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Wide Area Search: A Central Challenge in Countering Nuclear Terrorism

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Phases of Systems Analysis

	Questions Addressed	Examples
Strategic Study ↓	What is important? What is the problem?	Forensics (Brandt)
Framing ↓	What is the scope? What are the alternatives?	Transit Ports (Zhang)
Modeling and Analysis ↓	How do we systematically assess the alternatives?	Wide Area Search (Reinhardt) Adversary Models (Reinhardt)
Communication and Iteration	How do we communicate results? What is the impact?	Radiological (Connell)

Outline

- The Wide Area Search Problem
- An Example Scenario and Notional Model
- Example Analysis
- Conclusions and Next Steps

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Checkpoints, ports, and transit centers offer several operational advantages.

- Limited engagement geometries
- Operationally controlled environments
- Extensive support infrastructure
- Inspection of large volumes of people, vehicles, and cargo

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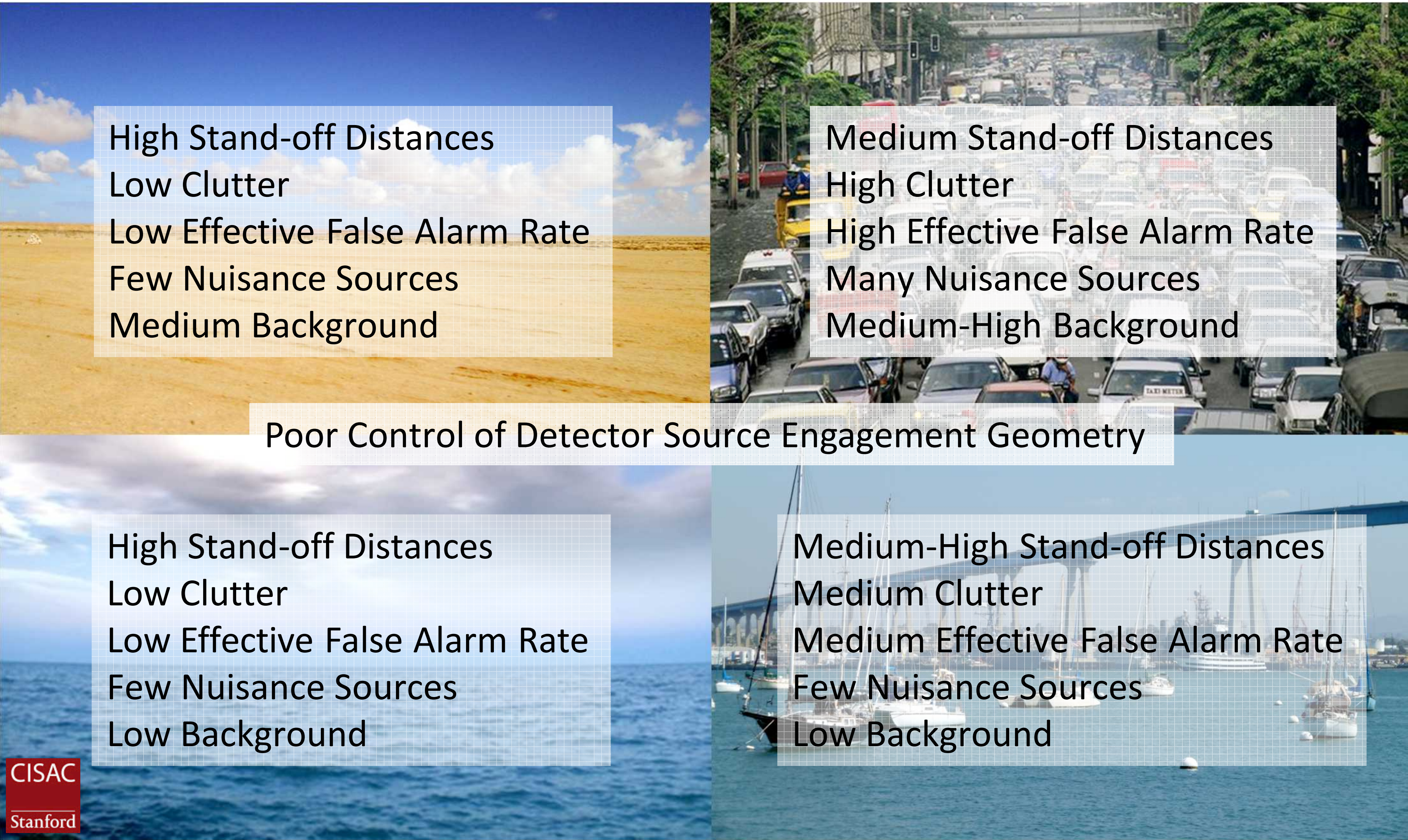
Wide Area Search often has ***none*** of these advantages.

Classes of Wide Area Search Problems



High Stand-off Distances
Low Clutter
Low Effective False Alarm Rate
Few Nuisance Sources
Medium Background

Medium Stand-off Distances
High Clutter
High Effective False Alarm Rate
Many Nuisance Sources
Medium-High Background

Poor Control of Detector Source Engagement Geometry

High Stand-off Distances
Low Clutter
Low Effective False Alarm Rate
Few Nuisance Sources
Low Background

Medium-High Stand-off Distances
Medium Clutter
Medium Effective False Alarm Rate
Few Nuisance Sources
Low Background

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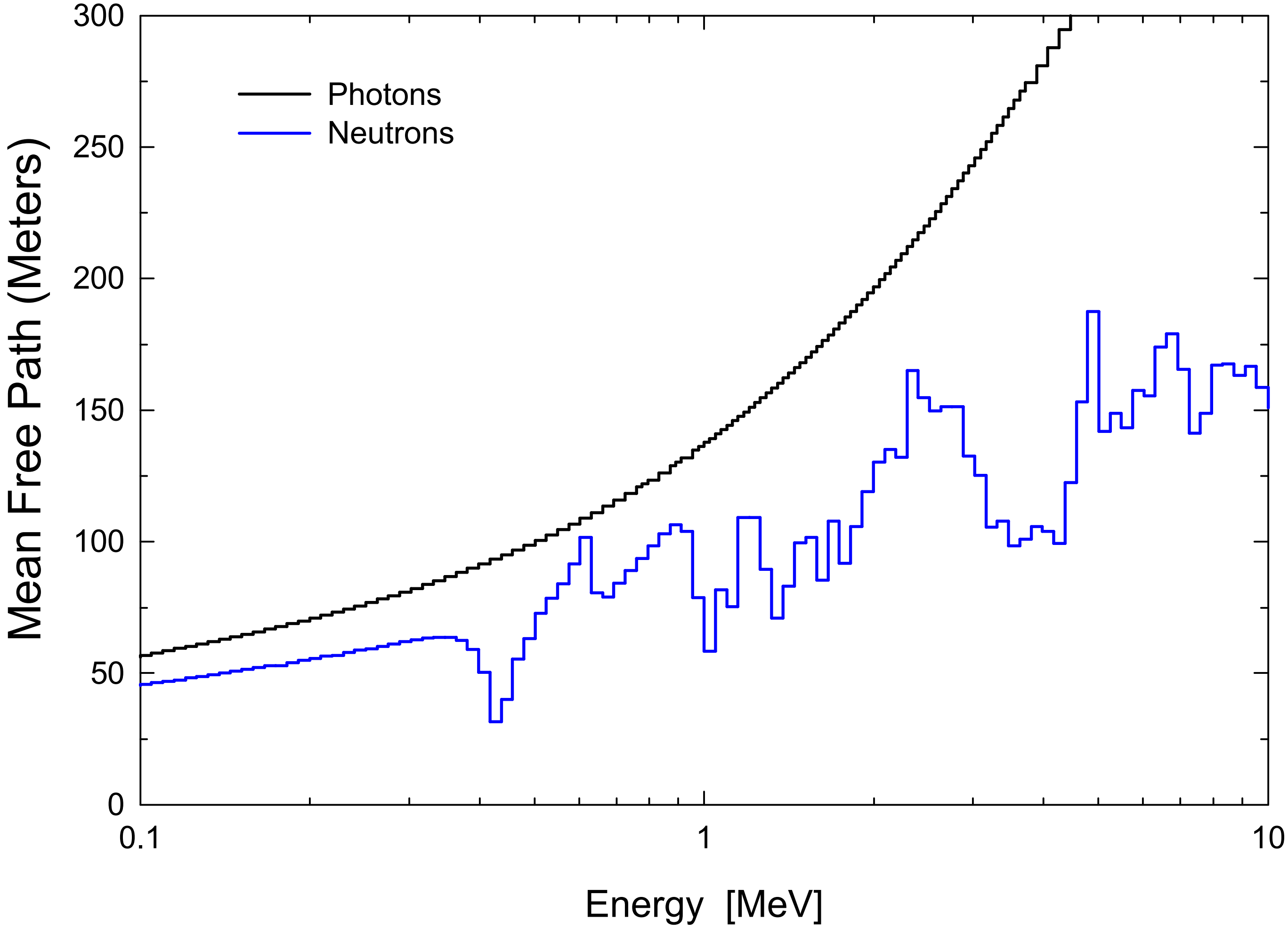
Physics limits the effectiveness of radiation detection systems.



In free air, maximum detection distance is a few hundred meters.

Taken from a presentation by Lund and Reinhardt, SNL

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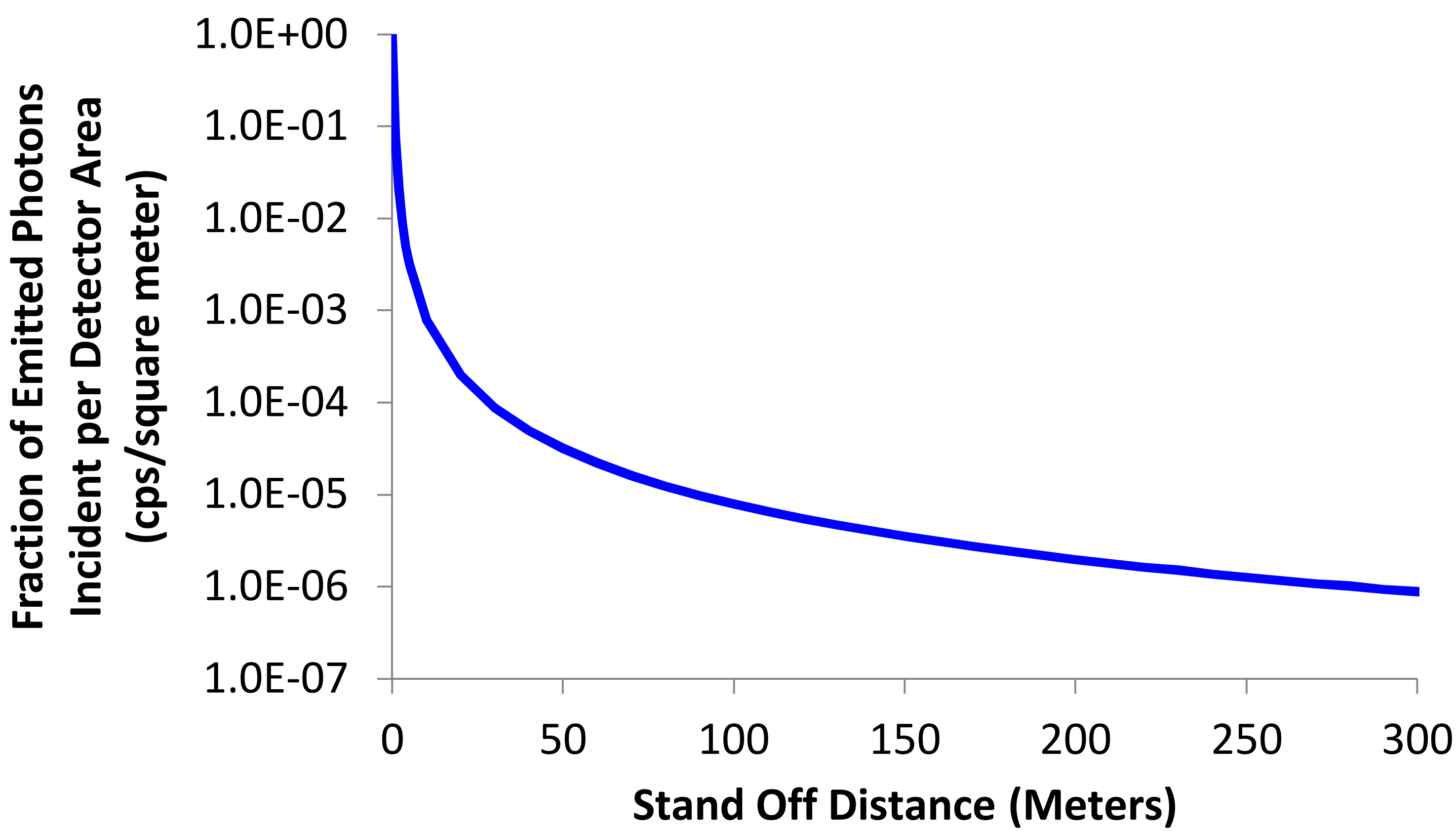
Physics limits the effectiveness of radiation detection systems.



Only very strong sources can be reasonably detected at any appreciable distance.

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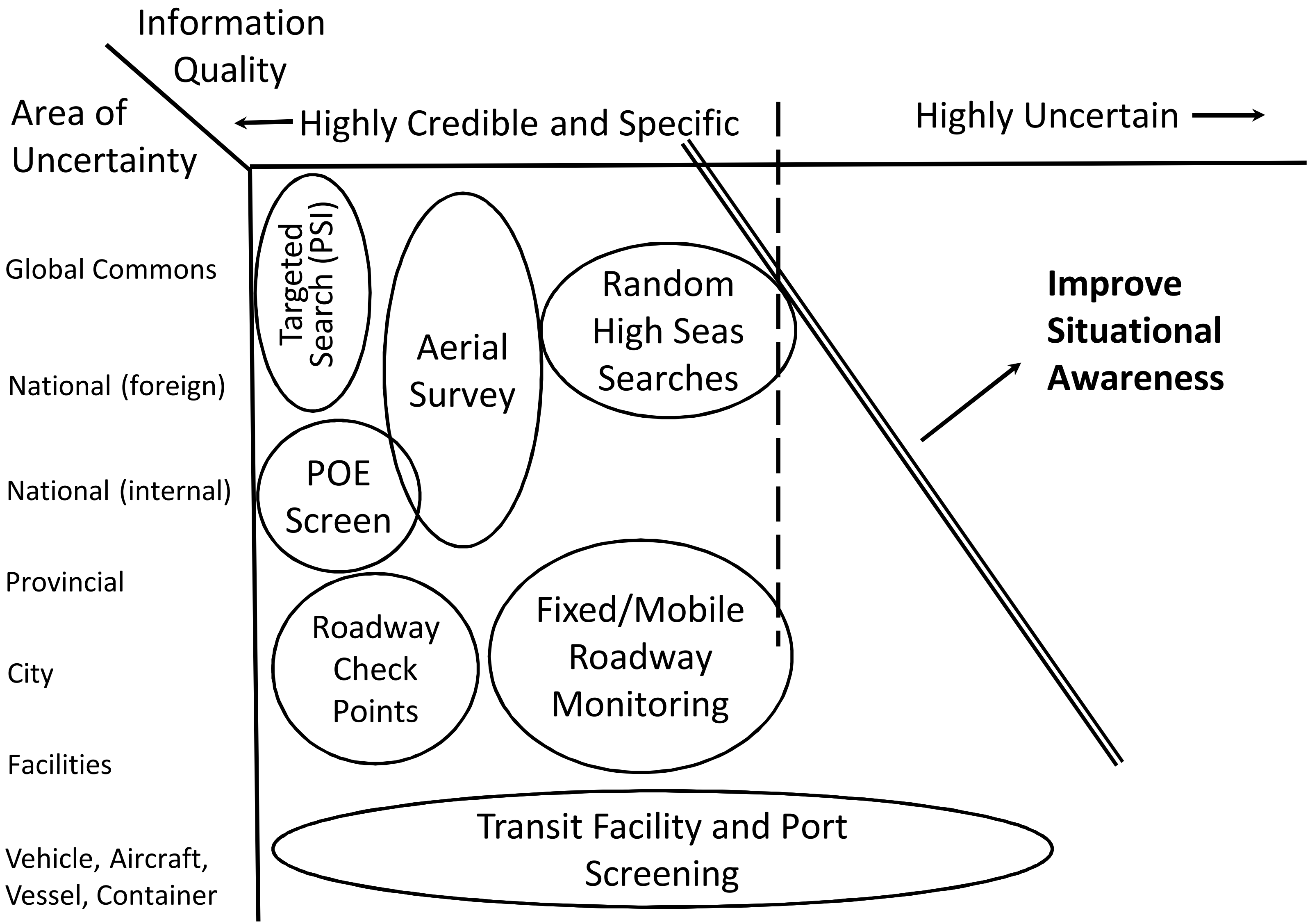
Many architecture strategies for wide area search have significant limitations.

- Ubiquitous Detection
  - Capital intensive, costly
  - False/Nuisance alarms frequent
- Stand-Off Detection
  - Physics limit feasibility at long distances
  - Operationally impractical in some cases
- Boundaries and Checkpoints
  - Difficult to establish effective borders
  - False/Nuisance alarms frequent
- Patrol Operations
  - Labor intensive, costly
  - Possibly low probability of encounter
- Responsive Search
  - Can be inefficient for large areas
  - Challenging in low information situations

Selected Architecture Components



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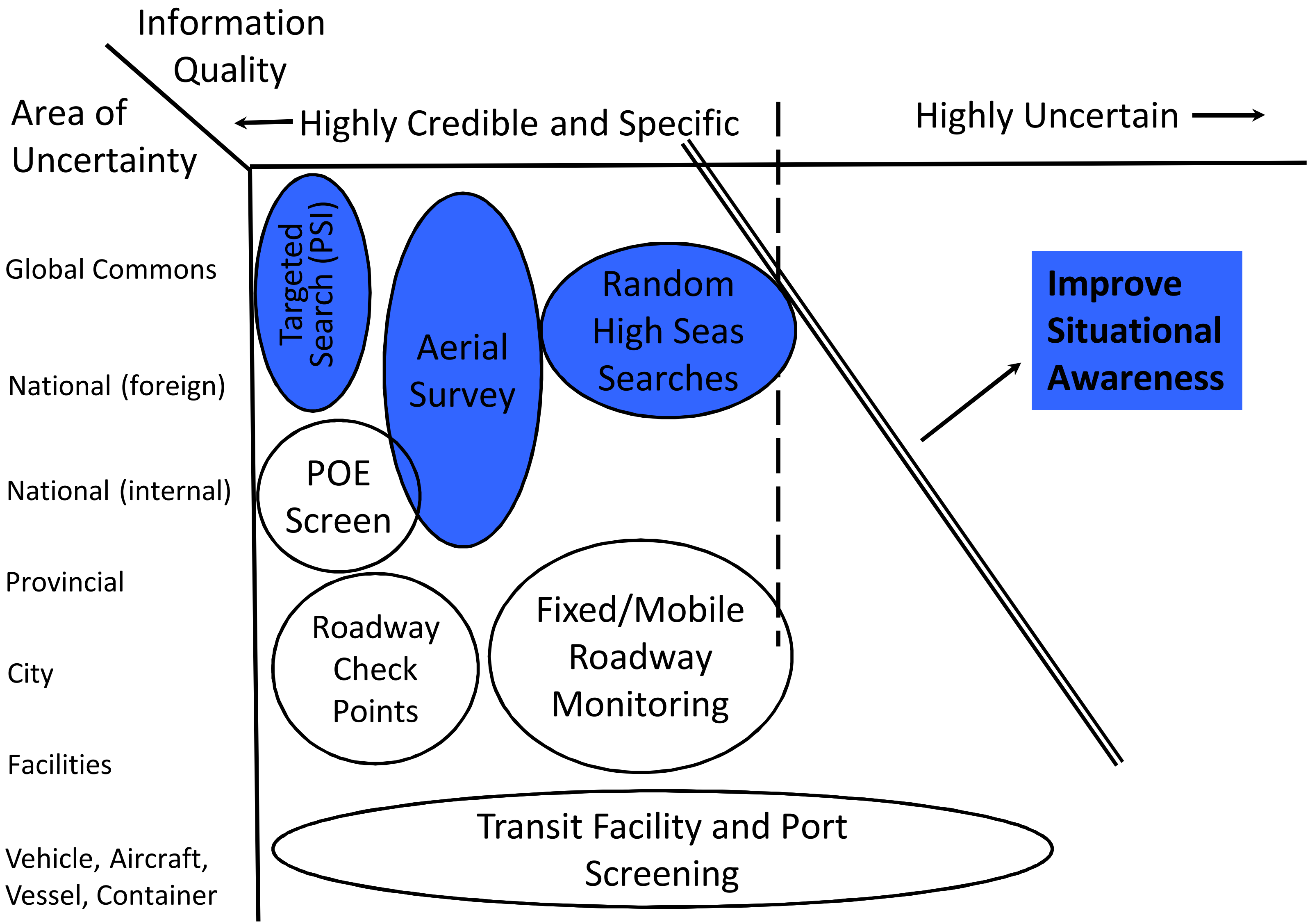
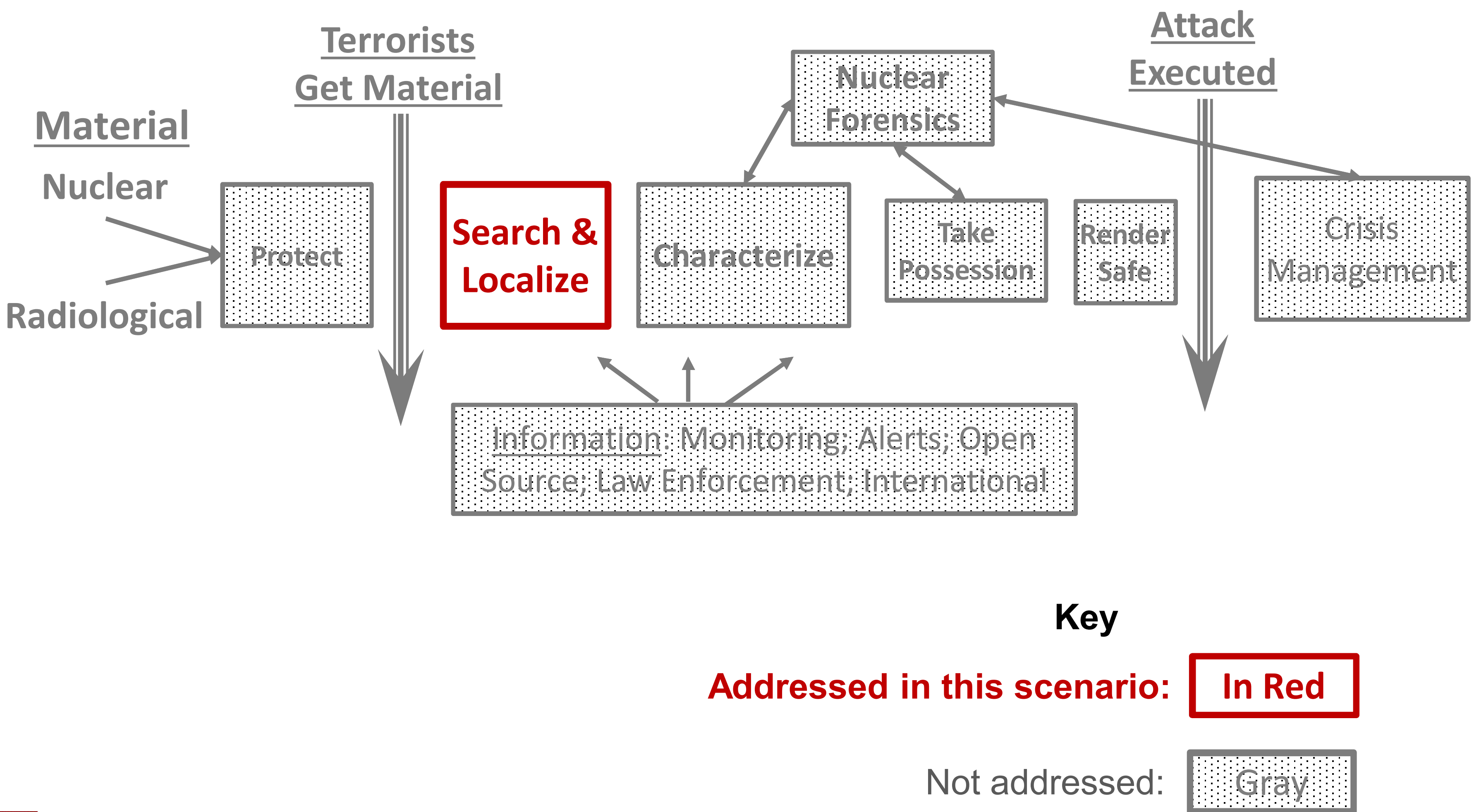
Options for Wide Area Search



A Notional Model: Caution!

- The model is meant to provide an **example** for the purposes of demonstration of the analysis.
- The data contained in the model are intended only to be suggestive of possible performance.
- The structure of the model is intended to be an "initial draft" and must be revised as collaborations continue.

Example Scenario: Focus Area



Example Scenario: Maritime Wide Area Search

- Assumptions:
  - Radiological source is missing and possibly in transit to target
  - Source is aboard an unknown vessel
  - Vessel believed to be traveling in coastal waters
  - Goal is to maximize probability of interdiction
- Questions:
  - What is the baseline probability of interdiction?
  - How can it best be improved through collaborative development ?
    - Information sharing
    - Improved area monitoring
    - Improved detection systems
    - Training response forces

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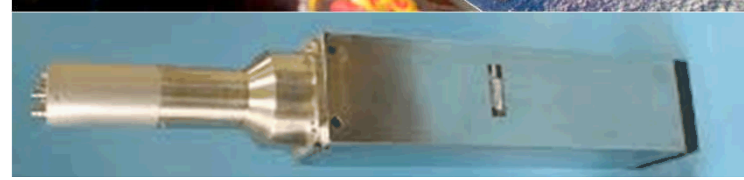
Wide Area Radiation Detection

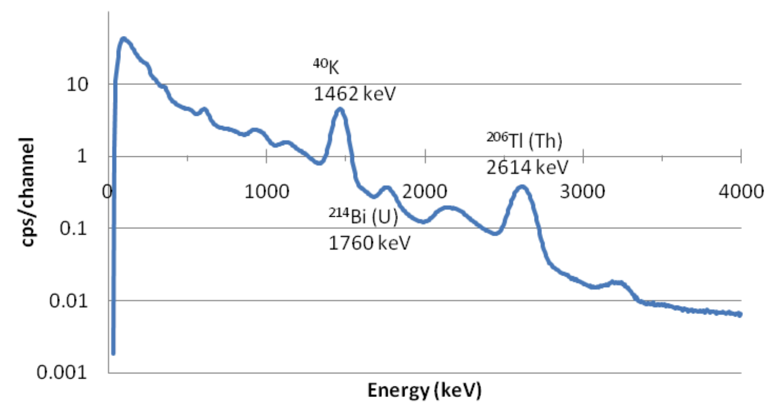
- Assume search teams are equipped with a 4”x4”x16” (10mm x 10mm x 40mm) NaI(Tl) detection system, measuring gross gamma counts.

- Detection goals
  - Find vessel in coastal ocean,
  - board it, and
  - search it to locate the source.

- Background radiation fluctuates around an expected spectra.



Unshielded NaI(Tl) Detector



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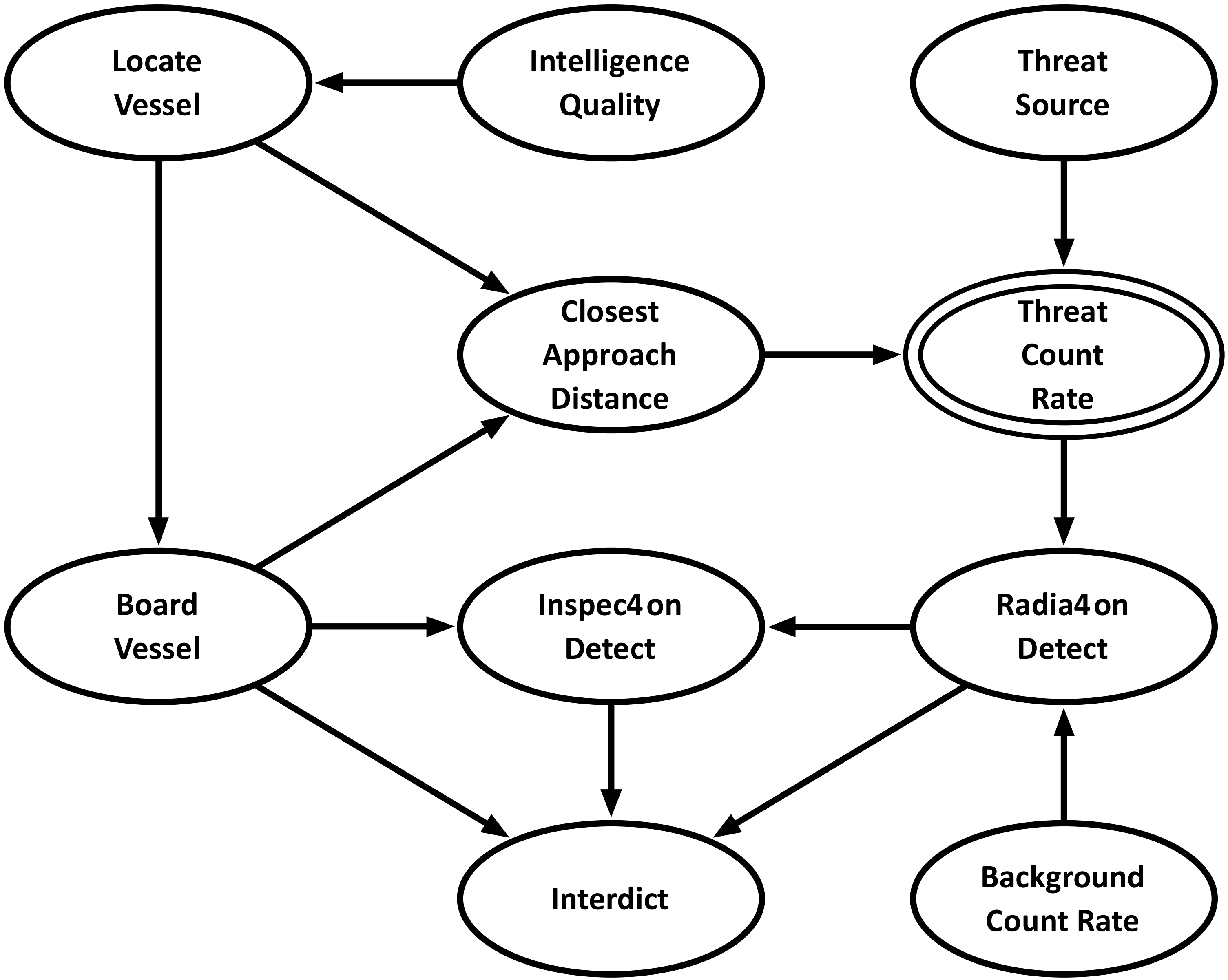
A Notional Model: Influence Diagram



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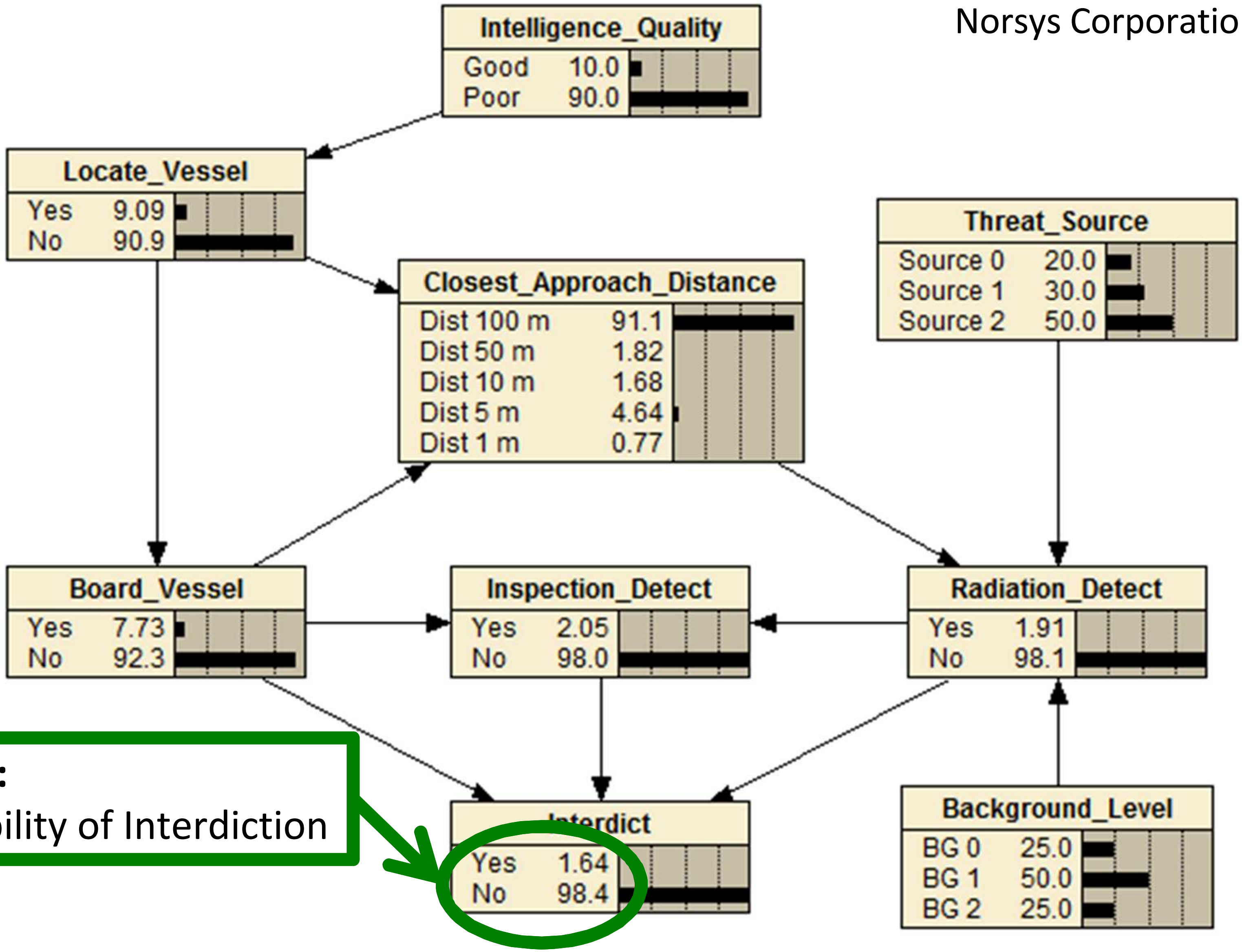
A Notional Model: Implementation

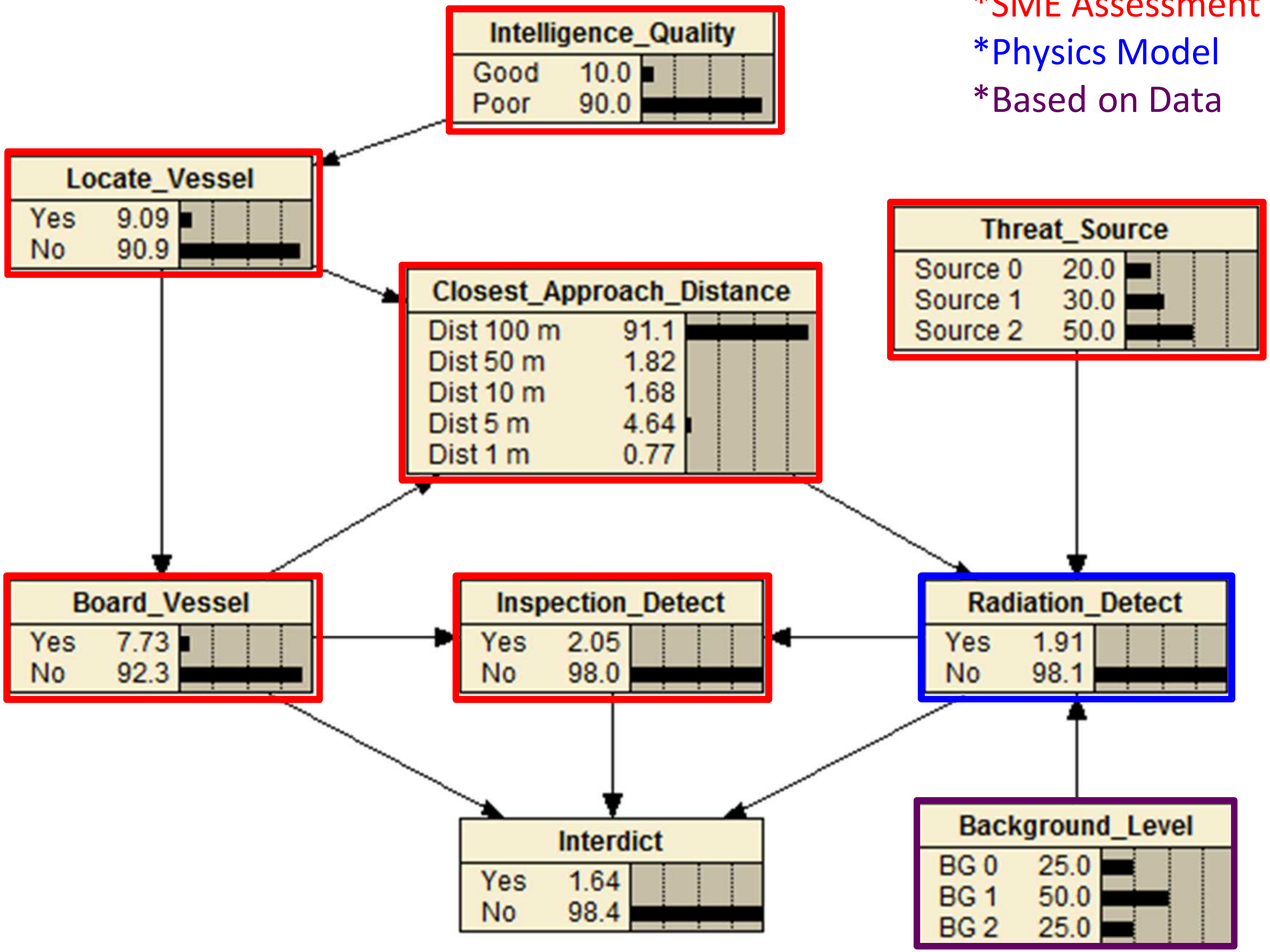
Using “Netica” from
Norsys Corporation



Metric:
Probability of Interdiction

A Notional Model: Implementation

*SME Assessment
*Physics Model
*Based on Data



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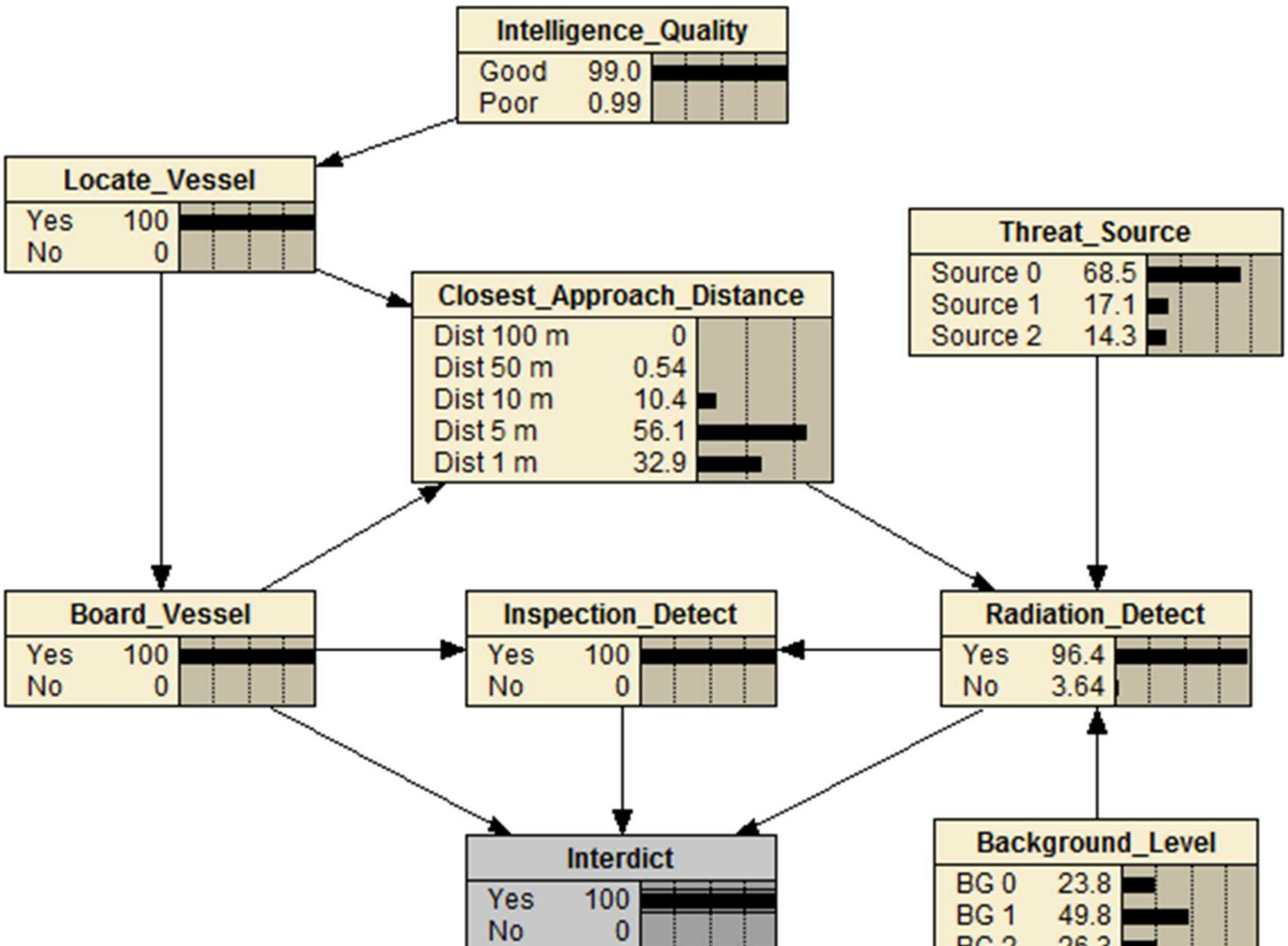
A Notional Model: Intuition Check



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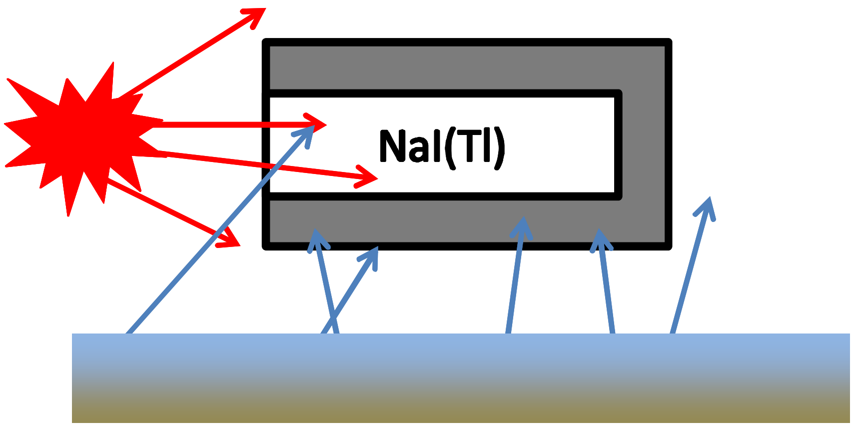
Detector Enhancement Alternatives

Alternative 1:

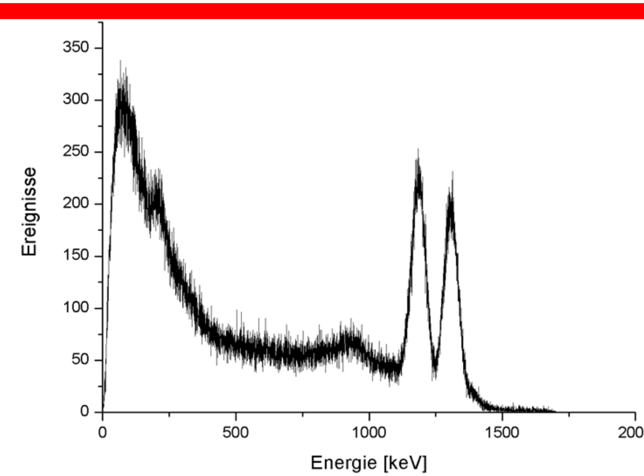
Background Suppression



- E.g. Collimation
- Lowers background levels
- Improves signal-to-noise

Alternative 2:

Improved Discrimination



- E.g. Spectral Identification
- Lowers effective alarm threshold
- Rejects false and nuisance alarms

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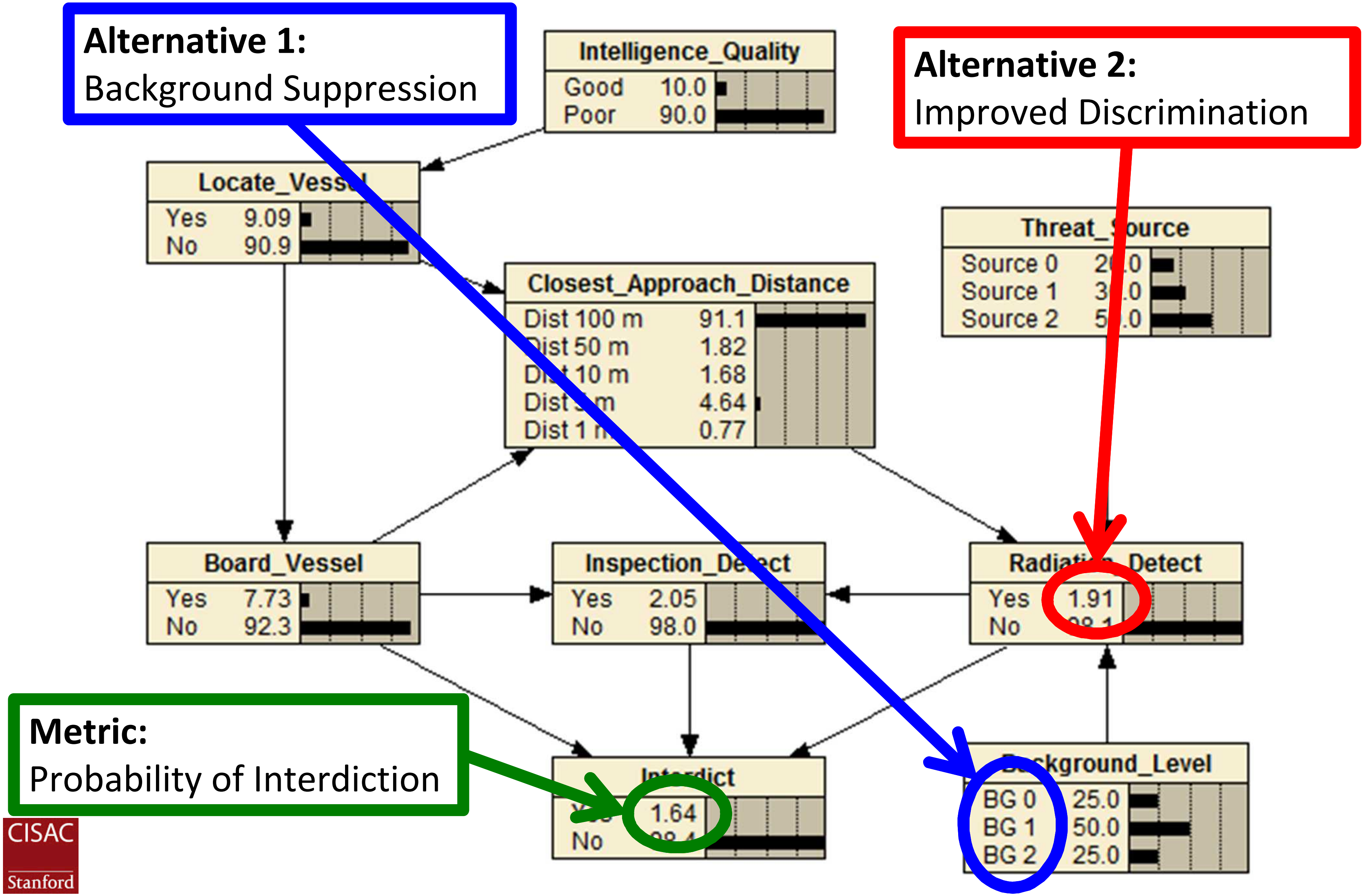
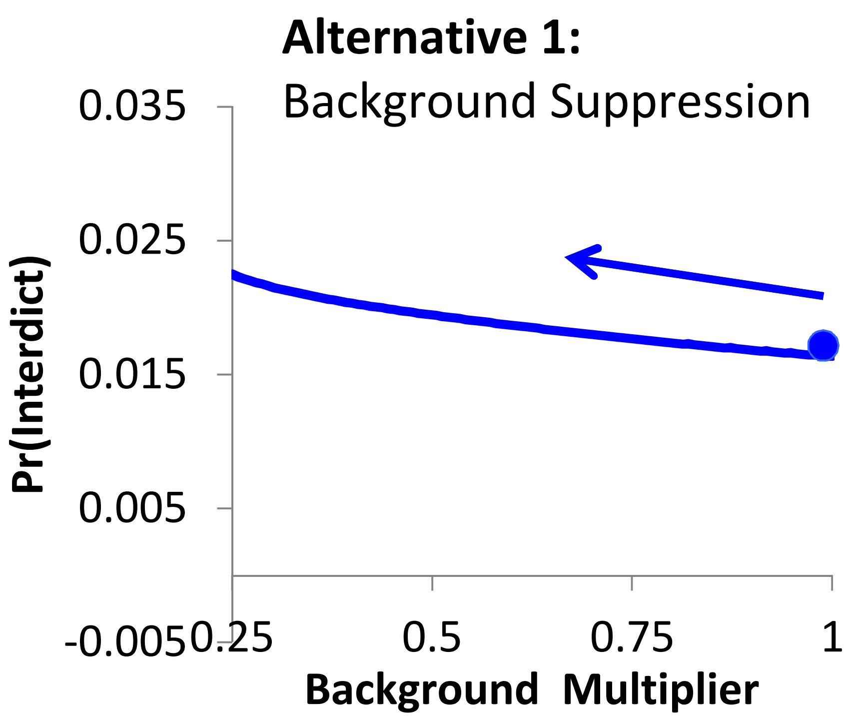
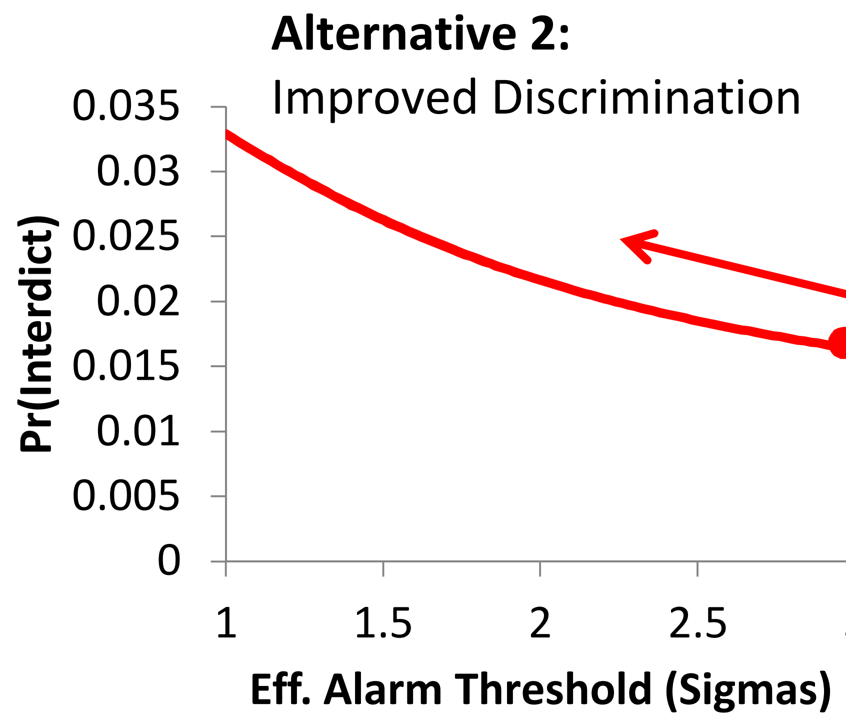
Comparing Alternative Enhancements



Enhancements to the detection system provide modest gains to overall system performance.





- Costs and achievable performance can be informed by laboratory experiments and further modeling.

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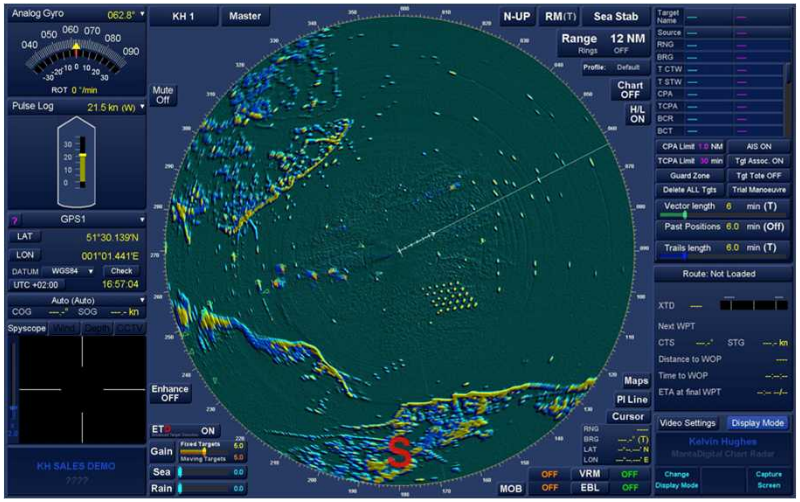
Maritime Operational Enhancement Alternatives

Alternative 1:
Improved monitoring of maritime commons

Alternative 2:
Improved vessel inspection techniques



- E.g. Radars, patrol
- Identifies and locates vessels of interest
- Improves search efficiency, probability of locating vessel

- E.g. Training on inspection
- Improves operational effectiveness
- Improves probability of finding contraband

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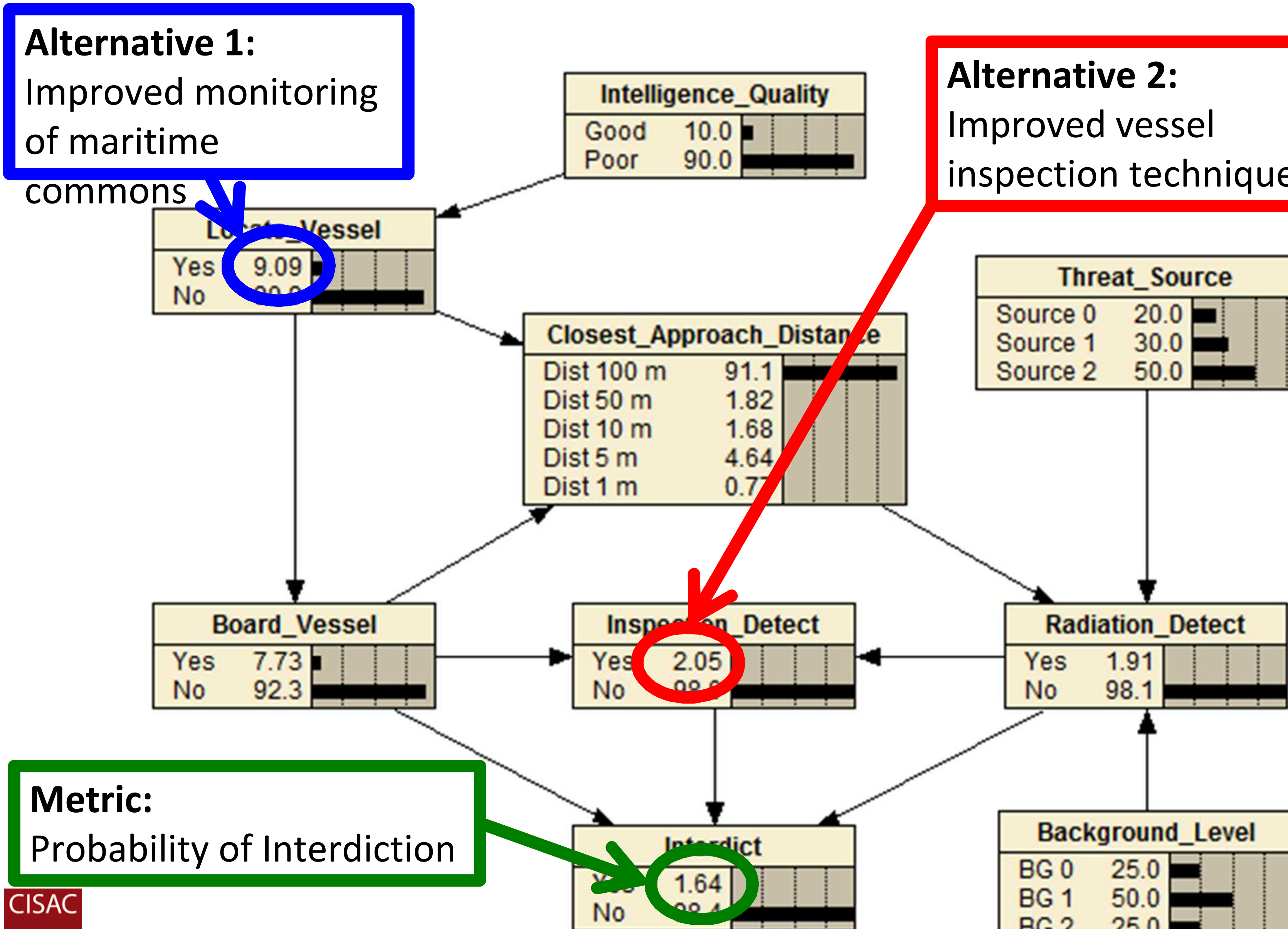
Comparing Alternative Enhancements



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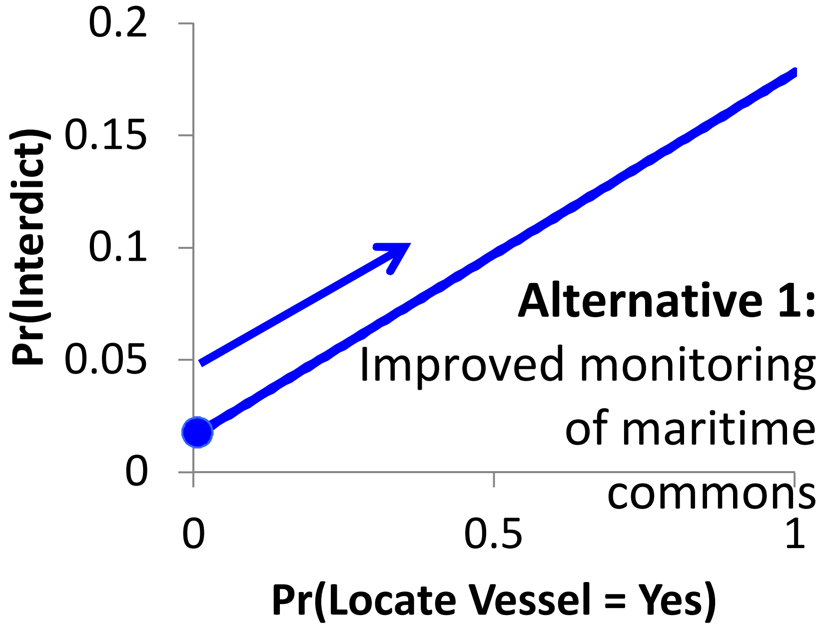
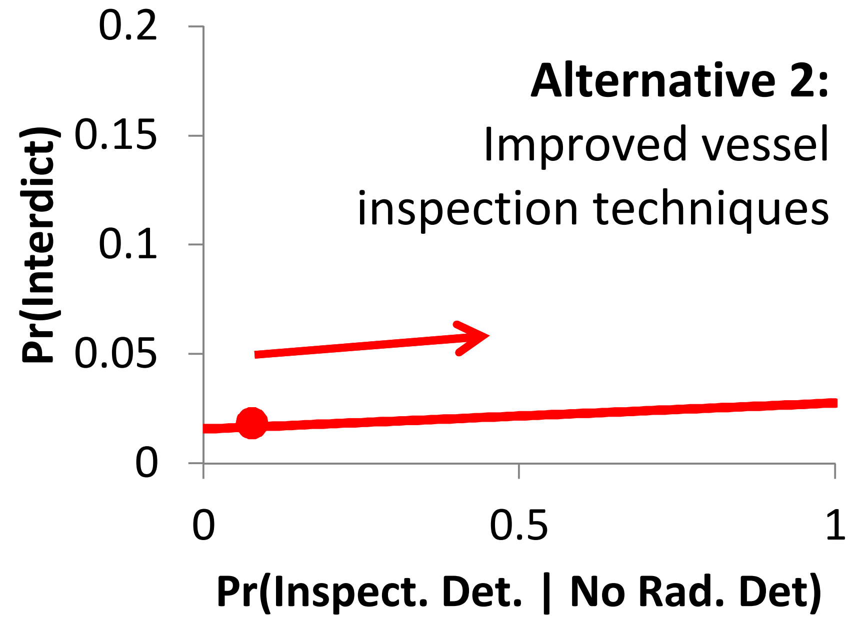
Improvements in inspection operations do not yield significant improvements in performance.





- Large improvements in inspection performance are overwhelmed by gains in improvements in locating the vessel.
- Technical improvements to the detection system are also less effective than improvements to locating the vessel.

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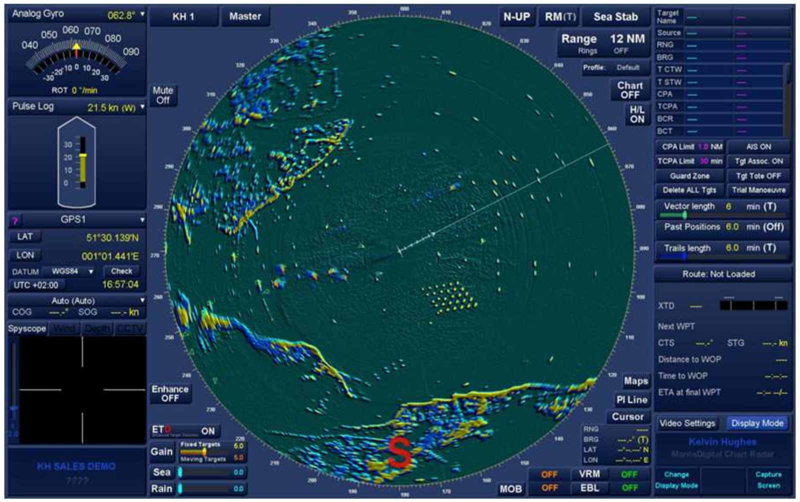
Information Quality Enhancement Alternatives

Alternative 1:
Improved monitoring of maritime commons

Alternative 2:
Information Sharing to Improve Intelligence



- E.g. Radars, patrol
- Identifies and locates vessels of interest
- Improves search efficiency, probability of locating vessel

- E.g. Crisis Co-operation
- Ensures the best possible knowledge of the threat
- Improves ability to locate the vessel quickly

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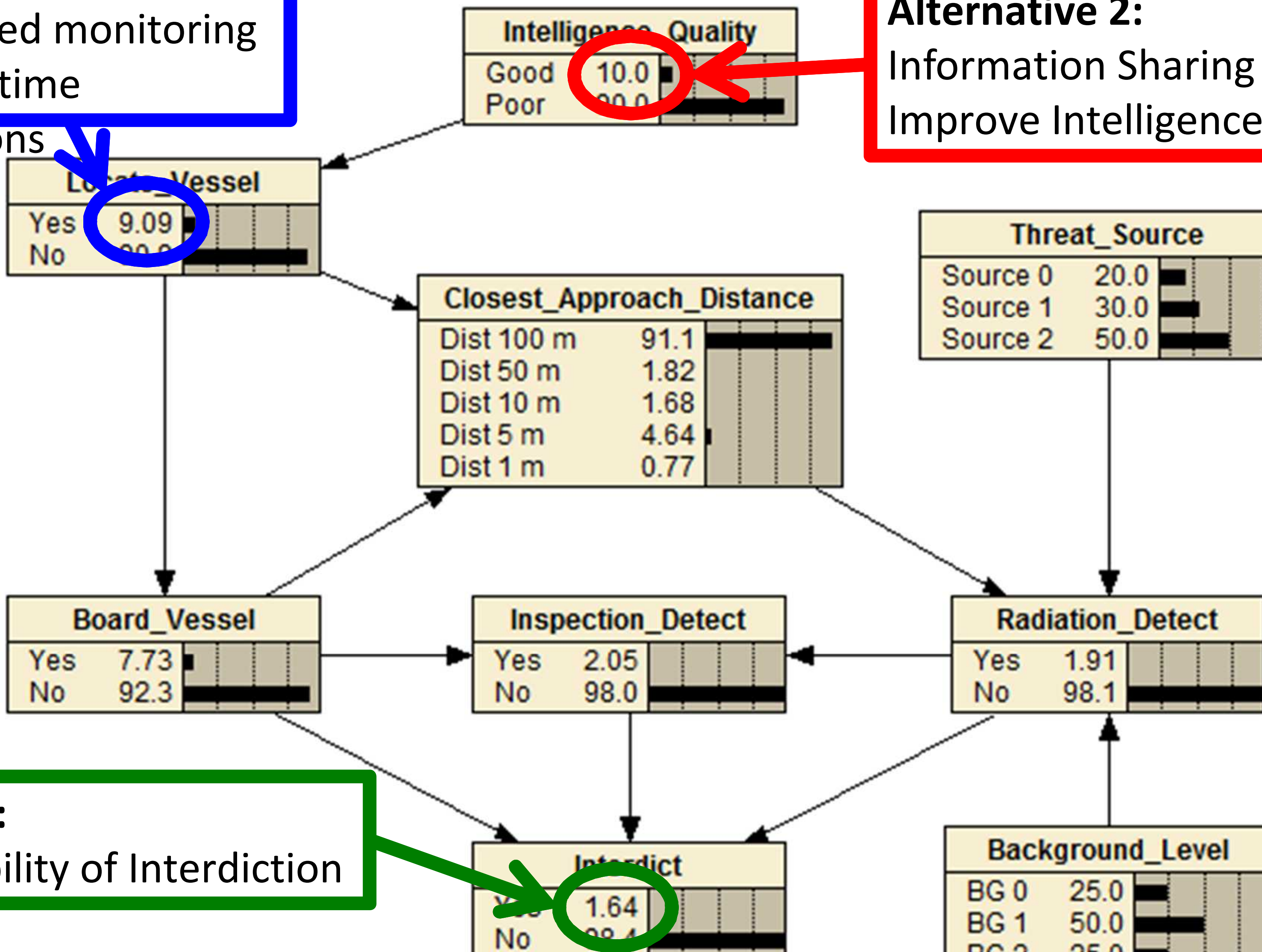
Comparing Alternative Enhancements

Alternative 1:
Improved monitoring of maritime commons

Alternative 2:
Information Sharing to Improve Intelligence



Metric:
Probability of Interdiction

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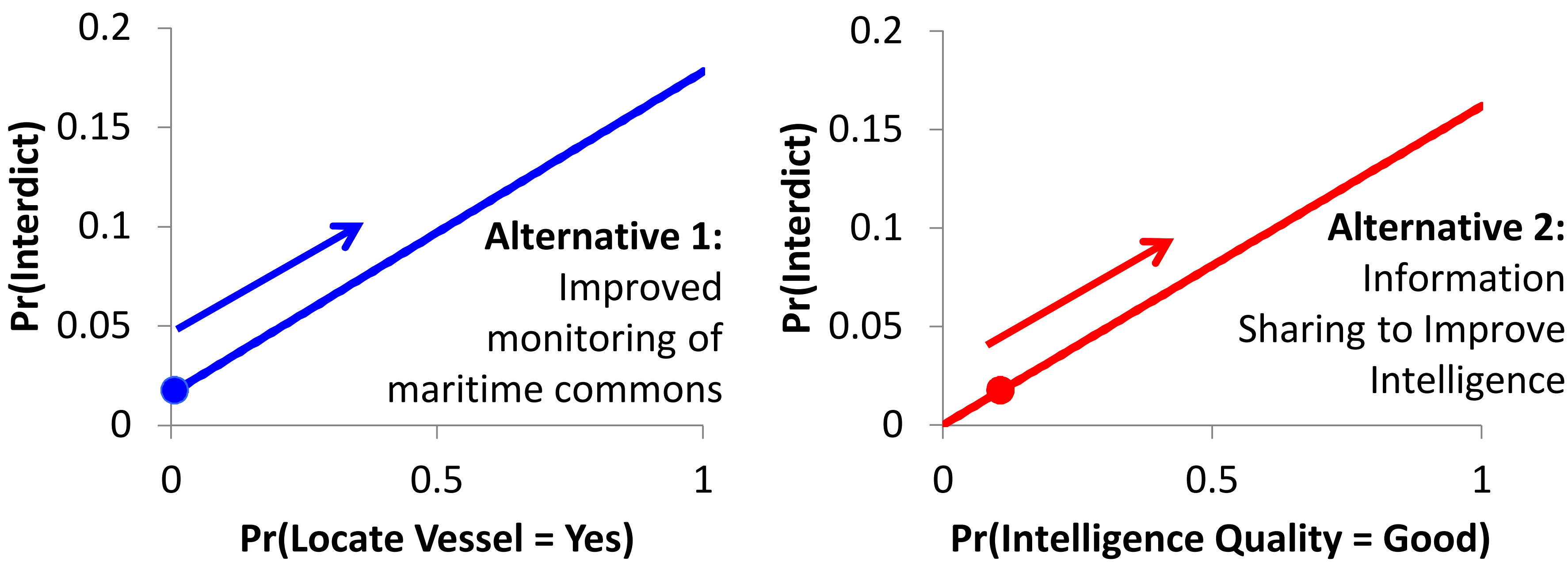
Enhanced maritime monitoring and information sharing approaches may yield similar gains



- Both yield similar improvements to interdiction probability
- Improved monitoring provides higher maximum performance
- Next steps of analysis may focus on:
  - Possible improvement options (e.g. improved maritime tracking, cooperative monitoring agreements, etc.)
  - Expected level of improvement
  - Cost per unit of improvement

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Conclusions

- Wide Area Search presents one of the most challenging problems for countering nuclear terrorism.
  - Depending on the environment, high clutter and high nuisance alarm rates present significant operational challenges.
  - Radiation detection, while important, may have a limited role due to physics and operational considerations.
  - A mix of strategies is often required, and is often dictated by the specific scenario.
- Under the assumptions and constraints of the example scenario and model in this presentation:
  - Enhancements to the ability to locate the vessel provide the best opportunities for improving interdiction probability.
    - Improved maritime surveillance (e.g. radars)
    - Increased patrols
    - Information sharing
    - Cooperative monitoring of the commons
  - Improvements to detection equipment or vessel inspection operations yield only limited performance enhancement.

Next Steps

- With this analysis as an example and starting point, collaborative efforts could include:
  - Refinement and enhancement of model structure
  - Development of enhanced sub-models and data
  - Re-assessment of possible technical and operational solutions
  - Development of additional models for additional architecture problems

Image Credits and References

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A Notional Model: Intuition Check