Introduction

In the beginning, the TSA had just one ATR that identified explosive threats in the bag scanned image. As the detection system matured and intel identified additional threats, different explosive ATRs were developed along with Prohibited Item (PI) algorithms. The TSA decided to expand the scope of the detection algorithms from just the OEM to Third-Parties and TSA-owned detection algorithms called Government-Owned Algorithms (GOAs). These are algorithms funded directly by the TSA and owned by the TSA.
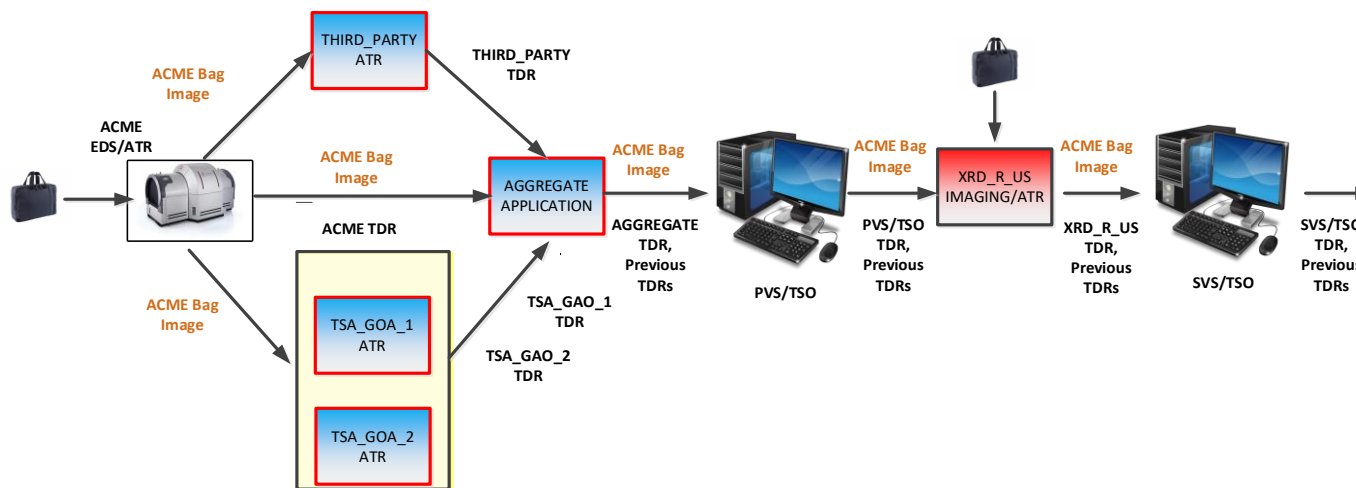

Figure 1. Example for the development of the Aggregate TDR from the ACME EDS image and sequence flow through the screening process with the accompanying TDRs.

Figure 1 shows an example of a screening process implementation with an aggregate of TDR for the different ATRs applied to the ACME EDS image, an Operator PVS TDR, an XRD_R_US TDR, and finally, an Operator SVS TDR. Each ATR generates its Threat Detection Report (TDR) for the ATRs used in the ACME EDS image. Each ATR generates its Threat Detection Report (TDR). In this case, there would be four different ATRs generated. One for the original ACME screening device, one for the THIRD_PARTY ATR,

two for the TSA GOAs, TSA_GOA_1TDR, and TSA_GOA_2 TDR. In DICOS and the TSA design, only one Aggregated TDR from the ACME EDS image would be presented to the Primary Viewing Station (PVS) TSO for alarm resolution.

In contrast, the image is given to the PVS. Offering four different TDRs with possible redundancy of PTOs submitted to the PVS TSO for alarm resolution. The solution is to combine these four ACME EDS Image TDRs into one Aggregated TDR.   The individual PTOs would be reordered to create a logic flow in developing the Aggregated TDR. In addition, any redundant PTOs in different TDRs will be reconciled in a forthcoming paper. The set theory representation of the solution of the Aggregate TDR is shown in Figure 2.

$$\text{Aggregate TDR} = \text{PTO(n)} (\text{ACME TDR} \cup \text{THIRD\_PARTY TDR} \cup \text{TSA\_GAO\_1 TDR} \cup \text{TSA\_GAO\_2 TDR}) -$$

$$\text{PTO(n)} (\text{ACME TDR} \cap \text{THIRD\_PARTY TDR} \cap \text{TSA\_GAO\_1 TTR} \cap \text{TSA\_GOA\_2}) +$$

$$\text{ROI/BB Resolution} [\text{PTO(n)} (\text{ACME TDR} \cap \text{THIRD\_PARTY TDR} \cap \text{TSA\_GAO\_1 TDR}) \cap \text{TSA\_GAO\_2 TDR})]$$

Figure 2. The resolution of the PTOs presented by each of the ACME EDS image ATRs.

This is an example of four independent Machine TDRs produced from the same ACME-generated image. The Aggregate TDR combines the original ACME TDR and the other three TDRs generated from the ACME-generated image. The ACME Machine TDR generated a PTO 1 identified as an explosive with a TIP threat introduced into the TDR as PTO 2. The THIRD_PARTY ATR analyzed the original ACME image was analyzed by the THIRD_PARTY ATR and generated a TDR with a Prohibited Item (PI) identified as a Medium Knife as PTO 1. A third ATR, TSA_GOA_1, was applied against the ACME-generated image and generated a TDR which identified an Explosive as PTO 1. Finally, a fourth ATR, TSA_GOA_2, was applied to the ACME-generated image and developed a clear TDR. The four different Machine TDRs aggregated into an Aggregate TDR are shown in Table 1. These will be aggregated into one final TDR, as shown in Table 2, which would be presented to the Operator PVS TSO for alarm resolution. The Operator PVS TSO TDR results would then be given to the XRD_R_US screening device in an attempt to resolve any outstanding explosive threats remaining from the Operator PVS TSO. The XRD_R_US cannot attempt to resolve any PI threats. The resulting XRD_R_US TDR is then presented to the Operator SVS TSO to perform the final alarm resolution of the bag before sending it to the local law enforcement agency if the concluding threats cannot be resolved.

Table 1: TDRs for four different detection algorithms applied to the same machine-generated bag image.

	Example Description → Attributes ↓	ACME 2019_10_2_3 Finds Explosive	THIRD_PARTY 2021_10_3_2 Finds PI Sharps	TSA_GOA_1 2020_4_2-35 Finds Explosives	TSA_GAO_2 2021_2_02A Finds PI Blunts
OOI Module					
	OOI ID	9000000001	9000000002	9000000003	9000000001
	Issuer of OOI ID	BHS-XYZ	BHS-XYZ	BHS-XYZ	BHS-XYZ
	Type of OOI ID	BARCODE	BARCODE	BARCODE	BARCODE
	Algorithm Routing Code Sequence	2019_10_2_3	2021_10_3_2	2020_4_2-35	Not present
	OOI Type	BAGGAGE	BAGGAGE	BAGGAGE	BAGGAGE
Additional Inspection Selection Criteria Module					
	Additional Screening Performed	YES	YES	YES	
	Additional Inspection Selection Criteria	BEHAVIORAL	BEHAVIORAL	BEHAVIORAL	
	Additional Inspection Method	-	-	-	
<Scan, Series, Frame of Reference, and Equipment Not Listed in these examples.>					
General Report Module					
	Instance Number	20201130.1	20201130.2	20201130.3	3345
	Content Date	20201130	20201130	20201130	20201130
	Content Time	120000.0	120000.0	120000.0	112330.000000
Threat Detection Report Module					
	TDR Type	MACHINE	MACHINE	MACHINE	MACHINE
	Image Scale Representation	1.0	.75	1.1	not present
	Alarm Decision Time	20201130120000.175	20201130120000.150	20201130120000.250	20090511110430.779
	Alarm Decision	ALARM	ALARM	ALARM	CLEAR

Example Description → Attributes ↓	ACME 2019_10_2_3 Finds Explosive	THIRD_PARTY 2021_10_3_2 Finds PI Sharps	TSA_GOA_1 2020_4_2-35 Finds Explosives	TSA_GAO_2 2021_2_02A Finds PI Blunts
Abort Flag	SUCCESS	SUCCESS	SUCCESS	SUCCESS
Abort Reason	-	-	-	-
Algorithm Developer Name	ACME	THIRD_PARTY	TSA_GOA_1	TSA_GOA_2
Threat Detection Algorithm and Version	2019_10_2_3	2021_10_3_2	2020_4_2-35	2021_2_02A
Operator Identification Sequence	-	-	-	-
> Person Identification Sequence Operator ID	-	-	-	-
> Person Identification Sequence Operator Name	-	-	-	-
> Organization Code Sequence Operator's Company	ORD	ORD	ORD	ORD
Number of Total Objects	2	1	1	0
Number of Alarm Objects	2	1	1	0
Total Processing Time [msec]	175	150	250	279
Threat Sequence Module [PTO 1]				
Algorithm Developer Name	ACME	THIRD_PARTY	TSA_GOA_1	
Threat Detection Algorithm and Version	2019_10_2_3	2021_10_3_2	2020_4_2-35	
Threat Sequence	Present	Present	Present	

Example Description → Attributes ↓	ACME 2019_10_2_3 Finds Explosive	THIRD_PARTY 2021_10_3_2 Finds PI Sharps	TSA_GOA_1 2020_4_2-35 Finds Explosives	TSA_GAO_2 2021_2_02A Finds PI Blunts
>Potential Threat Object ID	1	1	1	
>Referenced PTO Sequence	Not Present	Not Present	Not Present	
>>Potential Threat Object ID	Not Present	Not Present	Not Present	
>>Referenced TDR Instance Sequence	Not Present	Not Present	Not Present	
>Assessment Sequence	Present	Present	Present	
>>Threat Category	EXPLOSIVE	PI	EXPLOSIVE	
>>Threat Category Description	Explosive	Medium Knife	Explosive	
>>Ability Assessment	NO_INTERFERENCE	NO_INTERFERENCE	NO_INTERFERENCE	
>>Assessment Flag	THREAT	THREAT	THREAT	
>>Assessment Probability	90	95	80	
Start Time of Processing	20201130120000.05	20201130120000.05	20201130120000.05	
End Time of Processing	20201130120000.175	20201130120000.150	20201130120000.250	
Total Time for Processing	125	100	200	
Baggage-Specific TDR Details Macro [PTO 1]				
>PTO Representation Sequence	Present	Present	Present	
>Referenced Instance Sequence	Present	Present	Present	
>>Bounding Polygon	(241,90,0) (367,180,0)	(125,100,50) (125,175,120)	(111,222,333) (176,300,399)	
>>Threat ROI Voxel Sequence	Present	Present	Present	

Example Description → Attributes ↓	ACME 2019_10_2_3 Finds Explosive	THIRD_PARTY 2021_10_3_2 Finds PI Sharps	TSA_GOA_1 2020_4_2-35 Finds Explosives	TSA_GAO_2 2021_2_02A Finds PI Blunts
>>>Threat ROI Base	(241,90,0)	(125,100,50)	(111,222,333)	
>>>Threat ROI Extents	(126,90,0)	(125,175,120)	(66,79,67)	
>>>Threat ROI Bitmap	Present	Present	Present	
>>PTO Location Description	Present	Present	Present	
>>Center of PTO	(254,135, 0)	(125, 150, 80)	(124,255,370)	
>>Center of Mass	(288,129,0)	(125, 140, 100)	(124,255,370)	
>Mass of PTO	Present	Present	Present	
>Density of PTO	1.32	7.00	-	
>Z Effective	7.31	25	-	
>Volume of PTO	Present	Present	Present	

Threat Sequence Module [PTO 2]				
Algorithm Developer Name	TIP			
Threat Detection Algorithm and Version	Item: 1768			
Threat Sequence	Present			
>Potential Threat Object ID	1			
>Referenced PTO Sequence	Not Present			
>>Potential Threat Object ID	Not Present			
>>Referenced TDR Instance Sequence	Not Present			
>Assessment Sequence	Present			

Example Description → Attributes ↓	ACME 2019_10_2_3 Finds Explosive	THIRD_PARTY 2021_10_3_2 Finds PI Sharps	TSA_GOA_1 2020_4_2-35 Finds Explosives	TSA_GAO_2 2021_2_02A Finds PI Blunts
>>Threat Category	PI			
>>Threat Category Description	Large Gun			
>>Ability Assessment	NO_INTERFERENCE			
>>Assessment Flag	THREAT			
>>Assessment Probability	95			
Start Time of Processing	20201130120000.05			
End Time of Processing	20201130120000.150			
Total Time for Processing	100			
Baggage-Specific TDR Details Macro [PTO 2]				
>PTO Representation Sequence	Present			
>Referenced Instance Sequence	Present			
>>Bounding Polygon	(350,184,0) (437,336,0)			
>>Threat ROI Voxel Sequence	Present			
>>>Threat ROI Base	(350,184,0)			
>>>Threat ROI Extents	(87,152,0)			
>>>Threat ROI Bitmap	Present			
>>PTO Location Description	Present			

Example Description → Attributes ↓	ACME 2019_10_2_3 Finds Explosive	THIRD_PARTY 2021_10_3_2 Finds PI Sharps	TSA_GOA_1 2020_4_2-35 Finds Explosives	TSA_GAO_2 2021_2_02A Finds PI Blunts
>>Center of PTO	(393, 260, 0)			
>>Center of Mass	(393, 260, 0)			
>Mass of PTO	Present			
>Density of PTO	7.00			
>Z Effective	25			
>Volume of PTO	Present			

Table 2: The summation of four different TDRs into one Aggregated TDR is shown in the second column. Threats are referenced from original source TDRs and their bitmaps are not always included.

Example Description → Attributes ↓	Aggregate TDR w/ instance references
OOI Module	
OOI ID	9000000004
Issuer of OOI ID	BHS-XYZ
Type of OOI ID	BARCODE
Algorithm Routing Code Sequence	2019_10_2_3
OOI Type	BAGGAGE
Additional Screening Performed	YES
Additional Inspection Selection Criteria	BEHAVIORAL
Additional Inspection Method	-

	Example Description → Attributes ↓	Aggregate TDR w/ instance references
	<Scan, Series, Frame of Reference, and Equipment Not Listed in these examples.>	
General Report Module		
	Instance Number	20201130.1
	Content Date	20201130
	Content Time	120000.0
Threat Detection Report Module		
	TDR Type	AGGREGATE
	Image Scale Representation	present
	Alarm Decision Time	20201130120000.175
	Alarm Decision	ALARM
	Abort Flag	SUCCESS
	Abort Reason	-
	Algorithm Developer Name	AGG_COMPANY
	Threat Detection Algorithm and Version	2021_AGG1
	Operator Identification Sequence	-
	> Person Identification Sequence Operator ID	-
	> Person Identification Sequence Operator Name	-

	Example Description → Attributes ↓	Aggregate TDR w/ instance references
	> Organization Code Sequence Operator's Company	ORD
	Number of Total Objects	4
	Number of Alarm Objects	4
	Total Processing Time [msec]	575
Threat Sequence Module [PTO 1]		
	Threat Sequence	Present
	>Potential Threat Object ID	1
	>Referenced PTO Sequence	Present
	>>Potential Threat Object ID	1
	>>Referenced TDR Instance Sequence	SOP Instance UID TDR ACME 2019_10_2_3
	>Assessment Sequence	Present
	>>Threat Category	EXPLOSIVE
	>>Threat Category Description	Explosive
	>>Ability Assessment	NO_INTERFERENCE
	>>Assessment Flag	THREAT
	>>Assessment Probability	90
	Start Time of Processing	20201130120000.05
	End Time of Processing	20201130120000.175

	Example Description → Attributes ↓	Aggregate TDR w/ instance references
	Total Time for Processing	125
Baggage-Specific TDR Details Macro [PTO 1]		
	>PTO Representation Sequence	Present
	>Referenced Instance Sequence	Present
	>>Bounding Polygon	(241,90,0) (367,180,0)
	>>Threat ROI Voxel Sequence	Present
	>>>Threat ROI Base	(241,90,0)
	>>>Threat ROI Extents	(126,90,0)
	>>>Threat ROI Bitmap	Not Present
	>>PTO Location Description	Present
	>>Center of PTO	(254,135, 0)
	>>Center of Mass	(288,129,0)
	>Mass of PTO	Present
	>Density of PTO	1.32
	>Z Effective	7.31
	>Volume of PTO	Present
Threat Sequence Module [PTO 2]		
	Threat Sequence	Present
	>Potential Threat Object ID	2
	>Referenced PTO Sequence	Not Present

Example Description → Attributes ↓	Aggregate TDR w/ instance references
>>Potential Threat Object ID	2
>>Referenced TDR Instance Sequence	SOP Instance UID TDR ACME 2019_10_2_3
>Assessment Sequence	Present
>>Threat Category	PI
>>Threat Category Description	Large Gun
>>Ability Assessment	NO_INTERFERENCE
>>Assessment Flag	THREAT
>>Assessment Probability	95
Start Time of Processing	20201130120000.05
End Time of Processing	20201130120100.150
Total Time for Processing	1145
Baggage-Specific TDR Details Macro [PTO 2]	
>PTO Representation Sequence	Present
>Referenced Instance Sequence	Present
>>Bounding Polygon	(350,184,0) (437,336,0)
>>Threat ROI Voxel Sequence	Present
>>>Threat ROI Base	(350,184,0)

	Example Description → Attributes ↓	Aggregate TDR w/ instance references
	>>>Threat ROI Extents	(87,152,0)
	>>>Threat ROI Bitmap	Not Present
	>>PTO Location Description	Present
	>>Center of PTO	(393, 260, 0)
	>>Center of Mass	(393, 260, 0)
	>Mass of PTO	Present
	>Density of PTO	7.00
	>Z Effective	25
	>Volume of PTO	Present
Threat Sequence Module [PTO 3]		
	Threat Sequence	Present
	>Potential Threat Object ID	3
	>Referenced PTO Sequence	Not Present
	>>Potential Threat Object ID	Present
	>>Referenced TDR Instance Sequence	Present
	>Assessment Sequence	Present
	>>Threat Category	PI
	>>Threat Category Description	Medium Knife
	>>Ability Assessment	NO_INTERFERENCE
	>>Assessment Flag	THREAT
	>>Assessment Probability	95

Example Description → Attributes ↓	Aggregate TDR w/ instance references
Start Time of Processing	20201130120000.05
End Time of Processing	20201130121000.05
Total Time for Processing	10000
Baggage-Specific TDR Details Macro [PTO 3]	
>PTO Representation Sequence	1
>Referenced Instance Sequence	SOP Instance UID TDR THIRD_PARTY 2021_10_3_2
>>Bounding Polygon	(125,100,50) (125,175,120)
>>Threat ROI Voxel Sequence	Present
>>>Threat ROI Base	(125,100,50)
>>>Threat ROI Extents	(125,175,120)
>>>Threat ROI Bitmap	Not Present
>>PTO Location Description	Present
>>Center of PTO	(125, 150, 80)
>>Center of Mass	(125, 140, 100)
>Mass of PTO	Present
>Density of PTO	7.00
>Z Effective	25
>Volume of PTO	Present
Threat Sequence Module [PTO 4]	

Example Description → Attributes ↓	Aggregate TDR w/ instance references
Threat Sequence	Present
>Potential Threat Object ID	4
>Referenced PTO Sequence	Not Present
>>Potential Threat Object ID	1
>>Referenced TDR Instance Sequence	SOP Instance UID TDR TSA_GOA_1 2020_4_2-35
>Assessment Sequence	Present
>>Threat Category	EXPLOSIVE
>>Threat Category Description	Explosive
>>Ability Assessment	NO_INTERFERENCE
>>Assessment Flag	THREAT
>>Assessment Probability	80
Start Time of Processing	20201130120000.05
End Time of Processing	20201130120000.250
Total Time for Processing	200
Baggage-Specific TDR Details Macro [PTO 4]	
>PTO Representation Sequence	Present
>Referenced Instance Sequence	Present
>>Bounding Polygon	(111,222,333) (176,300,399)

Example Description → Attributes ↓	Aggregate TDR w/ instance references
>>Threat ROI Voxel Sequence	Present
>>>Threat ROI Base	(111,222,333)
>>>Threat ROI Extents	(66,79,67)
>>>Threat ROI Bitmap	Not Present
>>PTO Location Description	Present
>>Center of PTO	(124,255,370)
>>Center of Mass	(124,255,370)
>Mass of PTO	Present
>Density of PTO	-
>Z Effective	-
>Volume of PTO	Present