Better Security via Randomization: A Game Theoretic Approach and its Operationalization at the Los Angeles International Airport

Milind Tambe, Fernando Ordonez

CREATE: Homeland Security Center
University of Southern California, Los Angeles

Objective: Guarantee Randomness of Security Processes While Meeting Security Quality Requirements

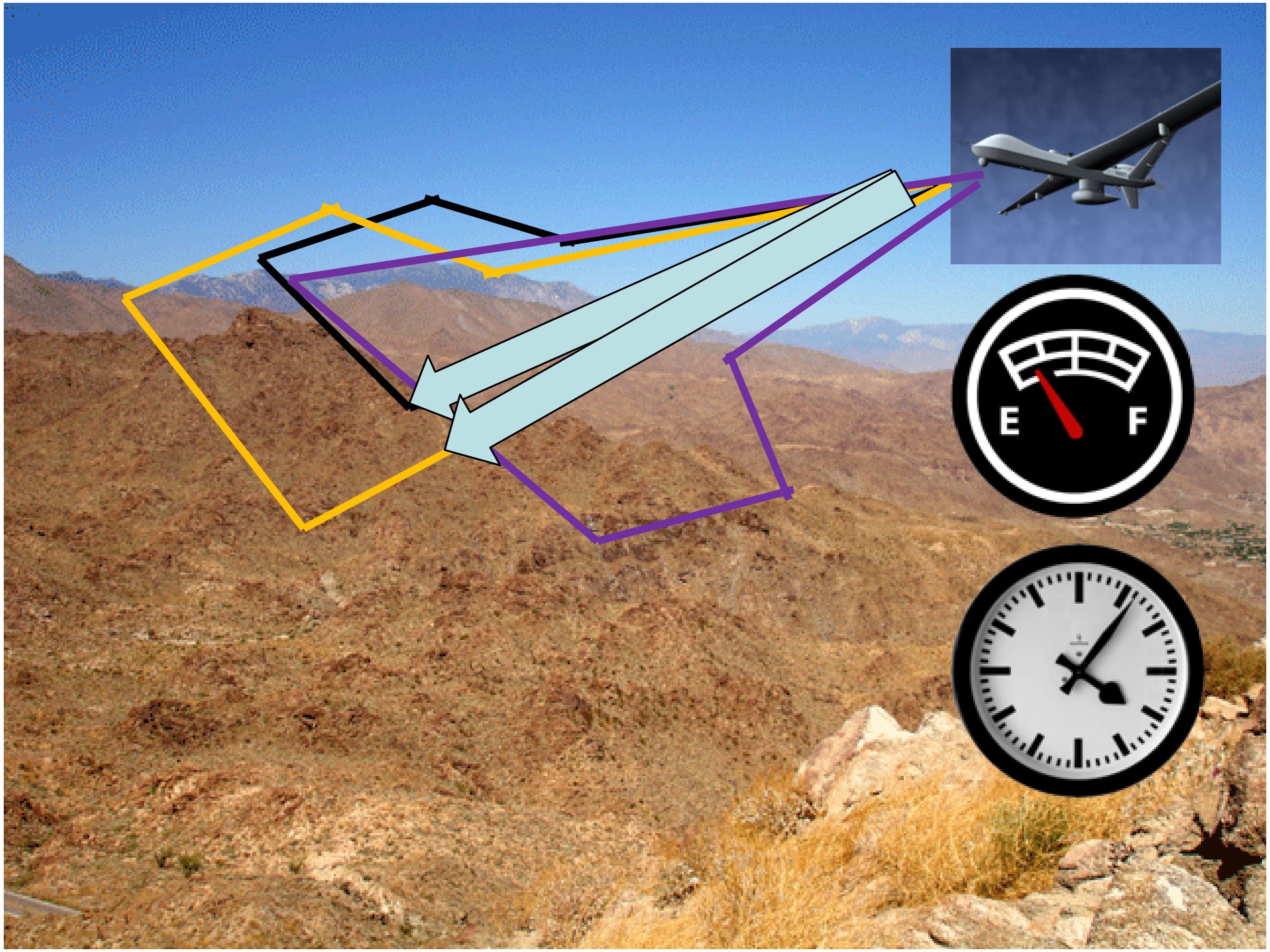
- *Limited /uncertain knowledge of opponent(s)*
- *Opponent monitors defenses, exploits patterns*
- *Examples: Patrolling, aerial surveillance,…*

Research Problem Definition and Results

- Randomize under uncertain adversarial domains

- Research results:
  - Part 1: Plan randomization with quality constraints
    - *No adversary model, Information minimization*
    - *Decision theory*
  - Part 2: Strategy randomization with quality constraints
    - *Partial adversary models*
    - *Game theory*
  - Part 3: Application to Airport Security

Part I: No Adversary Model Example



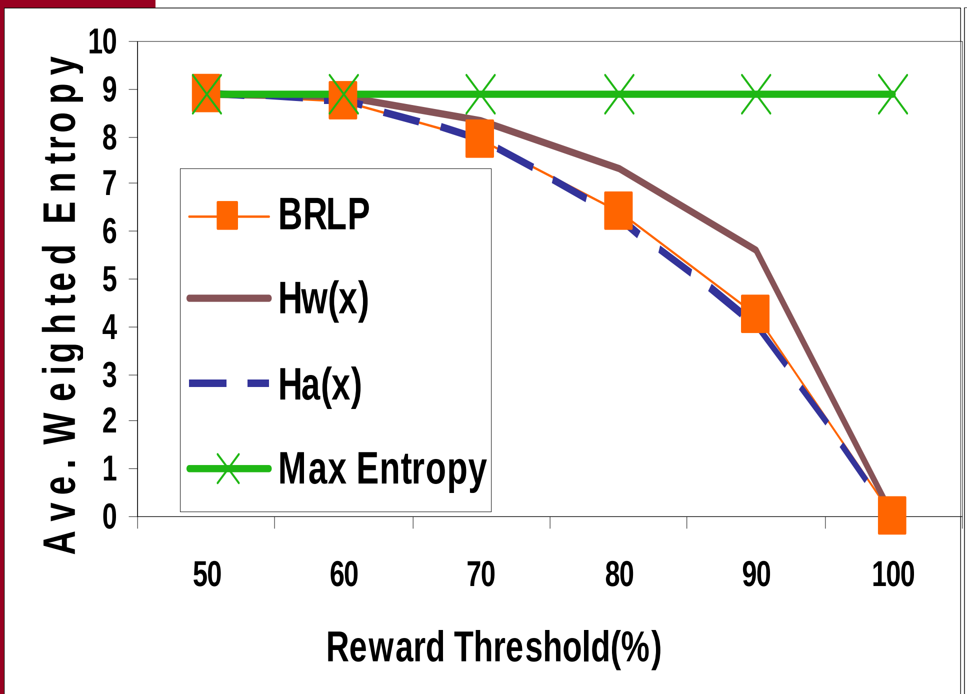
Part I: No Adversary Model: Information Minimization

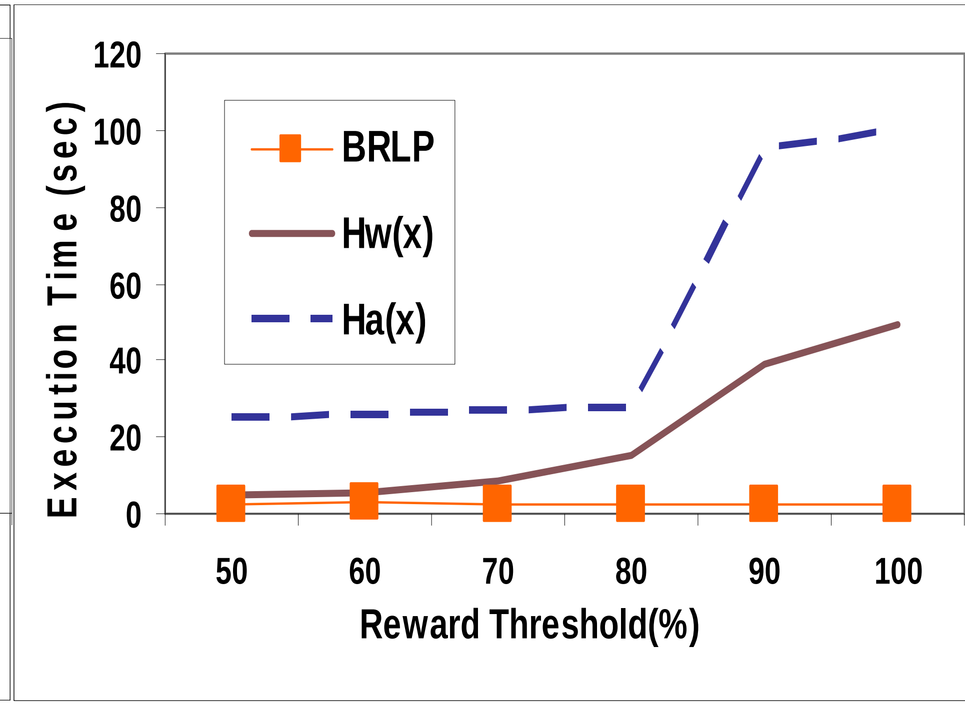
- Intentional plan randomization for security
  - *MDP/POMDP: Planning under uncertainty*
    - *MDP: Markov Decision problems*
  - *Difficult for adversary to predict even if knows plan*

- New algorithms: single agent & teams
  - *Reward > Threshold (e.g. fuel)*
  - Non-linear program (inefficient but exact), linear program (efficient but inexact)

Example Computational Results for Single Agent

Conclusion: Randomization Recommendation is Computationally Solvable





Part II: Security with Partial Adversary Models

Partial model of adversaries:

- *Hardline, well-funded, high capability adversary*
- *Moderate capability adversary*

- How to randomly allocate security resources:
  - k-9 units/officers to terminals

Part II: Model via Bayesian Stackelberg Game

- Agent (police) commit to strategy first, e.g. canine units to terminals
- Adversaries optimize against police strategy
- Bayesian: Probability distribution over different adversary types

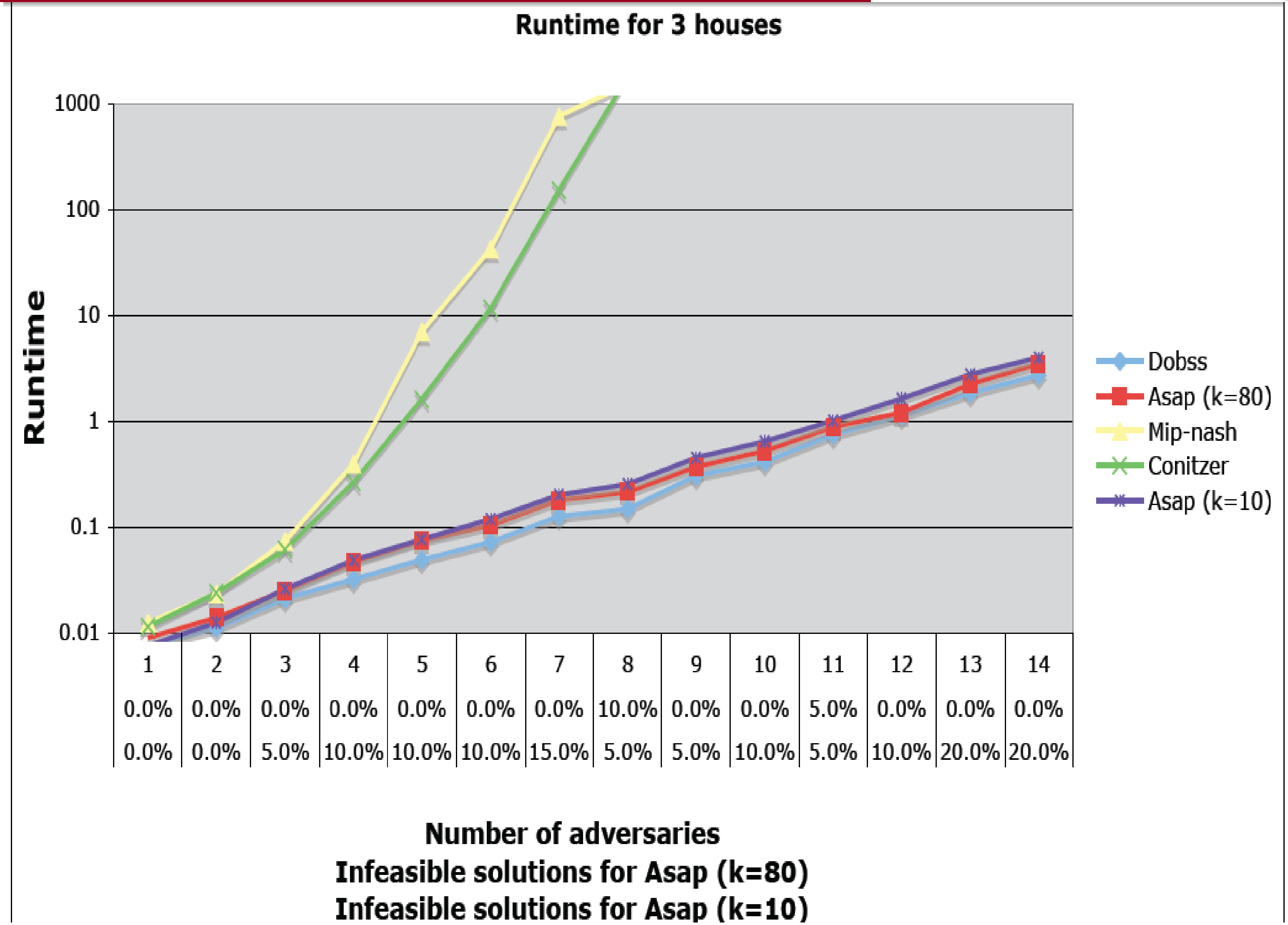
Adversary

Police

	Terminal #1	Terminal #2
Terminal #1	5, -4	-1, 3
Terminal #2	-5, 5	2, -1

Bayesian Stackelberg Game: New Algorithms

- Mixed-integer linear program (MILP)
  1. Exact Solution: DOBSS
  2. Heuristic solution: ASAP
  - *Mixed strategies*
    - Weighted randomization: non-uniform
    - E.g. Not 50%-50% split, but 73%-27% split
- Exponential speedups over prior algorithms



Once again, computational solution feasible

PART III: Application at LAX

Assistant for Randomized Monitoring Over Routes (ARMOR) Project

An Interdisciplinary Counter-Terrorism Research Partnership:

Los Angeles World Airports & The University of Southern California

PART III: Applications

- **Problem**: Setting checkpoints and allocating K9 units?
- **Approach**: Maximize security through mathematical randomization
- **Goal**: Create software assistants

ARMOR

- Assistant for Randomized Monitoring Over Routes
- DOBSS basis of ARMOR
- ARMOR-Checkpoints
- ARMOR-K9

ARMOR System

Provide inputs, constraints →

Schedule evaluation ←

ARMOR Knowledge Base

DOBSS: GAME THEORY ALGORITHMS

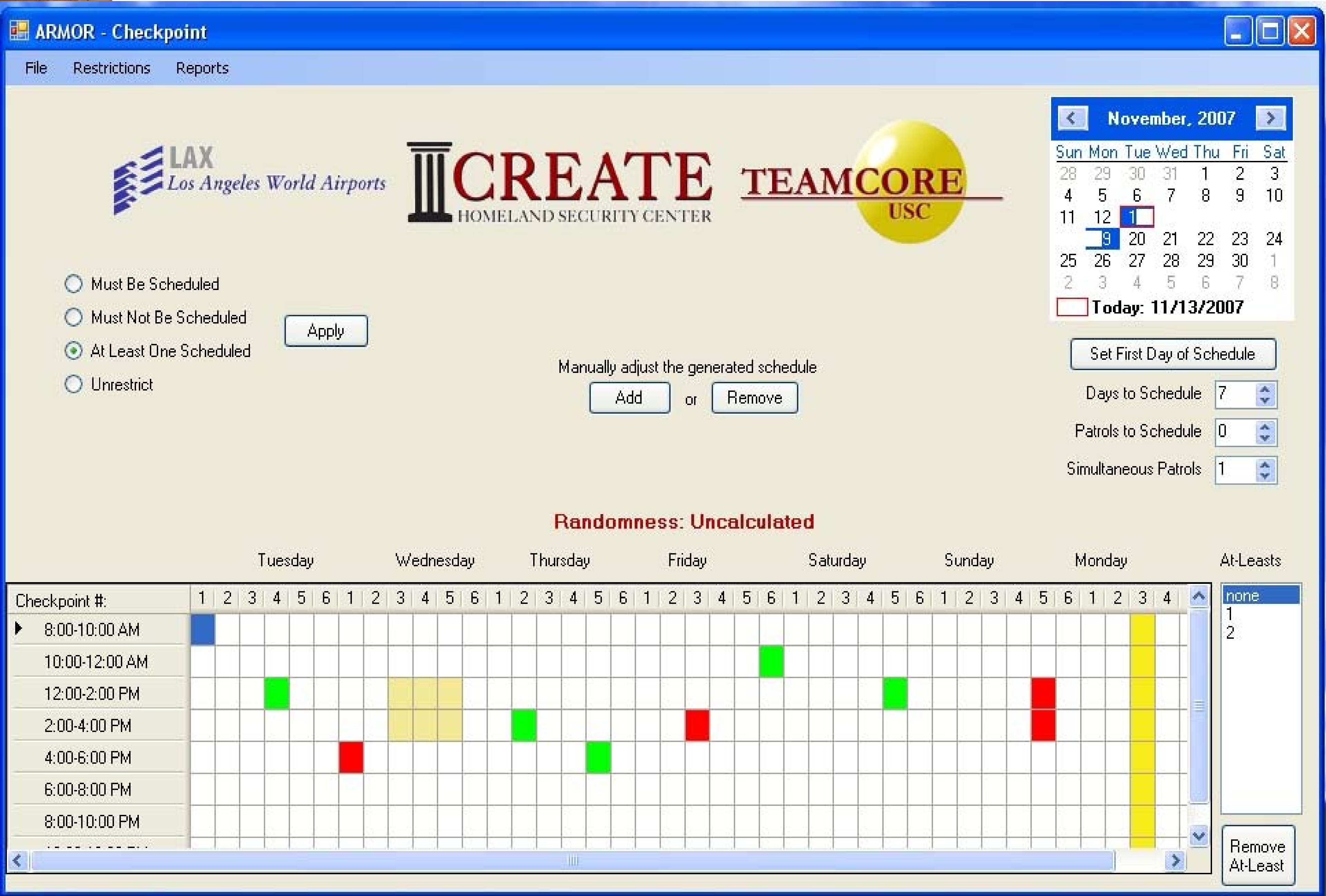
↓ **Weights for randomization**

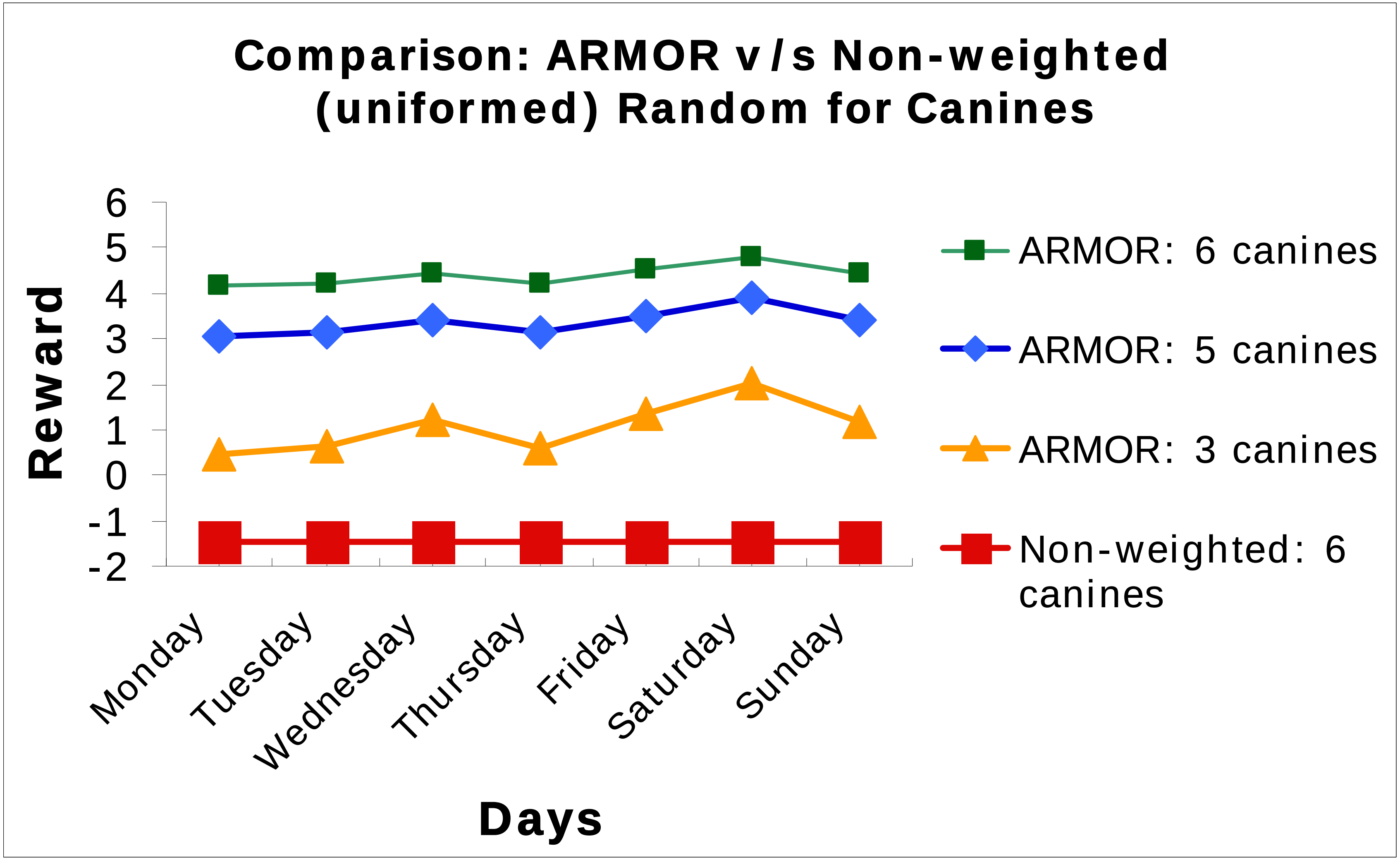
Randomized Schedule generation

Knowledge in ARMOR-checkpoint

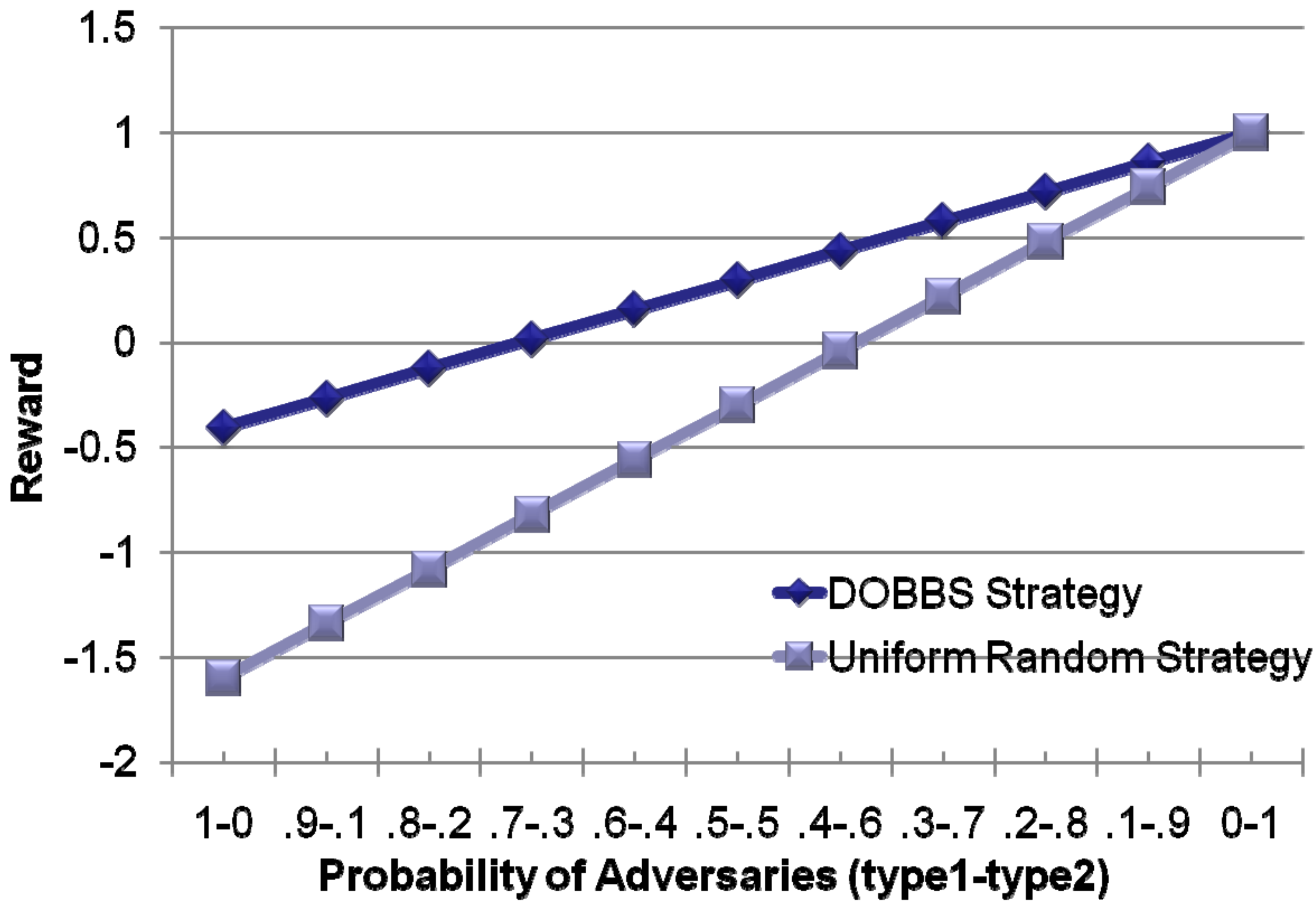
- *ARMOR-checkpoint base requires knowledge:*
  - Numbers of possible checkpoints
  - Time of checkpoint operation
  - Traffic flow and its impact on catching adversary
  - Estimated target priority for adversary
  - Estimates of cost of getting caught to adversaries
  - Estimates if “different types” of adversaries and their probabilities (e.g. differ in their capabilities)

- *Converted into utilities*


ARMOR - Checkpoint
File
Restrictions
Reports
LAX
Los Angeles World Airports
CREATE
HOMELAND SECURITY CENTER
TEAMCORE
USC
November, 2007
Sun Mon Tue Wed Thu Fri Sat
Today: 11/13/2007
Must Be Scheduled
Must Not Be Scheduled
At Least One Scheduled
Unrestrict
Apply
Manually adjust the generated schedule
Add
or
Remove
Set First Day of Schedule
Days to Schedule
Patrols to Schedule
Simultaneous Patrols
Randomness: Uncalculated
Tuesday
Wednesday
Thursday
Friday
Saturday
Sunday
Monday
At-Leasts
Checkpoint #:
8:00-10:00 AM
10:00-12:00 AM
12:00-2:00 PM
2:00-4:00 PM
4:00-6:00 PM
6:00-8:00 PM
8:00-10:00 PM
none
Remove At-Least



Comparison: ARMOR v/s Non-weighted (uniformed) Random for Canines
Reward
6
5
4
3
2
1
0
-1
-2
Monday
Tuesday
Wednesday
Thursday
Friday
Saturday
Sunday
Days
ARMOR: 6 canines
ARMOR: 5 canines
ARMOR: 3 canines
Non-weighted: 6 canines



1.5
1
0.5
0
-0.5
-1
-1.5
-2
Reward
DOBBS Strategy
Uniform Random Strategy
1-0 .9-.1 .8-.2 .7-.3 .6-.4 .5-.5 .4-.6 .3-.7 .2-.8 .1-.9 0-1
Probability of Adversaries (type1-type2)


LEE


992
4
KNBC.COM

September 28, 2007

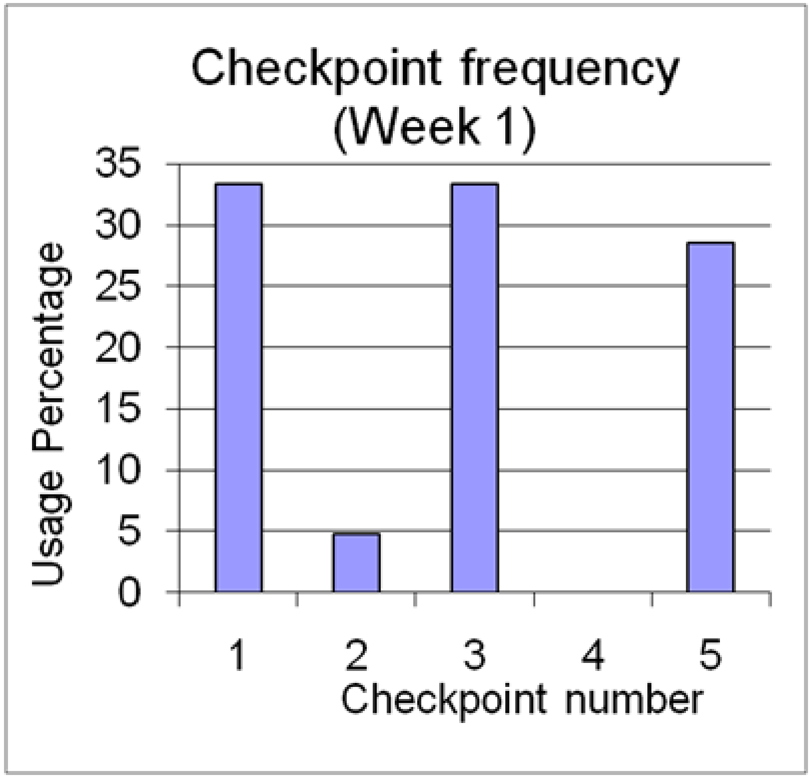
Newsweek National News

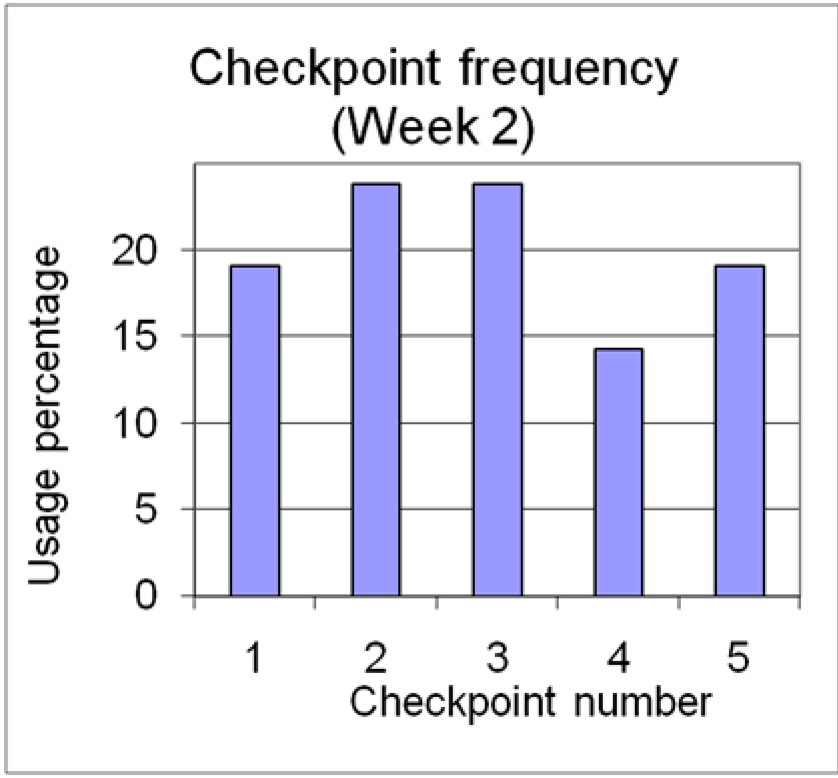
The Element of Surprise

To help combat the terrorism threat, officials at Los Angeles International Airport are introducing a bold new idea into their arsenal: random placement of security checkpoints. Can game theory help keep us safe?

Security forces work the sidewalk at LAX

Checkpoint Frequency





Conclusion

- New algorithms: guarantee randomness while meeting quality requirements
- Computational techniques that allow practical applications
- Initial demonstration with LAX working well

THE END