

A Transportation Network Perspective for Detecting HEU in Seaborne Containers

Texas A&M University

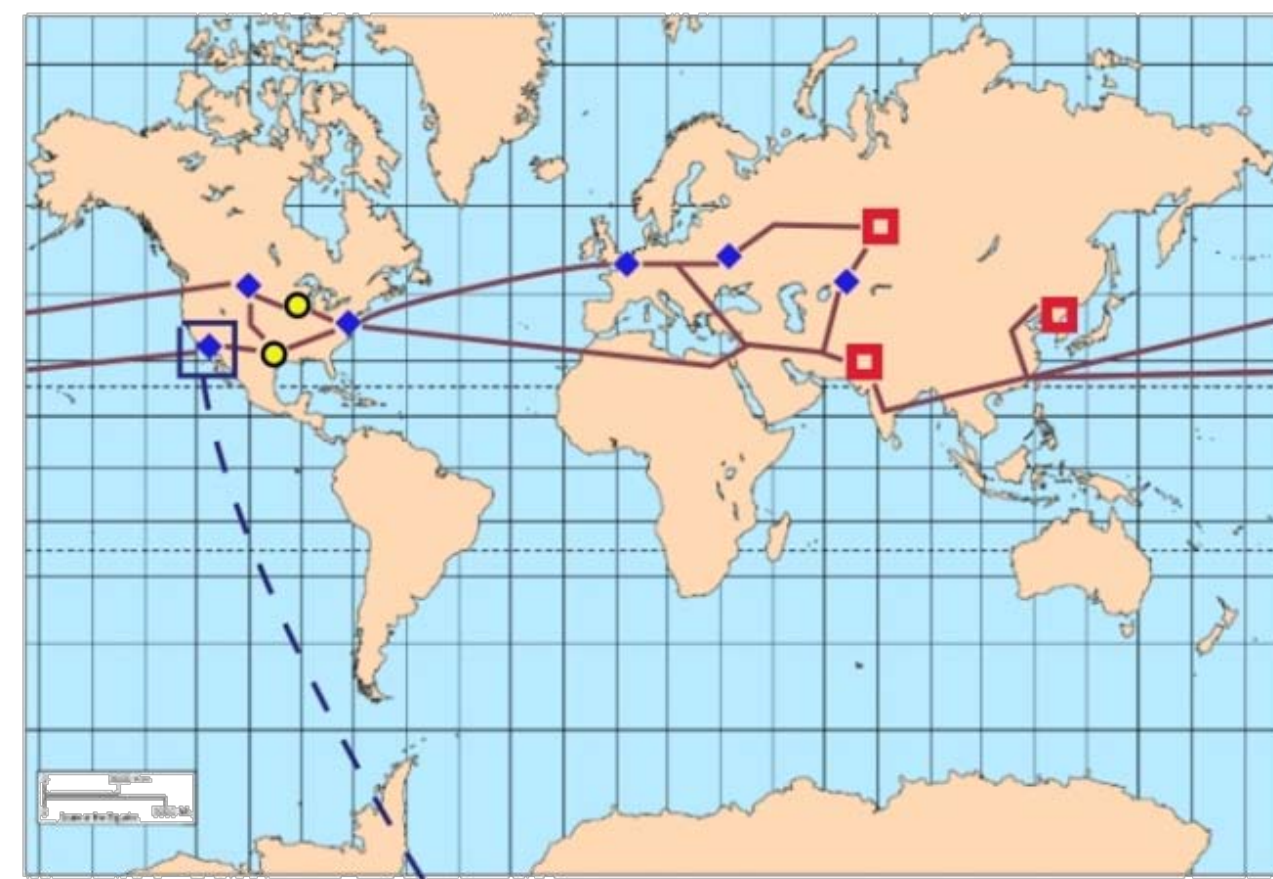
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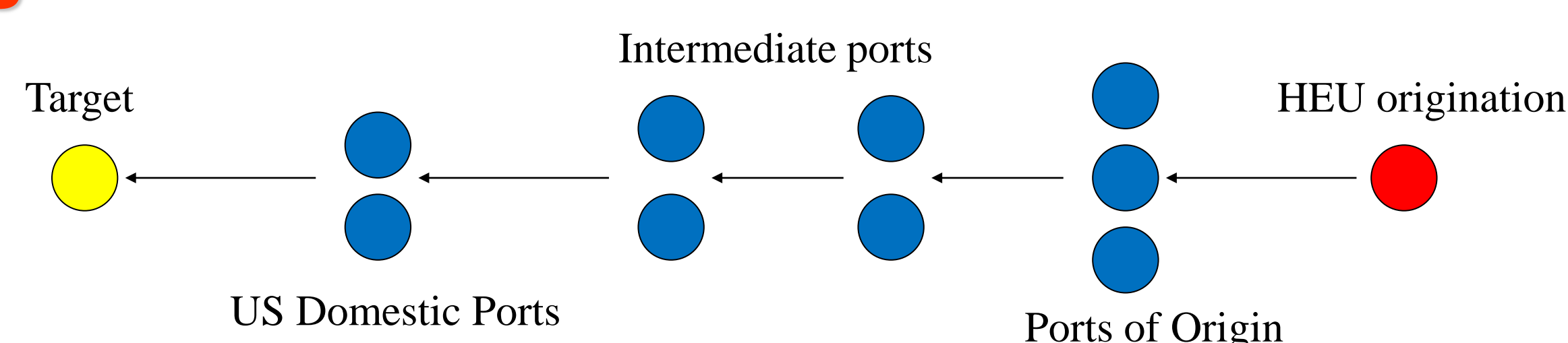
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The Global Nuclear Detection Architecture

- Sources: Locations at which material might be obtained
- Pathways: Routes the material must travel to reach its destination
- Detection Sites: Locations of detector systems which may be able to interdict the material
- Targets: Locations at which the material can be used for nefarious purposes



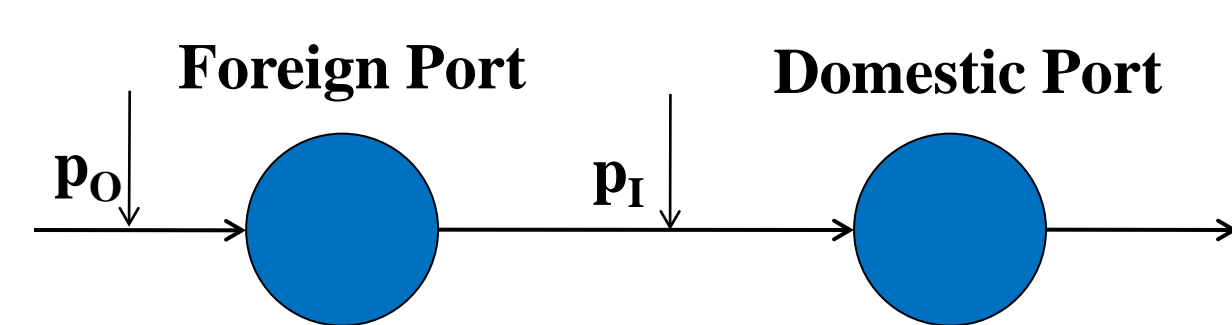
Strategic Problem



- Deal with multiple ports: foreign ports and domestic ports
- Each of these nodes requires a solution to the tactical problem, different operation parameters at different port
- Detector deployment with limited budget: where to deploy what type of detectors?
- Radiography equipment at foreign port or domestic port?

Simple Network Problem

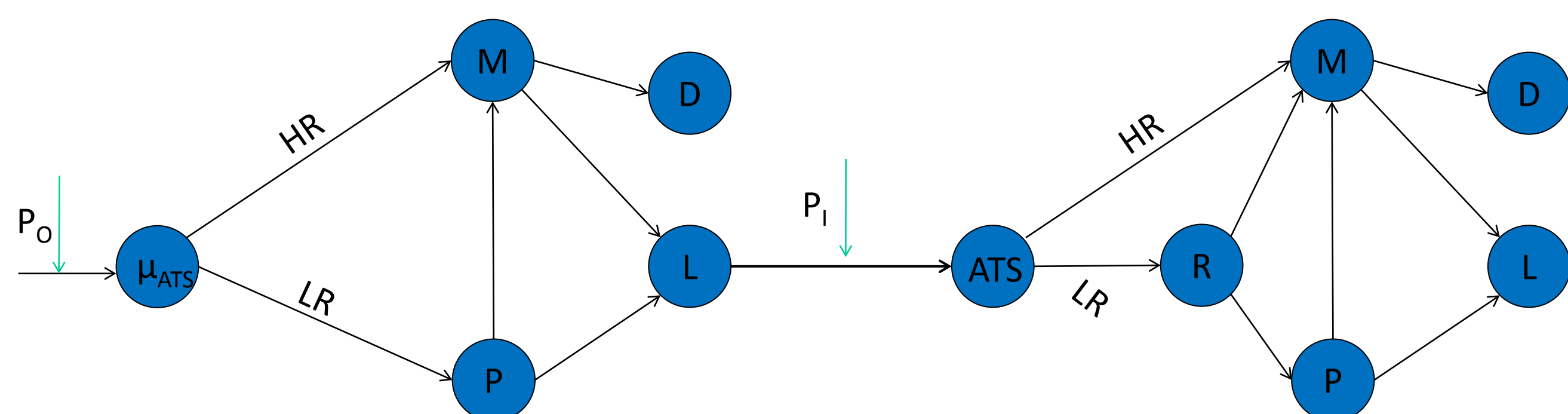
- Adversary has only one HEU source, and needs to determine when to put it into the container:
 - Before loading at the foreign port, with probability p_o
 - Infiltrating container during transit, with probability p_i , where $p_o + p_i = 1$



- Both ports have ATS, passive, and manual detection capabilities.
- ATS node at the foreign port, called μ_{ATS} , has a lower trust value than the ATS node at the domestic port.

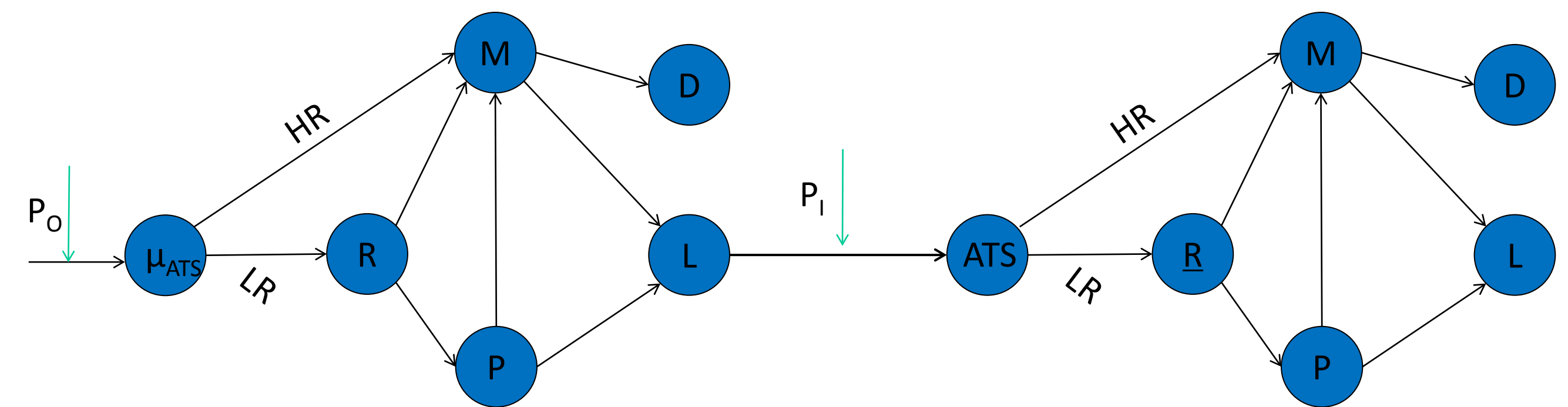
Radiography at Domestic Port

- Always obtain correct radiography information
- ATS system at foreign port, and HYB system at the domestic port
- Sojourn time increase at the domestic port due to radiography



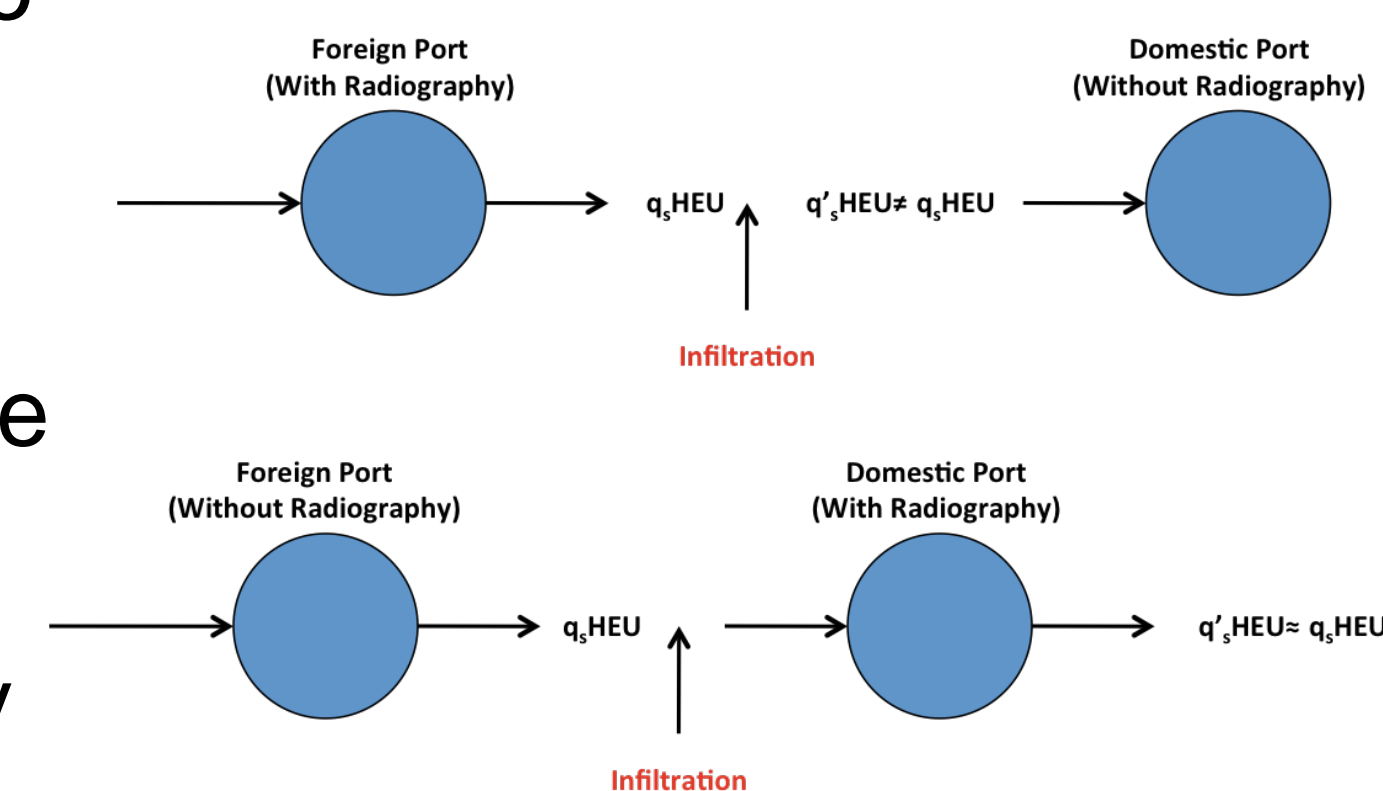
Radiography at Foreign Port

- Use radiography information at both ports
- HYB inspection system at both ports
- Risk of infiltration during transit



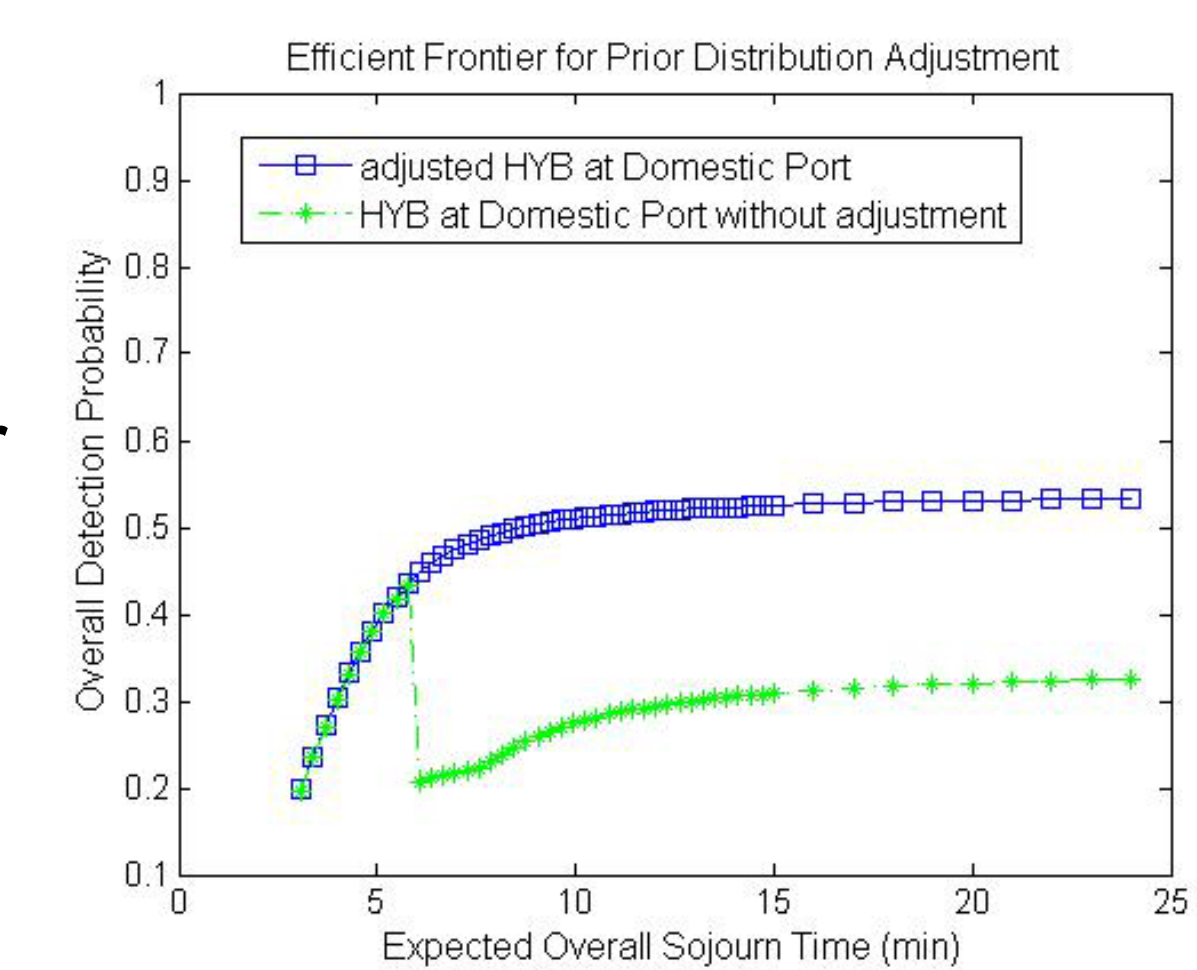
Risk of Infiltration

- Infiltration will turn “easy” container into “hard” container
- Misclassification error and prior distribution change if radiography at the foreign port
- Correct prior information if radiography at the domestic port

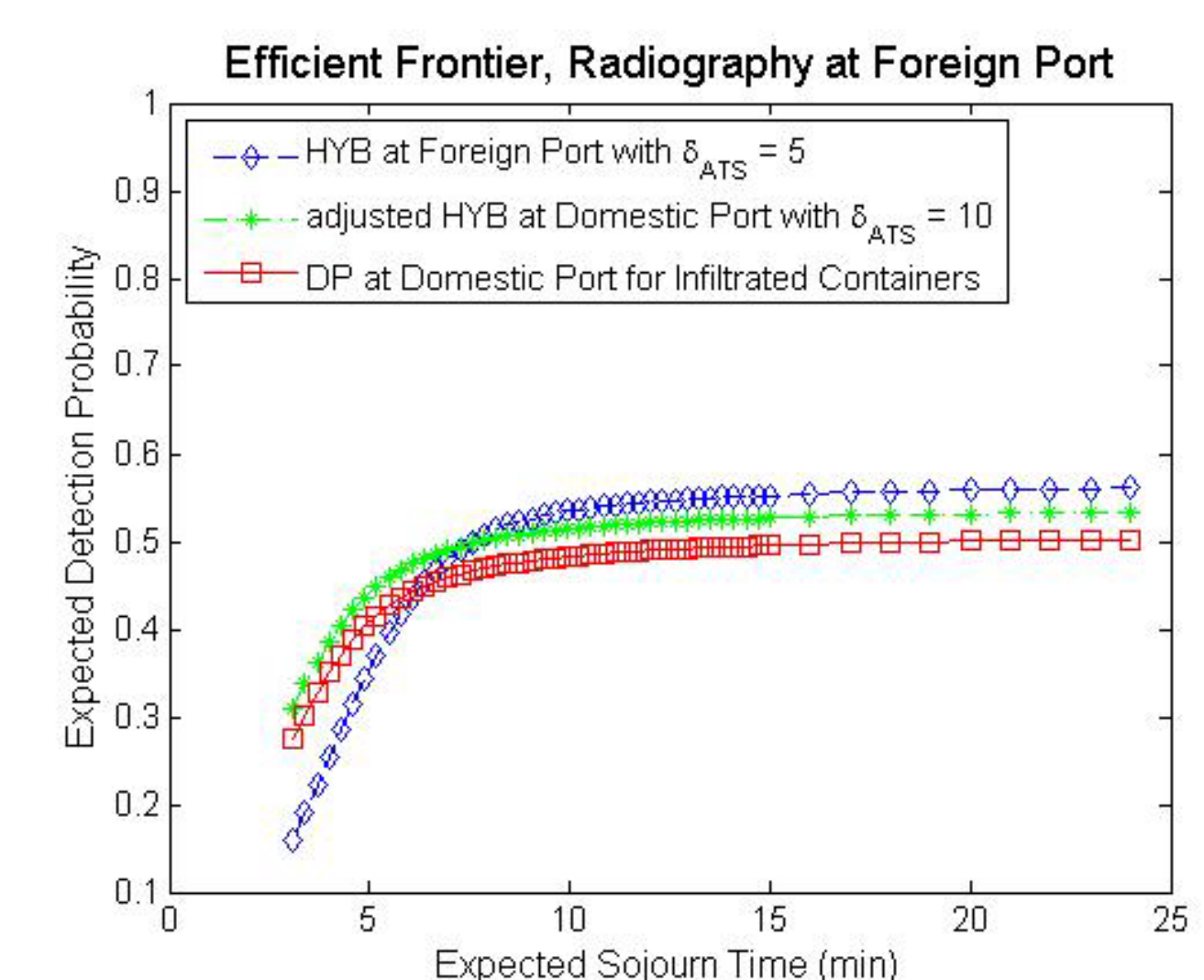
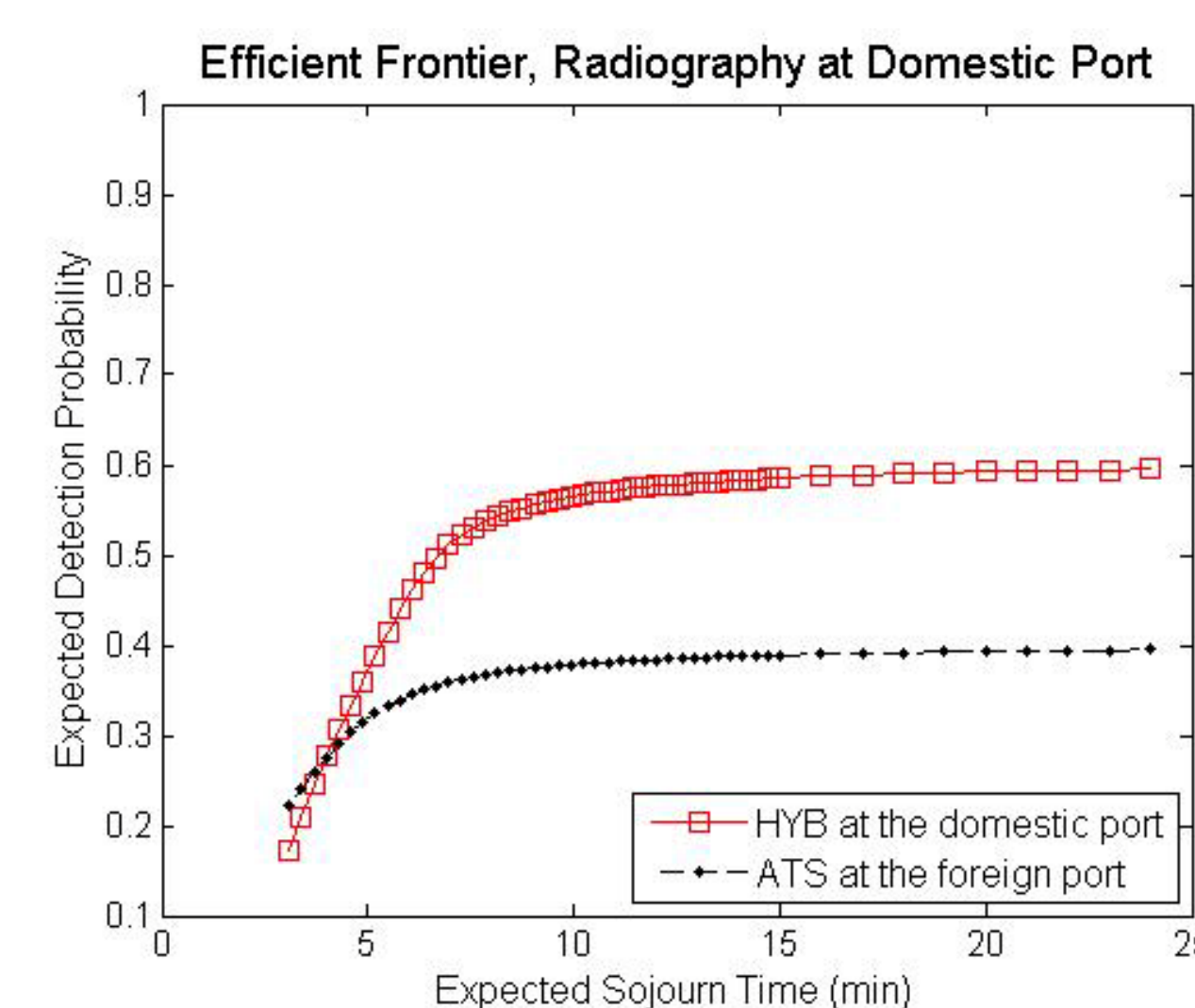


Prior Information Adjustment

- Each container scenario has a different detection probability at the foreign port
- Inspection at the foreign port changes prior distribution, $P(q_s^{HEU})$ into the domestic port
- It is advisable to use the prior information and adjust the thresholds at domestic port



Numerical Example



- Results show that:

- If infiltration probability is very low (close to 0), choose to install the radiography equipment at the foreign port
- Otherwise, the radiography equipment should be installed at the domestic port.

Numerical Example: Simulation Results Comparison

