PNNL-SA-148197

Pacific Northwest
NATIONAL LABORATORY

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

Abstract

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

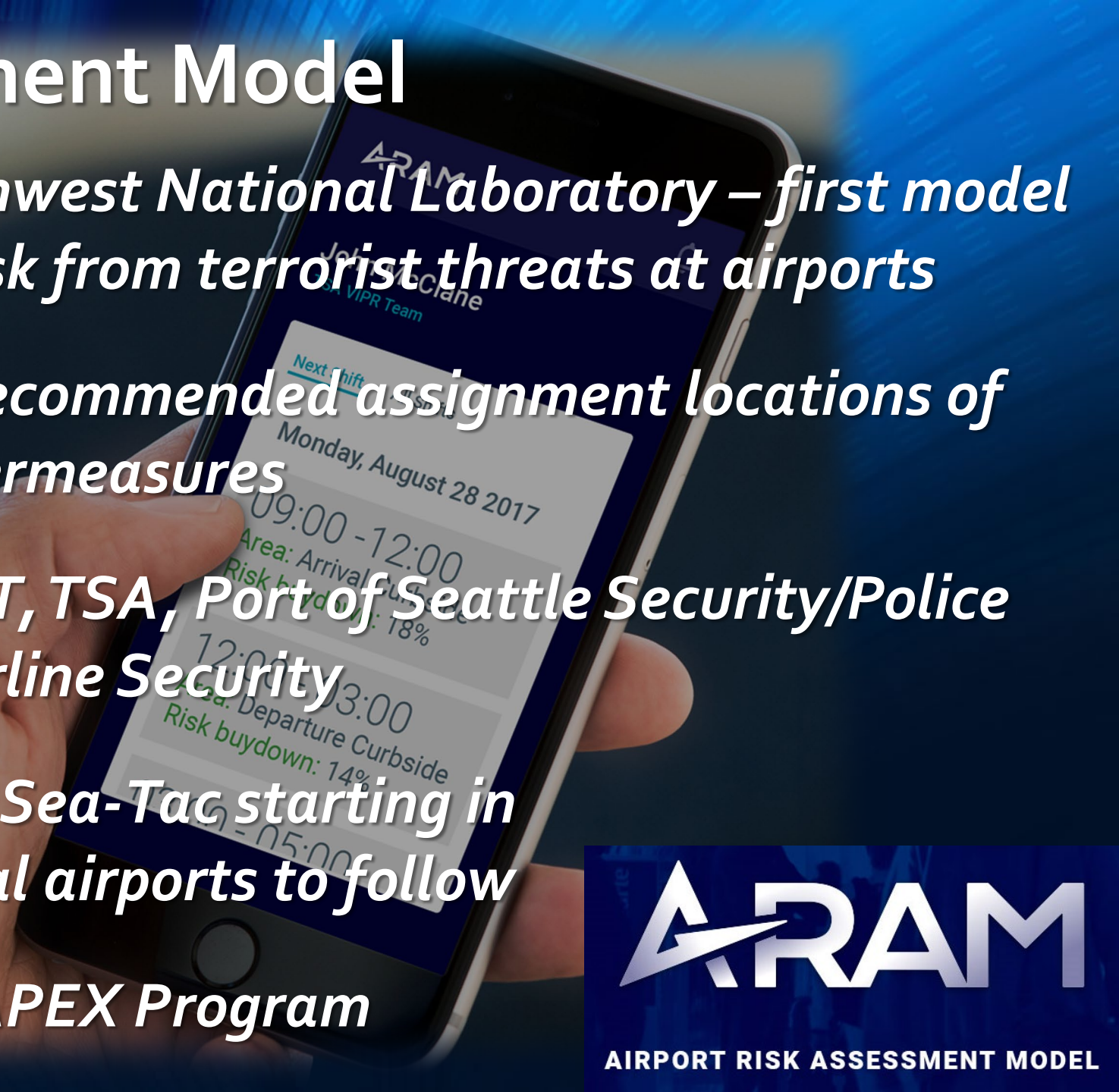
This presentation will review a vision enabled by our sponsor, U.S. Department of Homeland Security, Science and Technology Directorate (DHS S&T), and established by working closely with our partner stakeholders (e.g., TSA) for a tool that quantifies the risk from terrorist threats at U.S. airports and 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*
- *"Demo"*
- *Questions*

Airport Risk Assessment Model

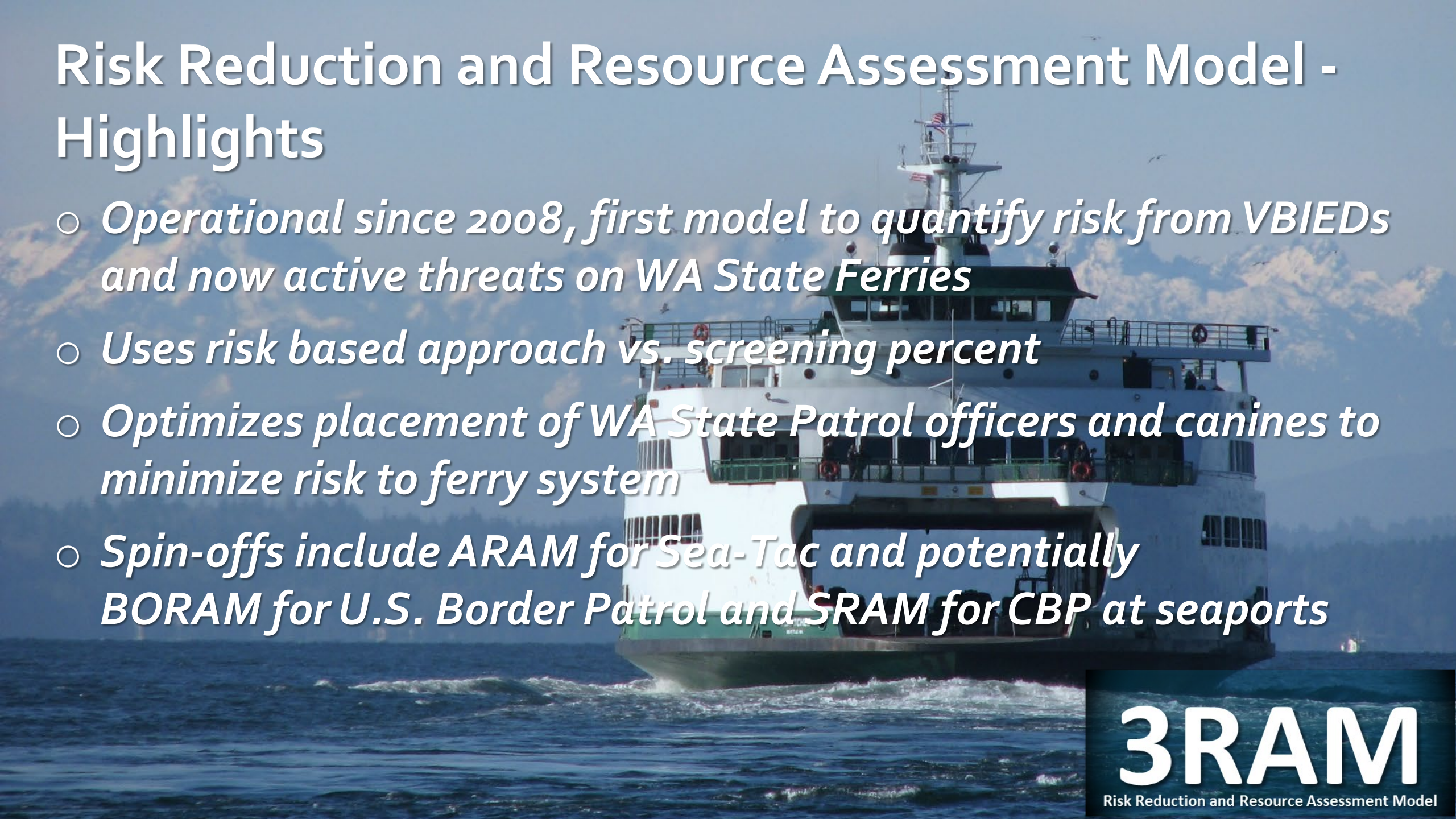
- *Developed by Pacific Northwest National Laboratory – first model to dynamically quantify risk from terrorist threats at airports*
- *Automatically optimizes recommended assignment locations of deployable security countermeasures*
- *Demonstrated to DHS S&T, TSA, Port of Seattle Security/Police Department, and Delta Airline Security*
- *Operationally deployed at Sea-Tac starting in September 2019; additional airports to follow*
- *Sponsored by DHS S&T – APEX Program*



ARAM
AIRPORT RISK ASSESSMENT MODEL

Risk Reduction and Resource Assessment Model - Highlights

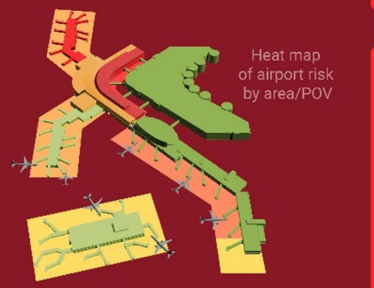
- *Operational since 2008, first model to quantify risk from VBIEDs and now active threats on WA State Ferries*
- *Uses risk based approach vs. screening percent*
- *Optimizes placement of WA State Patrol officers and canines to minimize risk to ferry system*
- *Spin-offs include ARAM for Sea-Tac and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



ARAM AIRPORT RISK ASSESSMENT MODEL

AIRPORT DEFINITION

AIRPORT AREAS
+ POINTS OF VULNERABILITY (POV)



DEPLOYABLE COUNTERMEASURES

- TSA Transportation Security Officer
- TSA Canine
- TSA Visible Intermodal Prevention and Response
- Airport Police Dept. Patrol
- Airport Police Dept. Canine
- Airport Security

ASSESSED INPUTS

THREATS

- PBIED
- VBIED
- Chem/Bio
- Active Shooter
- Insiders
- Placed IED

EFFECTIVENESS AGAINST THREAT

- Prevent & Detect
- Deterrence

DATA INPUTS

- Employees
- Vehicles
- Passengers
- Vendors
- Other
- Flights

RISK MODEL

RISK COMPONENTS

CONSEQUENCE

- Death/injury
- Economic Impact
- Environmental impact
- National Defense
- Symbolic Effect
- Recoverability
- Redundancy

VULNERABILITY

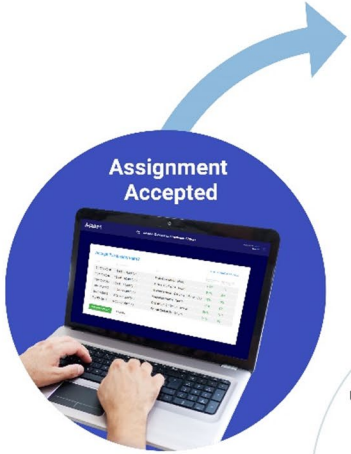
- Availability
- Accessibility
- Organic Security
- Target Hardness

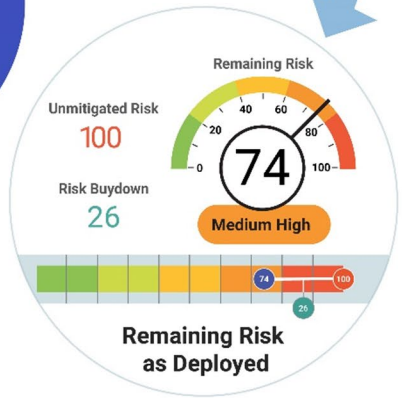
THREAT LIKELIHOOD

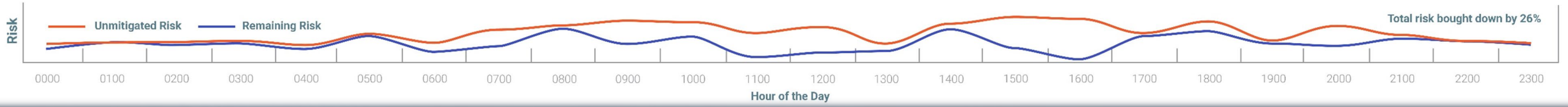
RISK ENGINE

Optimal countermeasure assignments: which POVs and when to patrol

OPERATIONS







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

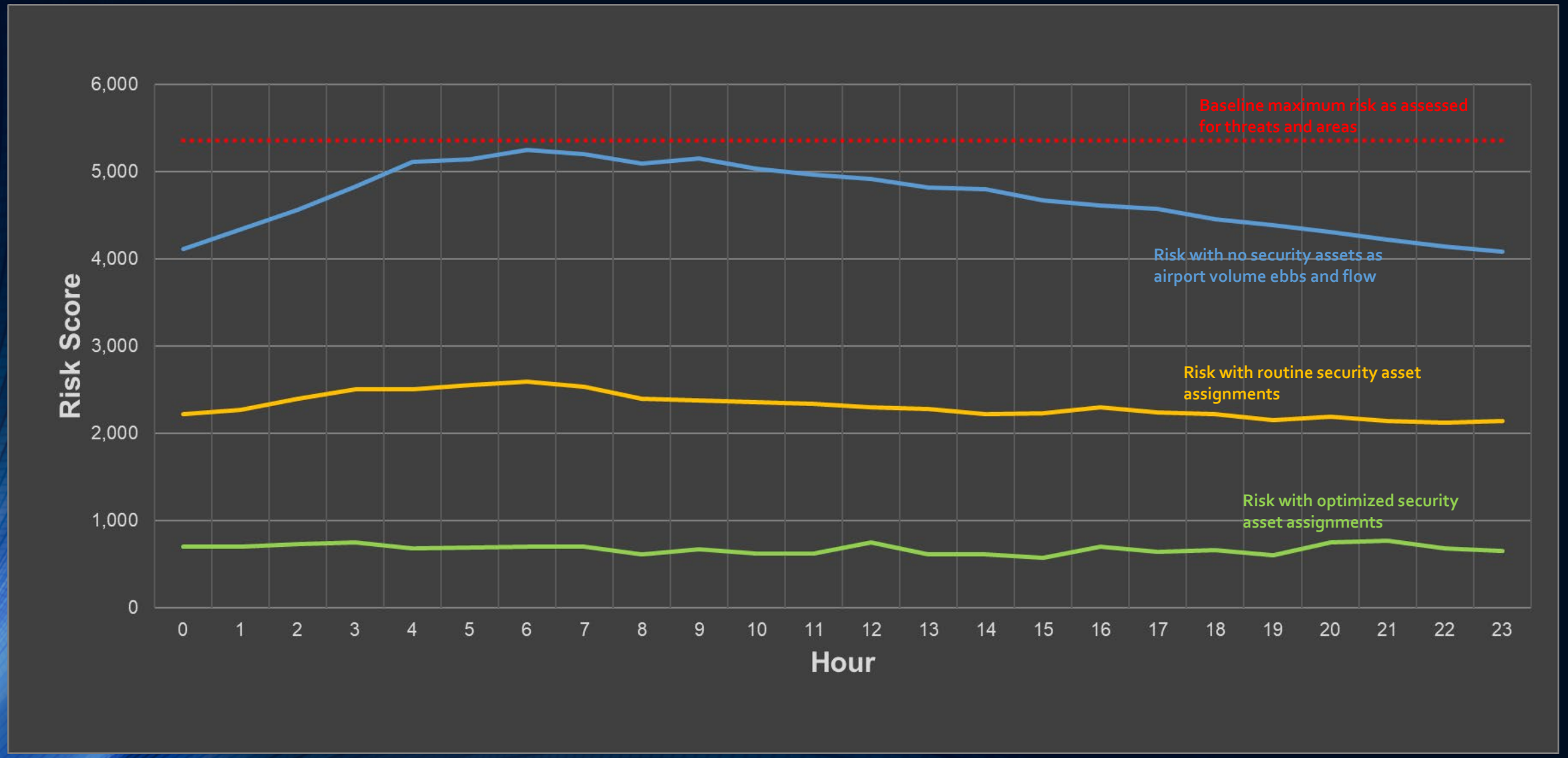
$$\min_{X_{ijk}^t} \sum_{k,l,t} R_{kl}^t = \sum_{k,l,t} S_{kl}^t \exp\left(\sum_{i,j} K_{li} X_{ijk}^t\right)$$

$$S_{kl}^t = \hat{C}_{kl}^t \hat{V}_{kl} \hat{T}_{kl} K_{li} = \ln E_{li} + \ln D_{li}$$

$$\sum_k X_{ijk}^t \leq a_{ij}^t, \ \forall\, i,j \in J(I), t$$

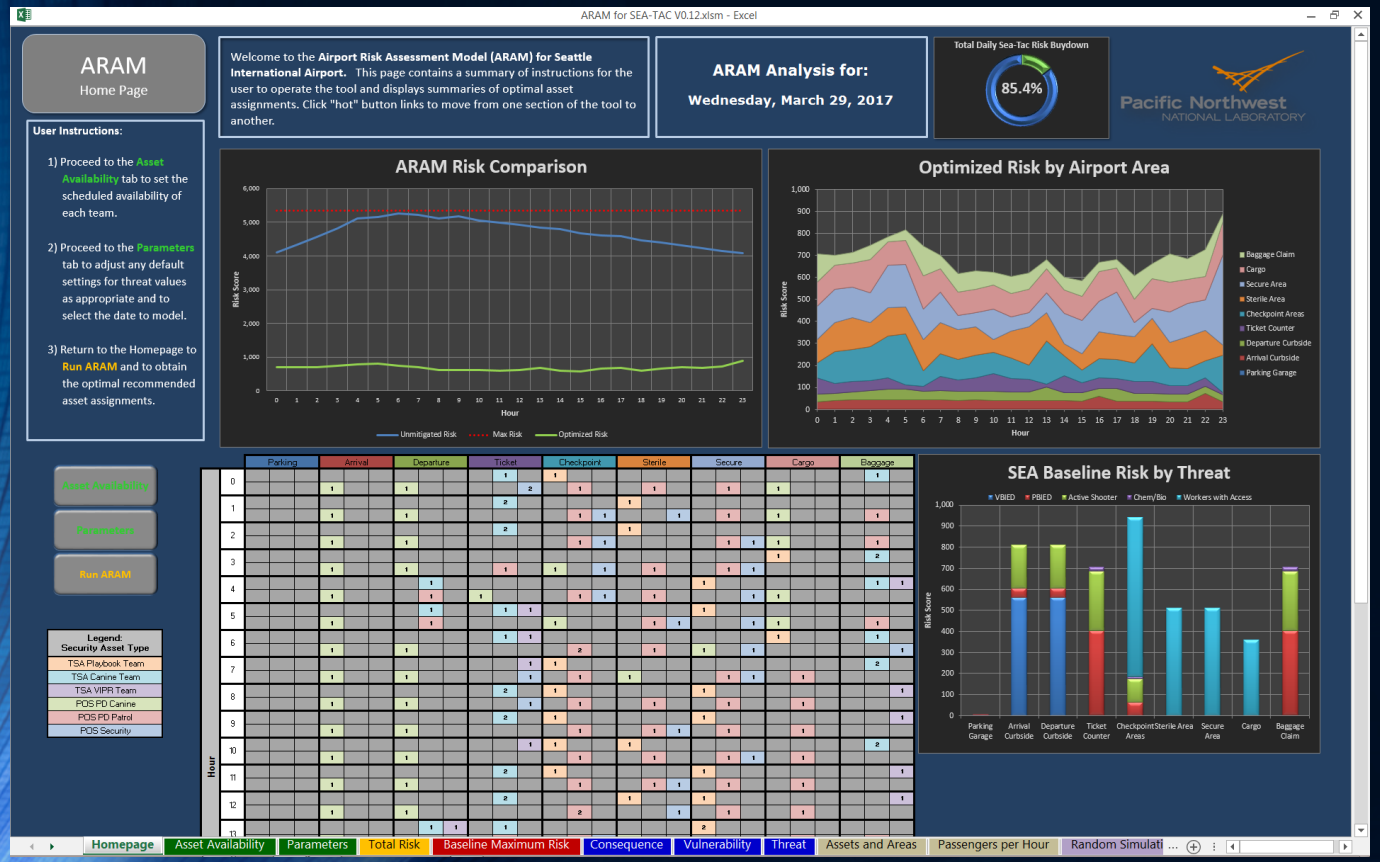
$$X_{ijk}^t \in \{0,1\}, \ \forall\, i,j \in J(I), k, t$$

ARAM Typical Results – Risk Comparison

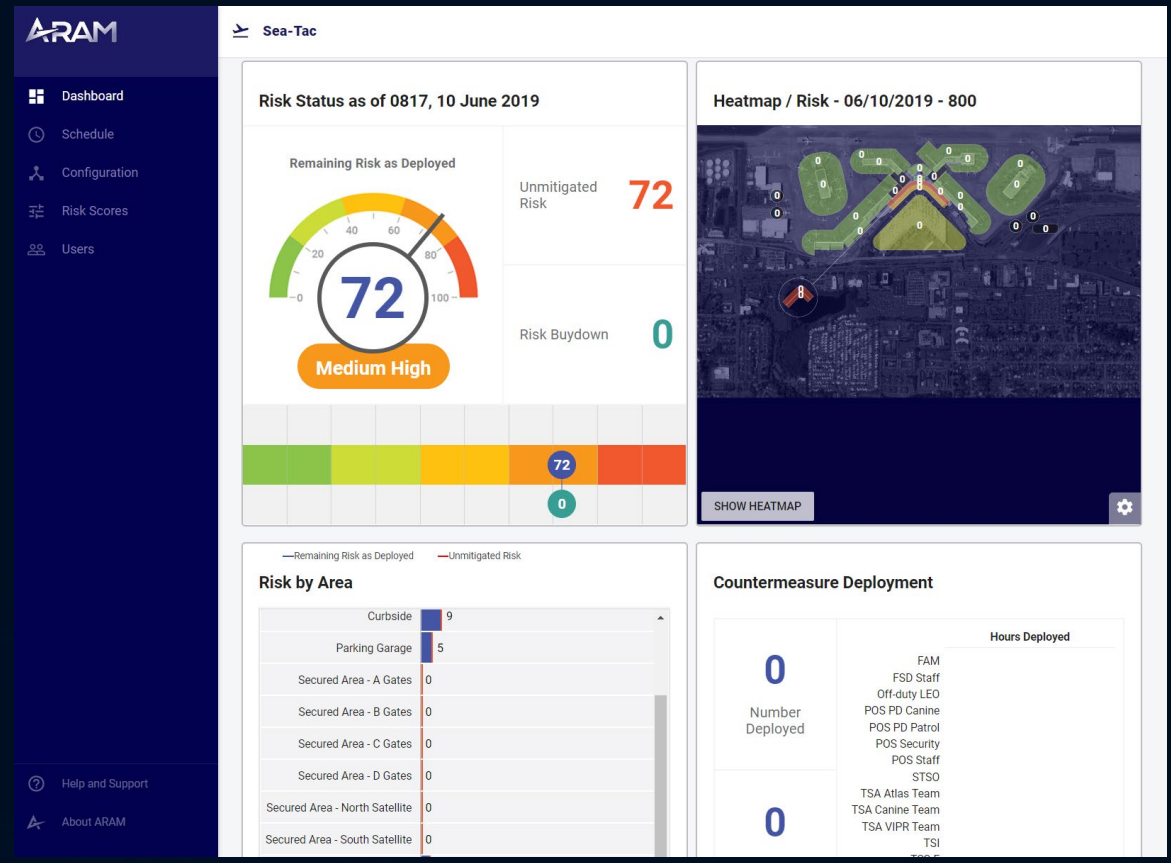


Then and Now

Spring 2017



Summer 2019

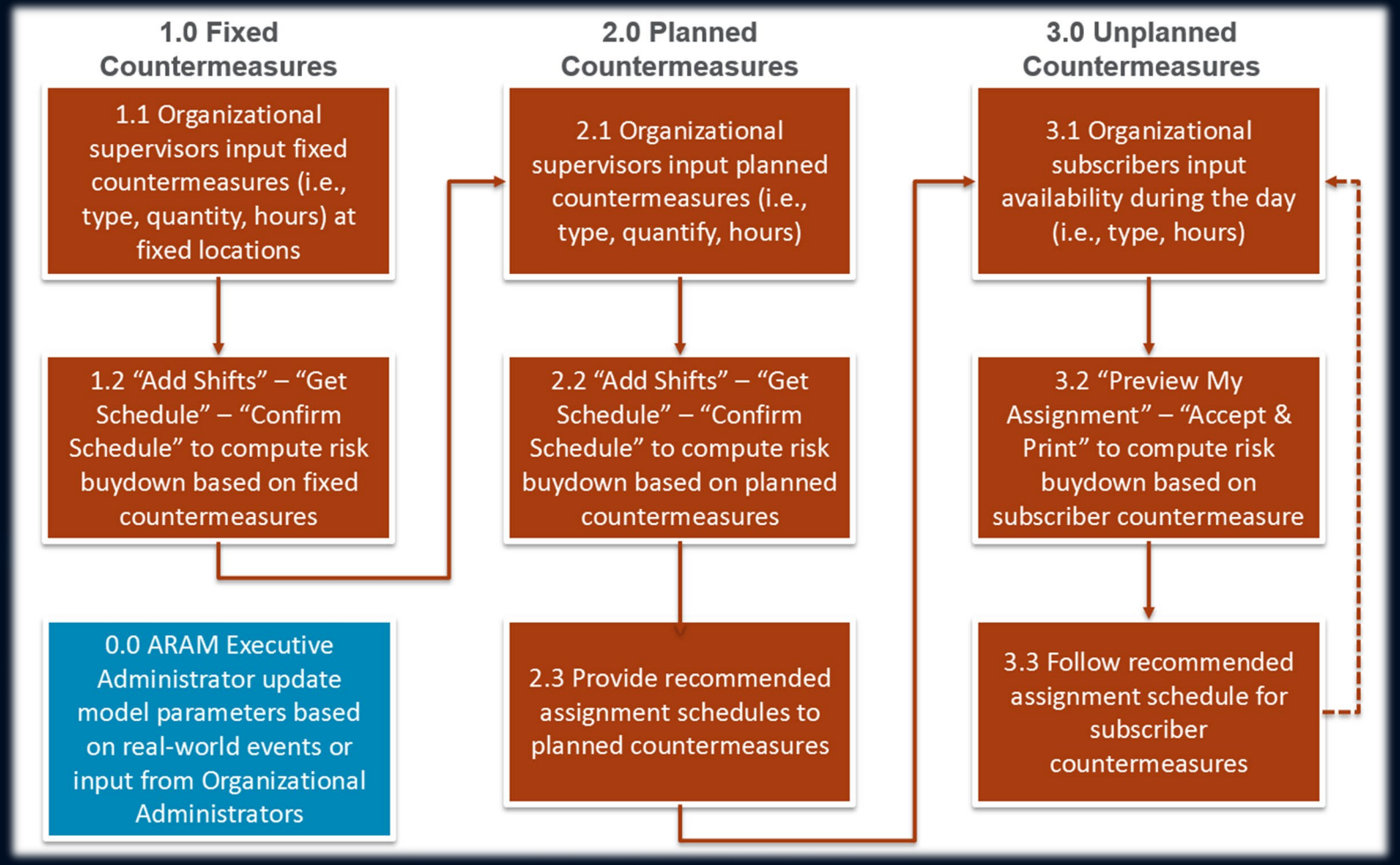


ARAM Demo

- ***Workflow:***
  - CONOPS
  - Model setup
  - Inputting countermeasures
  - Notional results

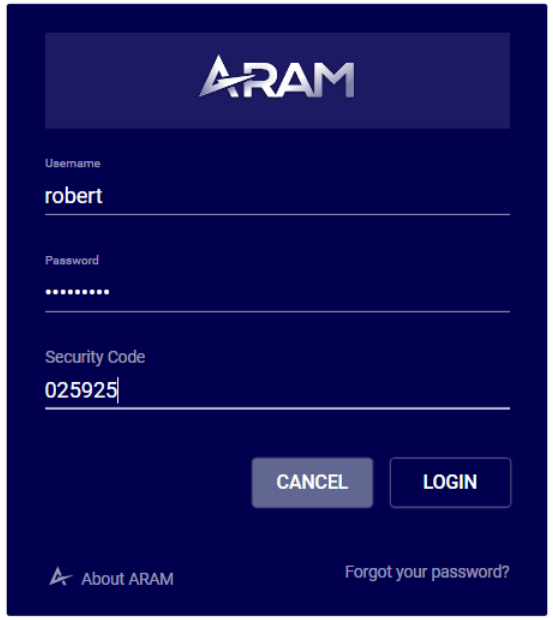
ARAM CONOPS

1. 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



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ARAM

Dashboard
Schedule
Configuration
Risk Scores
Users

Help and Support
About ARAM

ARAM DASHBOARD

Sea-Tac

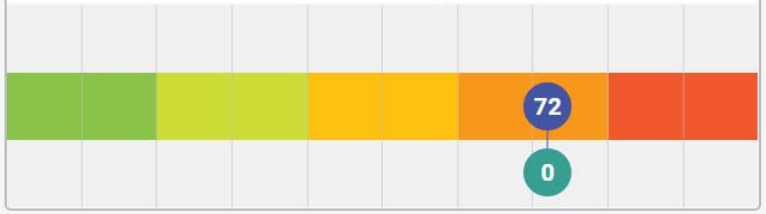
robert LOGOUT

Risk Status as of 0817, 10 June 2019

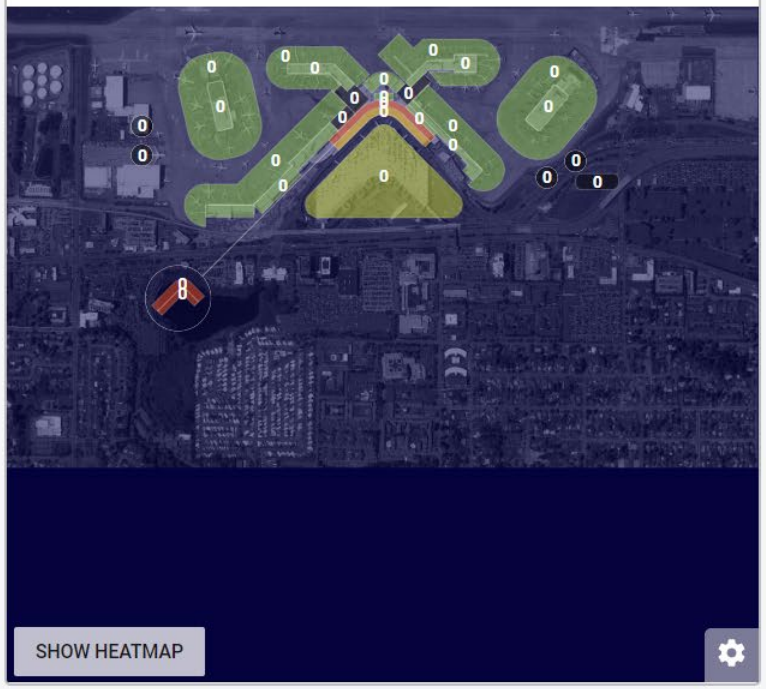
Remaining Risk as Deployed

Unmitigated Risk 72

Risk Buydown 0



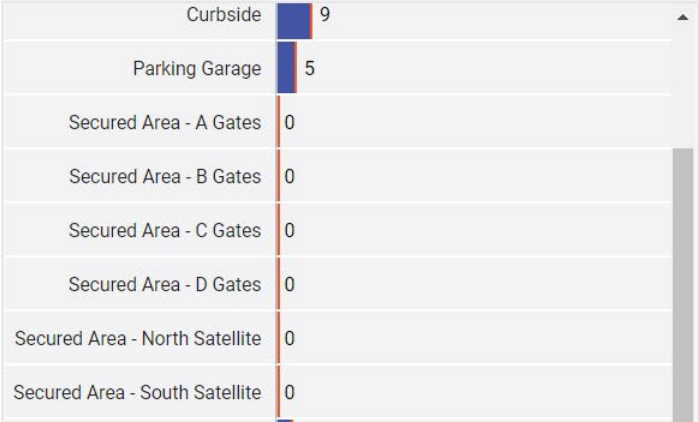
Heatmap / Risk - 06/10/2019 - 800



SHOW HEATMAP

—Remaining Risk as Deployed —Unmitigated Risk

Risk by Area



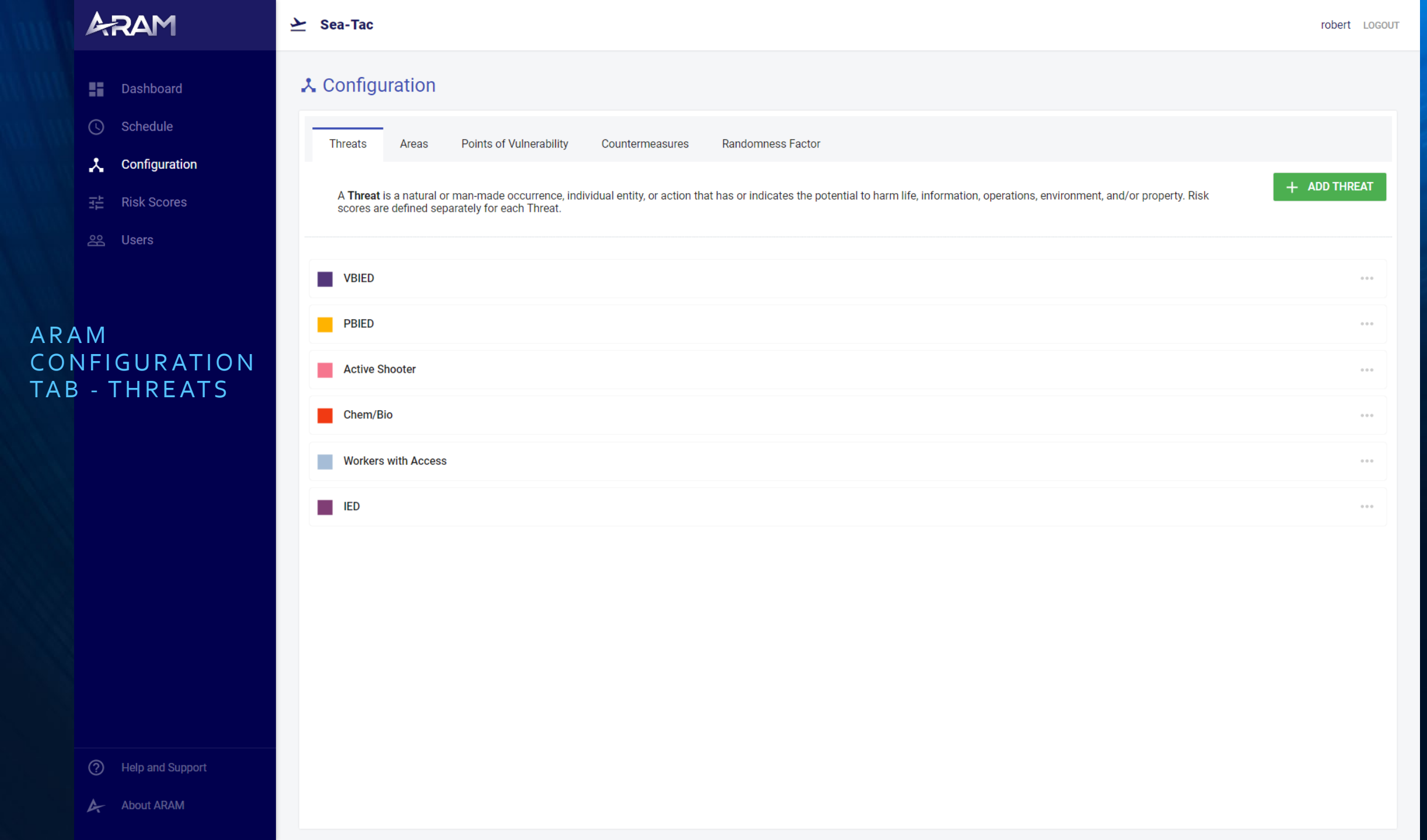
Countermeasure Deployment

0
Number Deployed

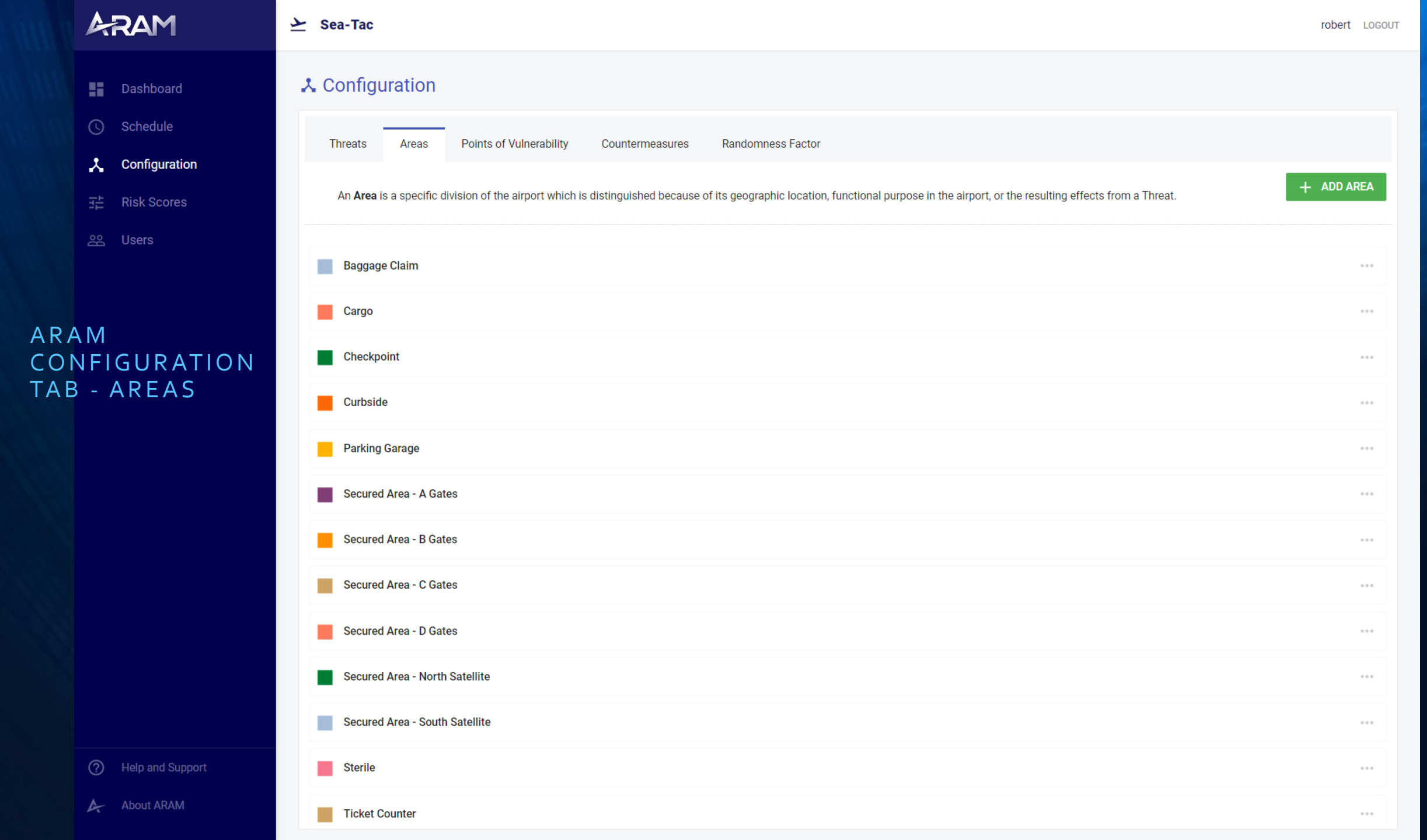
0

Hours Deployed

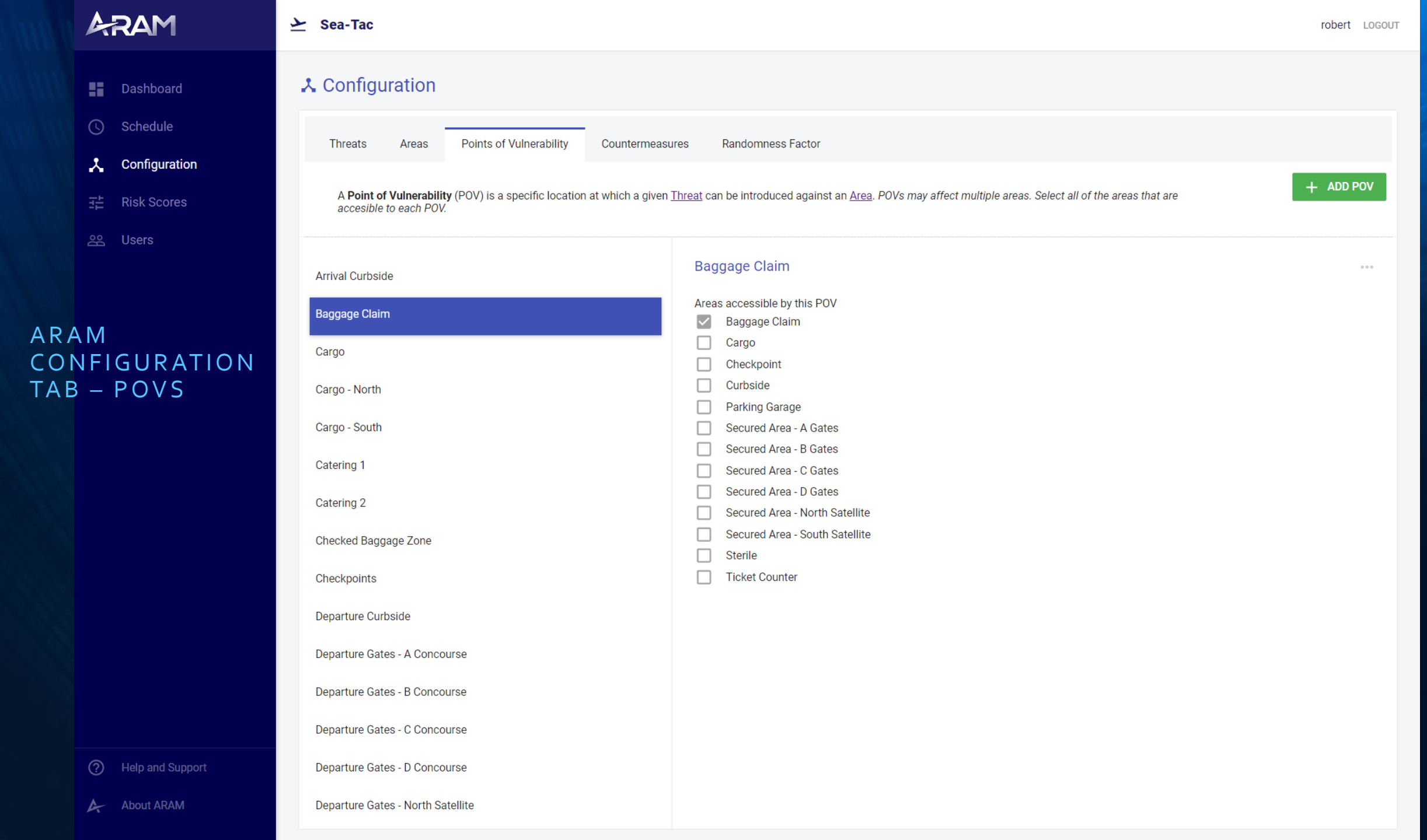
FAM
FSD Staff
Off-duty LEO
POS PD Canine
POS PD Patrol
POS Security
POS Staff
STSO
TSA Atlas Team
TSA Canine Team
TSA VIPR Team
TSI



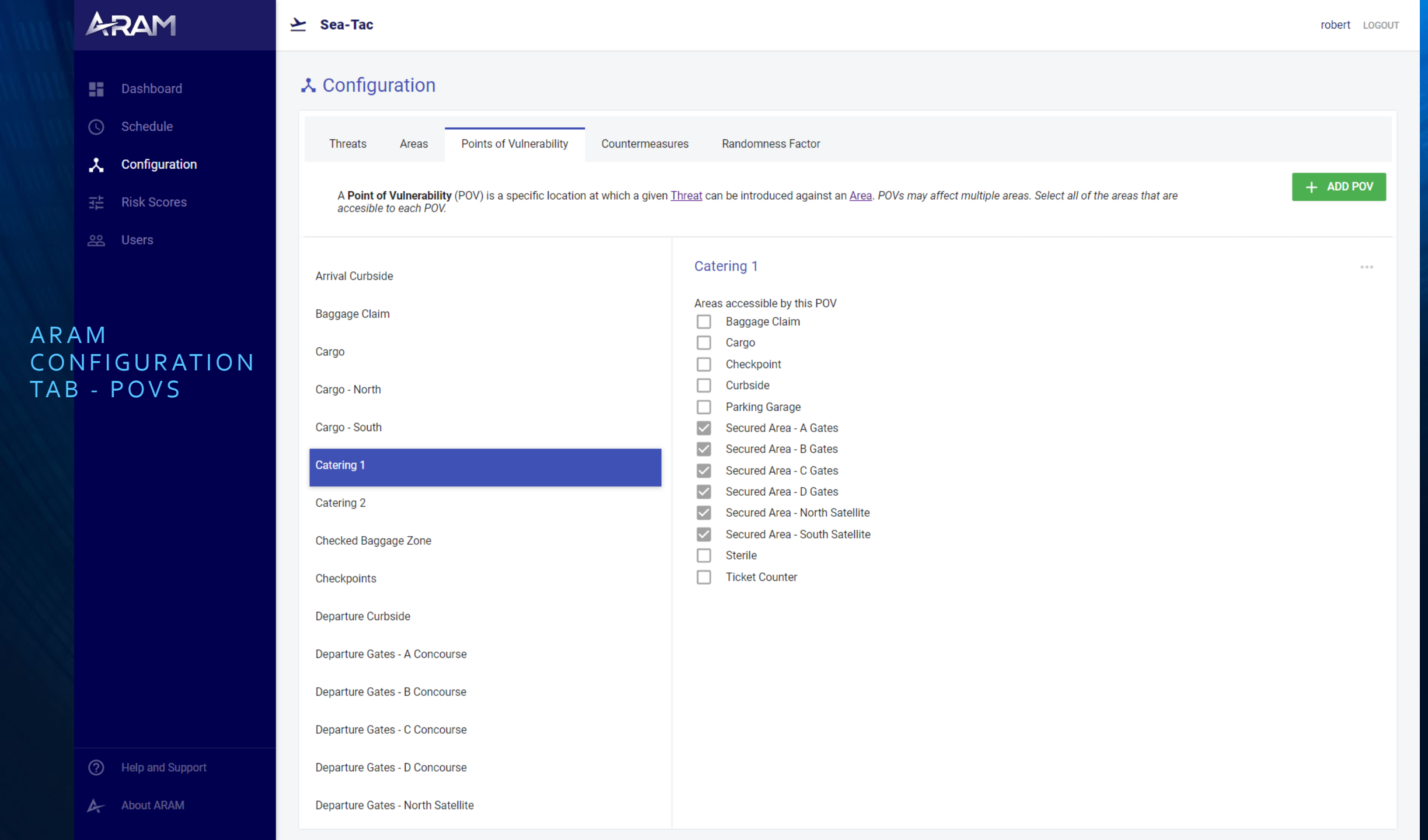
ARAM CONFIGURATION TAB - THREATS



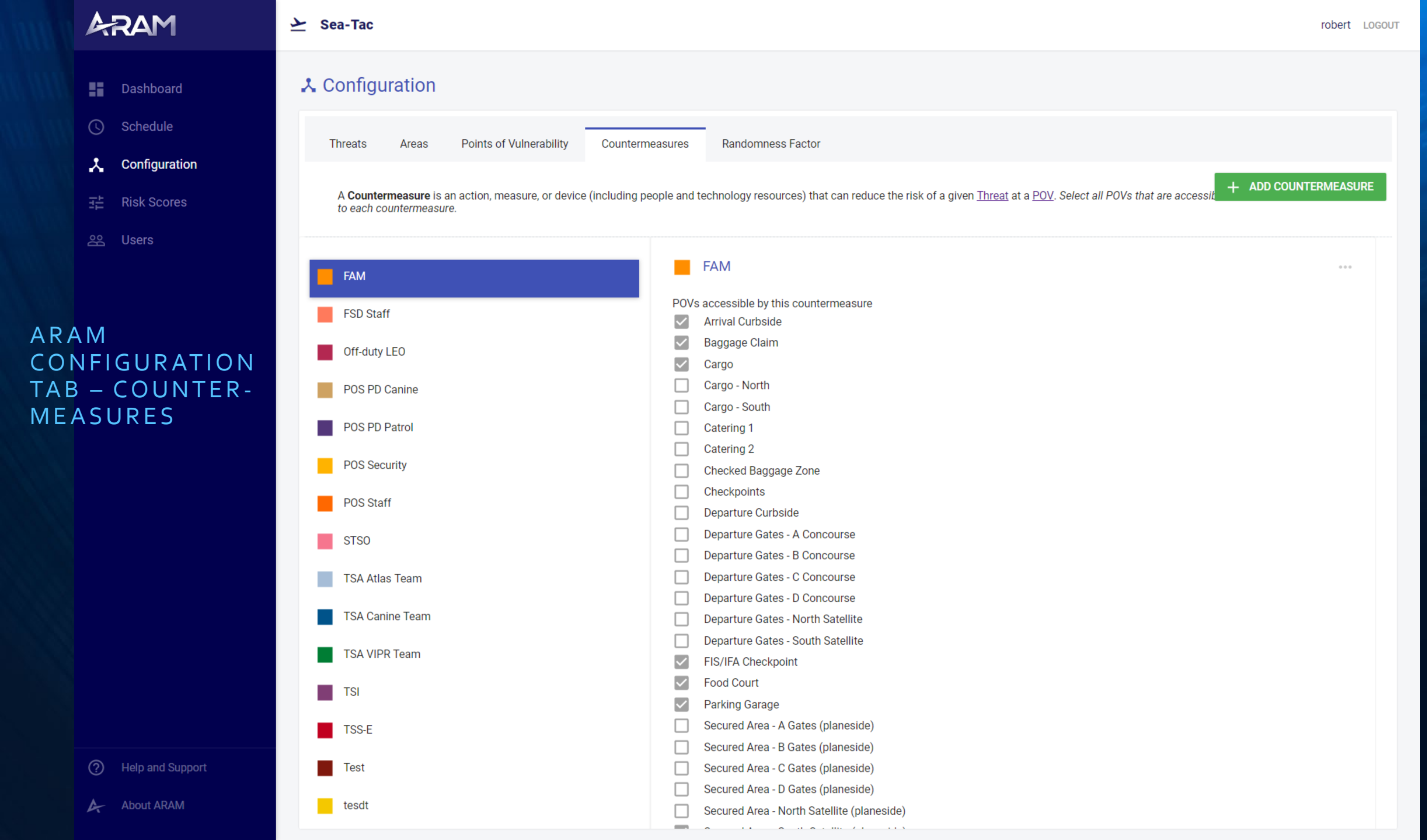
ARAM CONFIGURATION TAB - AREAS



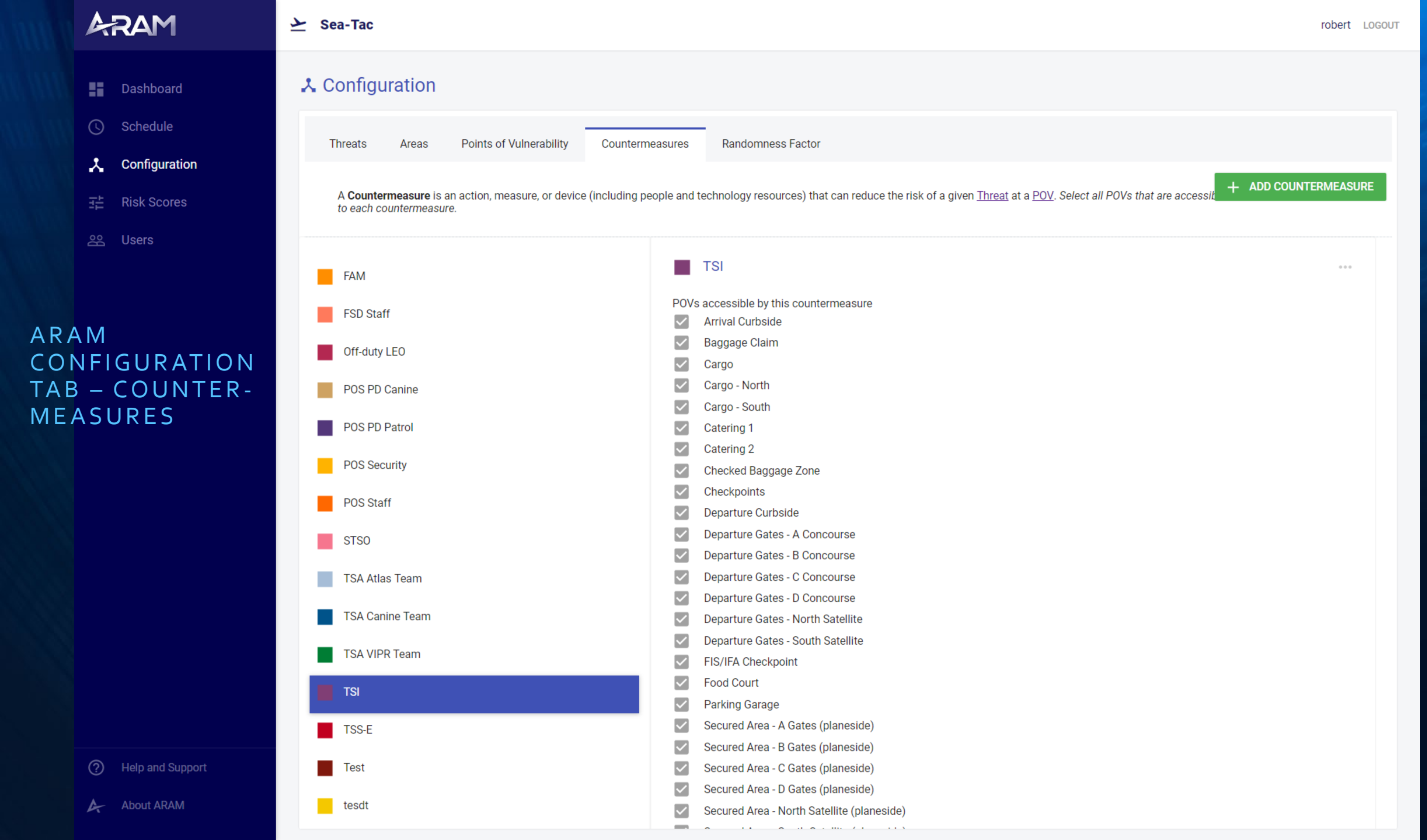
ARAM CONFIGURATION TAB – POVS



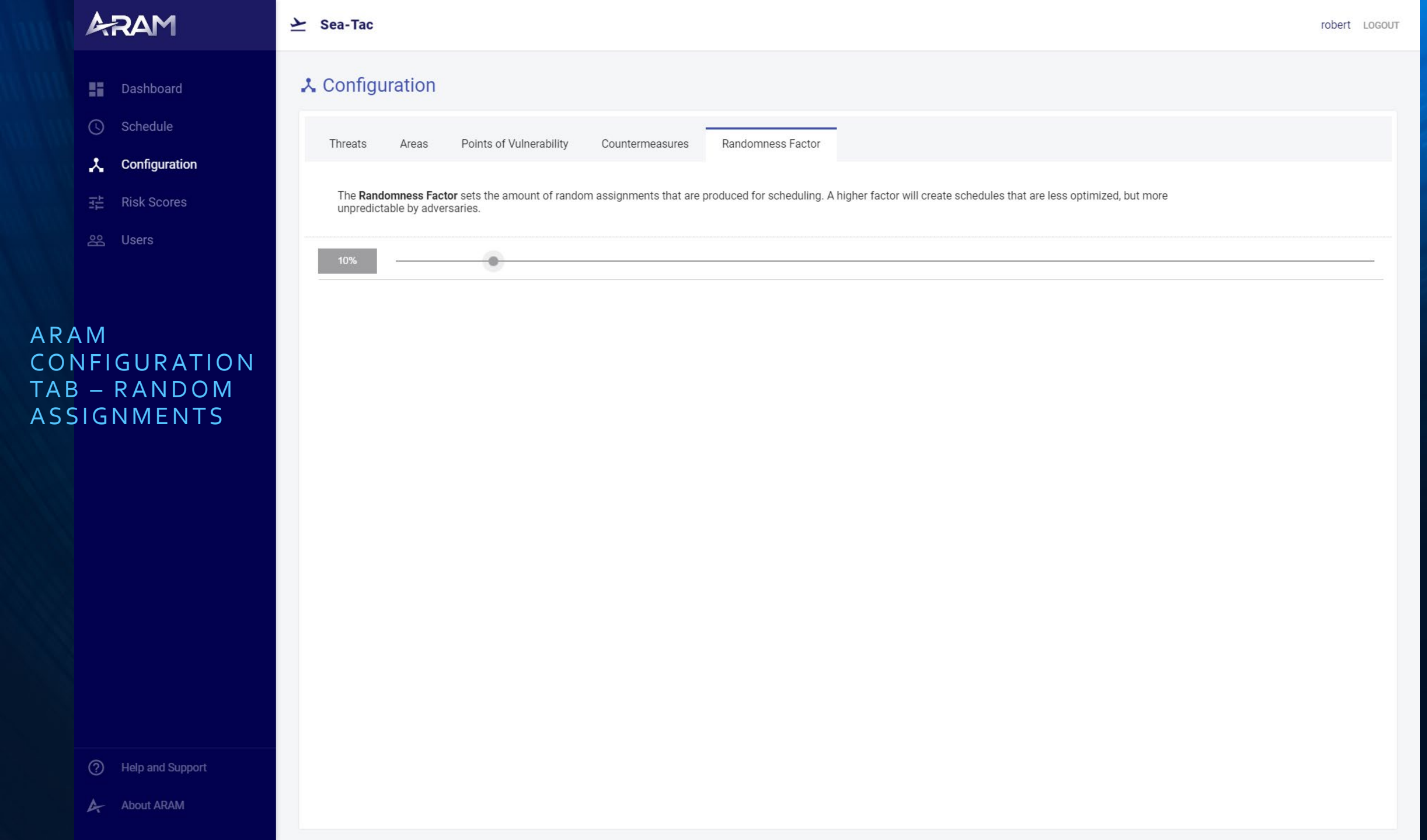
ARAM CONFIGURATION TAB - POVS



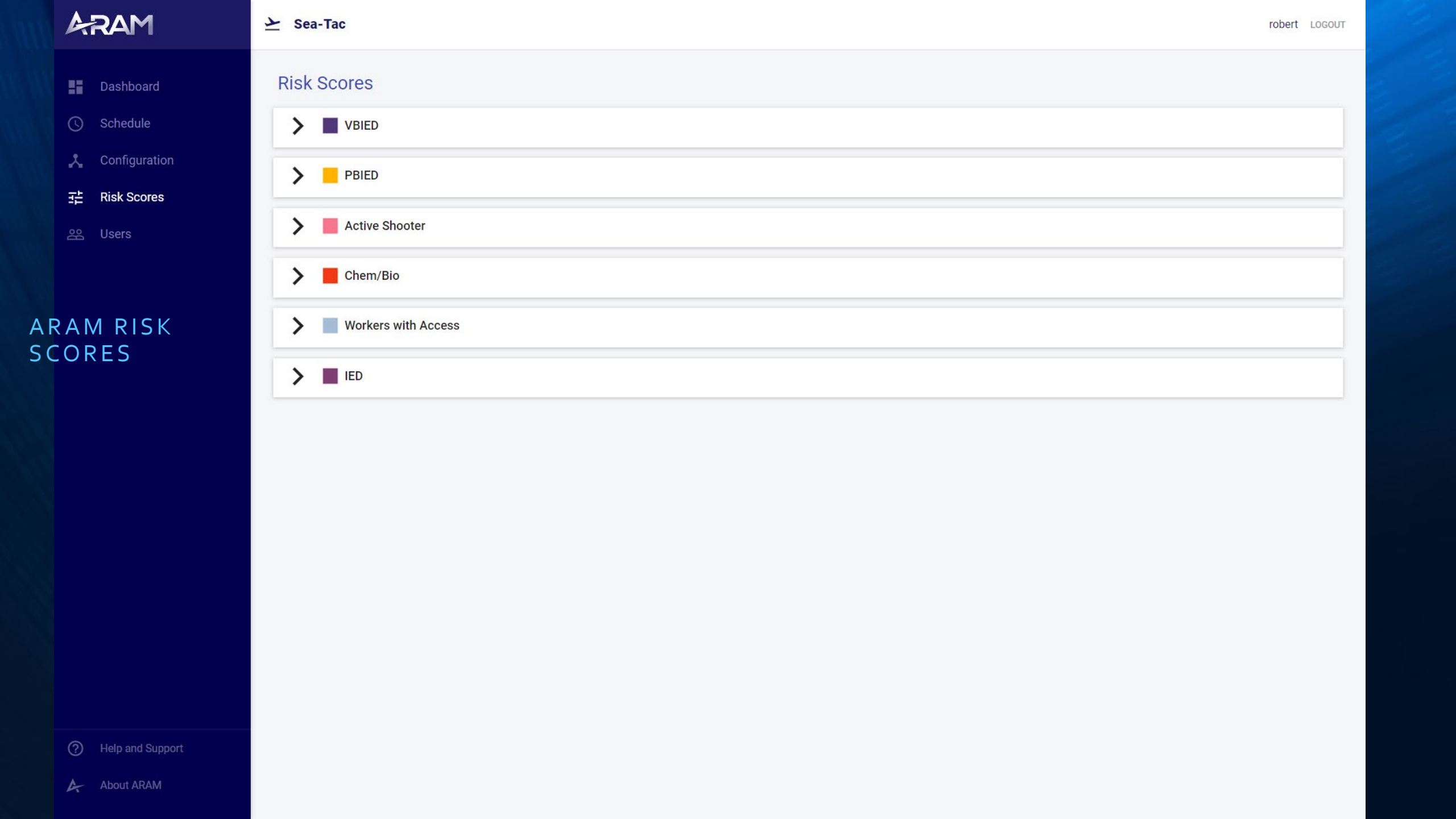
ARAM CONFIGURATION TAB – COUNTER-MEASURES



ARAM CONFIGURATION TAB – COUNTER-MEASURES



ARAM CONFIGURATION TAB – RANDOM ASSIGNMENTS


ARAM
Sea-Tac
robert
LOGOUT
Dashboard
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Risk Scores
Users
Help and Support
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Risk Scores
VBIED
PBIED
Active Shooter
Chem/Bio
Workers with Access
IED
ARAM RISK SCORES

ARAM RISK SCORES – THREAT SCORE TAB

ARAM

Sea-Tac

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- Dashboard
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- About ARAM

Risk Scores

VBIED

PBIED

Active Shooter

AREAS/POVS

Threat Score | Consequence | Vulnerabililty

COUNTERMEASURES

Effectiveness | Deterrence

Threat of Active Shooter to Area

Baggage Claim	3
Ticket Counter	3
Sterile	1
Parking Garage	1
Cargo	1
Curbside	2
Checkpoint	3
Secured Area - A Gates	1
Secured Area - B Gates	1
Secured Area - C Gates	1
Secured Area - D Gates	1
Secured Area - South Satellite	1
Secured Area - North Satellite	1

ARAM RISK SCORES – CONSEQUENCE SCORE TAB

ARAM

Sea-Tac

robert LOGOUT

- Dashboard
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- Users

Risk Scores

VBIED

PBIED

Active Shooter

AREAS/POVS

Threat Score | Consequence | Vulnerabililty

COUNTERMEASURES

Effectiveness | Deterrence

Consequence of Active Shooter to Area

	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	1	1	1	1	1	1
Curbside	3	2	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	3	1	2	1	1	1	1
Secured Area - C Gates	3	3	1	2	1	1	1	1
Secured Area - D Gates	3	3	1	2	1	1	1	1
Secured Area - North Satellite	3	3	1	2	1	1	1	1
Secured Area - South Satellite	3	3	1	2	1	1	1	1
Sterile	3	3	1	1	1	1	1	1
Ticket Counter	3	2	1	1	1	1	1	1

Chem/Bio

Workers with Access

- Help and Support
- About ARAM

ARAM RISK SCORES – VULNERABILITY SCORE TAB

ARAM

Sea-Tac

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- About ARAM

Risk Scores

VBIED

PBIED

Active Shooter

AREAS/POVS

Threat Score | Consequence | Vulnerabililty

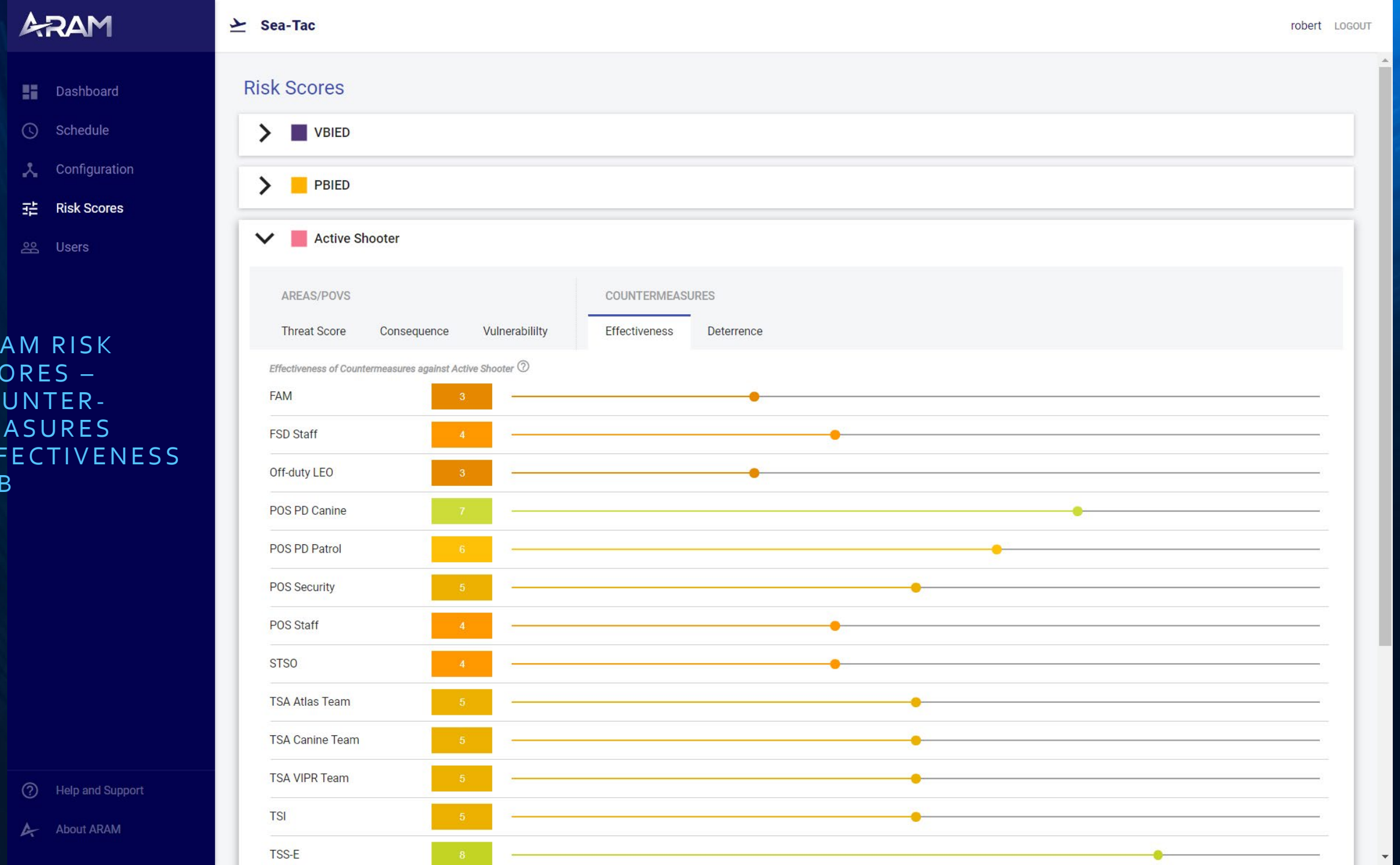
COUNTERMEASURES

Effectiveness | Deterrence

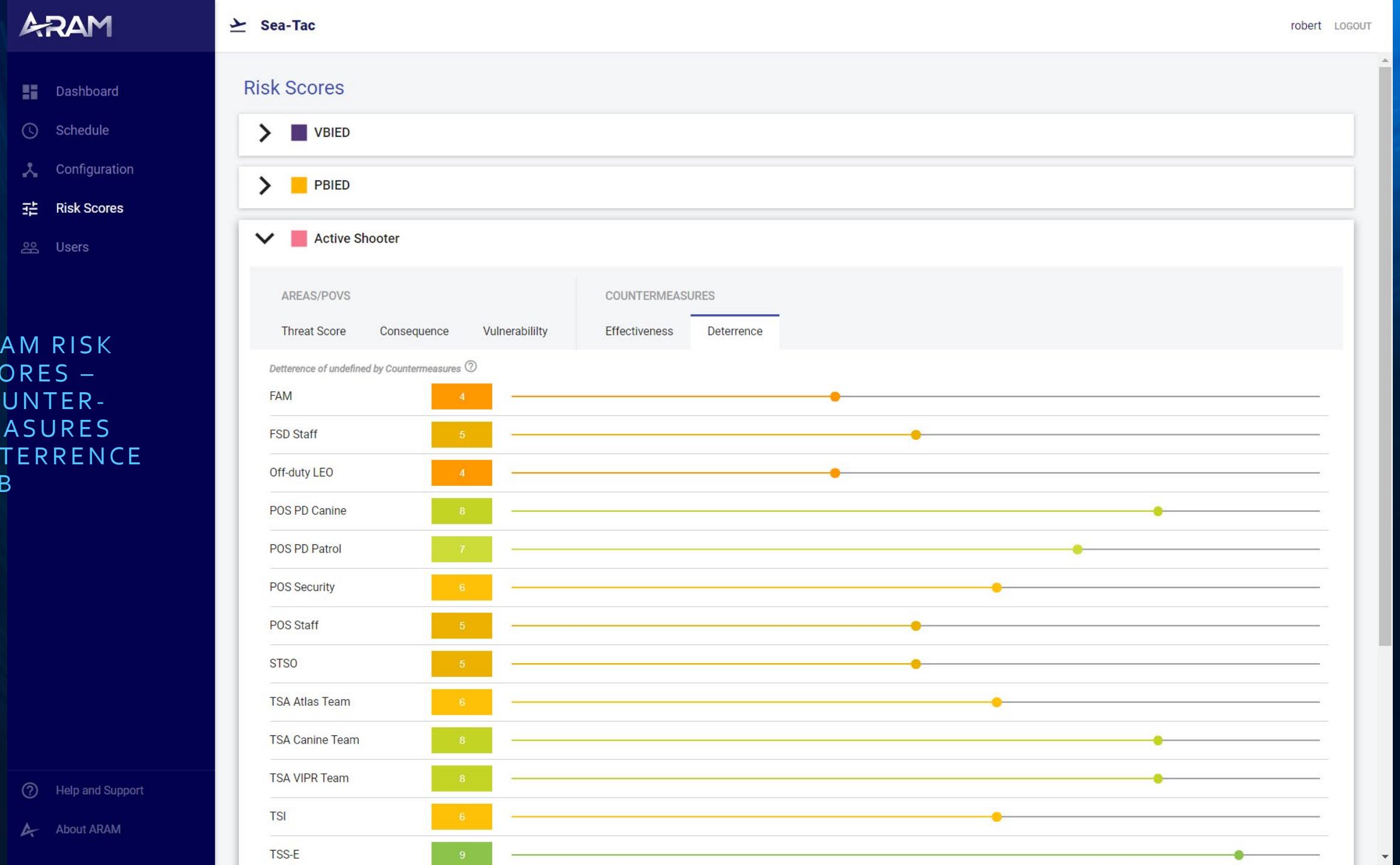
Vulnerability of POV to Active Shooter

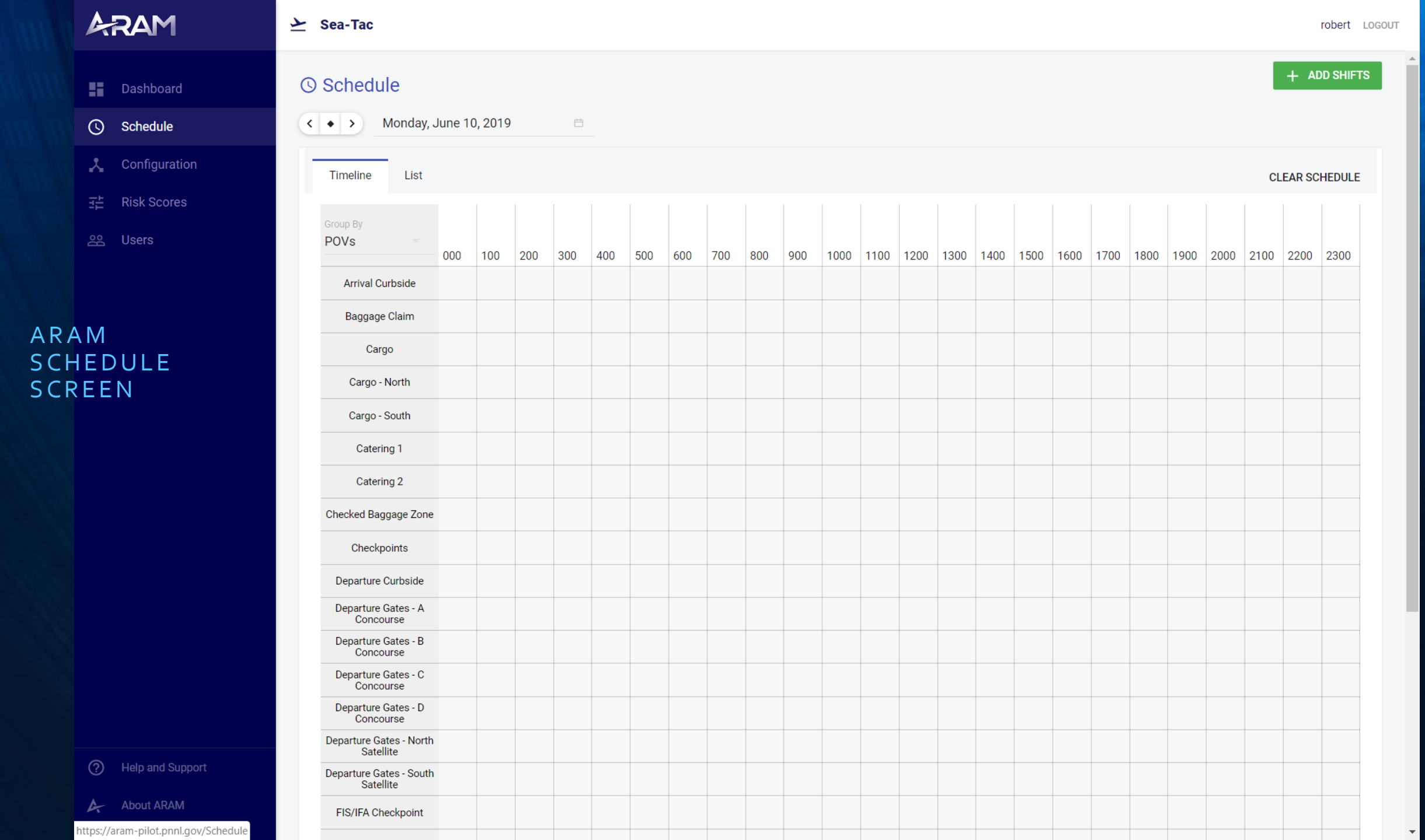
	Availability	Accessibility	Organic Security	Target Hardness
Arrival Curbside	5	5	3	5
Baggage Claim	5	5	3	5
Cargo	4	1	2	5
Cargo - North	4	4	3	5
Cargo - South	4	4	3	5
Catering 1	4	1	2	5
Catering 2	4	1	2	5
Checked Baggage Zone	4	1	2	5
Checkpoints	5	5	2	5
Departure Curbside	5	5	3	5
Departure Gates - A Concourse	5	2	2	4
Departure Gates - B Concourse	5	2	2	4
Departure Gates - C Concourse	5	2	2	4
Departure Gates - D Concourse	5	2	2	4
Departure Gates - North Satellite	5	2	2	4
Departure Gates - South Satellite	5	2	2	4
FIS/IFA Checkpoint	1	1	1	1

ARAM RISK SCORES – COUNTER-MEASURES EFFECTIVENESS TAB

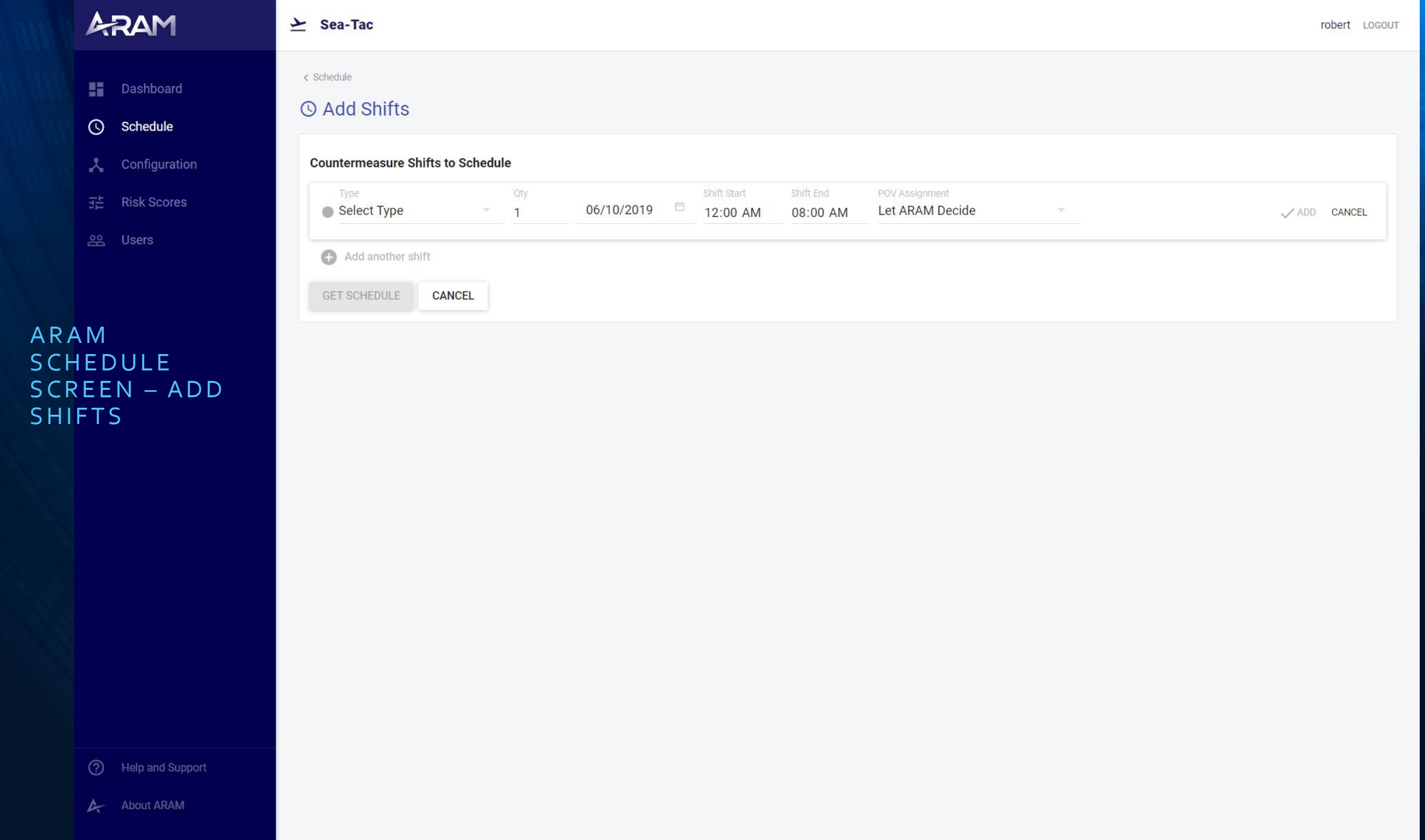


ARAM RISK SCORES – COUNTER-MEASURES DETERRENCE TAB

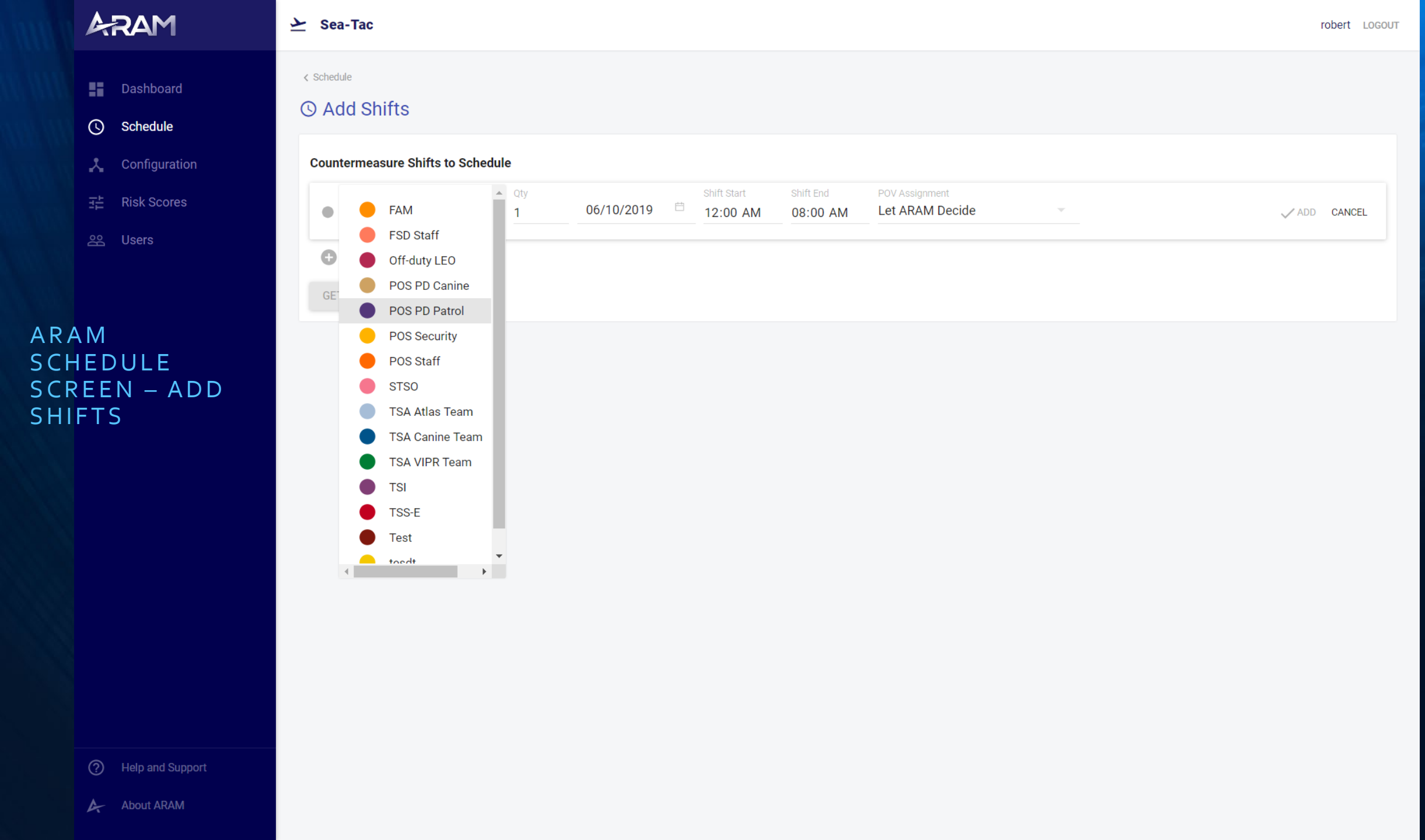




ARAM SCHEDULE SCREEN



ARAM SCHEDULE SCREEN – ADD SHIFTS



ARAM SCHEDULE SCREEN – ADD SHIFTS

ARAM

Sea-Tac

robert LOGOUT

- Dashboard
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Schedule

Add Shifts

Countermeasure Shifts to Schedule

POS PD Patrol	4	06/10/2019	12:00 AM	08:00 AM	Let ARAM Decide	
TSA VIPR Team	1	06/10/2019	08:00 AM	04:00 PM	Let ARAM Decide	
FAM	1	06/10/2019	06:00 AM	02:00 PM	Let ARAM Decide	
TSI	3	06/10/2019	12:00 AM	08:00 AM	Let ARAM Decide	
TSA Canine Team	4	06/10/2019	10:00 AM	06:00 PM	Let ARAM Decide	

Add another shift

GET SCHEDULE CANCEL

"EASY BUTTON"

- Help and Support
- About ARAM

ARAM SCHEDULE SCREEN – ADD SHIFTS

ARAM

Sea-Tac

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- Dashboard
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- Help and Support
- About ARAM

ARAM RECOMMENDED ASSIGNMENTS

< Schedule

Confirm Shifts

Confirm Countermeasure Shifts Scheduled

TSI / 1

Date	Start - End (Duration)	POV	Risk Buydown % (POV/Hour)	Risk Buydown Value
06/10/2019	00:00 - 08:00 (8h)	Cargo - South	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

POS PD Patrol / 2

Date	Start - End (Duration)	POV	Risk Buydown %	Risk Buydown Value

Dashboard
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Risk Scores
Users

ARAM RECOMMENDED ASSIGNMENTS

06/10/2019	10:00 - 11:00 (1h)	Ticket Counter	12%	834.5
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

TSA Canine Team / 2

Date	Start - End (Duration)	POV	Risk Buydown % (POV/Hour)	Risk Buydown Value
06/10/2019	10:00 - 11:00 (1h)	Baggage Claim	11%	783.7
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

TSA Canine Team / 3

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
06/10/2019	17:00 - 18:00 (1h)	Arrival Curbside	8%	174.8

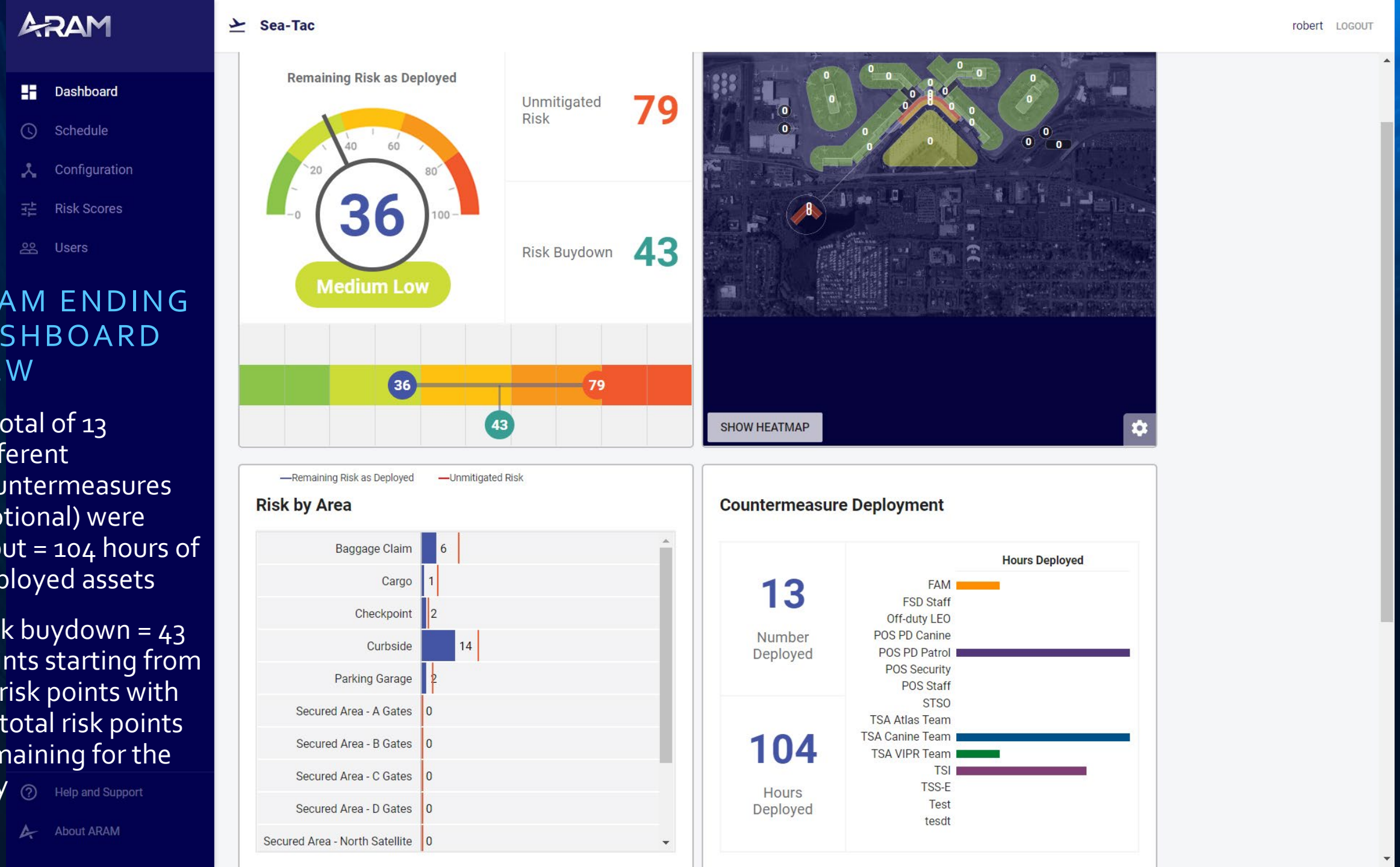
CONFIRM SCHEDULE PRINT CANCEL

Help and Support
About ARAM

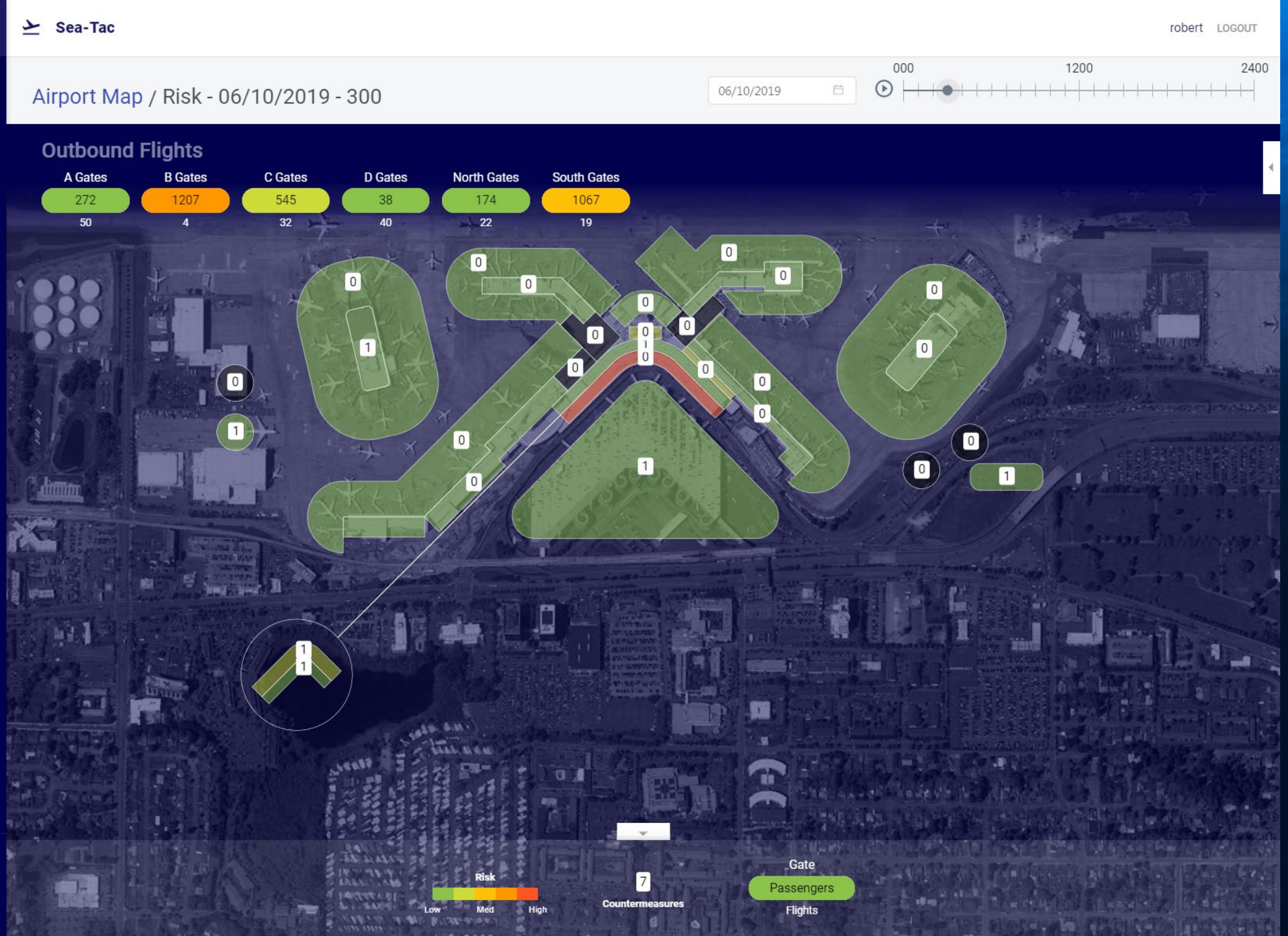
ARAM ENDING DASHBOARD VIEW

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

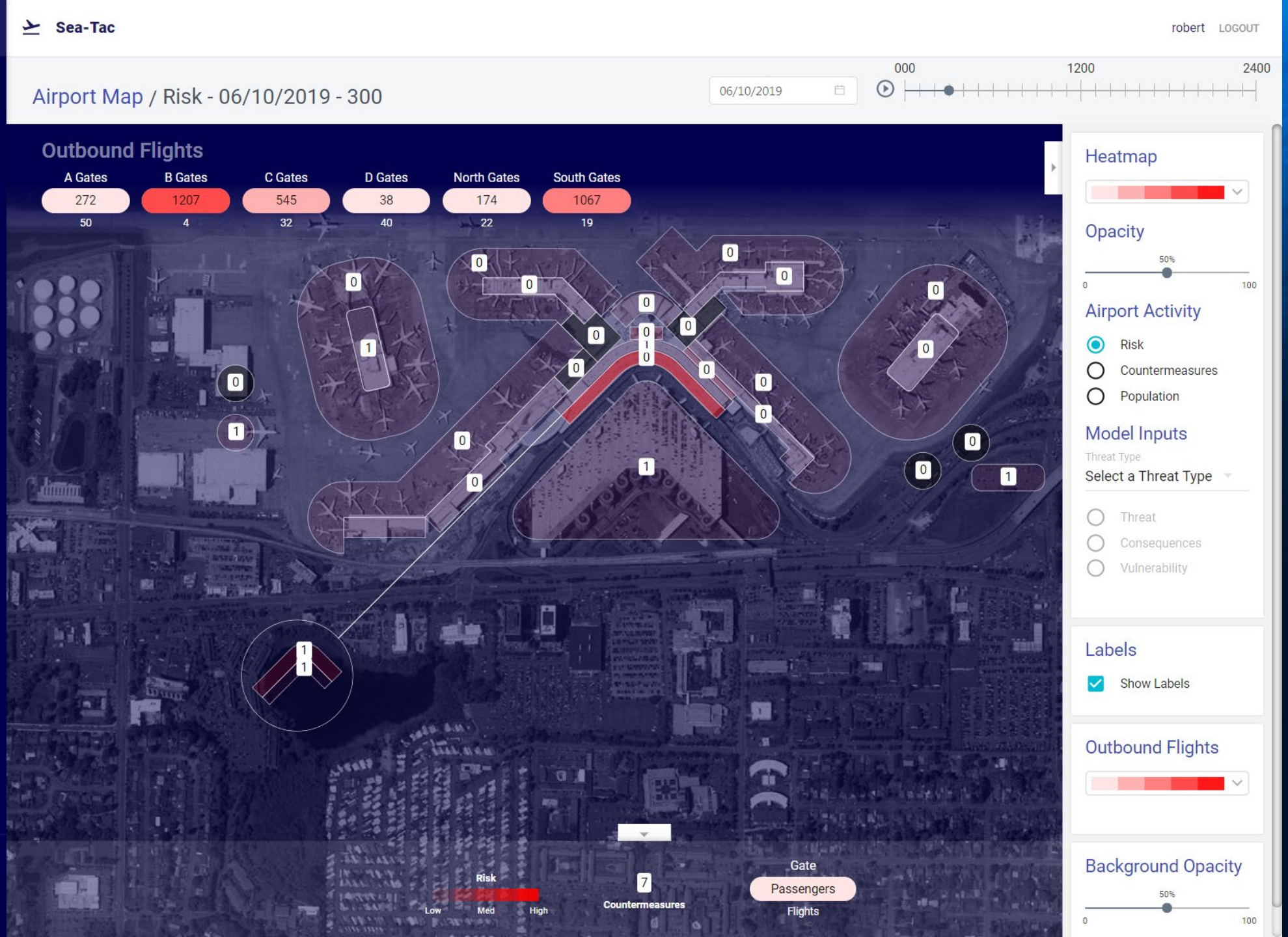
Risk buydown = 43 points starting from 79 risk points with 36 total risk points remaining for the day

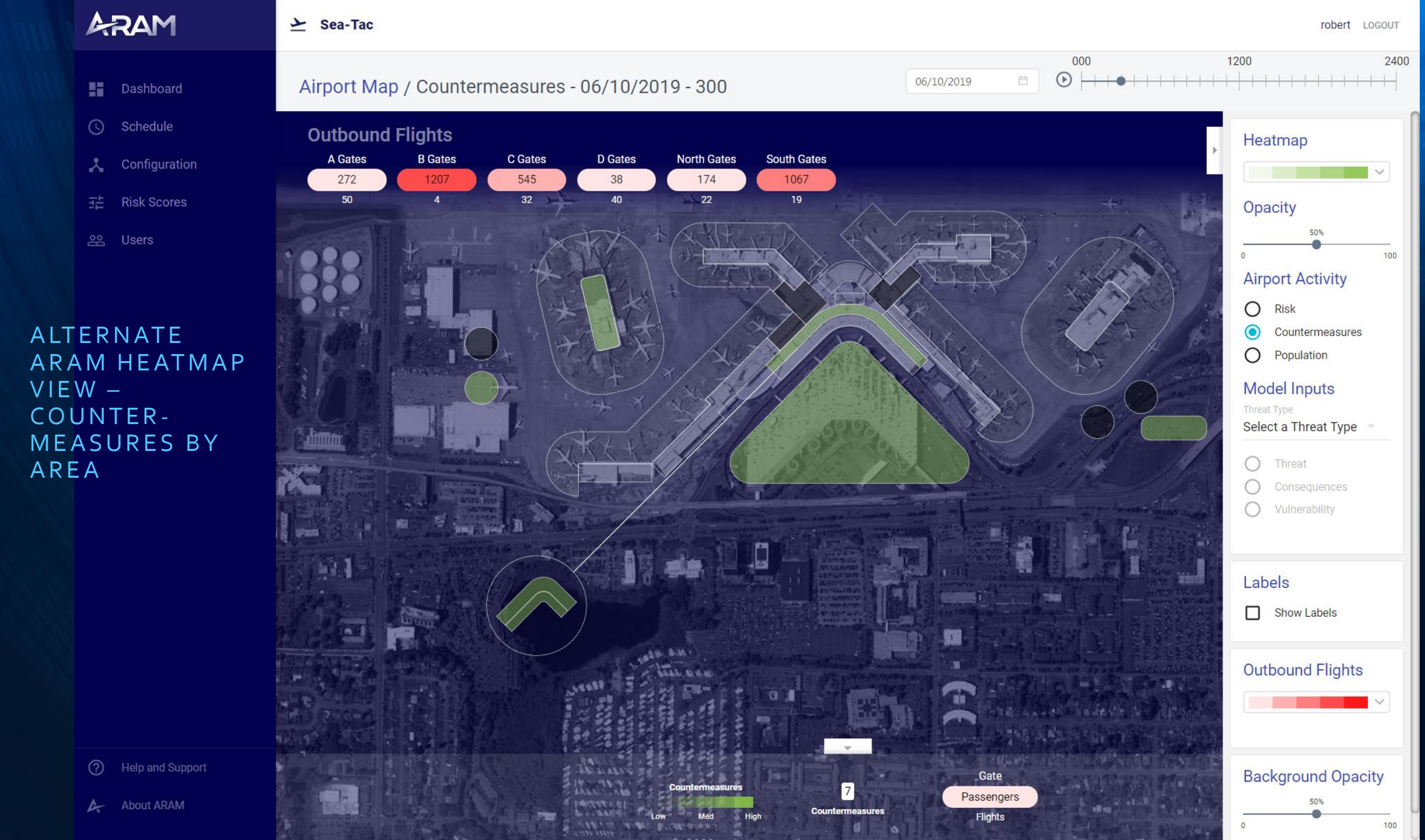


ARAM HEATMAP VIEW – RISK BY AREA AND COUNTER-MEASURE ASSIGNMENTS AT 0300



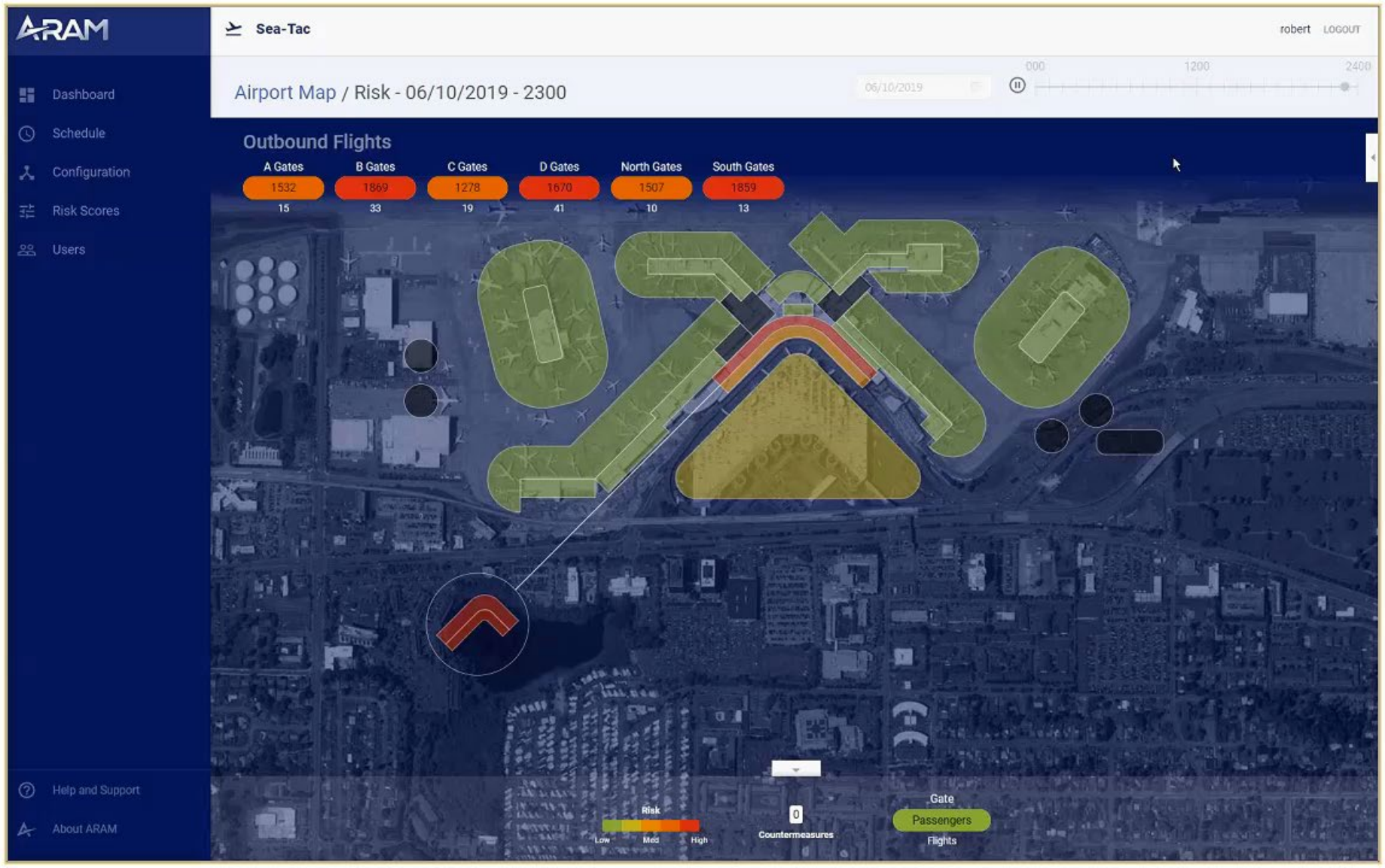
ALTERNATE ARAM HEATMAP VIEW – RISK BY AREA AND COUNTER-MEASURE ASSIGNMENTS AT 0300

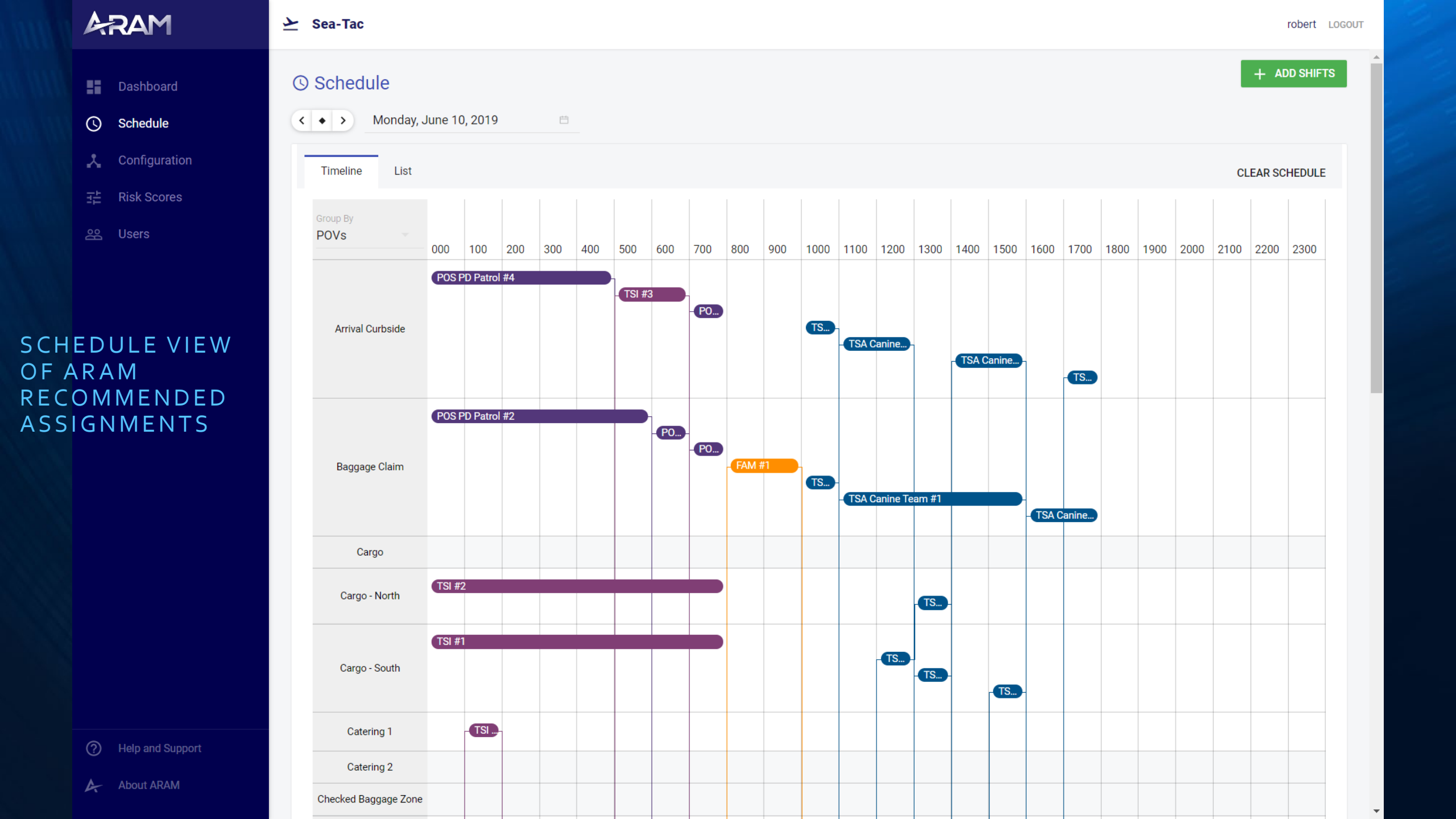




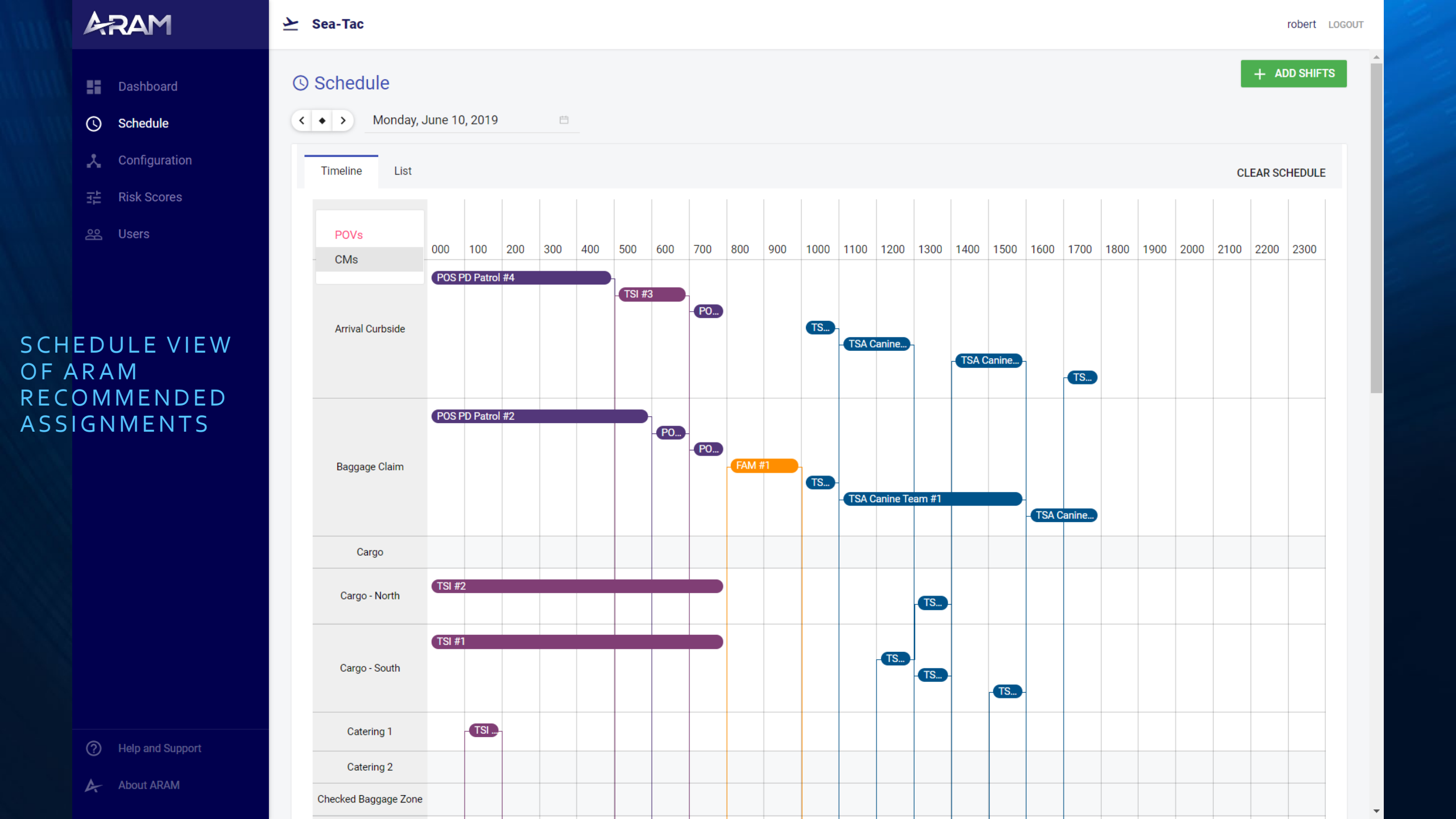
ALTERNATE ARAM HEATMAP VIEW – COUNTER-MEASURES BY AREA

HEATMAP OF RISK CAN ALSO BE ANIMATED OVER TIME



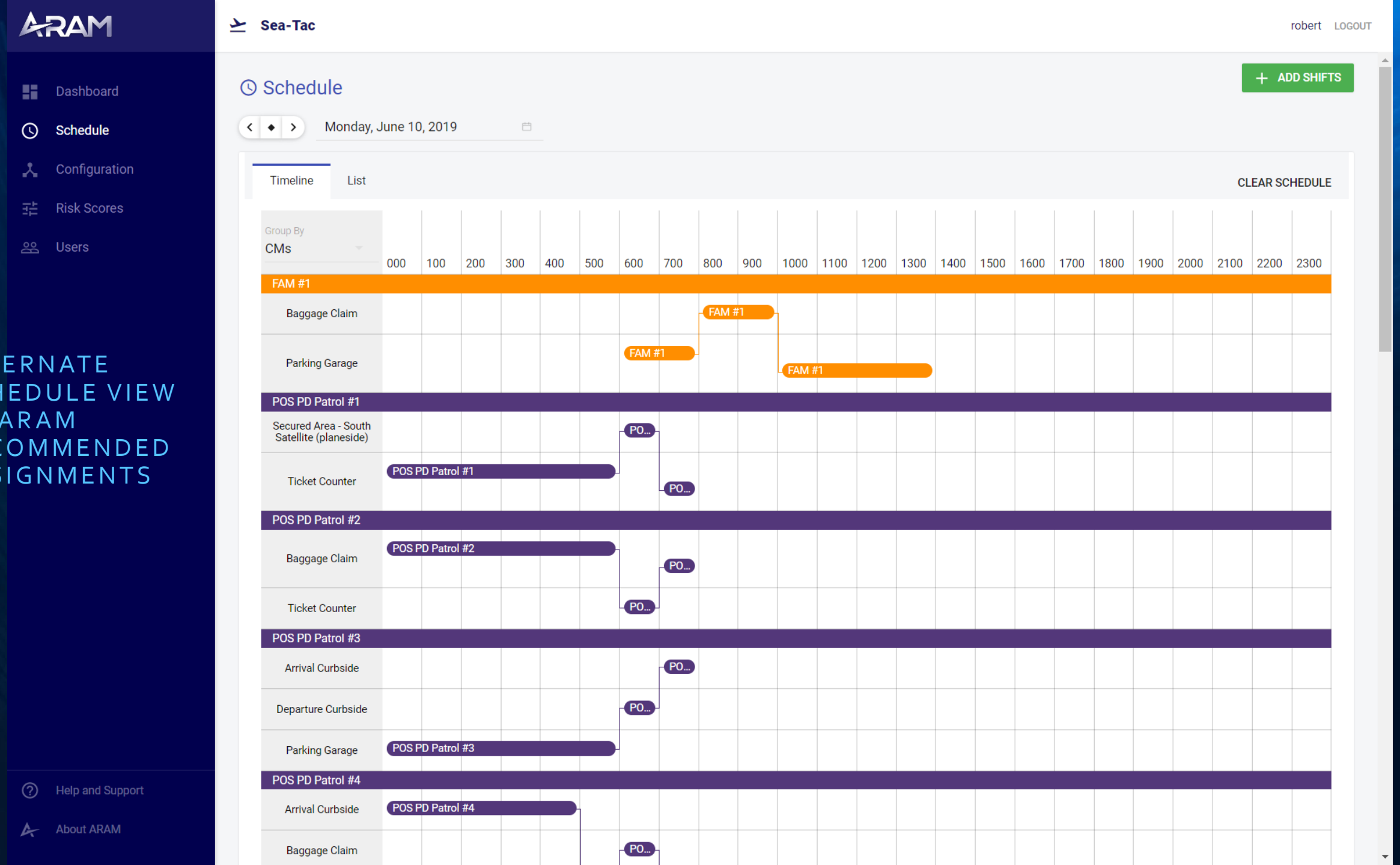


SCHEDULE VIEW OF ARAM RECOMMENDED ASSIGNMENTS



SCHEDULE VIEW OF ARAM RECOMMENDED ASSIGNMENTS

ALTERNATE SCHEDULE VIEW OF ARAM RECOMMENDED ASSIGNMENTS



ALTERNATE SCHEDULE VIEW OF ARAM RECOMMENDED ASSIGNMENTS

ARAM

Sea-Tac

robert LOGOUT

- Dashboard
- Schedule
- Configuration
- Risk Scores
- Users
- Help and Support
- About ARAM

Schedule

ADD SHIFTS

Monday, June 10, 2019

Timeline | List

CLEAR SCHEDULE

Countermeasure	Area/POV	Arrive	Depart	Shift Start	Shift End	Type	% Risk Buydown
FAM / 1	Parking Garage	06:00	08:00	06:00	14:00	Optimized	Multiple Values
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
POS PD Patrol / 4	Departure Gates - South Satellite	05:00	06:00	00:00	08:00	Random	12.00%
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*

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ARAM
AIRPORT RISK ASSESSMENT MODEL