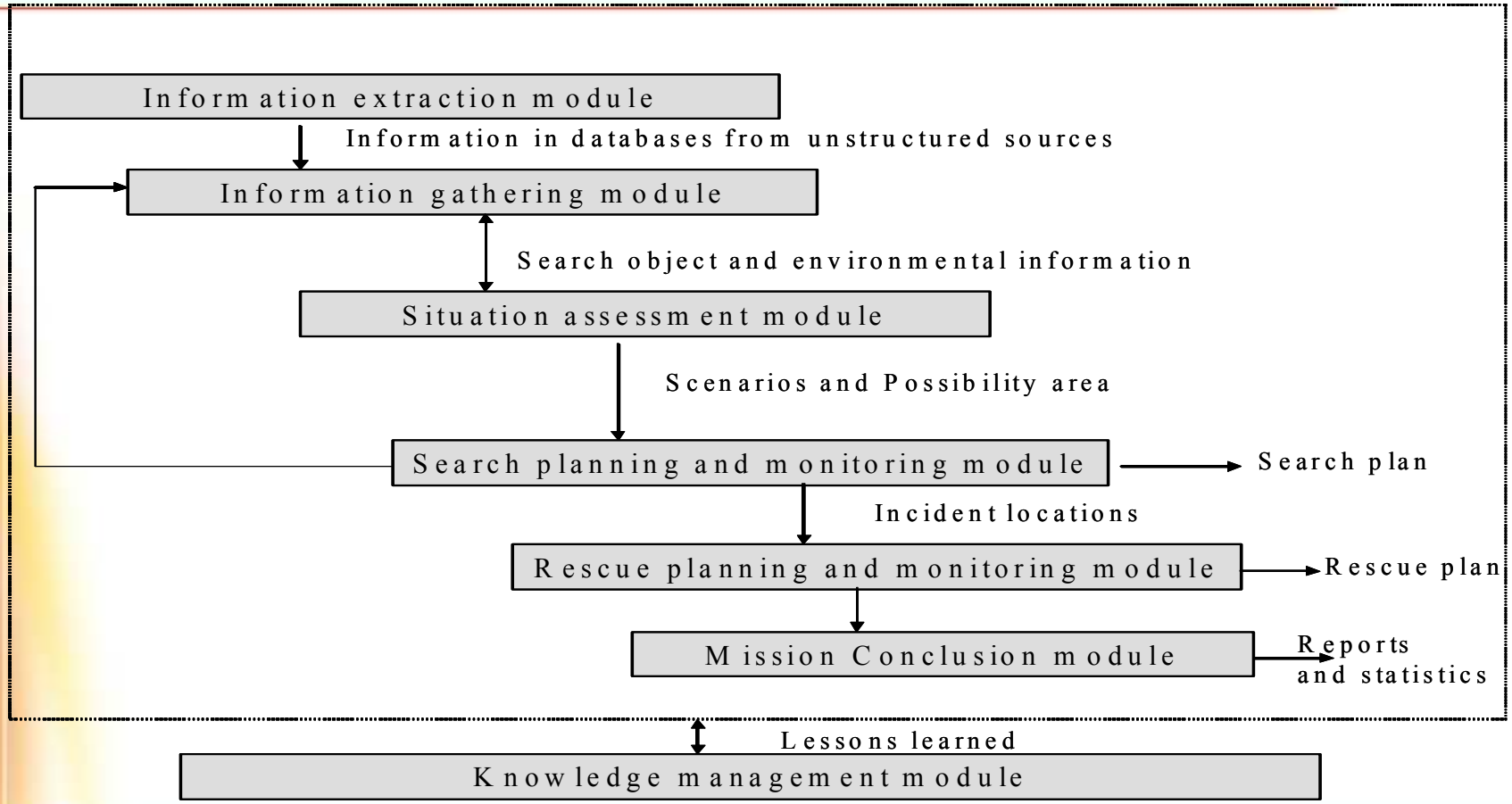
A model of a coordinator's main knowledge intensive tasks



A SAR knowledge system's services



A SAR knowledge system's modules



How? Decision Science

- The science of helping decision makers make informed decisions
- A multidisciplinary field that draws on mathematics, statistics, information systems, computer science, economics and cognitive psychology
  - Operational Research
  - Expert Systems

Decision Science

- Operational Research:
  - Concerned with mathematical methods and tools for solving problems relating to the allocation of scarce resources subject to constraints

- Expert Systems:
  - Knowledge intensive tasks, expert knowledge
  - Qualitative, tacit, experience-based
  - Not captured by mathematical models

Decision Science and SAR

- « A rash or misdirected effort will greatly reduce the chance of locating survivors but so will a well-planned operation which has been delayed because too much time was used for planning. » (ICAO, Chapter 5, p. II-5-1)

Search planning – SARPlan

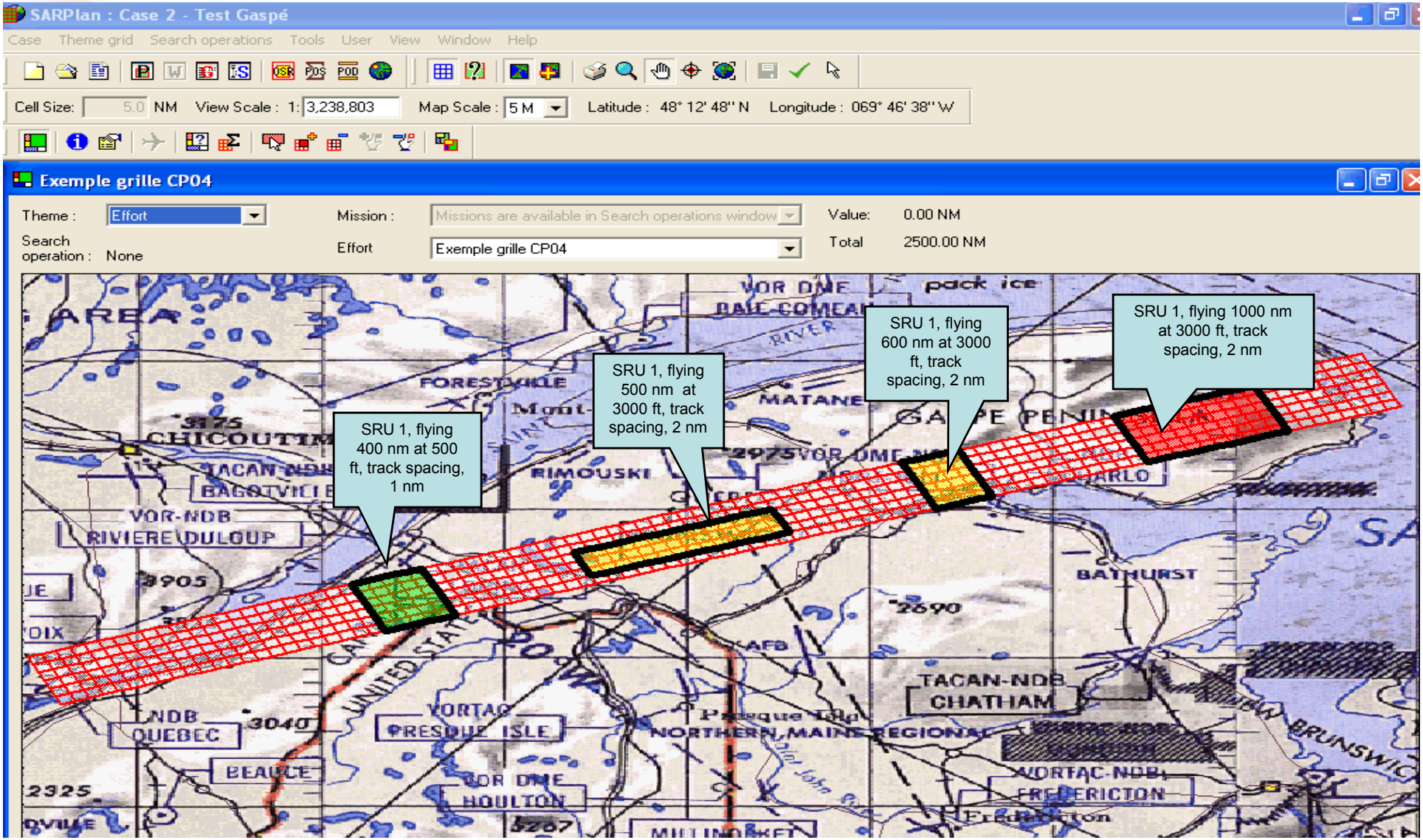
- Where to deploy available search efforts to maximize the chances of finding the search object?
    - Resource allocation problem
- Input:
    - Probability distribution of the whereabouts of the search object
    - Detection function
- Output:
    - "Optimal" search plan
        - Probability of success

Search planning – SARPlan

- Geographic decision support system
- Stationary search object overland
- One-sided search
- Multiple search aircraft
- Rectangular search sub-areas

Funded by National SAR secretariat

Search planning – SARPlan



Multi-Criteria Path Planning with Terrain Visibility Constraints

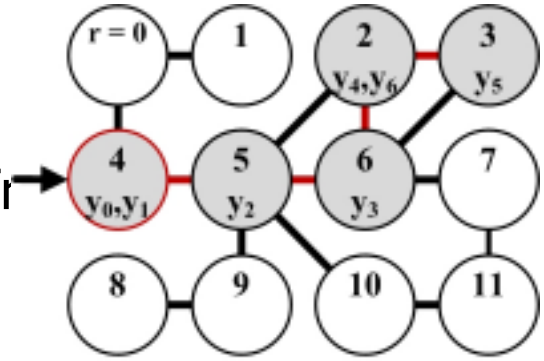
- Where to deploy a constrained search unit
- Search path for locating a search object (moving or not)

- Terrain and searcher's constraints
  - model inter-region accessibility
  - model inter-region visibility
  - model limited detection capabilities and
  - model uncertainty on the object's location

Funded by MITACS and in collaboration with DRDC-Valcartier

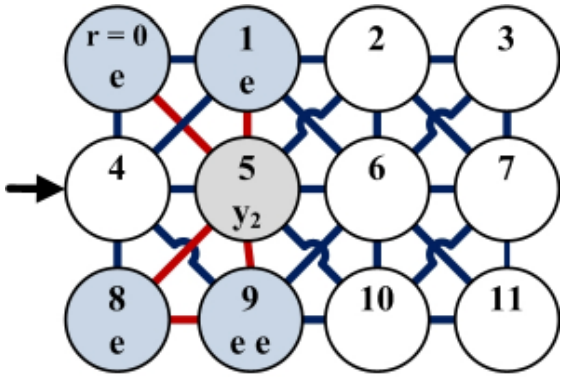
Constrained path

- Q glimpses and T time steps
- The unit chooses its path
  - considering accessible regions fr
    its current position



$T = 6$

- The unit allocates glimpses
  - considering visible regions from
    its current position

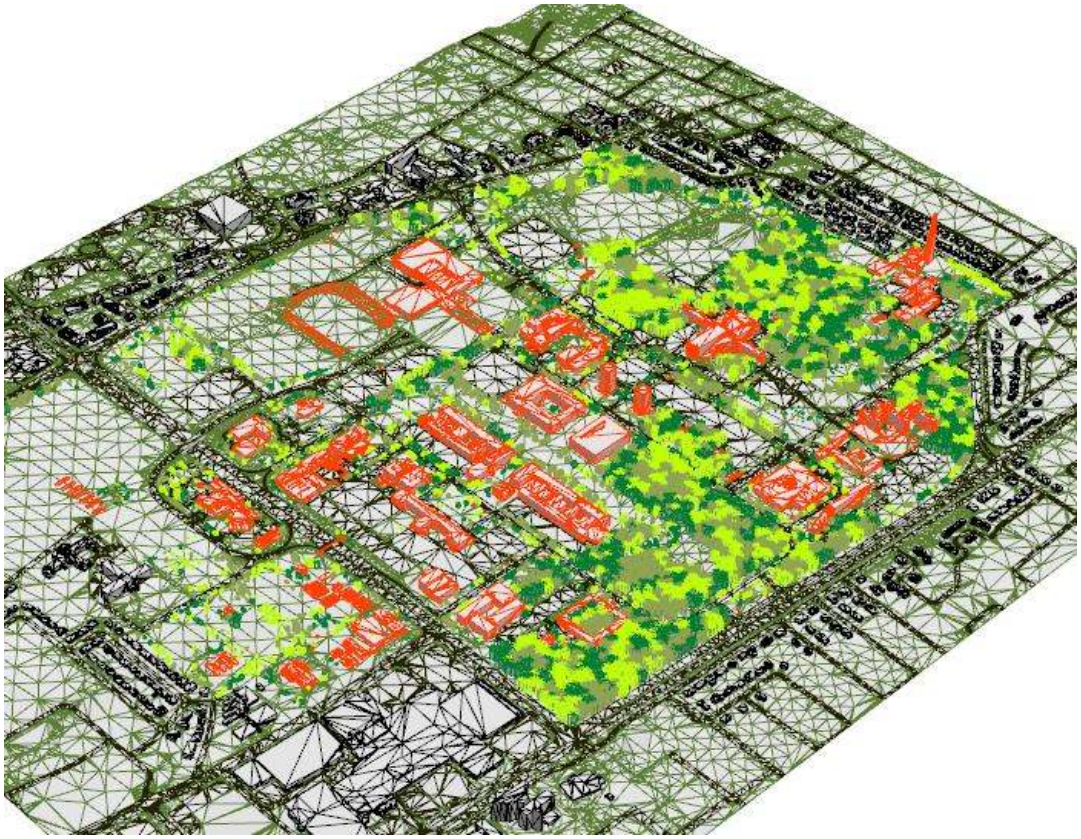


$t = 2, Q = 5$

Constrained path

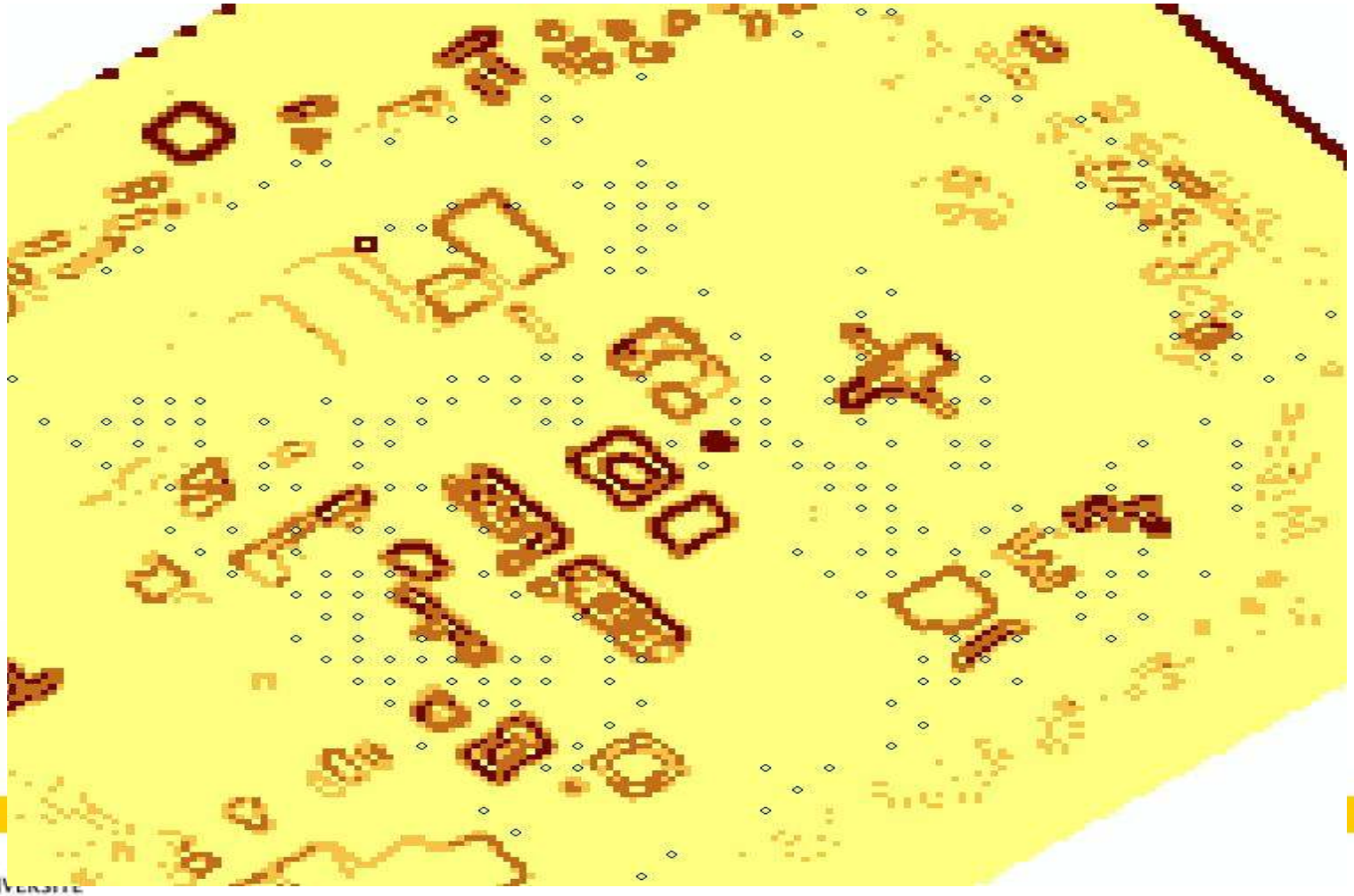
- **Multiple criteria**
  - Minimize the cumulative probability of hazard
  - Minimize the total path cost
  - Maximize cumulative probability of success

Laval University Campus 3D

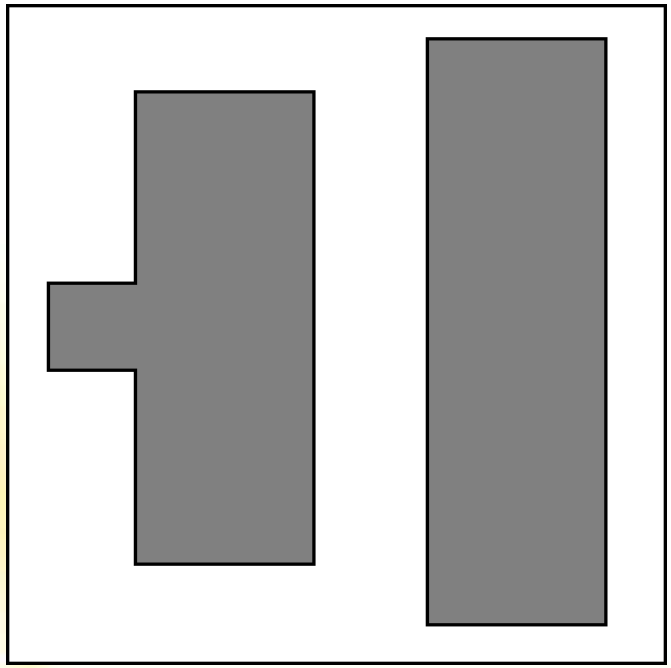


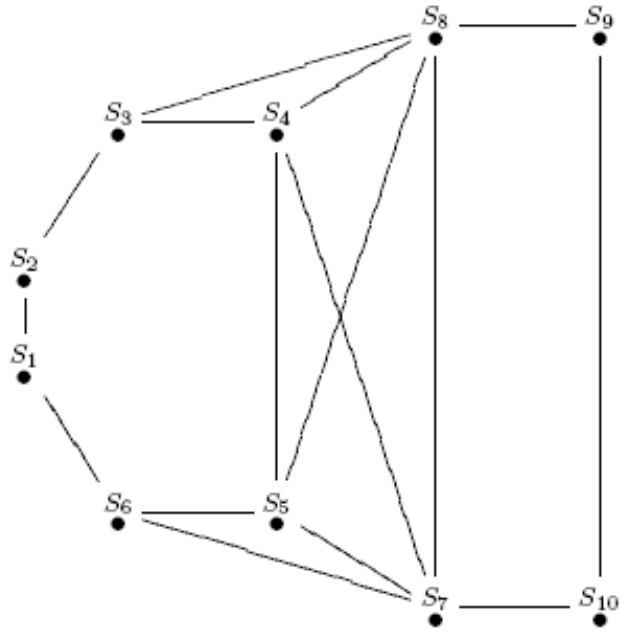
Laval University Campus 2D

Obstacles



Visibility graph





Rule-based system - SARSim

- Assist search mission coordinator in determining the possibility area of aeronautical incidents overland
- Capture knowledge and expertise
- Develop knowledge models
- Implement knowledge models in a rule-based system prototype

Funded by National SAR secretariat

Rule-based system - SARSim

- Knowledge acquisition based on documents, past cases reports, interviews with experts, participation in training and simulations
- Model validation by expert coordinator/trainer
- Structured method to guide the SMC in generating various possible scenarios

Rule-based system - SARSim

- Three types of hypotheses
  - Event: what might have happened?
  - Decision: what did the pilot decide to do?
  - Consequence: what was the outcome of the pilot's actions?
- Segment associated with each hypotheses triplet
- Presumed missing aircraft's route constructed from segments
- Addition of Datum points

Rule-based system - SARSim

- Interactive prototype
- Advisor tool in the form of a wizard
- Consists of a geographic information system and an expert system

Future work

- Extend models to cover:
  - Multiple search objects
  - Presence of false targets
  - Noisy sensor management
  - Hierarchical search planning
    - Optimal search sub-areas
    - Constrained paths within search sub-area
  - Improving algorithms performance
- Implementation in operational tools

References

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