PNNL-SA-148197



Implementing a Vision to Create and Deploy the Airport Risk Assessment Model

Presented to INFORMS Session TC31 - Applications in Military Operations Research

> 22 October 2019 Seattle, WA



AIRPORT RISK ASSESSMENT MODEL

Abstract

Implementing a Vision to Create and Deploy the Airport Risk Assessment Model (ARAM)

This presentation will review a vision enabled by our sponsor, U.S. Department of Homeland Security, Science and Technology Directorate (DHS S&T), and established by working closely with our partner stakeholders (e.g., TSA) for a tool that quantifies the risk from terrorist threats at U.S. airports and then optimally deploys resources to reduce this risk. This tool is called the Airport Risk Assessment Model (ARAM). This presentation will also outline the methods for quantifying key risk components, along with resource effectiveness. Finally, we will discuss the potential extensions of ARAM to other domains that are applicable to a range of military and civilian critical infrastructure systems.

Agenda

- What is ARAM?
- Background on how we got here
 Risk basics and ARAM methods
 Then and now
- o "Demo"
- Questions

Airport Risk Assessment Model

 Developed by Pacific Northwest National Laboratory – first model to dynamically quantify risk from terrorist threats at airports

 Automatically optimizes recommended assignment locations of deployable security countermeasures

 Demonstrated to DHS S&T, TSA, Port of Seattle Security/Police Department, and Delta Airline Security

 Operationally deployed at Sea-Tac starting in September 2019; additional airports to follow

Sponsored by DHS S&T – APEX Program



Risk Reduction and Resource Assessment Model -Highlights

- Operational since 2008, first model to quantify risk from VBIEDs and now active threats on WA State Ferries
- Uses risk based approach vs. screening percent
- Optimizes placement of WA State Patrol officers and canines to minimize risk to ferry system
- Spin-offs include ARAM for Sea-Tac and potentially BORAM for U.S. Border Patrol and SRAM for CBP at seaports



ARAM AIRPORT RISK ASSESSMENT MODEL



ARAM Risk Engine *MP Formulation:*

- Decision variables: where and when to place assets
- Objective function: Minimize Daily Risk
- Constraints: asset availability and other imposed requirements

$$\begin{split} \min_{X_{ijk}^t} \sum_{k,l,t} R_{kl}^t &= \sum_{k,l,t} S_{kl}^t \exp\left(\sum_{i,j} K_{li} X_{ijk}^t\right) \\ S_{kl}^t &= \hat{C}_{kl}^t \hat{V}_{kl} \hat{T}_{kl} K_{li} = \ln E_{li} + \ln D_{li} \\ \sum_k X_{ijk}^t &\leq a_{ij}^t, \ \forall \ i, j \in J\left(I\right), t \\ X_{ijk}^t \in \{0,1\}, \ \forall \ i, j \in J\left(I\right), k, t \end{split}$$

ARAM Typical Results – Risk Comparison



Then and Now

Spring 2017



Summer 2019

ARAM Demo

• Workflow:

- CONOPS
- Model setup
- Inputting countermeasures
- Notional results

ARAM CONOPS

- Stakeholders input availability of deployable countermeasures
- 2. Hit the "easy button" to obtain schedule of optimal assignments
- 3. Patrol assigned areas per defined stakeholder CONOPS
- 4. View risk buydown and heat maps to evaluate benefits in terms of countermeasure contributions to overall risk reduction



Typical ARAM Operational Flow Process

ARAM LOGIN SCREEN

A	RAM	
Usemame		
robert		
Password		
Security Code		
025925		
	CANCEL	LOGIN
About ARAM	Forgo	t your password?

This is a Federal computer system and is the property of the United States Government. It is for authorized use only. Users (authorized or unauthorized) have no explicit or implicit expectation of privacy.

Any or all uses of this system and all files on this system may be intercepted, monitored, recorded, copied, audited, inspected, and disclosed to authorized site, Department of Energy, and law enforcement personnel, as well as authorized officials of other agencies, both domestic and foreign. By using this system, the user consents to such interception, monitoring, recording, copying, auditing, inspection, and disclosure at the discretion of authorized to repartment of Energy personnel.

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	ARAM	<u>≻</u> Sea-Tac	robert LOGOUT
	Dashboard	A Configuration	
		Threats Areas Points of Vulnerability Countermeasures Randomness Factor	
	국는 Risk Scores	A Threat is a natural or man-made occurrence, individual entity, or action that has or indicates the potential to harm life, information, operations, environment, and/or property. Risk scores are defined separately for each Threat.	+ ADD THREAT
	Users	VBIED	***
ARAM CONFIGURATION TAB - THREATS	PBIED	***	
	NFIGURATION	Active Shooter	000
	S - INKLAIS	Chem/Bio	***
		Workers with Access	0.0.0
		IED	0.0.0

	ARAM	▶ Sea-Tac	robert LOGOUT
	 Dashboard Schedule Configuration Risk Scores 	Configuration Threats Areas Points of Vulnerability Countermeasures Randomness Factor An Area is a specific division of the airport which is distinguished because of its geographic location, functional purpose in the airport, or the resulting effects from a Threat.	+ ADD AREA
	<u>ജ</u> Users	Baggage Claim	
ARA CON TAB	M FIGURATION - AREAS	Checkpoint	
		Parking Garage	
		Secured Area - A Gates Secured Area - B Gates	
		Secured Area - C Gates Secured Area - D Gates	000
		Secured Area - North Satellite Secured Area - South Satellite	
	 Help and Support About ARAM 	Sterile	

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Schedule

Dashboard

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E Risk Score

ARAM CONFIGURATION TAB – POVS

Arrival Curbside	Baggage Claim	
Baggage Claim	Areas accessible by this POV Image: Second	
Cargo	Cargo Checkpoint	
Cargo - North	Curbside Parking Garage	
Cargo - South	 Secured Area - A Gates Secured Area - B Gates 	
Catering 1	Secured Area - C Gates Secured Area - D Gates	
Catering 2	Secured Area - North Satellite Secured Area - South Satellite	
Checkpoints	Sterile	
Departure Curbside		
Departure Gates - A Concourse		
Departure Gates - B Concourse		
Departure Gates - C Concourse		
Departure Gates - D Concourse		

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robert LOGOUT

Dashboard

L Configuration

ARAM CONFIGURATION TAB - POVS

, Configuration		
Threats Areas Points of Vulnerability Countermea	asures Randomness Factor	
A Point of Vulnerability (POV) is a specific location at which a give accesible to each POV.	en <u>Threat</u> can be introduced against an <u>Area</u> . POVs may affect multiple areas. Select all of the areas that are	+ ADD POV
Arrival Curbside Baggage Claim Cargo Cargo - North Cargo - South Catering 1 Catering 2	Catering 1 Areas accessible by this POV Baggage Claim Cargo Checkpoint Curbside Parking Garage Secured Area - A Gates Secured Area - B Gates Secured Area - C Gates Secured Area - D Gates Secured Area - North Satellite	
Checked Baggage Zone Checkpoints	 Secured Area - South Satellite Sterile Ticket Counter 	
Departure Curbside		
Departure Gates - A Concourse		
Departure Gates - B Concourse		
Departure Gates - C Concourse		
Departure Gates - D Concourse		
Departure Gates - North Satellite		

ARAM 🗠 Sea-Tac robert LOGOUT ♣ Configuration Dashboard Threats Areas Points of Vulnerability Countermeasures Randomness Factor * Configuration + ADD COUNTERMEASURE A Countermeasure is an action, measure, or device (including people and technology resources) that can reduce the risk of a given Threat at a POV. Select all POVs that are accessi ∃≟ Risk Scores to each countermeasure. FAM FAM POVs accessible by this countermeasure FSD Staff \checkmark Arrival Curbside ARAM \checkmark Baggage Claim Off-duty LEO CONFIGURATION \checkmark Cargo TAB – COUNTER-Cargo - North POS PD Canine Cargo - South MEASURES POS PD Patrol Catering 1 Catering 2 POS Security Checked Baggage Zone \square Checkpoints POS Staff Departure Curbside Departure Gates - A Concourse STS0 Departure Gates - B Concourse Departure Gates - C Concourse TSA Atlas Team Departure Gates - D Concourse \square TSA Canine Team Departure Gates - North Satellite Departure Gates - South Satellite TSA VIPR Team \checkmark FIS/IFA Checkpoint \checkmark Food Court TSI \checkmark Parking Garage Secured Area - A Gates (planeside) TSS-E Secured Area - B Gates (planeside) (?) Help and Support Secured Area - C Gates (planeside) Test Secured Area - D Gates (planeside) tesdt Secured Area - North Satellite (planeside) -

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	Dashboard	A Configuration		
	Schedule	Threats Areas Points of Vulnerability Countermeasures Randomness Factor		
	· Configuration	The Randomness Factor sets the amount of random assignments that are produced for scheduling. A higher factor will create schedules that are less optimized, but more unpredictable by adversaries.		
	്പ Users	10%		
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	(?) Help and Support			
	About ARAM			

DashboardSchedule

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ARAM RISK SCORES

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Risk Scores	
VBIED	
> PBIED	
Active Shooter	
Chem/Bio	
Workers with Access	
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ARAM RISK SCORES -THREAT SCORE TAB



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ARAM RISK SCORES – CONSEQUENCE SCORE TAB

Risk Scores								
> VBIED								
> PBIED								
Active SI	hooter							
AREAS/POVS		3	COUNTERMEASURES					
Threat Score	Consequence \	/ulnerabililty	Effectiveness Deter	rence				
Consequence of Active	e Shooter to Area ⑦							
	Death/Injury	Economic Impact	Environmental Impact	National Defense	Symbolic Effect	Recoverability	Redundancy	test
Baggage Claim	4	3	1	1	1	1	1	1
Cargo	2	1	1	1	1	1	1	1
Checkpoint	4	3	11	1	(i)	(i)	i i	1
Curbside	3		1	1	1	1	1	1
Parking Garage	2	1	1	1	1	1	1	1
Secured Area - A Gates	3	3	1	2	1	1	1	1
Secured Area - B Gates	3		1		1	1	1	1
Secured Area - C Gates	3		1		1	1	1	1
Secured Area - D Gates	3		1		1	1	(1)	1
Secured Area - North Satellite	3		1		1	1	1	1
Secured Area - South Satellite	3		4		1	1	1	1
Sterile	3		1	1	1	1	1	1
Ticket Counter	3		1	Ĩ Î	4	1	1	1

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Chem/Bio

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Dashboard Schedule Configuration Risk Scores

ARAM RISK SCORES – VULNERABILITY SCORE TAB

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sk Scores				
VBIED				
PBIED				
Active Shooter				
AREAS/POVS	COUNTERMEA	SURES		
Threat Score Consequence	Vulnerabililty Effectiveness	Deterrence		
Vulnerability of POV to Active Shooter ⑦				
	Δvailability	Accessibility	Organic Security	Tarriet Hardness
Arrival Curbside	5	5	3	5
Baggage Claim	5	5	3	5
Cargo	4	1	2	5
Cargo - North	4	4	3	5
Cargo - South	4	4	3	5
Catering 1	4	1	2	5
Catering 2	4	1	2	5
Checked Baggage Zone	4	1	2	5
Checkpoints	5	5	2	5
Departure Curbside	5	5	3	5
Departure Gates - A Concourse	5	2	2	4
Departure Gates - B Concourse	5	2		
Departure Gates - C Concourse	5	2		
Departure Gates - D Concourse	5	2		
Departure Gates - North Satellite	5	2		
Departure Gates - South Satellite	5	2		
FIS/IFA Checkpoint	1	1	1	

LOGOUT

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ARAM RISK SCORES – COUNTER-MEASURES EFFECTIVENESS TAB



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Risk Scores

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ARAM RISK SCORES – COUNTER-MEASURES DETERRENCE TAB



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Schedule

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SCHEDULE

SCREEN

Configuration

Risk Scores

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Satellite FIS/IFA Checkpoint robert LOGOUT

+ ADD SHIFTS () Schedule Monday, June 10, 2019 < + > Timeline List CLEAR SCHEDULE POVs 000 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000 2100 2200 2300 Arrival Curbside Baggage Claim Cargo Cargo - North Cargo - South Catering 1 Catering 2 Checked Baggage Zone Checkpoints Departure Curbside Departure Gates - A Concourse Departure Gates - B Concourse Departure Gates - C Concourse Departure Gates - D Concourse Departure Gates - North Satellite Departure Gates - South

https://aram-pilot.pnnl.gov/Schedule

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ARAM SCHEDULE SCREEN – ADD SHIFTS

ntermeasure Shifts f	to Schedu	le						
Type Select Type		Qty 1	06/10/2019	Ē	Shift Start 12:00 AM	Shift End 08:00 AM	POV Assignment Let ARAM Decide	 VADD CA

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< Schedule

() Add Shifts

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Schedule

Dashboard

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ARAM SCHEDULE SCREEN – ADD SHIFTS

Countermeasure Shifts to Schedule												
•	•	FAM FSD Staff	•	Qty 1	06/10/2019	Ë	Shift Start 12:00 AM	Shift End 08:00 AM	POV Assignment Let ARAM Decide	v	🗸 ADD	CANCEL
Ð		Off-duty LEO										
GF		POS PD Canine										
0L		POS PD Patrol										
	•	POS Security										
		POS Staff										
		STSO										
		TSA Atlas Team										
		TSA Canine Team										
		TSA VIPR Team										
		TSI										
		TSS-E										
		Test										
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ARAM SCHEDULE SCREEN – ADD SHIFTS



"EASY BUTTON"

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Dashboard

Schedule

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- ∃≟ Risk Score
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ARAM RECOMMENDED ASSIGNMENTS

^{Schedule}) Confirm Shifts	5			
Confirm Countermeas	ure Shifts Scheduled			
TSI / 1				
Date	Start - End (Duration)	POV	Risk Buydown %	Risk Buydown Value
06/10/2019	00:00 - 08:00 (8h)	Cargo - South	(POV/Hour) 12%	173.3
TSI / 2				
Date	Start - End (Duration)	POV	Risk Buydown % (POV/Hour)	Risk Buydown Value
06/10/2019	00:00 - 08:00 (8h)	Cargo - North	12%	173.3
TSI / 3				
Date	Start - End (Duration)	POV	Risk Buydown % (POV/Hour)	Risk Buydown Value
06/10/2019	00:00 - 01:00 (1h)	Departure Curbside	18%	145.0
06/10/2019	01:00 - 02:00 (1h)	Catering 1	14%	0.1
06/10/2019	02:00 - 03:00 (1h)	Departure Curbside	18%	141.2
06/10/2019	03:00 - 04:00 (1h)	Departure Gates - South Satellite	12%	1.6
06/10/2019	04:00 - 05:00 (1h)	FIS/IFA Checkpoint	20%	0.0
06/10/2019	05:00 - 07:00 (2h)	Arrival Curbside	18%	159.2
06/10/2019	07:00 - 08:00 (1h)	Departure Curbside	18%	156.5
POS PD Patrol / 1				
Date	Start - End (Duration)	POV	Risk Buydown % (POV/Hour)	Risk Buydown Value
06/10/2019	00:00 - 06:00 (6h)	Ticket Counter	7%	836.5
06/10/2019	06:00 - 07:00 (1h)	Secured Area - South Satellite (planeside)	10%	0.9
06/10/2019	07:00 - 08:00 (1h)	Ticket Counter	7%	872 1

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About ARAM

POS PD Patrol / 2

Start - End (Duration)

Date

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		06/10/2019	10:00 - 11:00 (1h)	Ticket Counter	12%	834.5
	Dashboard	06/10/2019	11:00 - 16:00 (5h)	Baggage Claim	11%	720.0
		06/10/2019	16:00 - 18:00 (2h)	Ticket Counter	12%	825.7
	Schedule					
	L Configuration	TSA Canine Team /	2			
		Date	Start - End (Duration)	POV	Risk Buydown % (POV/Hour)	Risk Buydown Value
	王 Risk Scores	06/10/2019	10:00 - 11:00 (1h)	Baggage Claim	11%	783.7
	😤 Users	06/10/2019	11:00 - 13:00 (2h)	Arrival Curbside	8%	180.7
		06/10/2019	13:00 - 14:00 (1h)	FIS/IFA Checkpoint	12%	0.0
		06/10/2019	14:00 - 16:00 (2h)	Parking Garage	12%	234.9
		06/10/2019	16:00 - 18:00 (2h)	Baggage Claim	11%	746.5
ARA		TSA Canine Team /	3			
RE(AS	LOMMENDED SIGNMENTS	Date	Start - End (Duration)	POV	Risk Buydown % (POV/Hour)	Risk Buydown Value
		06/10/2019	10:00 - 11:00 (1h)	Arrival Curbside	8%	187.0
		06/10/2019	11:00 - 13:00 (2h)	Departure Curbside	8%	180.7
		06/10/2019	13:00 - 14:00 (1h)	Cargo - South	12%	173.3
		06/10/2019	14:00 - 16:00 (2h)	Arrival Curbside	8%	183.4
		06/10/2019	16:00 - 18:00 (2h)	Parking Garage	12%	226.9
		TSA Canine Team /	4			
		Date	Start - End (Duration)	POV	Risk Buydown % (POV/Hour)	Risk Buydown Value
		06/10/2019	10:00 - 11:00 (1h)	Departure Curbside	8%	187.0
		06/10/2019	11:00 - 12:00 (1h)	Secured Area - B Gates (planeside)	13%	0.4
		06/10/2019	12:00 - 13:00 (1h)	Cargo - South	12%	173.3
		06/10/2019	13:00 - 14:00 (1h)	Cargo - North	12%	173.3
		06/10/2019	14:00 - 15:00 (1h)	Departure Curbside	8%	183.4
		06/10/2019	15:00 - 16:00 (1h)	Cargo - South	12%	173.3
		06/10/2019	16:00 - 17:00 (1h)	Departure Gates - B Concourse	15%	1.8
	Help and Support	06/10/2019	17:00 - 18:00 (1h)	Arrival Curbside	8%	174.8
	About ARAM	CONFIRM SCHEDULE	PRINT CANCEL			

Dashboard

Dashboard

Schedule

Configuration

Risk Scores

Users

ARAM ENDING DASHBOARD VIEW

A total of 13 different countermeasures (notional) were input = 104 hours of deployed assets

Risk buydown = 43 points starting from 79 risk points with 36 total risk points remaining for the day (2) Help and Support

About ARAM



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HEATMAP OF RISK CAN ALSO BE ANIMATED OVER TIME



🗠 Sea-Tac

robert LOGOUT

() Schedule

Dashboard

- Configuration

SCHEDULE VIEW OF ARAM RECOMMENDED ASSIGNMENTS



(?) Help and Support

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SCHEDULE VIEW OF ARAM RECOMMENDED ASSIGNMENTS



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Risk Scores

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ALTERNATE

OF ARAM

SCHEDULE VIEW

RECOMMENDED ASSIGNMENTS

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+ ADD SHIFTS () Schedule Monday, June 10, 2019 < • > Timeline List CLEAR SCHEDULE CMs 000 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000 2100 2200 2300 FAM #1 Baggage Claim FAM #1 Parking Garage FAM #1 POS PD Patrol #1 Secured Area - South P0... Satellite (planeside) POS PD Patrol #1 Ticket Counter P0... POS PD Patrol #2 POS PD Patrol #2 Baggage Claim P0... P0... Ticket Counter POS PD Patrol #3 P0... Arrival Curbside - PO... Departure Curbside POS PD Patrol #3 Parking Garage POS PD Patrol #4 POS PD Patrol #4 Arrival Curbside -**PO**... Baggage Claim

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Dashboard	Schedule ✓ ◆ → Monday, June	10.2019 🛱						+ ADD SHIFTS
Configuration	Timeline List							CLEAR SCHEDULE
ి Users	Countermeasure 🔺	Area/POV	Arrive	Depart	Shift Start	Shift End	Туре	% Risk Buydown
	● FAM / 1	Parking Garage	06:00	08:00	06:00	14:00	Optimized	Multiple Values
ALTERNATE SCHEDULE VIEW OF ARAM RECOMMENDED ASSIGNMENTS	● FAM / 1	Baggage Claim	08:00	10:00	06:00	14:00	Optimized	Multiple Values
	• FAM / 1	Parking Garage	10:00	14:00	06:00	14:00	Optimized	Multiple Values
	POS PD Patrol / 1	Ticket Counter	00:00	06:00	00:00	08:00	Optimized	Multiple Values
	POS PD Patrol / 1	Secured Area - South Satellite (planeside)	06:00	07:00	00:00	08:00	Random	10.37%
	POS PD Patrol / 1	Ticket Counter	07:00	08:00	00:00	08:00	Optimized	6.93%
	POS PD Patrol / 2	Baggage Claim	00:00	06:00	00:00	08:00	Optimized	Multiple Values
	POS PD Patrol / 2	Ticket Counter	06:00	07:00	00:00	08:00	Optimized	7.02%
	POS PD Patrol / 2	Baggage Claim	07:00	08:00	00:00	08:00	Optimized	11.66%
	POS PD Patrol / 3	Parking Garage	00:00	06:00	00:00	08:00	Optimized	Multiple Values
	POS PD Patrol / 3	Departure Curbside	06:00	07:00	00:00	08:00	Random	11.00%
	POS PD Patrol / 3	Arrival Curbside	07:00	08:00	00:00	08:00	Optimized	10.97%
	POS PD Patrol / 4	Arrival Curbside	00:00	05:00	00:00	08:00	Optimized	Multiple Values
⑦ Help and Support	POS PD Patrol / 4	Departure Gates - South Satellite	05:00	06:00	00:00	08:00	Random	12.00%
About ARAM	POS PD Patrol / 4	Baggage Claim	06:00	07:00	00:00	08:00	Optimized	11.66%

ARAM Summary

- Risk-based approach to decide on best use of discretionary resources
- Accounts for multiple threats
- Unity of effort across stakeholder organizations / reduces duplication of effort
- Tracks risk and risk reduction trends over time
- Easy to use

Acknowledgements

• Some of our risk sponsors



Transportation Security Administration







Homeland Security

Science and Technology





Washington State Ferries

For more information, contact:

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