Modeling the Detection of Smuggled Nuclear Materials at Land Border Crossings

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Objectives

- Model land ports of entry designed to detect smuggled HEU
- Evaluate impact of inspection procedures on detection probabilities, false alarm rates, and waiting times
- Discuss the impact of waiting space sizes, lane-switching policies, and congestion control measures
- Investigate the vulnerability of inspection policies to denial-of-service attacks by adversaries
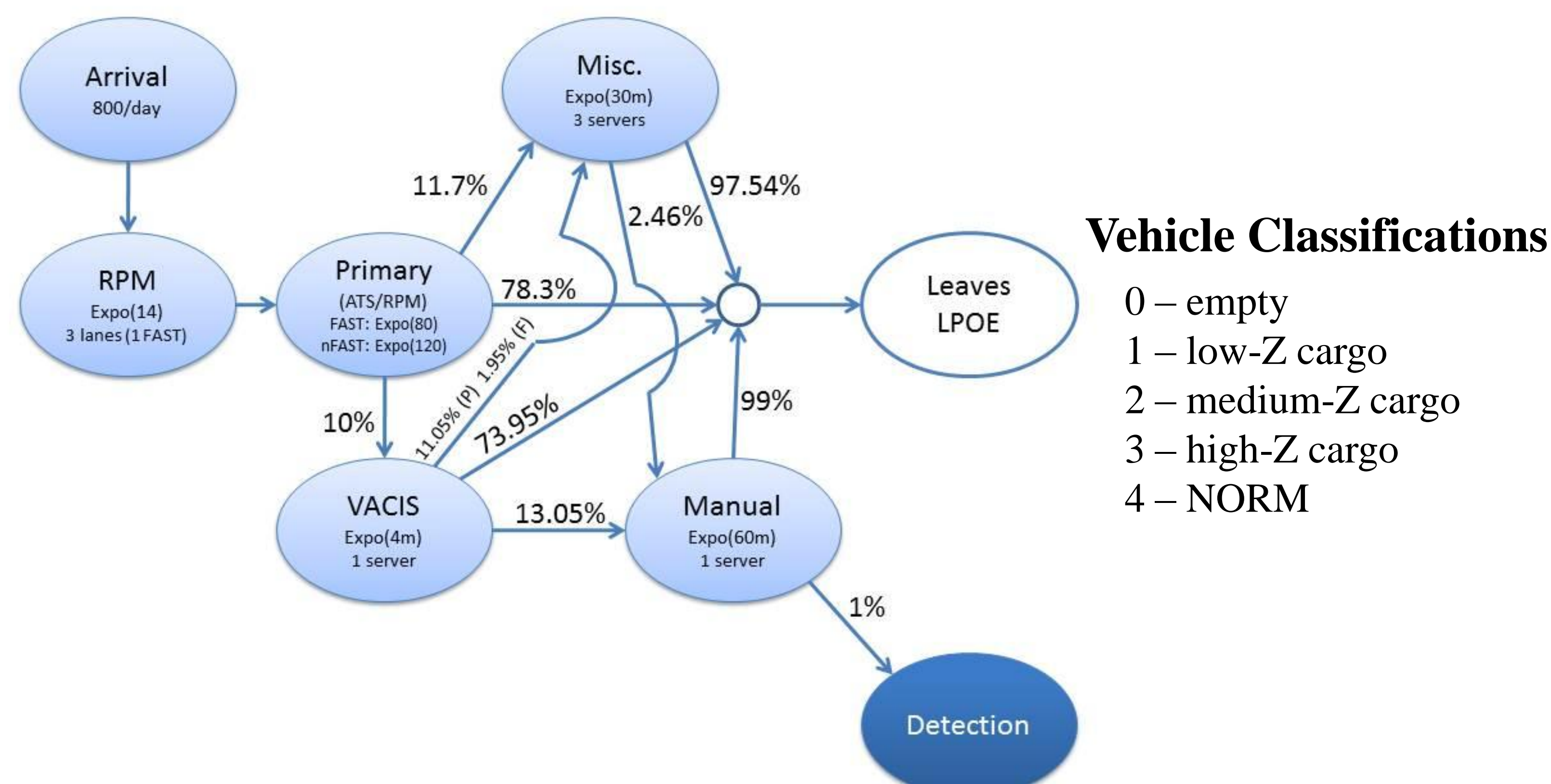
Inspection Procedures

- Every vehicle undergoes inspection via RPM and ATS system
- If there is an alarm, vehicle enters secondary inspection to undergo either "miscellaneous" or VACIS inspection
- Vehicles may enter manual inspection if the source of the alarm is not identified by the first phase of secondary inspection

Land Port of Entry Simulation Model

- Modeled after Pacific Highway land port of entry, Blaine, WA
- Applies ATS, RPM, VACIS, manual, and "miscellaneous" inspection

Vehicle Classifications

- 0 – empty
- 1 – low-Z cargo
- 2 – medium-Z cargo
- 3 – high-Z cargo
- 4 – NORM

- Inputs: vehicle information (arrival rate and vehicle scenario information) and service procedures (service rate, detection capability, and number of agents);
- Performance indices:
- Detection probability
- False alarm rates
- Vehicle Waiting Times

Infrastructure Impact

- Limited physical space at a port constrains the number of vehicles that can wait for inspection (buffer space) at each inspection area
- The current design of the Blaine border crossing consists of 3 buffer spaces in VACIS inspection, 4 spaces in manual inspection, and 5 spaces in "miscellaneous" inspection
- Adding additional buffer space to the "miscellaneous" inspection queue shows a considerable effect on the average sojourn time through the port
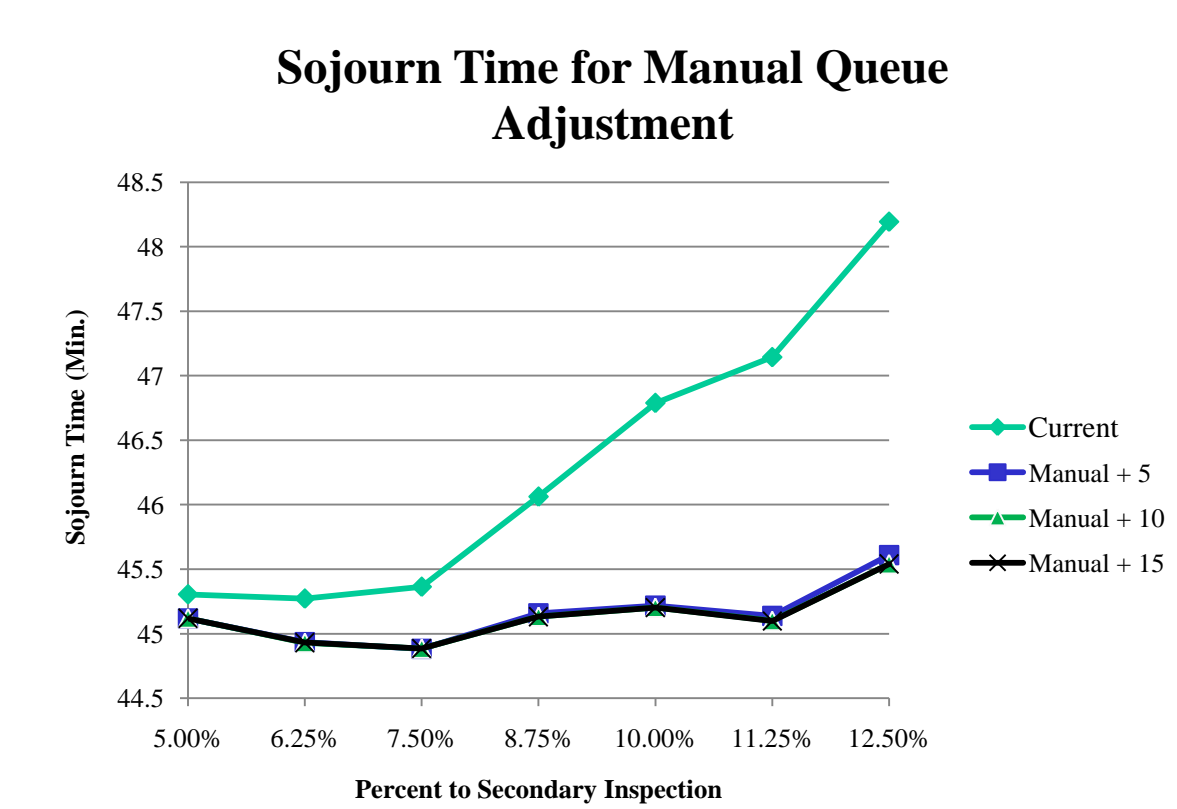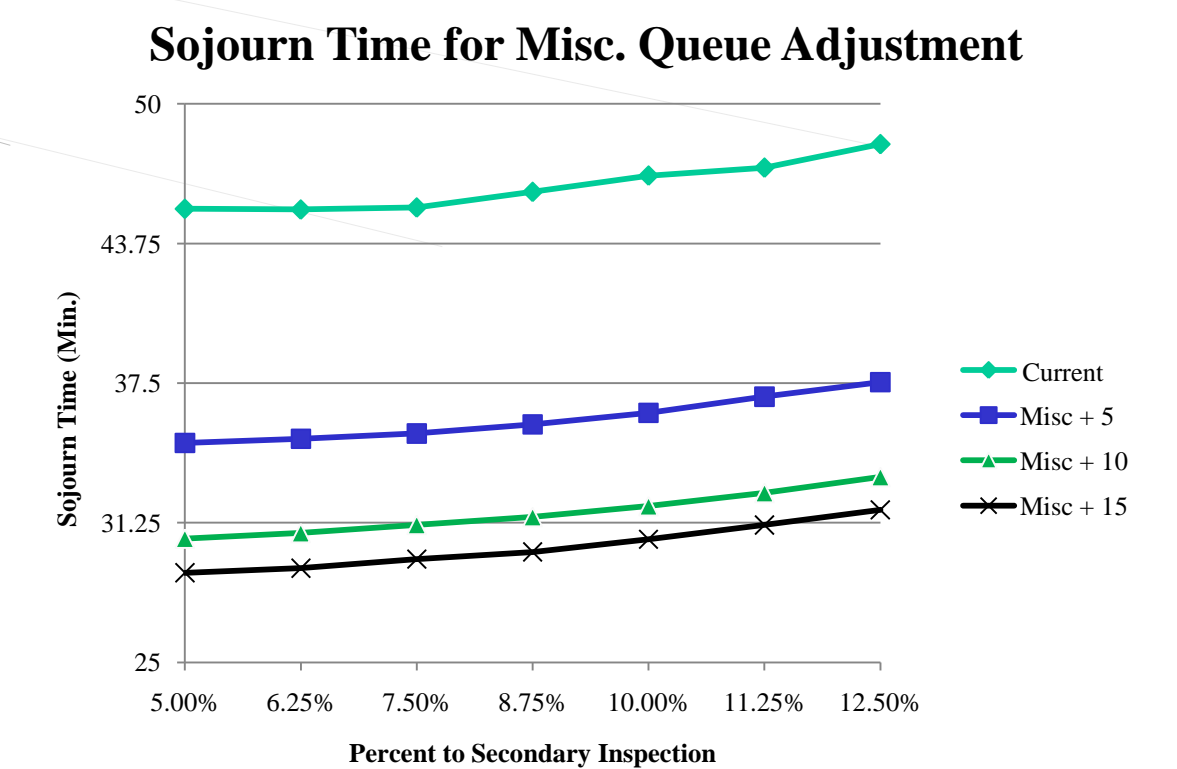
Managing Temporary Congestion

- Management must balance HEU detection with sojourn time, or overall vehicle time at the port
- When sojourn time is perceived to be too long, e.g. greater than a threshold T, management may:
  - keep current procedures
  - let all vehicles pass by secondary inspection
  - inspect only vehicles that fail both RPM and ATS inspections
  - Inspect only certain types of cargo
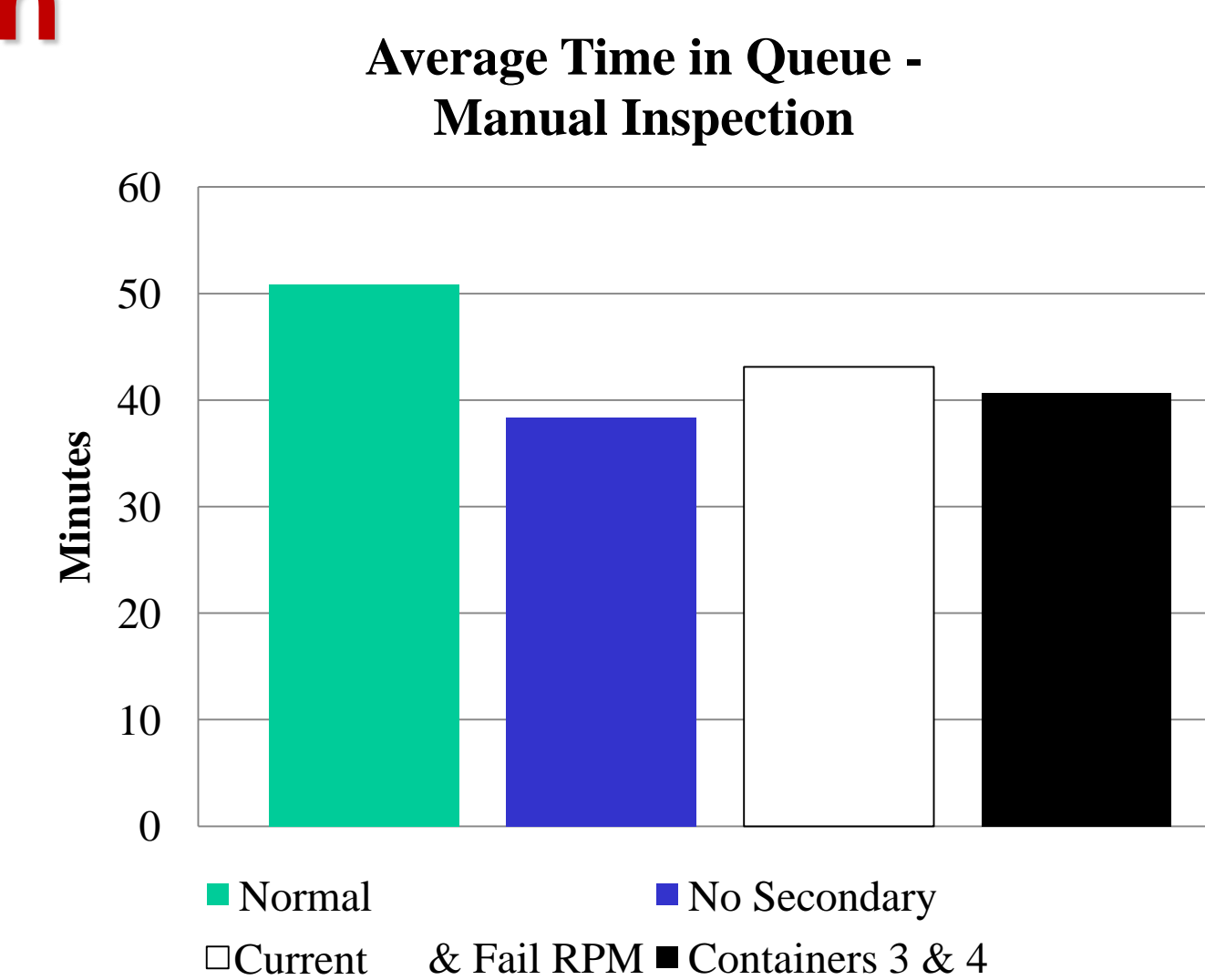
- The most effective congestion control measure is letting vehicles bypass secondary inspection. However, this also allows adversaries to game the system.

Gaming Congestion Control Measures

- A Denial-of-Service attack occurs when an adversary first forces batched arrivals to provoke temporary changes in inspection procedures, then submits an HEU-carrying vehicle
- In this analysis, we study the impact of batches of normal vehicles and suspicious vehicles, or vehicles that may need secondary inspection
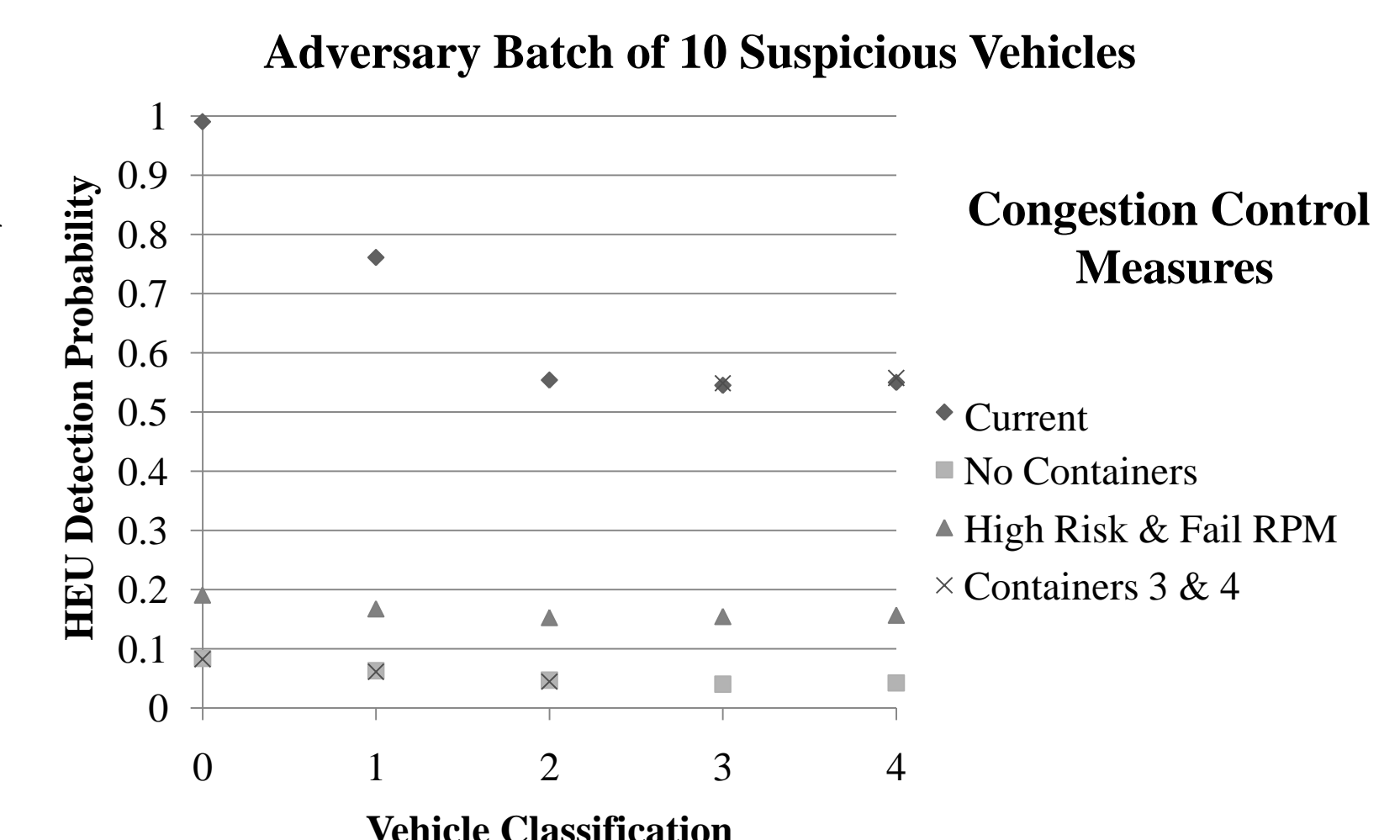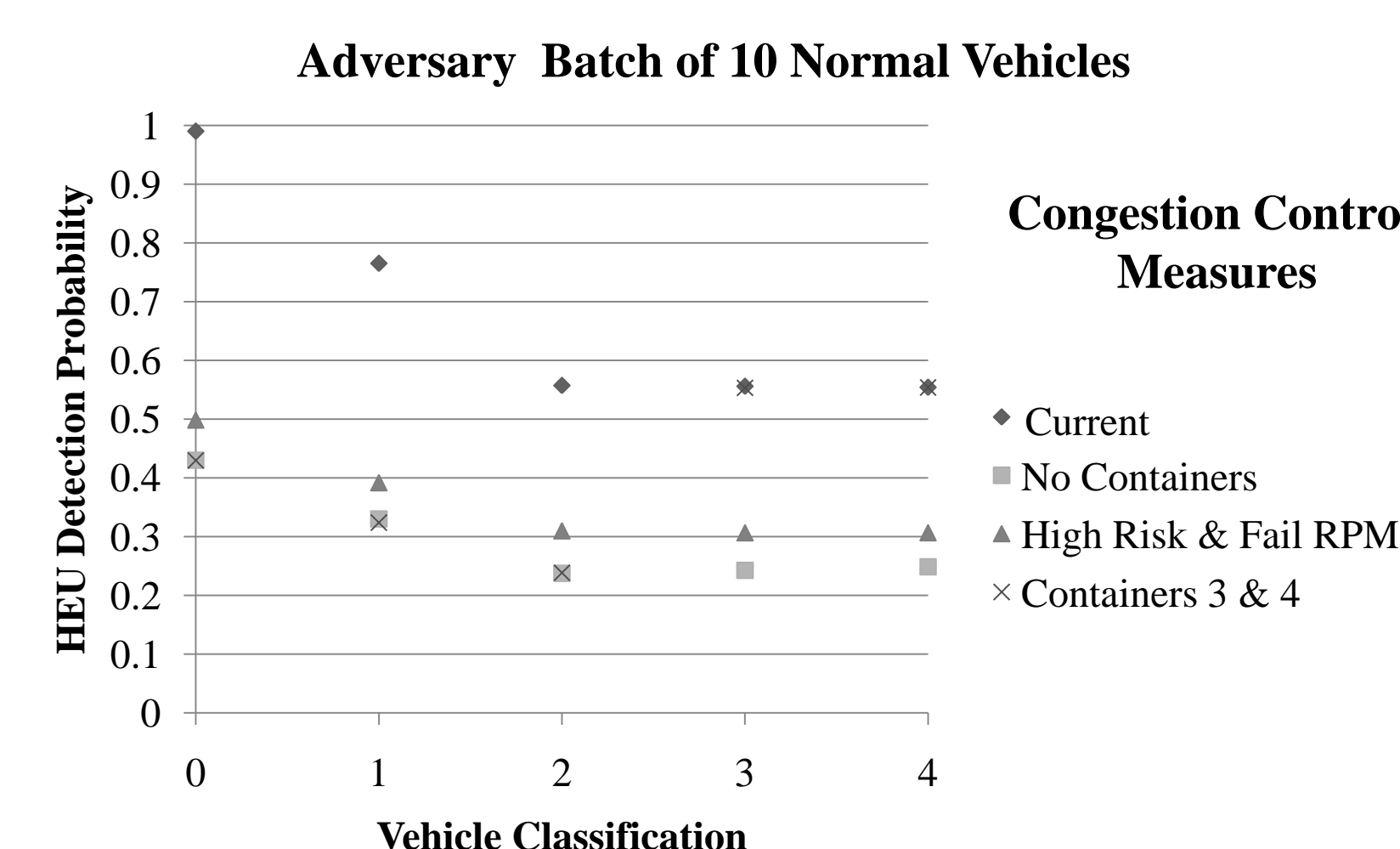
- If a congestion control measure is implemented, detection probability is at least 20% lower than under regular inspection procedures