PNNL-SA-185155

Pacific Northwest
NATIONAL LABORATORY

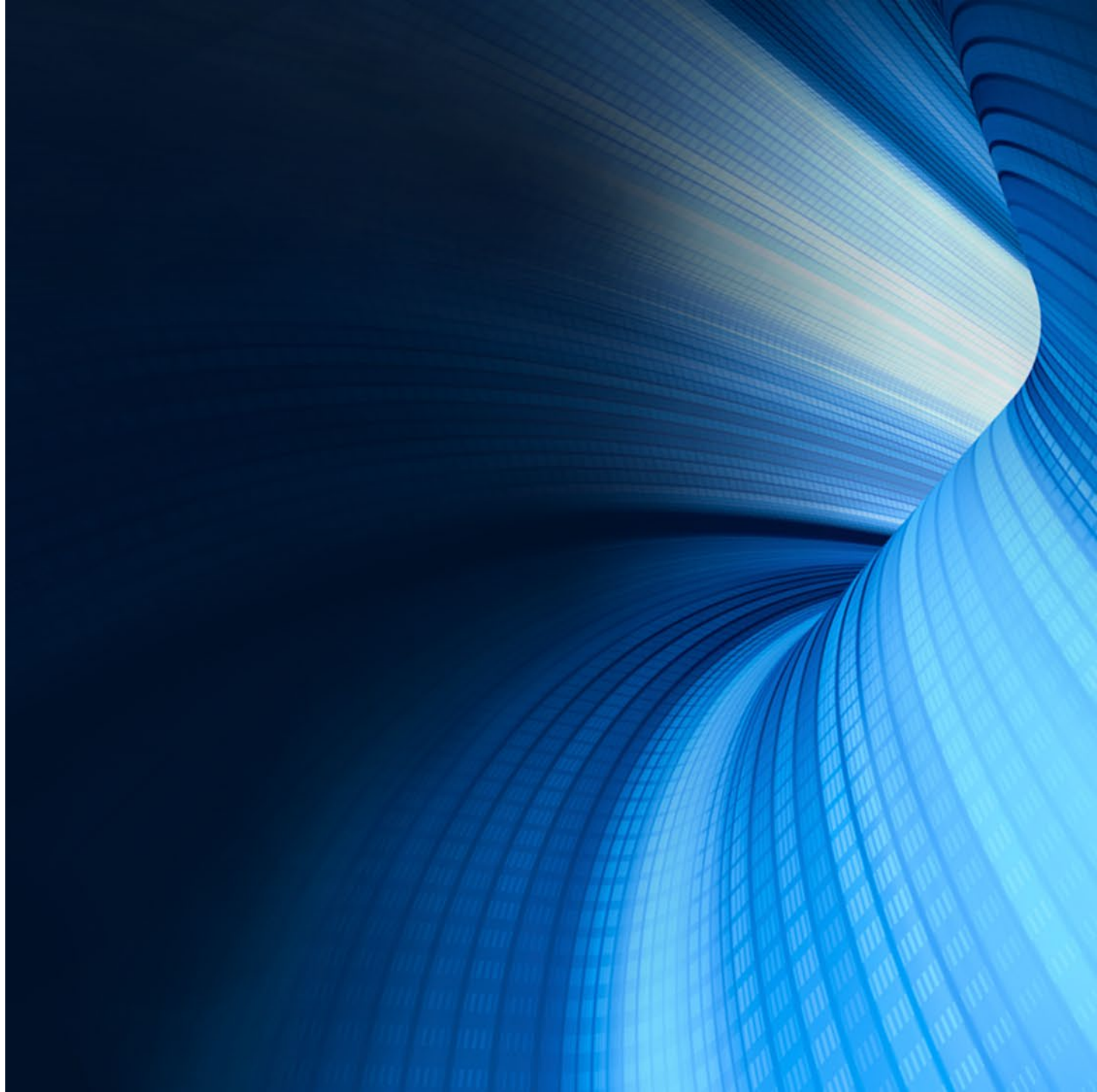
The Aviation Security Screening Optimizer for Risk and Throughput (ASSORT)

Funded by the Department of Homeland Security (DHS)
Science & Technology Directorate (S&T)

Disclaimer: The views expressed in this presentation are solely those of the presenter and not necessarily those of DHS S&T.

15 June 2023

Nick Betzsold



Operations Research at PNNL

- ✓ *One of the largest OR capabilities within national lab complex*
- ✓ *Decades of operational experience in diverse domains*
- ✓ *Mainstay skills in:*
  - *Discrete event simulation*
  - *Optimization*
  - *Mathematical modeling*
  - *Decision analysis*
  - *Life cycle cost analysis*

Risk Modeling Examples

- ✓ *Successful identification of current and future threats and risk assessments for:*
  - *DHS*
  - *DOE*
  - *DoD*
  - *IC*
  - *State and local governments*
- ✓ *Efforts require interdisciplinary teams, ability to leverage experts in variety of domains, and working directly with our sponsors*

Definitions and Risk Analysis Introduction

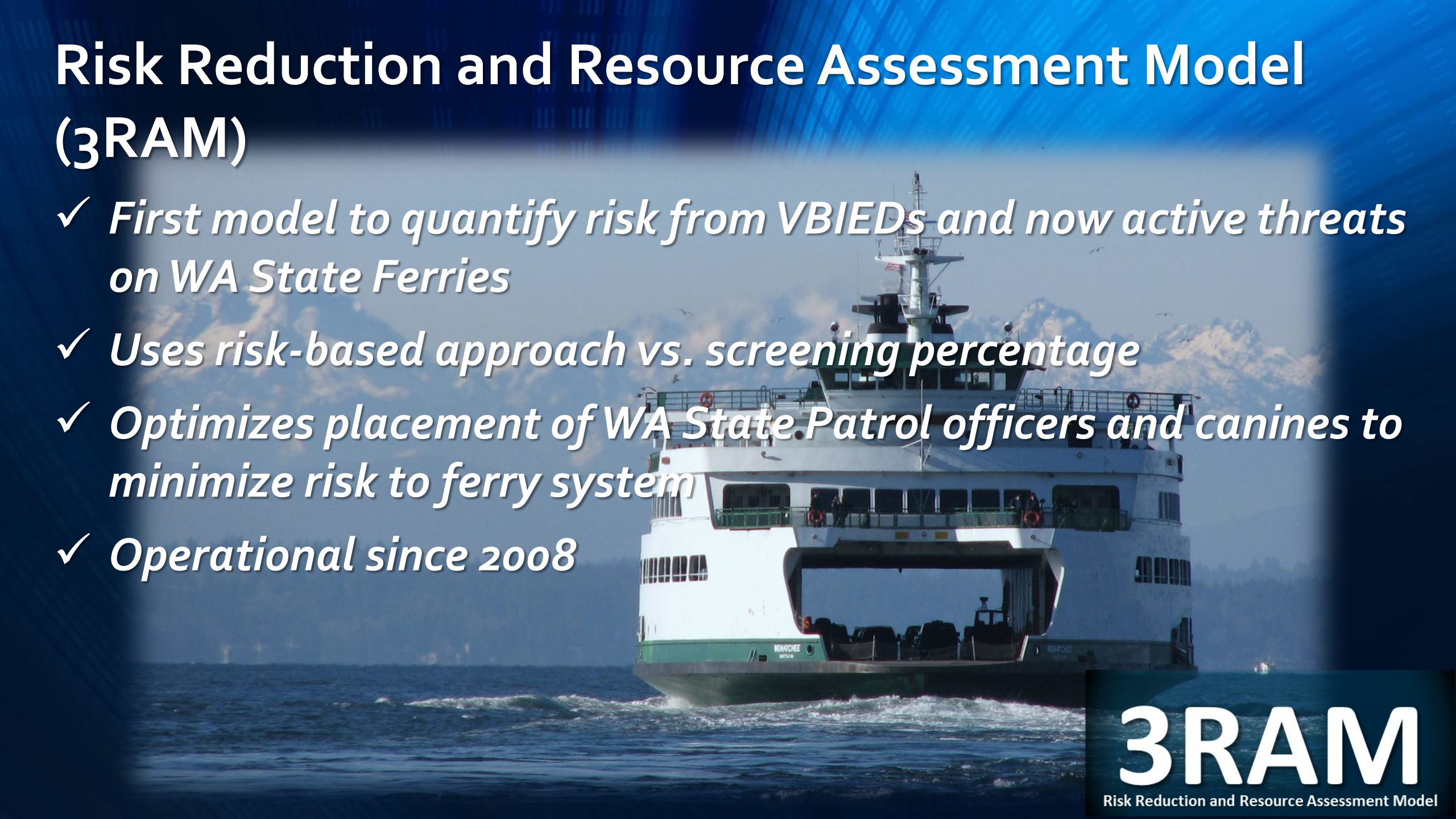
- ✓***Risk***: Potential for an unwanted outcome resulting from an incident, event, or occurrence, as determined by its likelihood and the associated consequences
- ✓***Risk Score***: Numerical result of a semi-quantitative risk assessment methodology
  - Gauges the combination of ***threat***, ***vulnerability***, and ***consequence*** at a specific moment and location
- ✓***Basic risk equation***:

$$R = f(T, V, C)$$

How likely? How difficult? How impactful?

Risk Reduction and Resource Assessment Model (3RAM)

- ✓ *First model to quantify risk from VBIEDs and now active threats on WA State Ferries*
- ✓ *Uses risk-based approach vs. screening percentage*
- ✓ *Optimizes placement of WA State Patrol officers and canines to minimize risk to ferry system*
- ✓ *Operational since 2008*



Airport Risk Assessment Model (ARAM)

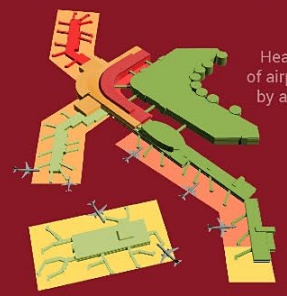
- ✓ *Airport security countermeasures work together in innumerable ways to counter potential threats and to create uncertainty*
  - *… but which way is best?*
- ✓ *Founded on DHS risk doctrine, ARAM is …*
  - *A risk-based, intel-driven decision platform (web-based software tool)*
  - *to assess and quantify terrorism risk at airports*
  - *and optimally deploy available countermeasures to minimize risk*

ARAM
AIRPORT RISK ASSESSMENT MODEL

ARAM AIRPORT RISK ASSESSMENT MODEL

AIRPORT DEFINITION

AIRPORT AREAS
+ VULNERABILITY NODES (VNs)



Heat map of airport risk by area/VN

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

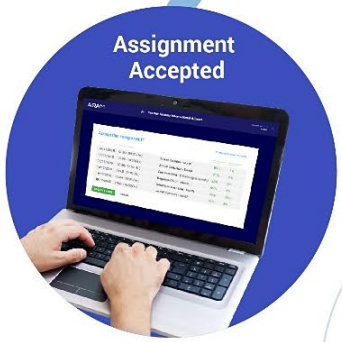
THREAT LIKELIHOOD

RISK ENGINE

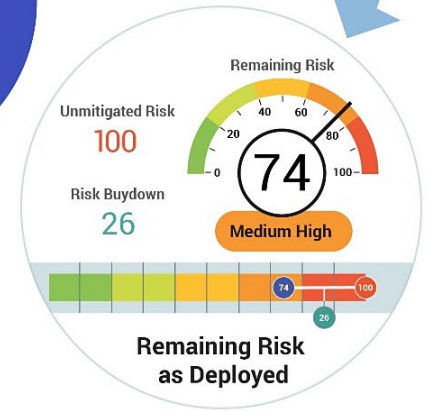
Optimal countermeasure assignments: which VNs and when to patrol

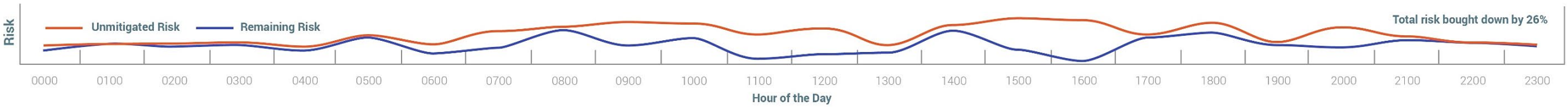
OPERATIONS

Assignment Accepted



Deployment Made (Terminal C)





ARAM Overview Video

ARAM

AIRPORT RISK ASSESSMENT MODEL

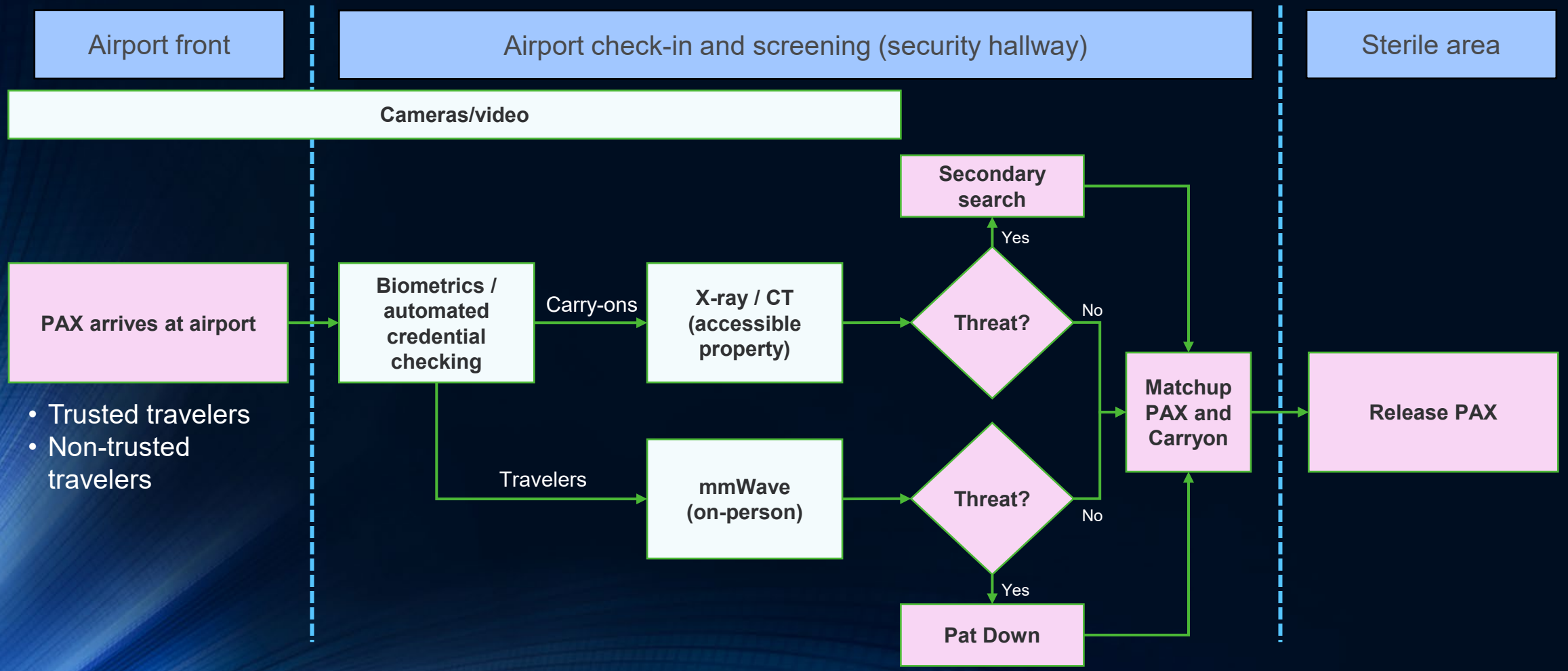
Aviation Security Screening Optimizer for Risk and Throughput (ASSORT)

- ✓ *Explore risk-based approach to screening and checkpoint operations*
  - *Risk mitigation benefits of new technologies, policies, and CONOPS*
  - *Resource requirements, both personnel and systems*
- ✓ *Employ DHS risk components: R = f (T, V, C)*
- ✓ *Opportunities for optimization and trade-off analysis*
  - *Increased risk mitigation*
  - *Reduced staffing and life cycle costs*
  - *Increased risk deterrence*
  - *Improved passenger experience*

Distributed Architecture Physical Layout (Notional)

ASSORT Technologies/Processes:

- *Cameras/video* -- "Vis" (visual data) with AI/ML for anomaly detection; initially looking for suspect threat via facial recognition, but may also consider tips about known entity (human sensor)
- *Biometrics/automated credential checking* -- face match ID, etc.
- *X-ray* -- bag screening at checkpoint using phased contrast x-ray, etc.
- *mmWave* -- As-is and walk-by (future)



ASSORT

AVIATION SECURITY SCREENING OPTIMIZER FOR RISK AND THROUGHPUT

Checkpoint Definition

Number of Checkpoints

CHECKPOINT CONFIGURATION

Number and type of lanes for each checkpoint

- General
- Trusted
- Trusted+

Attack Scenario

ITEM OF CONCERN

- Knife
- Handgun
- Rifle
- Explosive (solid)
- Explosive (powder)
- Explosive (liquid)
- Chem / bio Agent

TARGET

- Checkpoint
- Aircraft

Countermeasures

- Camera / Video
- Biometrics
- mmWave
- X-Ray
- Transportation Security Officers
  - Random pat-down
  - Random bag screening

Data Driven Models

Effectiveness Against Attack Scenario

- SCREENING PROCESS
- DETERRENCE
- PROBABILITY OF DETECTION

Risk Components

TRUST
- Passenger Type

THREAT
- Scenario Likelihood
- System Threat Likelihood

VULNERABILITY
- Organic Security
- Target Hardness

CONSEQUENCE
- Death / Injury
- Economic Impact

Data Inputs

- Flights
- Passengers
- Realtime Data

Multiple Use Cases

System Trade-Offs

- Risk
- Passenger Experience
- Life Cycle Costs

What-Ifs

- New Technologies
- New CONOPS

1. Simulated Environment

Risk Engine

Optimal checkpoint settings to balance risk and passenger experience

2. Operational Environment

Realtime Mode

- Responsive to live conditions
- Automatic adjustments
- Alerts

Pacific Northwest
NATIONAL LABORATORY

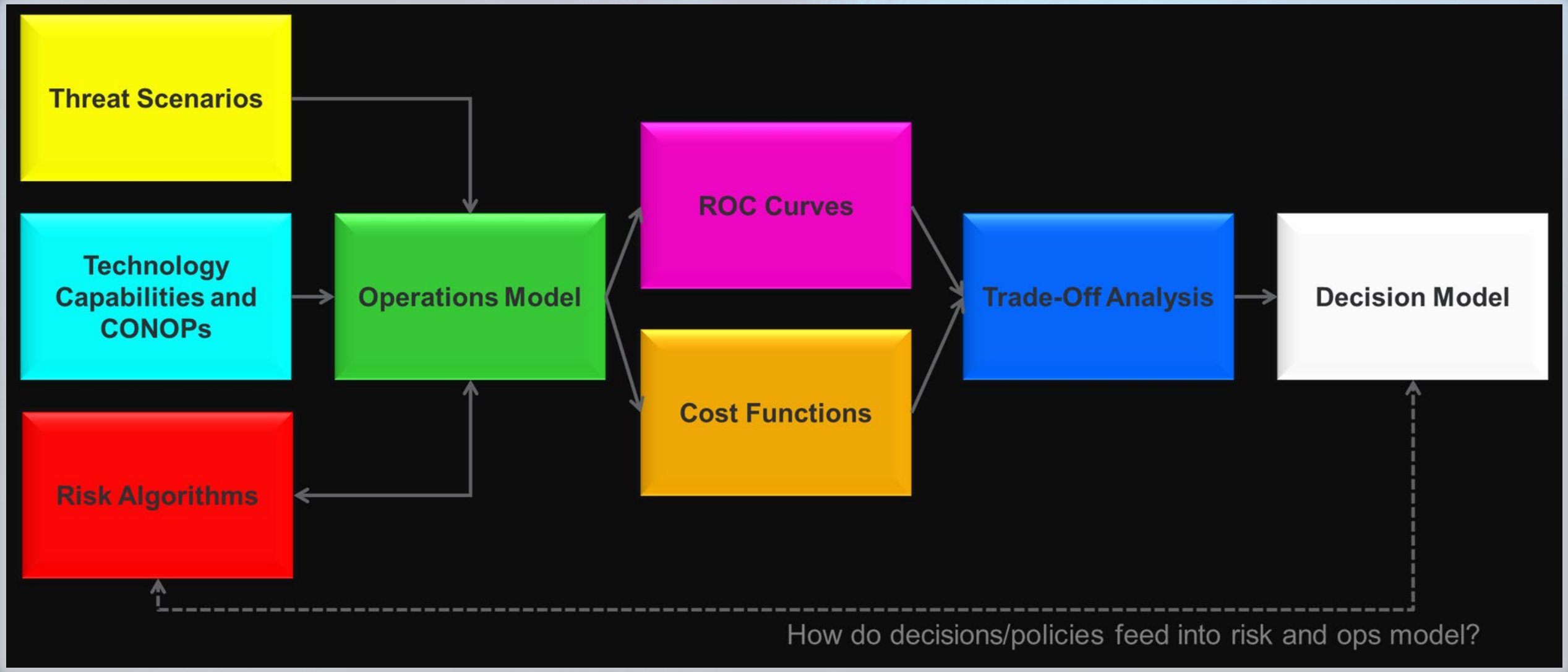
Questions?

For more information, contact:

Nick Betzsold
Data Scientist
Aviation Security & Soft Targets
NATIONAL SECURITY DIRECTORATE

Pacific Northwest National Laboratory
Richland, WA 99352 USA
Tel: (509) 375-4583
nicholas.betzsold@pnnl.gov

ASSORT Modeling Process Flow



Risk Equations

Threat	=	System Threat x Scenario Threat x Deterrence Modifier
Vulnerability	=	Target Hardness x Organic Security
Consequence	=	Death/Injury + Economic Impact
Baseline Risk	=	Threat x Vulnerability x Consequence
Total Risk	=	Baseline Risk / Passenger Trust

Ops Model: Passenger Flow

Three classes

- ✓General
- ✓Trusted
- ✓Trusted+

Technology	General Passengers	Trusted Passengers	Trusted+ Passengers
Baseline Trust	0.10	0.30	0.50
Camera/Video	0.325	0.533	0.75
Biometrics	0.55	0.766	1.0
mmWave	0.775	1.0	
X-Ray	1.0		

Passenger trust levels after each technology

*Data on this slide is completely notional.

Ops Model: User Inputs & Modifications

Simulation Config.	Airport Config.	Passengers	Risk
Duration	Number of lanes	Arrival rate[3]	Risk calculation interval
Time units	Lane statuses[2]	% Trusted travelers	Initial security posture[4]
Random seed[1]	Tech mod per set	% Trusted+ travelers	Security posture impacts[5]

1. Allows replication of results and different time periods to run (i.e., testing 100 random seeds for 24 * 60 minutes runs the simulation for 100 different days)
2. Options: "Trusted+", "Trusted", "General"
3. Currently modeled as a Poisson arrival process at overall airport checkpoint
4. Options: "High", "Medium", "Low"
5. Security posture impacts screening times for each technology, random screening rates, and false alarm rates for each technology

ASSORT Dashboard View

Auto-hide Ribbon

General Settings

Setting	Lane Type: General	Lane Type: Trusted	Lane Type: Trusted+
System Threat Likelihood	3	2	1
TSO Staffing (Checkpoint)	Average	Average	Average
Security Posture	Medium	Medium	Medium
Random Screening Level	Medium	Medium	Medium
PAX Volume	25	10	5

Instructions: user's can enter preferences on any of the green shaded cells either via dropdown lists and or direct entry of values. A description of each setting is provided by hovering mouse cursor over the parameter heading.

Reset Parameters

Additional Settings

Setting	On / Off
Human Machine Teaming	Off
Insider Threat	Off

Instructions: the default for these additional settings is off, but users can toggle these settings on to ascertain their influence on risk as well.

Attack Scenario	Scenario Total Risk Score: General	Scenario Total Risk Score: Trusted	Scenario Total Risk Score: Trusted+	Total Scenario Risk Score
1 - Knife: Checkpoint	5.0107	0.8480	0.0375	5.8961
2 - Knife: Aircraft	0.0022	0.0042	0.0004	0.0068
3 - Handgun: Checkpoint	3.0923	0.2642	0.0117	3.3682
4 - Handgun: Aircraft	0.0061	0.0229	0.0024	0.0314
5 - Rifle: Checkpoint	7.1277	0.6090	0.0269	7.7637
6 - Rifle: Aircraft	0.0003	0.0634	0.0068	0.0705
7 - Explosive (solid): Checkpoint	3.7655	0.3643	0.0237	4.1535
8 - Explosive (solid): Aircraft	0.3745	0.3636	0.0386	0.7767
9 - Explosive (powder): Checkpoint	2.5605	0.2477	0.0161	2.8244
10 - Explosive (powder): Aircraft	1.8504	1.6015	0.1701	3.6220
11 - Explosive (liquid): Checkpoint	1.8390	0.1779	0.0116	2.0284
12 - Explosive (liquid): Aircraft	0.6736	0.4397	0.0467	1.1600
13 - Chem/bio agent: Checkpoint	1.1775	0.1139	0.0074	1.2988
14 - Chem/bio agent: Aircraft	0.0452	0.0111	0.0011	0.0574

Go To General Traveler Settings

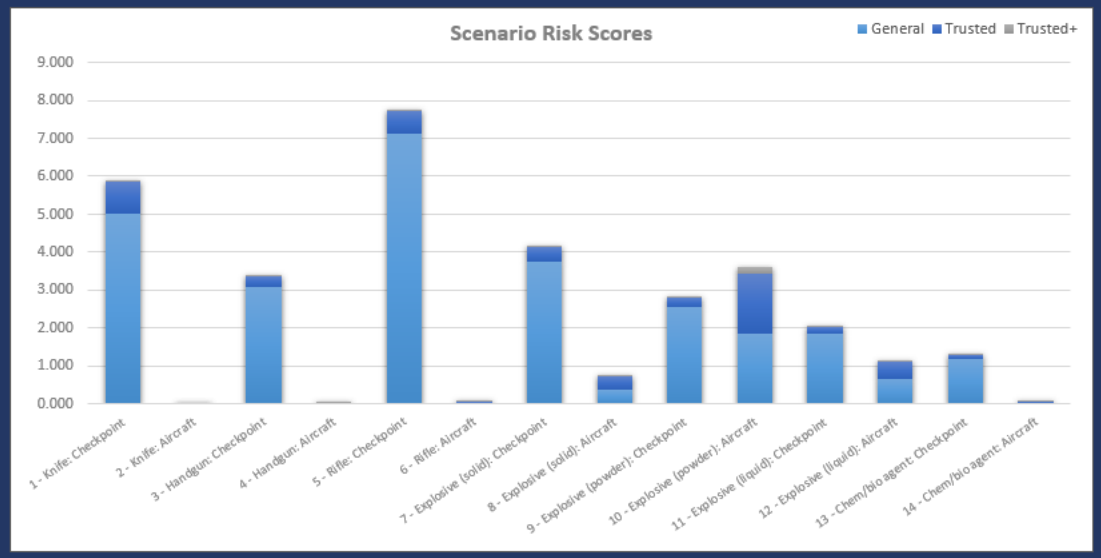
Go To Trusted Traveler Settings

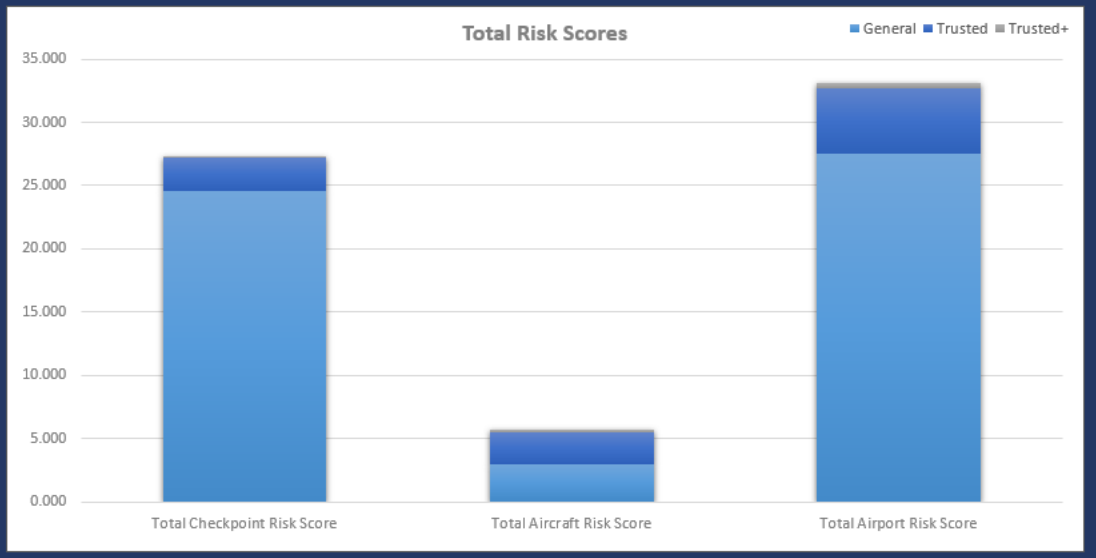
Go To Trusted+ Traveler Settings

Technology	General	Trusted	Trusted+
Camera/video	x	x	x
Biometrics	x	x	x
mmWave	x	x	
X-ray	x		
Pat down (if randomly selected)	x	x	x

Location	General	Trusted	Trusted+
Total Checkpoint Risk Score	24.5732	2.6251	0.1348
Total Aircraft Risk Score	2.9522	2.5064	0.2662
Total Airport Risk Score	27.5254	5.1315	0.4010

Top Three Risk Scenarios:
1st: 5 - Rifle: Checkpoint
2nd: 1 - Knife: Checkpoint
3rd: 7 - Explosive (solid): Checkpoint





Risk Model (Dashboard) | Risk Model (General) | Risk Model (Trusted) | Risk Model (Trusted+) | Technology Capabilities | Trust Paths | Insider Threat

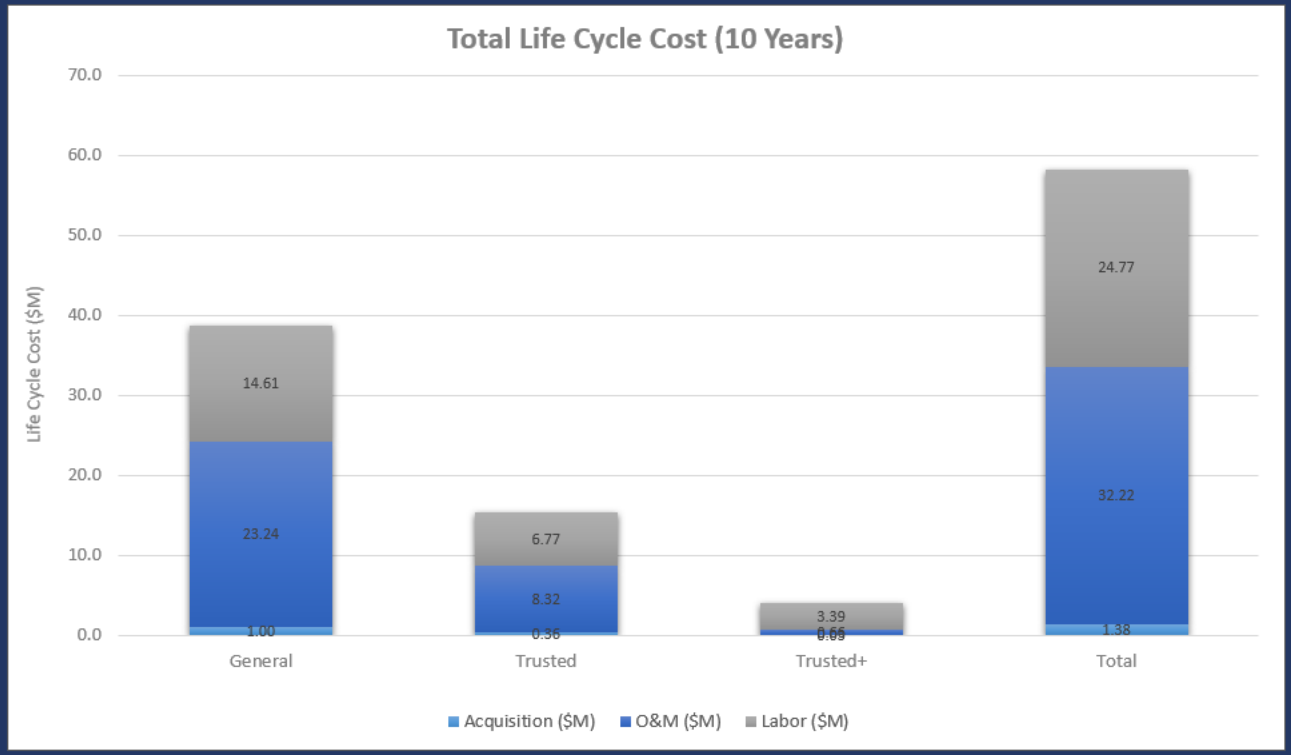
ASSORT Cost Model Dashboard

Auto-hide Ribbon

Setting	Lane Type: General	Lane Type: Trusted	Lane Type: Trusted+
Number of Lanes	3	2	1

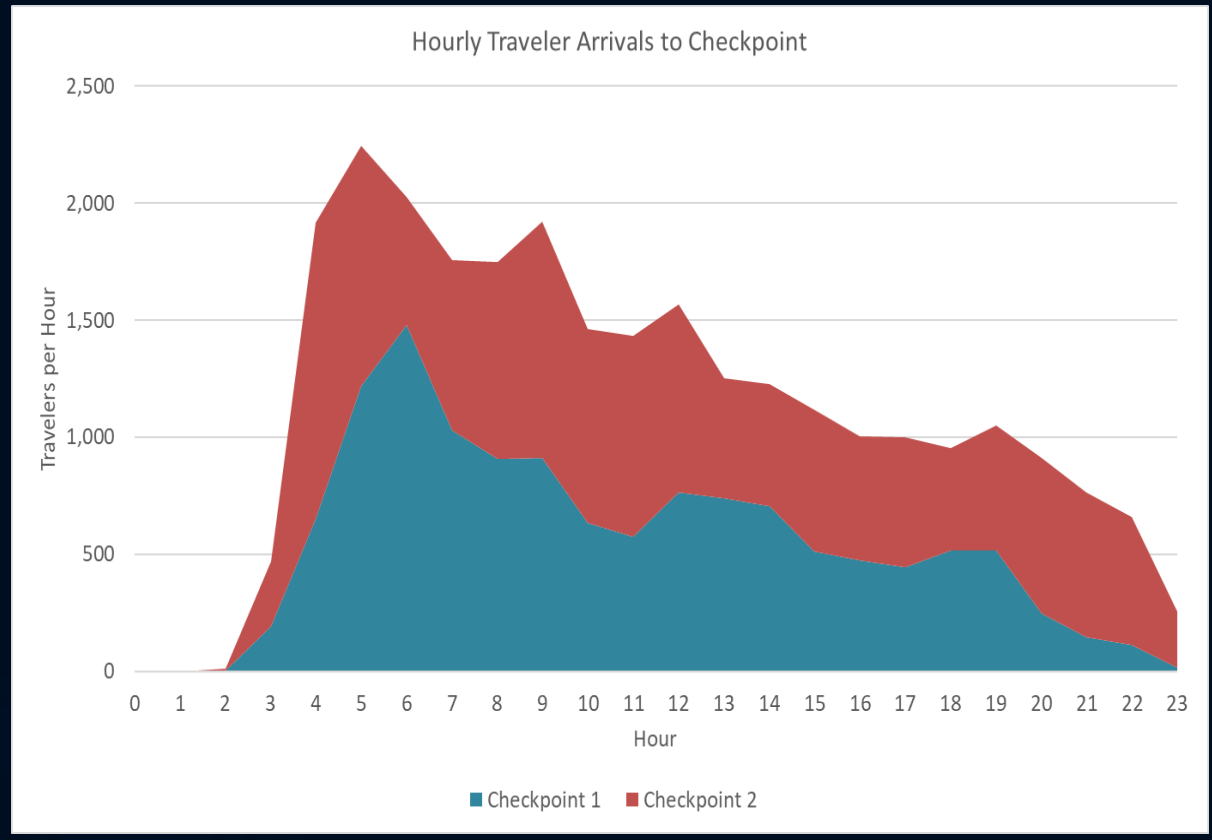
Technology	General	Trusted	Trusted+
Camera/video	x	x	x
Biometrics	x	x	x
mmWave	x	x	
X-ray	x		
Pat down (if randomly selected)	x	x	x

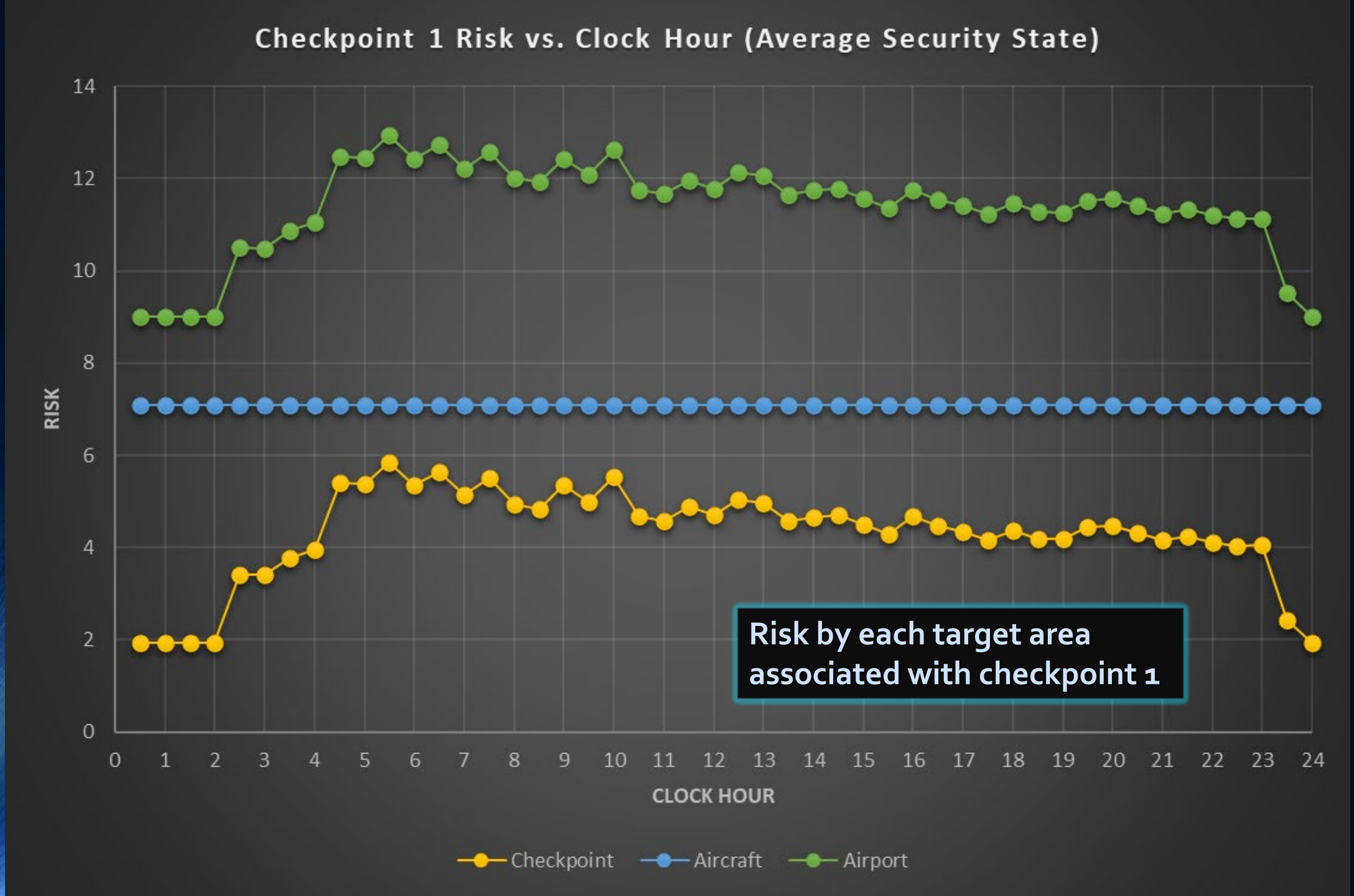
Cost Category	General	Trusted	Trusted+	Total
Acquisition ($M)	1.00	0.36	0.03	1.38
O&M ($M)	23.24	8.32	0.66	32.22
Labor ($M)	14.61	6.77	3.39	24.77
Total Life Cycle Cost ($M)	38.84	15.45	4.08	58.37

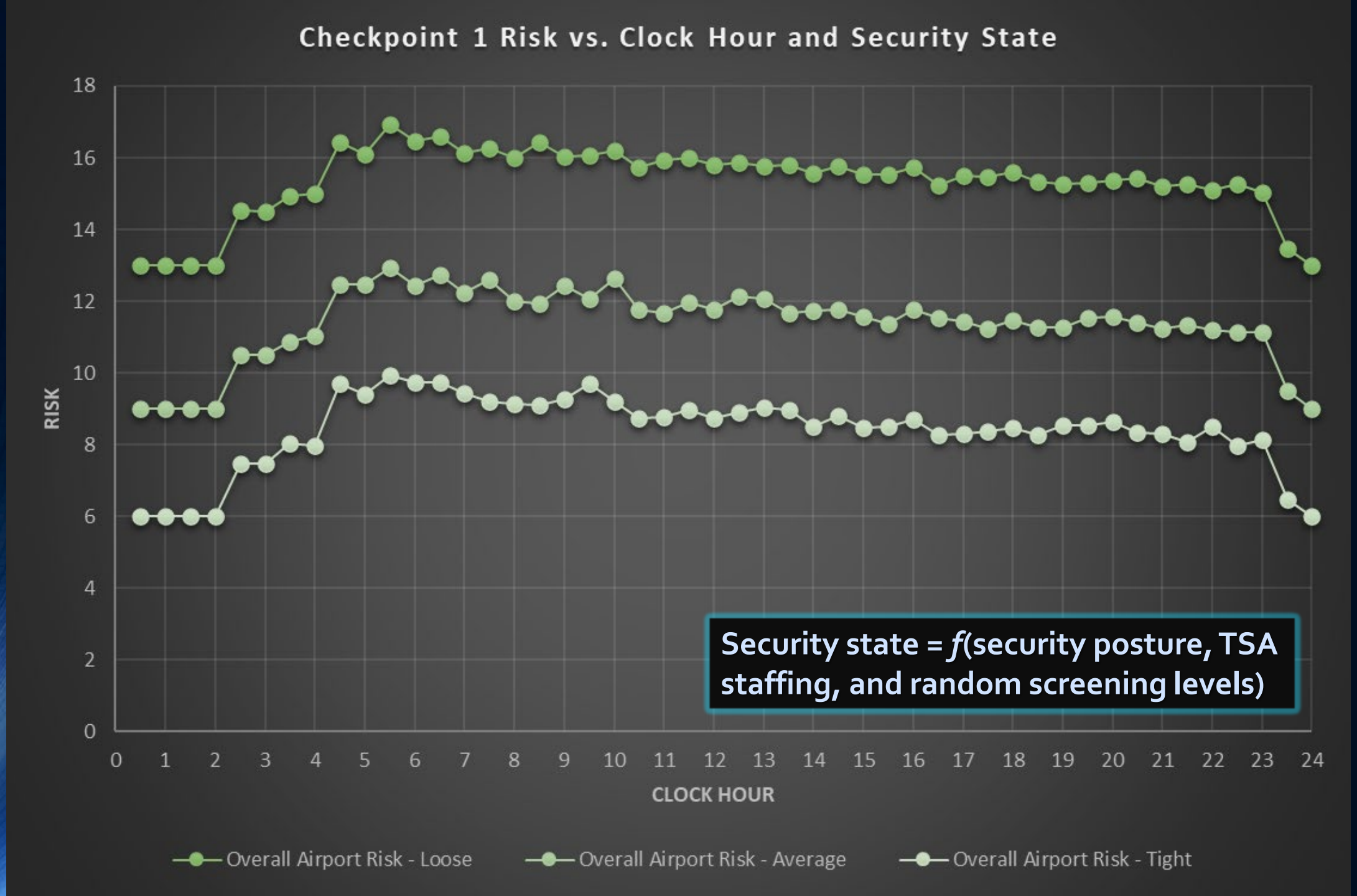


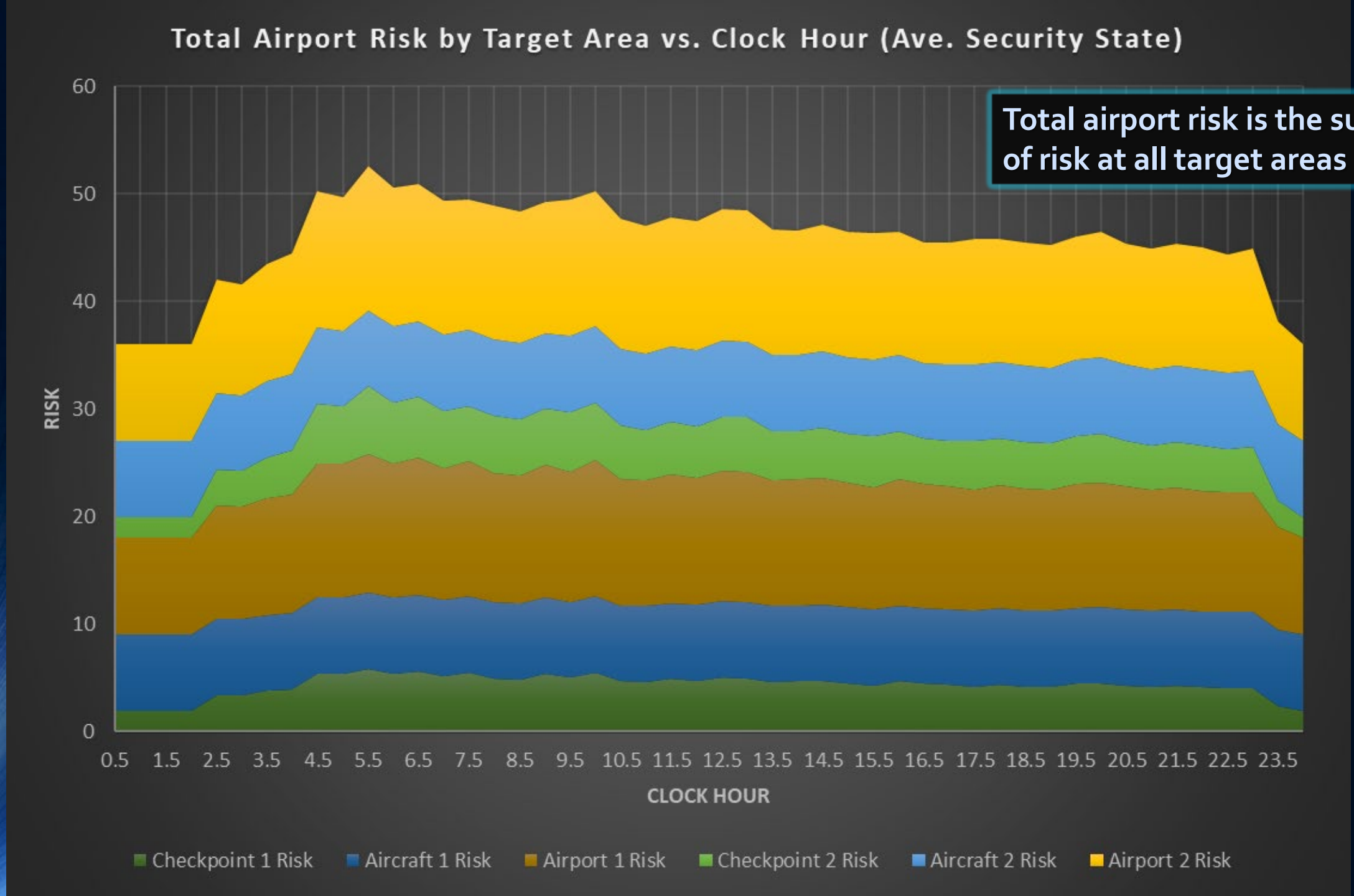
ASSORT "Demo"

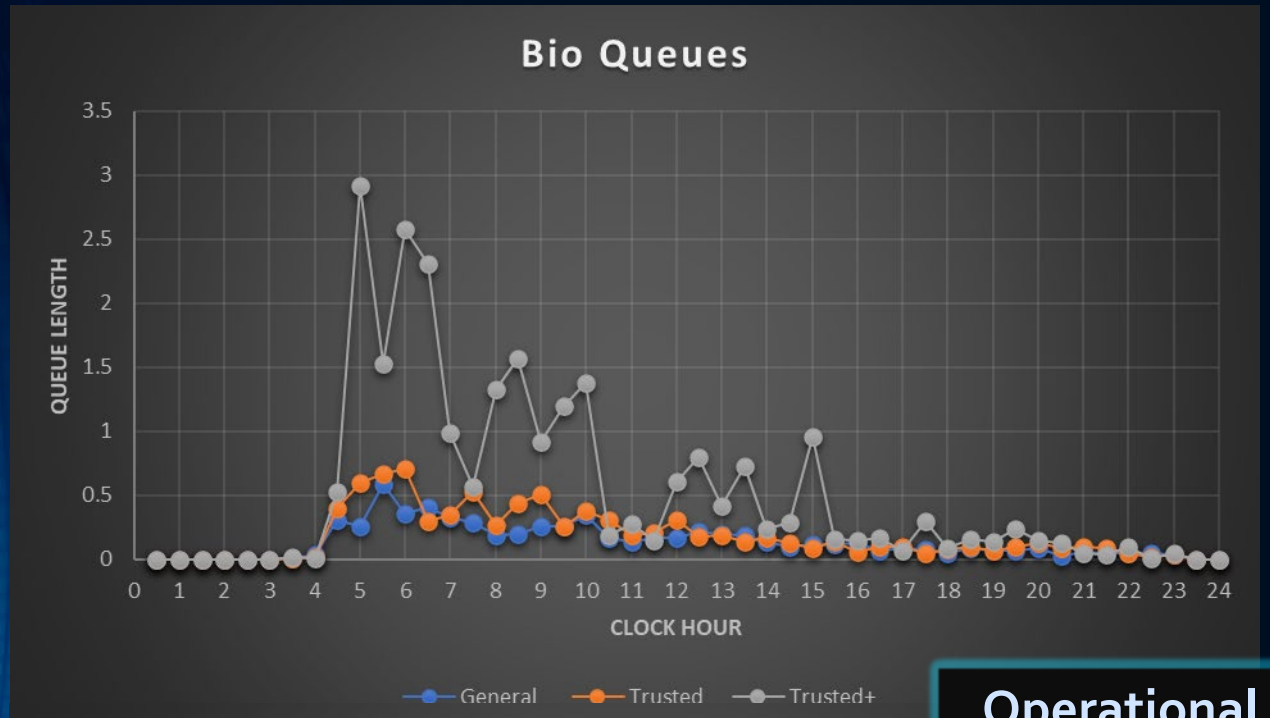
- ✓ *Setup for modeling PDX checkpoints*
  - *Checkpoint 1: 6 general lanes, 2 trusted lane, 1 trusted+ lane*
    - *50% / 30% / 20% traffic by lane type*
    - *47.8% total airport traffic*
  - *Checkpoint 2: 6 general lanes, 2 trusted lane, 1 trusted+ lane*
    - *50% / 30% / 20% traffic by lane type*
    - *52.2% total airport traffic*
  - *Typical day: 26,762 total PAX*
  - *Total LCC: 2 x $97M = $194M*

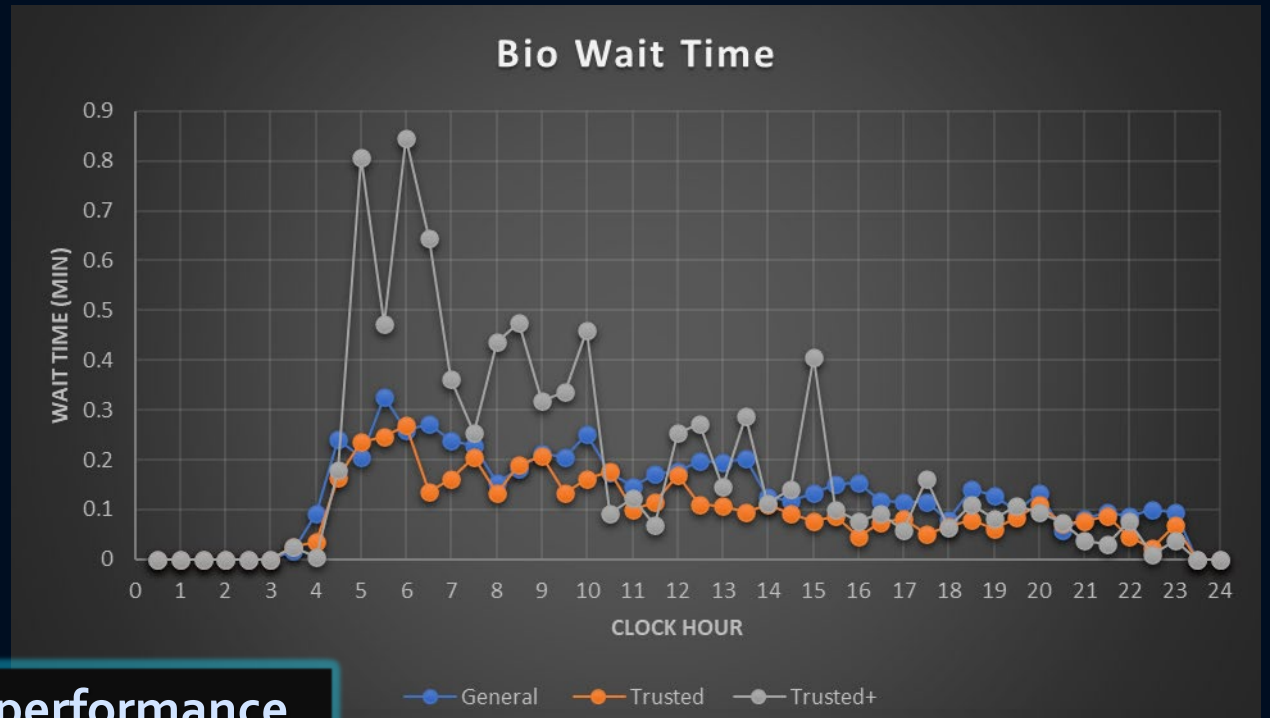



Checkpoint 1 Risk vs. Clock Hour (Average Security State)
RISK
0
2
4
6
8
10
12
14
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
CLOCK HOUR
Checkpoint
Aircraft
Airport
Risk by each target area associated with checkpoint 1

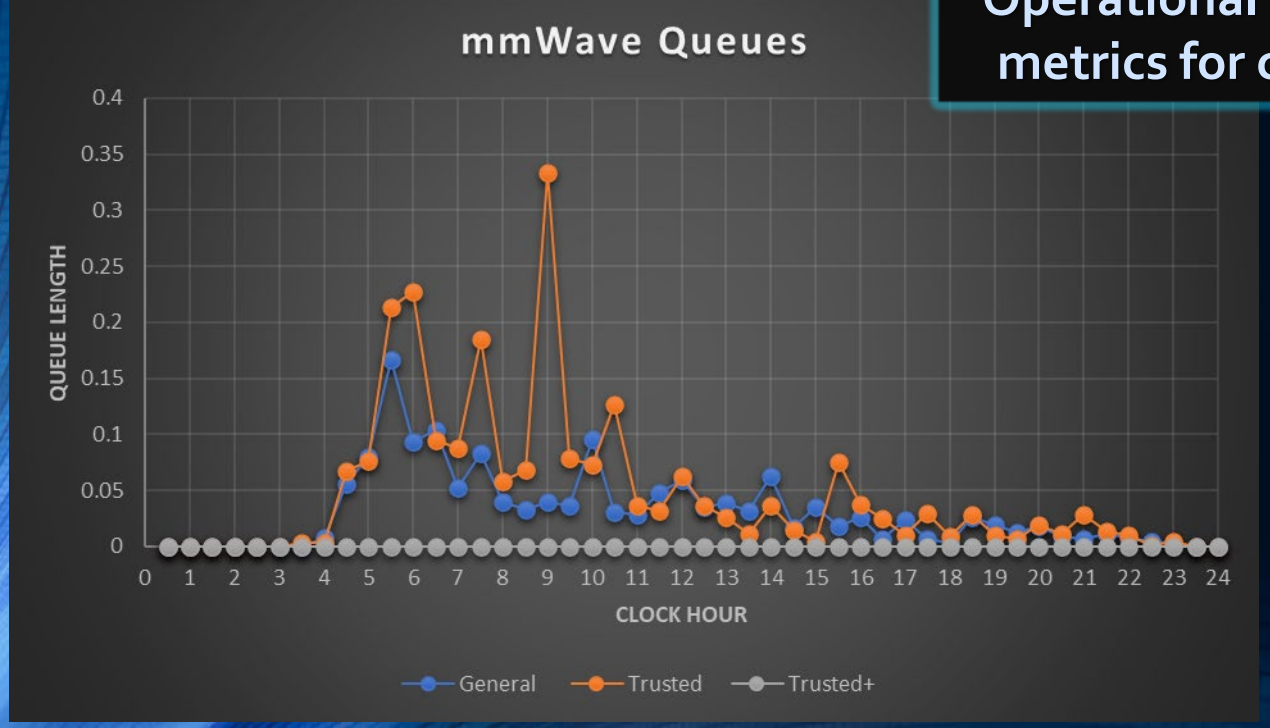

Checkpoint 1 Risk vs. Clock Hour and Security State
RISK
0
2
4
6
8
10
12
14
16
18
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
CLOCK HOUR
Security state = f(security posture, TSA staffing, and random screening levels)
Overall Airport Risk - Loose
Overall Airport Risk - Average
Overall Airport Risk - Tight

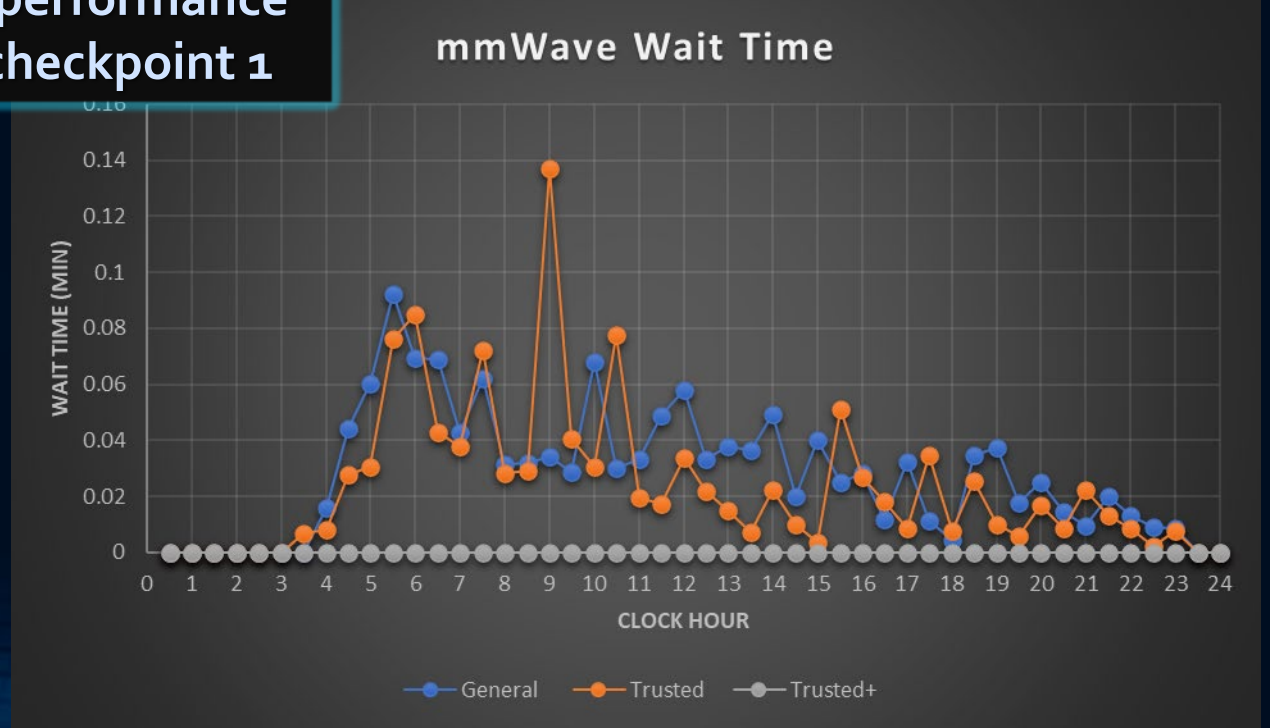

Total Airport Risk by Target Area vs. Clock Hour (Ave. Security State)
Total airport risk is the sum of risk at all target areas
RISK
60
50
40
30
20
10
0
0.5 1.5 2.5 3.5 4.5 5.5 6.5 7.5 8.5 9.5 10.5 11.5 12.5 13.5 14.5 15.5 16.5 17.5 18.5 19.5 20.5 21.5 22.5 23.5
CLOCK HOUR
Checkpoint 1 Risk
Aircraft 1 Risk
Airport 1 Risk
Checkpoint 2 Risk
Aircraft 2 Risk
Airport 2 Risk



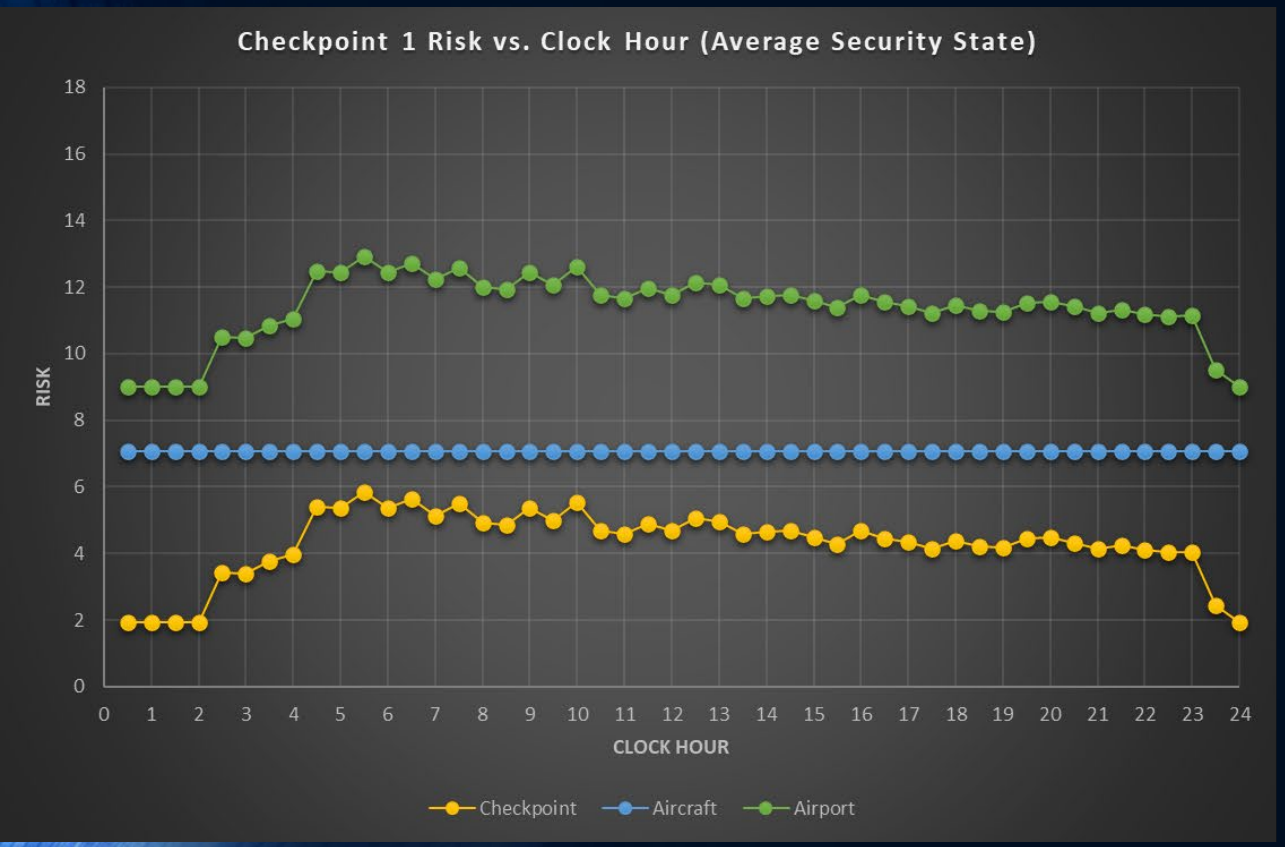


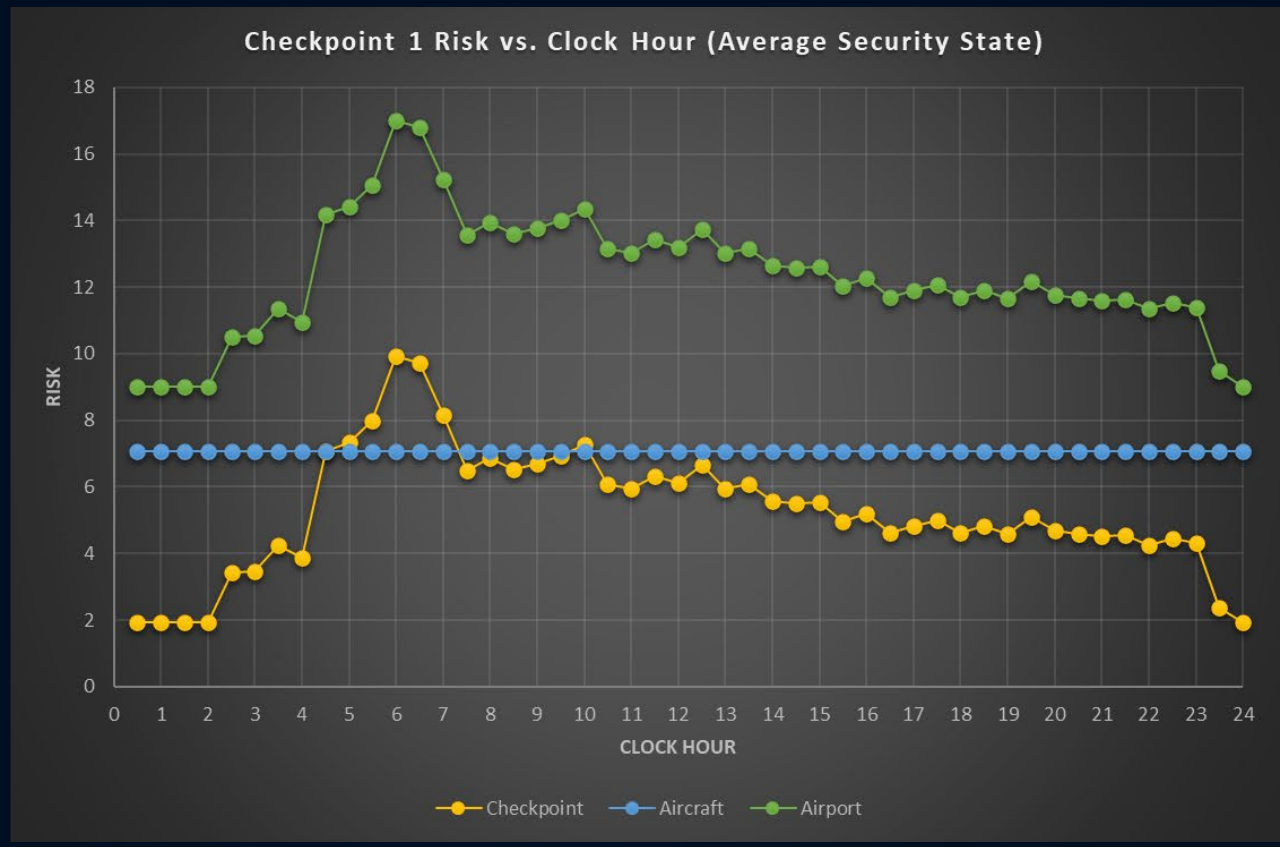
Operational performance metrics for checkpoint 1



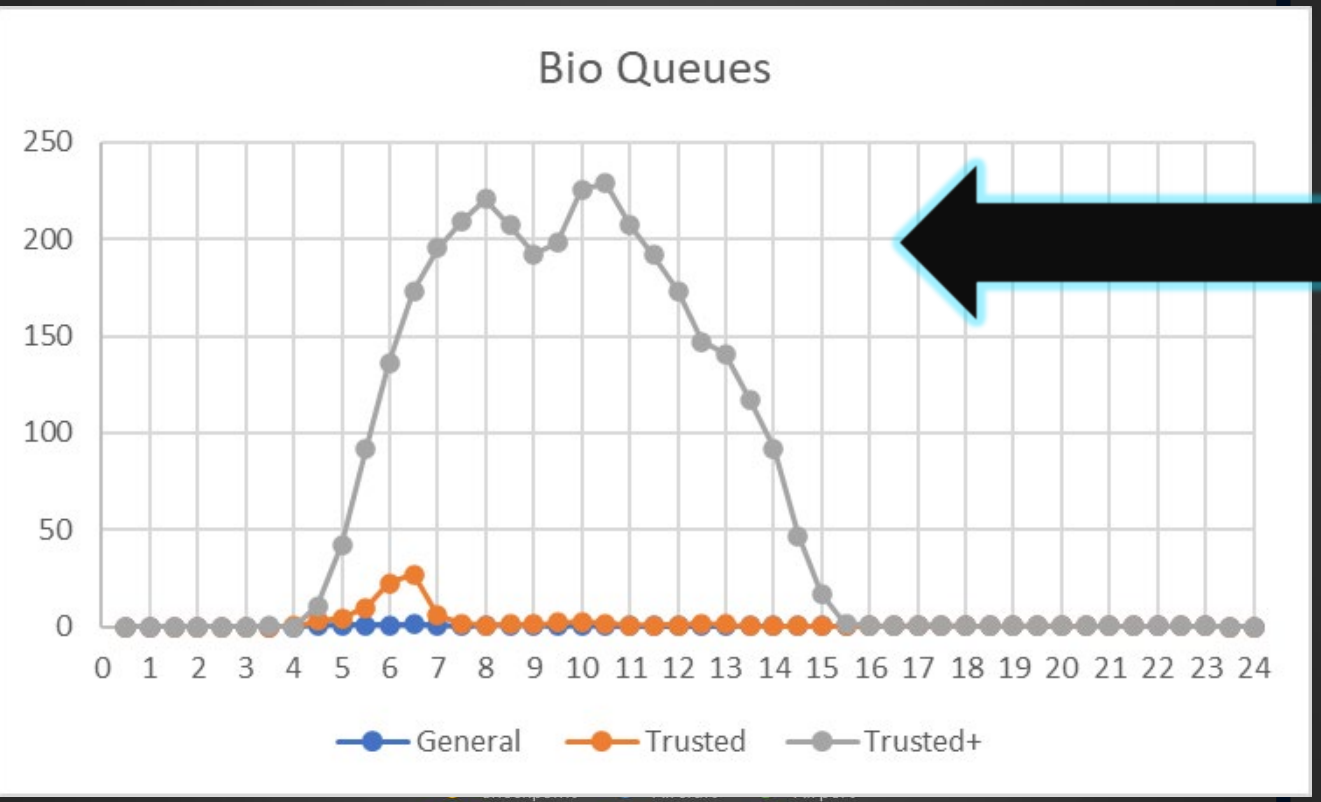


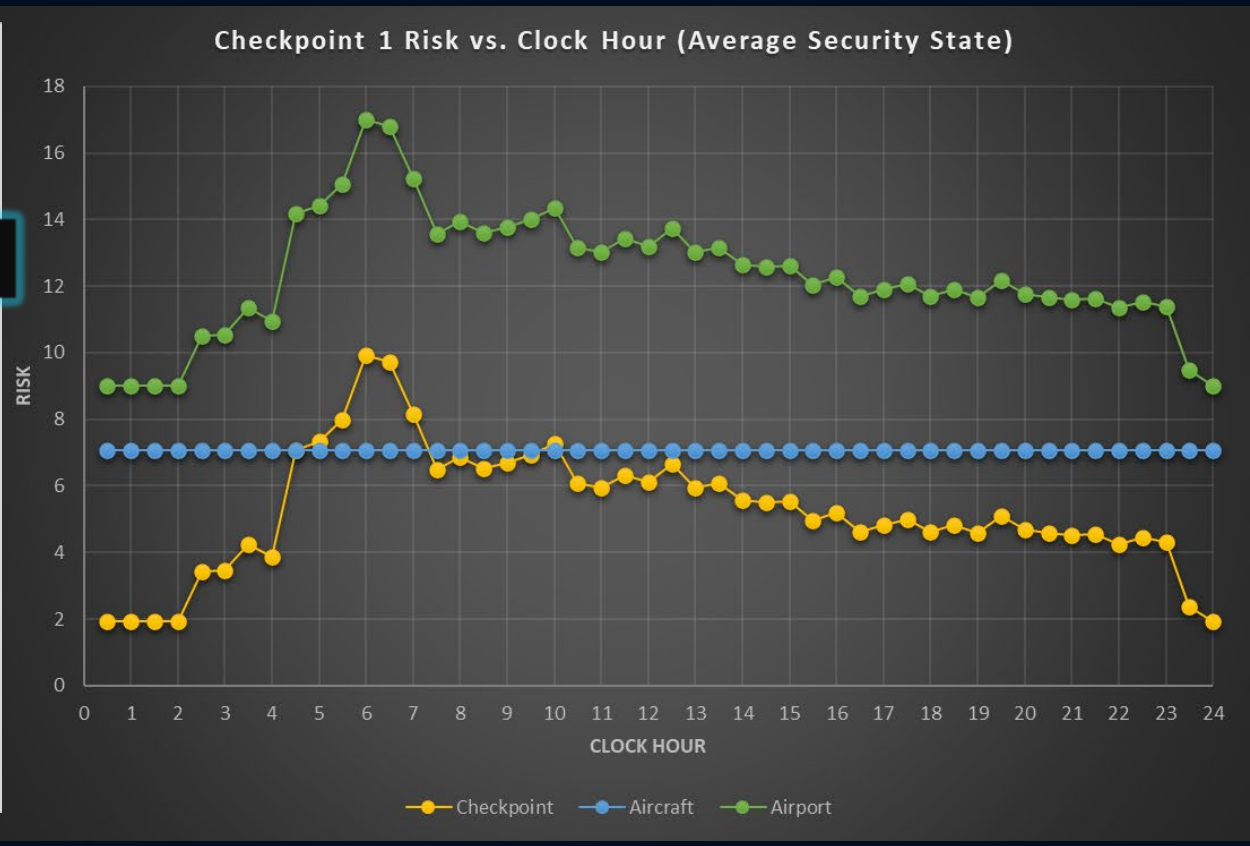
Risk by each target area associated with checkpoint 1 with 50% increase in total airport PAX





Increase in risk is associated with increased PAX queues (e.g., bio queue length)





ASSORT

- Dashboard
- Checkpoints
- Parameters
- Admin Controls

SeaTac International Airport Placeholder

Notifications Username

Airport Total Risk Scores

Select Date or Date Range

Number of PAX per Day

27,000

Checkpoint: checkpoint1

25-45	35	+05%
Range Goal	Score Now	Last Hour

Lane Type	General	Trusted	Trusted +
Pax Volume	[###]	[###]	[###]
Average Wait Time	[##] min	[##] min	[##] min
Risk Score	[##]	[##]	[##]
Countermeasures	#/#	#/#	#/#

Top Checkpoint Threats	Risk Score
1. [Scenario Name]	[##]
2. [Scenario Name]	[##]
3. [Scenario Name]	[##]

View Checkpoint

Checkpoint: checkpoint2

25-45	35	+05%
Range Goal	Score Now	Last Hour

Lane Type	General	Trusted	Trusted +
Pax Volume	[###]	[###]	[###]
Average Wait Time	[##] min	[##] min	[##] min
Risk Score	[##]	[##]	[##]
Countermeasures	#/#	#/#	#/#

Top Checkpoint Threats	Risk Score
1. [Scenario Name]	[##]
2. [Scenario Name]	[##]
3. [Scenario Name]	[##]

View Checkpoint

ASSORT

- Dashboard
- Checkpoints
- Parameters
- Admin Controls

SeaTac International Airport Placeholder

Notifications Username

Airport Total Risk Scores

Friday, Apr 25, 2022

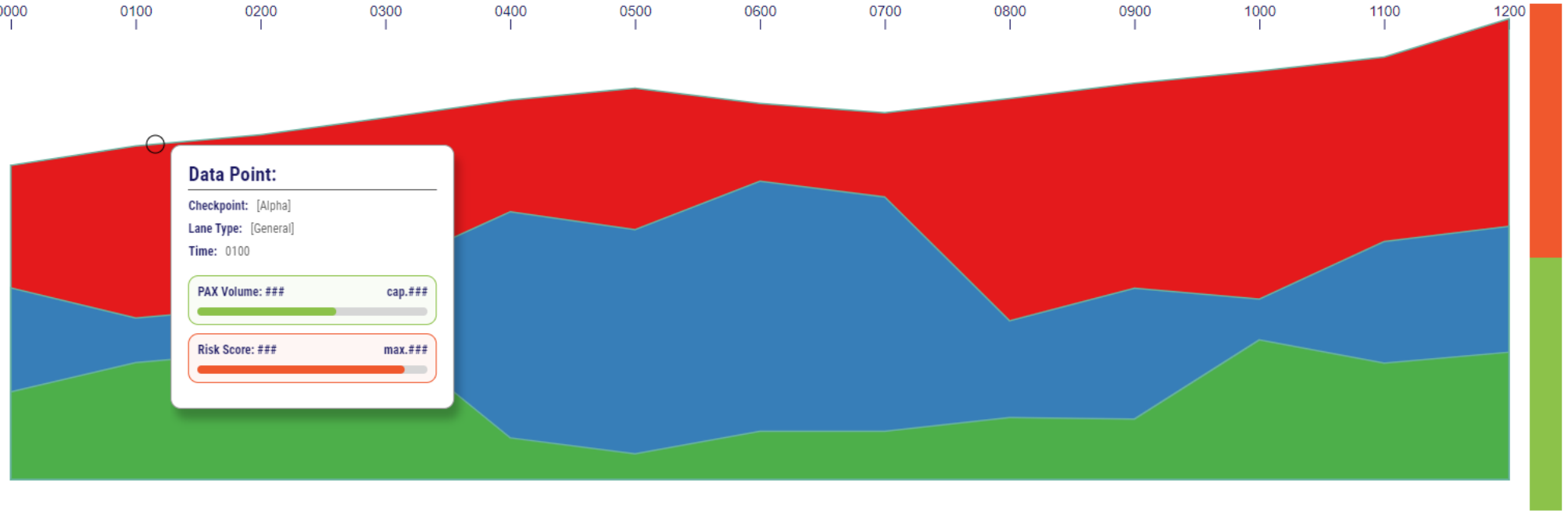
0 Checkpoints	0 Aircrafts	0 Airport

Checkpoint Risk Overview

Filter Panel

0 Checkpoints	0 Aircrafts	0 Airport

Alpha | Beta | Charlie | General | Trusted | Trusted+ | PAX Volume | Average Wait Time | Risk Score | Countermeasures



ASSORT

- Dashboard
- Checkpoints
- Parameters
- Admin Controls

All Filters

Checkpoints
- Alpha
- Beta
- Charlie

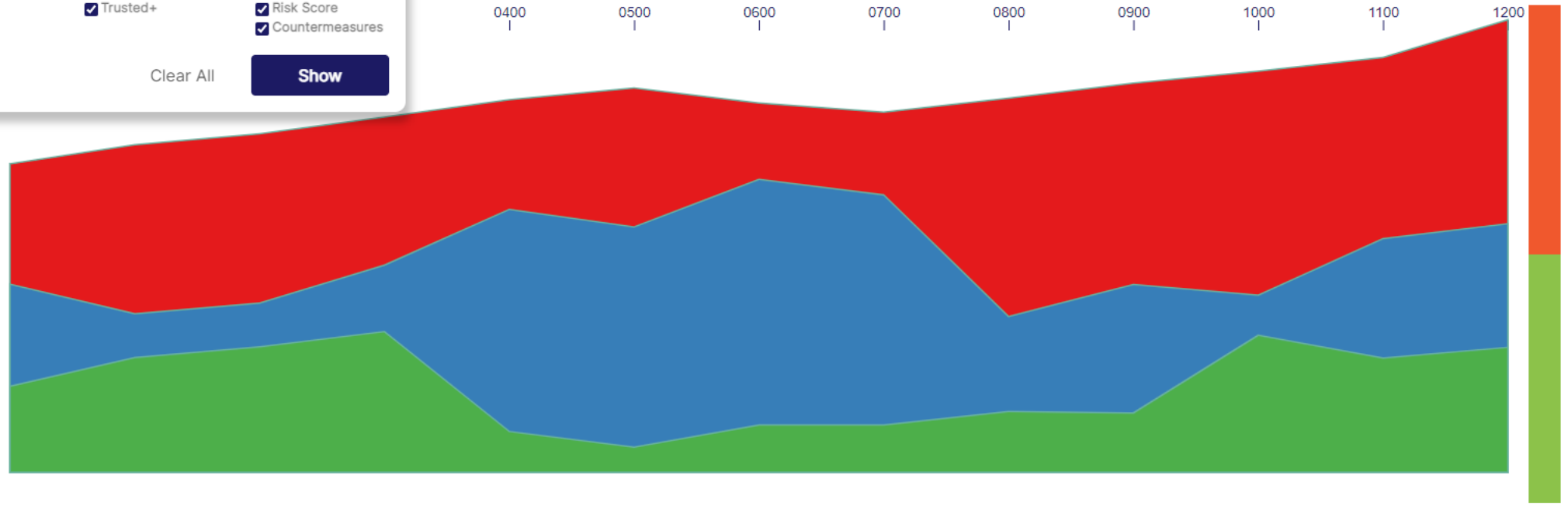
Lane Type
- General
- Trusted
- Trusted+

Show Data
- PAX Volume
- Average Wait Time
- Risk Score
- Countermeasures

Clear All | Show

0 Checkpoints | 0 Aircrafts | 0 Airport

ted | Trusted+ | PAX Volume | Average Wait Time | Risk Score | Countermeasures



Threat Scenario Risk : Checkpoint

Threat Scenario	General	Trusted	Trusted+	Score
Knife	##.##	##.##	##.##	##.##

Threat Scenario Risk : Aircraft

Threat Scenario	General	Trusted	Trusted+	Score
Knife	##.##	##.##	##.##	##.##

ASSORT

- Dashboard
- Checkpoints
- Parameters

Admin Controls

SeaTac International Airport Placeholder

Notifications Username

Parameters

edit

X-ray

Low | Medium | High

Attack Scenario	Item of Concern	Threat Target	PD1	PD2	PD3	PD4	PFA1	PFA2	PFA3	PFA4
1	Knife	Checkpoint	0	0	0	0	0.05	0.05	0.05	0.05
2	Knife	Aircraft	0.9	0.9	0.9	0.9	0.05	0.05	0.05	0.05
3	Handgun	Checkpoint	0	0	0	0	0.05	0.05	0.05	0.05
4	Handgun	Aircraft	0.95	0.95	0.95	0.95	0.05	0.05	0.05	0.05
5	Rifle	Checkpoint	0	0	0	0	0.05	0.05	0.05	0.05
6	Rifle	Aircraft	0.999	0.999	0.999	0.999	0.05	0.05	0.05	0.05
7	Explosive (solid)	Checkpoint	0	0	0	0	0.05	0.05	0.05	0.05
8	Explosive (solid)	Aircraft	0.8	0.8	0.8	0.8	0.05	0.05	0.05	0.05
9	Explosive (powder)	Checkpoint	0	0	0	0	0.05	0.05	0.05	0.05
10	Explosive (powder)	Aircraft	0.775	0.775	0.775	0.775	0.05	0.05	0.05	0.05
11	Explosive (liquid)	Checkpoint	0	0	0	0	0.05	0.05	0.05	0.05
12	Explosive (liquid)	Aircraft	0.7	0.7	0.7	0.7	0.05	0.05	0.05	0.05
13	Chem/bio agent	Checkpoint	0	0	0	0	0.05	0.05	0.05	0.05
14	Chem/bio agent	Aircraft	0.2	0.2	0.2	0.2	0.05	0.05	0.05	0.05