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PLANNING FOR THE NEW GENERATION LARGE AIRCRAFT SUBSTANTIAL INCREASES IN PASSENGER TRAFFIC AND CHECKED BAGGAGE SCREENING SYSTEMS EFFECTIVENESS VERSUS EFFICIENCIES

Overview

The author raises the question of whether the world aviation industry is prepared for the arrival of the new generation large aircraft (NGLA) and the anticipated continued increase in passenger air travel. He suggests that this is in question and gives as an example the difficulty being experienced in accommodating the current passenger traffic levels from a baggage security screening standpoint. Included in this review is a look at the variables associated with checked baggage screening, some history of baggage screening before and since the 9/11 attacks, and some of the costs associated with checked baggage screening. He will address other aspects of accommodating the NGLA in subsequent articles on passenger screening and other subjects. Lastly, the author does not cover several aspects of baggage security screening because of the sensitive security information (SSI) involved.

1.0 Introduction

Prior to the 9/11 terrorist attacks, the front-end aviation security design at world airports to accommodate existing aircraft operations was seldom adequate. Planning for and accommodating aviation security design needs has now changed somewhat worldwide, but not completely, as a consequence of the 9/11 attacks. So, based on this checkered history, what can we logically expect in accommodating the newer large aircraft category[1] – the behemoth Airbus 380 with its double decks that will accommodate over 550 passengers[2] in its initial operations and the somewhat fewer passengers in the projected Boeing 747-Advanced technology aircraft?. Additionally, given the anticipated continued growth in passengers in future years will other airports be able to accommodate these increases?

A380

[1] Or as some are inclined: New Generation Large Aircraft, i.e. NGLA

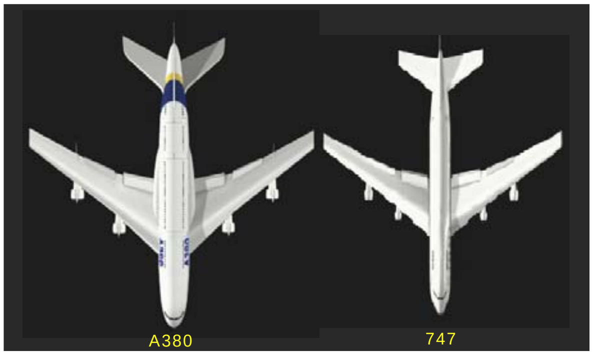
[2] Reportedly the A380 will be tested for evacuation of 853 passengers to permit planned high density configurations.

The first new generation large aircraft will be a masterpiece of ingenuity and enhancement over the current large aircraft. According to the Airbus Industries website[3] "The A380 will generate half the noise level at take-off and carry 35 per cent more passengers than its competitor over distances such as London-Singapore and Los Angeles-Sydney." And "the A380 will be the first long-haul aircraft to consume less than three litres of fuel per passenger over 100 kilometres – a fuel burn comparable with the best of small modern turbo-diesel cars."

1.1 The New Generation Large Aircraft

The new A380 made its maiden flight on Wednesday April 27, 2005 with six test pilots/engineers and several thousands pounds of test and monitoring equipment on board. It is supposed to enter commercial airline service in late 2006 after an estimated 2,500 of hours of certification testing.

I foresee difficulty in accommodating the new aircraft[4] at many airports, particularly in the U.S., because of a number of variables. First, from a construction standpoint only four U.S. airports[5] currently meet the runway and taxiway widths to accommodate the A380. The most significant of the variables from an aviation security standpoint however is that the peak periods at most large international airports occur a few times each day and airport/airline manpower must be adjusted to accommodate these peaks. These peaks are tied to local conditions for domestic flights and to the Atlantic or the Pacific intercontinental traffic for very large aircraft. These patterns result from airlines' need to meet established international connection patterns and the need to provide flights at the times most desired by passengers. The new generation large aircraft flight schedules are anticipated to conform to today's service patterns. The addition of new generation large aircraft flights may therefore be expected to increase passenger traffic during peaks at international airports. The daily traffic peaks are factors that are known and are predictable, so how will the airports satisfactorily address the issues associated with these new large aircraft?



Obviously, at major airports traffic peaks involve large numbers of a variety of airplanes. In the future, absent good airport design planning, problems may arise whenever there are two or more of the new generation large airplanes processing passengers and baggage at the same time. There are on-going discussions about when and where multi-new generation large aircraft operations

[3] See: www.airbus.com/media/a380_family.asp.
[4] The B747 Advanced Technology aircraft will offer less of a problem as its dimensions are not as large and hopefully will be able to be accommodated within the "footprint" of its predecessor – the B747-400.
[5] This includes Los Angeles, Miami, San Francisco and John F. Kennedy International Airports for commercial operations and Memphis and Anchorage say they can support A380 cargo operations. Atlanta Hartsfield-Jackson International Airport has reportedly said that they cannot support the A380 and Chicago O'Hare has also reportedly stated that they will not be able to support the A380 for some time.

will occur simultaneously. Robert Payne, a spokesman for Frankfurt International Airport - Fraport - apparently believes that this will not be an immediate problem:

> "One should not forget that in the initial years of the superjumbo, there will not be a large number of A380s arriving at any one hub at the same time, or within a short time span.[6]"

While I believe he is probably correct, I am not as sanguine as Mr. Payne as the same article also enumerates the order list of the purchasing airlines:

According to Airbus Industries fifteen airlines have ordered A380 aircraft:

Air France	10	Malaysian Airlines	6
China Southern Airlines	5	Qantas	12
Emirates	41+2F[7]	Qatar Airways	2
Etihad	4	Singapore	10
Federal Express	10F	Thai Airways	6
IFLC	10	United Parcel Service	10F
Korean Air Lines	5	Virgin Atlantic	6
Lufthansa	15		
		Total	154

Preparation for the A380 can take many forms, e.g. "Los Angeles International Airport (LAX) will add six new airfield buses to its fleet next year to accommodate the expected November 2006 arrival of the Airbus 380 . . . the new airfield buses have a capacity for up to 140 passengers and their carry-on baggage"[8]. "As part of a $10 million project, two of the contact gates at TBIT will be equipped for the A380[9]". LAX is also making some other modifications to the airport to accommodate the A380[10]. San Francisco International Airport (SFO) has likewise made modifications in addition to having designed its new International Terminal to be able to accommodate the A380.

Heathrow International Airport in London has probably made the most modifications to accommodate the A380 – reportedly as much as $845 million in enhancements. These include modifications to Terminal 3 to include four gates to handle the A380. When the new Terminal 5 (T-5) is complete in 2008 it will include "infrastructure to handle five A380s (four contact gates and one remote). According to officials, by 2011, the new T5 will have a total of 14 gates equipped for the A380.[11]" Many subsystems of the airport

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[6] Mike Vines, Airport Magazine, *Heathrow, Charles de Gaulle and Frankfurt are gearing up for the world's biggest passenger jets and all they will carry*, September/October 2004, pg. 66.
[7] Designates a Freighter version.
[8] The Argonaut, March 31, 2005 page 8. This article also noted that the normal LAX airside bus would only carry 60 to 80 persons. It is obvious from these data that LAX plans to deplane and board some passengers for the A380 at a remote location.
[9] Jodi Richards, Airport Business Magazine *Here comes the A380*, January 2005. TBIT is: The Bradley International Terminal at LAX.
[10] Ibid.
[11] Ibid.

will have to be revised to accommodate the larger aircraft, as an example at Heathrow International Airport:

> "Ian Gatherum, media relations manager, explains that because of the increased amount of baggage the aircraft will naturally carry, the baggage system being installed in the new construction will also be upgraded. Normally, baggage belts are some 50-60 meters long. The baggage belts that will be installed in Pier 6 will be 75-90 meters in length."[12]

The addition of the new generation large aircraft can be considered an instant precursor to the future air transportation system passenger increases. One of the concerns in accommodating the new generation airplanes is the current heightened aviation security system in most countries. Processing 550[13] passengers per A380 in multiple numbers will initially put a severe strain on any aviation security screening system, particularly the existing U.S. aviation security system. Where two or more of these super-jumbo aircraft depart within a short period, it will intensify the peak traffic period problems associated with security screening of passengers and their carry-on articles and the security screening of their checked bags, not to mention the airlines' check-in processes.

1.2 AVSEC Effectiveness versus Processing Efficiency

One of the limitations on passenger traffic growth may very well be an airport's inability to efficiently process passengers and their carry-on articles, and the screening of their checked baggage without having a negative impact on on-time departures. Notice I said efficiently process, not effectively screen passenger and their carry-on articles, and the screening of checked baggage. From a safety standpoint the job of aviation security professionals – *is to move people and their airplanes safely from one point to another – not to put bombs and hijackers on airplanes faster*!

However, not to acknowledge the importance of facilitation of passengers to the aviation industry would be a failure to acknowledge reality. And, reality is that the commercial airline industry has been adversely affected by passengers' negative views of the inconveniences associated with today's airline travel. Will the introduction of the A380 exacerbate these negative views?

Initial operations with the new A380s will probably operate without full passenger loads and, if this happens it will be the classic – "good news - bad news" situation. The good news is that less than a profit-generating passenger load will mitigate problems of massive numbers of passengers to be processed at the same time. But, an unknown is how many initial A380 flights will generate full-passenger loads because of the novelty of flying the world's biggest commercial airplane. Generally these initial euphoric passenger loads have a tendency to quickly settle back to normal passenger levels. When this happens, the bad news is that airlines must attain a specific passenger load,

[12] Jodi Richards, Airport Business Magazine *Here comes the A380*, January 2005.
[13] Actually the A380 will carry considerably greater numbers of passengers depending on the individual customer requirement but 550 is the standard initial layout.

depending on a number of economic variables such as fuel, labor, airport facility costs, etc., in order to realize a profit[14]. As a consequence, airlines operating the A380 will probably begin operations with the new aircraft on high-density routes but even these may initially operate at a deficit, given the history of airline economics.

As airlines cannot operate a deficit system indefinitely, they may eventually have to offer incentives to prospective passenger groups in order to improve their initial traffic load factors on the new generation large aircraft. Depending on the success of the incentives offered, they should be able to draw the additional numbers of passengers into the system and may result in peak traffic loads that result in passenger processing problems. The irony of this is that the success of the airlines in promoting air travel may eventually result in its own limits on growth depending on the ability of the airports to accommodate the massive number of passengers involved. This is where the efficiency of airport design becomes critical.

Airbus Industries, the A380 manufacturer, sees it another way in their promotional literature by stating:

> "And because Airbus has taken care of the boarding and deplaning issue, cutting out choke points by using ergonomic research to design two sets of doors, turn-round time is significantly lower. This allows schedules to be kept tight and extra flights flown.[15]"

Side by Side Comparison

Airports however will probably see the introduction of the A380 in a different light as a myriad number of events have to unfold in proper sequence in order to accommodate the new generation large aircraft, e.g., runway and taxiway strengthening and widening, separation of taxiways[16], passenger check-in areas, reconfiguration of boarding facilities, building of new terminals, processing of passengers, and security screening. In other words, simply providing two sets of doors for boarding at each passenger cabin level of the A380 doesn't solve the problems in accommodating the new generation large aircraft.

To this end Singapore Changi, Heathrow and Dubai International Airports, as three of the first airports that will handle multiple A380 operations, have invested several hundred

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[14] See Airbus website http://www.airbus.com/product/a380_economics.asp Economics – *A new way to fly gives Airlines a New Way to Make Profits*.

[15] See http://www.airbus.com/product/a380_economics.asp .

[16] See http://www.airbus.com/media/programme.asp - *Airport compatibility* states "Tests from the six-year programme confirm that the A380 will have no greater impact on the runways than those aircraft already in operation." This does not appear to hold true however as airports that will service the A380 have already begun modifying taxiways, runways, etc. in order to accommodate the NGLA.

million dollars in construction of new terminal buildings, widening of taxiways, strengthening of runways and other enhancements to accommodate the new generation large aircraft.

One of the major hassles that airports will have to contend with on the A380 will have to do with passengers and their carry-on articles screening, baggage screening, etc.

1.3 Checked Baggage Screening and the NGLA

The inconveniences associated with passenger and carry-on article security screening notwithstanding, a bigger problem in accommodating the new A380 may well be the problems associated with security screening of checked baggage. ICAO Annex 17[17] Standard 4.4.8, requires that all checked baggage on international flights be screened by January 1, 2006:

> "From 1 January 2006, each Contracting State shall establish measures to ensure that originating hold baggage intended to be carried in an aircraft engaged in international civil aviation operations is screened prior to being loaded into the aircraft."

It should be noted that this standard does not specify exactly how the baggage is to be "screened," only that it must be screened. The problems associated with 100% screening of checked baggage is already with us as many ICAO Contracting States[18] have already begun screening checked baggage using technical means to do so[19].

The TSA began screening all checked baggage at U.S. airports as a result of the U.S. Congress' mandate that all checked bags be screened effective December 31, 2002[20]. Again, there are a number of variables associated with the current and future capability of screening checked baggage – not the least of which is the present and projected state-of-the-art technology available for screening baggage.

Two principal standards currently exist for the certification of Explosives Detection System (EDS) equipment – one adopted by the U.S. and a second adopted by the Europeans that is also followed by many non-European nations. In addition to these two EDS standards there are individual national variations around the world. As an example, the Israelis have established their own certification standard. The U.S. certification standards are more stringent than the European and the Israeli standards are the most stringent of all. All EDS certification standards are either treated as classified or

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[17] One of a total of 18 ICAO Annexes that set the standards for aviation worldwide. The International Civil Aviation Organization (ICAO) was established at the Chicago Convention in 1944 and is a part of the UN.
[18] ICAO currently has 188 Contracting States, i.e. members.
[19] Technical means is used in the sense of a method of non-intrusive examination, e.g. X-ray or an Explosive Detection System or Unit.
[20] Aviation and Transportation Security Act (ATSA) (Public Law 107-71, 115 Stat. 597 November 19, 2001). This deadline was subsequently extended to December 31, 2003 (Homeland Security Act of 2002, Pub. Law No. 107-296, 116 Stat. 2135).

sensitive security information (SSI) and are not publicly available – so the specifics of these standards will not be discussed in this paper.

Generally speaking, the more stringent the certification standard the more impact on the speed of processing of checked baggage. The current U.S. certified EDS[21] machines, with one exception[22], are based upon computed tomography (CT). The CT based EDS units process checked baggage at rates between 120 to roughly 500[23] bags per hour in actual operation depending on how the EDS units are installed, the EDS model, operating mode, and configuration. An exception to this processing rate is the new Reveal Imaging CT-80 EDS that has a throughput of approximately 80 bags per hour.

The most efficient configurations install and integrate the EDS units into the airport conveyor system. This configuration is generally referred to as an In-line EDS system, i.e. EDS installed in-line in the airport/airline baggage conveyor system where the conveyor feeds the bags directly into the EDS[24].

A less efficient system is commonly known as the "Stand-Alone installation". Simply stated, stand-alone installations are EDS or X-ray units located in airport terminal building lobbies and basements and have no direct "feed" from airport conveyor systems. In rare instances these stand-alone installations can be connected to a discharge conveyor where the scanned bag with no suspicious articles is released directly into the conveyor system.

[21] Only four companies (GE-formerly InVision, L-3, Reveal Imaging and Analogic) now have EDSs certified by the FAA/TSA.

[22] The Yxlon 3000 and 3500 are exceptions to this as they are X-ray diffraction technology.

[23] EDS equipment suppliers will claim higher processing rates but these rarely seem to be achieved in an airport operational environment.

[24] See GAO study entitled *AVIATION SECURITY Systematic Planning Needed to Optimize the Deployment of Checked Baggage Screening Systems*, GAO-05-365 March 2005.

1.4 U.S. versus European Baggage Screening Systems

Here again the U.S. and European aviation communities differ. As a result of this difference there are two concepts of In-line systems. The U.S. policy is that U.S. airports and airlines can only use U.S. certified EDS, or U.S. certified Explosive Trace Detection (ETD) systems in coordination with a physical search to screen baggage. All currently U.S. certified EDS units, with one exception, are based upon Computed Tomography (CT) technology that is effective, but relatively slow and costly. The European policy is that any nationally certified EDS units may be used in a nation's In-line systems. Many X-ray models that would be classified as Advanced Technology in the US are certified and used by European nations as EDS. These units have invariably either failed US certification tests or have never been submitted for FAA/TSA testing, but have the advantage of higher processing speed and lower cost. Some equipment certified under European national standards may exceed 1200 bags per hour and cost less than 20% to 60 % of the U.S. certified EDS equipment. At first this greater European EDS throughput rate may not seem like a great difference but in actual operation it can have a major cost impact and on airline on-time operations.

The European checked baggage screening philosophy was developed much earlier than the U.S. entry into this security field. U.S. suppliers and manufactures of X-ray equipment, along with one European supplier, developed what subsequently became known as Advanced Technology X-ray units. The Europeans then began developing baggage screening systems using these X-ray units in the early 1990s. The U.S. did not enter the field until the mid- to late 1990s and then only in a half-hearted basis even though the first U.S. EDS unit was certified in December 1994. It was not until after the 9/11 attacks that the U.S. really became interested in implementing a full-scale U.S. nation-wide EDS program to screen checked baggage.

2.0 U.S. EDS Checked Baggage Screening Systems

The U.S. policy is readily apparent at the U.S. port of entry as all transfer bags coming off incoming aircraft have to be screened using U.S. certified EDS (or ETDs) absent a U.S. approved EDS operation at the point of departure of these aircraft. An example of this is at one of the U.S. medium category International airports where six West Pacific originating wide-body aircraft are scheduled to arrive between 11:00 and 14:00 daily. If the early wide-bodies are delayed, or the later scheduled aircraft arrive early, the airport experiences multiple aircraft arrivals, each containing up to 400 passengers and as many as 600 pieces of transfer luggage that have to be screened prior to being loaded for on-ward travel in the U.S. domestic system. These situations are the prelude to the future with multiple arriving and/or departing A380s each with 800 or more checked bags.

The U.S. In-line concept using <u>only</u> U.S. certified EDS can be either single or multi-stage systems. The problem with using only the U.S. In-line concept is that the maximum throughput is considerably constrained because of the low throughput rate of the U.S.

certified EDS units. As noted earlier, European certified EDS equipment is available with throughput rates exceeding 1200 bags per hour.

The U.S. Government also uses Explosive Trace Detection (ETD) combined with physical searches, as one primary method of screening bags at selected U.S. airports. This baggage screening process is very slow and time consuming and is reportedly only being used as an interim measure until enough EDS units are available for less intrusive/invasive searches. The GAO reports that the TSA's ETD baggage throughput is 36 bags per hour[25]. The use of ETDs is only addressed in this paper as a method of confirming or clearing bags that remain in an alarm condition after an EDS examination.

2.1 U.S. EDS Operating Modes[26]

Some manual lobby and basement EDS installation units are operated on a "Hold-on-Alarm" basis, i.e., if the EDS alarms on a bag then that bag is automatically held in the EDS unit. Operators then review the EDS on-screen data of alarmed bags for the location and details of the items that caused the alarm before clearing the bag for transport or sending the bag for a physical search. In extreme cases the operators may elect to leave the bag in the EDS unit and call the Explosives Ordnance Disposal (EOD) unit for intervention.

Even when the EDS units are not operated in the "Hold-on-Alarm" basis, the bags may be retained at the EDS until: 1) the automatic clear/unclear decision is available from the EDS processor[27]; and/or 2) the image of uncleared bags is presented to the on-screen-review operator, and the operator decision is rendered. The GAO[28] estimates that the throughput of a manual lobby and basement EDS installation unit will be 120 to 180 bags per hour for the largest and fastest currently certified EDS (some smaller EDS units are limited to 80 bags per hour, according to their manufacturer).

[25] GAO-05-365, *AVIATION SECURITY*, pgs. 23 & 44, March 2005.
[26] These EDS operating modes generally apply to the European concept as well as the U.S. However, the numbers cited in this section apply to U.S. systems only.
[27] In one of the EDS supplier's units there may be a delay period of a few seconds while the detection algorithm is being processed.
[28] GAO-05-365, *AVIATION SECURITY*, pgs. 23 & 44, March 2005.

Most U.S. In-line EDS Dual-Stage[29] systems are operated in a "show alarm" mode. Once the system "alarms" on a bag the operators in a Resolution Room at multiplexed[30] Baggage Viewing Stations (BVS) have a set amount of time to resolve an alarm as everything keeps moving on the conveyor belts or trays. The bag viewing station operators must make a decision to "clear" or leave the bag(s) in an 'uncleared" status before any uncleared bag(s) reached a 'decision point'. Decision points are usually associated with the bag(s) reaching a kicker/pusher mechanism or tilt tray in the conveyor system at which point it, if the on-screen-review operator has failed to take any action, defaults in a secure mode to the next evaluation stage that may be a second EDS unit, or manual search with ETD confirmation.

Ideally a bag should not reach the kicker/pusher default point until the on-screen-resolution decision is available. Therefore, the conveyor design must allow for a decision review time of 20 or more seconds before the bag reaches the mandatory decision point to avoid sending bags for additional inspection unnecessarily. This is especially true if multiplexed operator review is used to avoid queuing effects, which can substantially reduce baggage screening throughput. These factors translate into critical space requirements in the conveyor design. Unfortunately some existing airports do not have this available space within their terminals.

Manually loaded lobby or basement EDS configurations, units not connected to a computer controlled conveyor system, are very labor intensive and the bag screening throughput is substantially constrained at approximately 120 to 180 bags an hour[31]. In this configuration a high level of manpower is needed to react to alarms, and to physically search or resolve issues associated with "uncleared" bags as well as to manually load and unload bags. This configuration operated in a 'hold on alarm' doubles or triples the time required to run an EDS system on a per-bag basis.

Three airports of with differing traffic configurations were initially selected by the Transportation Security Administration[32] (TSA) as models for the development of In-line CT baggage screening methodology in the U.S. Two of the three airports selected by TSA were major U.S. airports with substantial international traffic – one Pacific and the other Atlantic traffic. One of these major airports has a GE InVision CTX stage-1 operating in "hold no bags" mode with operator "override" as the second stage, and another GE InVision CTX scanner operating in "hold on alarm" mode with operator

[29] Dual-stage In-line U.S. EDS certified checked baggage screening systems contain a U.S. certified EDS unit at stage-one and a Baggage Viewing Station at stage-two followed by a search station for any uncleared bags.
[30] Multiplexed systems enable BAG VIEWING STATION operators to view alarm images sequentially from several EDS units, rather than by machine. This feature allows for a substantial increase in manpower efficiency.
[31] GAO-05-265 *AVIATION SECURITY*, pg. 23, March 2005.
[32] TSA is the U.S. Government organization responsible for aviation security. The TSA was created by the Aviation and Transportation Security Act (ATSA) Public Law No. 107-71, 115 Statute597 November 19, 2001.

"override[33]" for the third stage. The second major airport had an L3 eXaminer 3DX 6000 single scanner stage system installed with operator "override." A fourth international airport with an early installation has a combination of Pacific and U.S. traffic with an L3 eXaminer 3DX 6000 single scanner stage. All U.S. EDS model and installation configurations are consistent with the Congressional EDS only mandate[34].

L3 eXaminer 3DX 6000

2.2 U.S. Scan Center EDS Installation

L-3 MVT

One U.S. medium sized airport was selected to participate by TSA as it had planned its EDS installation for integration into the baggage conveyor and initially ordered two InVision CTX EDS units in 1998. Following the events of 9/11 and the creation of TSA, the TSA assumed responsibility for airport baggage and passenger screening at U.S. airports. Thereafter, this medium sized airport's checked baggage system concept was expanded and completed as a cooperative effort of the airport authority and TSA. After the 9/11 terrorist attacks, the airport reportedly tried to obtain approval from the TSA to install a European style multi-stage checked baggage screening system using an L-3 MVT (see Section 3.2) high speed X-ray unit at all Stage 1 locations. The TSA refused to approve this design.

This Airport's CTX units are housed in the 18,000 square foot scanner room of the new building dedicated to baggage inspection. The building also contains the threat resolution

[33] The term "override" is simply another word for on-screen-review where the operator can clear, i.e. override the EDS alarm because they recognize the alarm as being a false positive.
[34] Aviation and Transportation Security Act (ATSA) (Public Law 107-71, 115 Stat. 597 November 19, 2001). This deadline was subsequently extended to December 31, 2003 (Homeland Security Act of 2002, Pub. Law No. 107-296, 116 Stat. 2135).

room with the bag viewing station units for operator review and the TSA and airport system monitoring rooms that are approximately another 2000 square feet.

The installation model developed at this airport is referred to as a "Scan Center" in which all baggage is delivered to a central location for screening then, after being cleared, is redistributed according to airline and flight. The Scan Center configuration at this airport consists of a single scanner stage of paralleled EDS units operating in a "hold no bag" mode. As the bag is ejected from the scanner housing before the automatic clearance decision has been completed, the operator review of uncleared bags is performed with stored images while the bag is being transported on the conveyor. If the operator review is not completed before the bag reaches a mechanical conveyor switch, it is automatically routed to the manual search room equipped with image displays of the recorded image indicating suspect items and ETD units for bag opening and examination.

Planned performance of the airport's baggage system was to handle all baggage at the 5 million passenger per-year level with 5 EDS units and space reserved for an additional 3 EDS units to be installed when the airport traffic level increases to 8 million passengers per year. The designers stated that although the InVision CTX 9000DSi had been certified at 500 bags per hour, their tests had indicated operation was limited to 400 bags per hour, and recommended that a figure of 300 bags per hour be used for future designs (in "hold no bags" mode – other modes would have lower throughput). The system with five paralleled units achieved throughputs of 1400-1500 bags per hour.

InVision CTX 9000DSi

The overall purchase, facility construction, and installation cost of the airport's system was estimated to be $23.9 million, or nearly $5 million to bring each EDS unit on line. This cost, however, included extensive conveyor construction, a special building, and provided future expansion capability. However, this cost may be typical for such small-scale systems[35].

A multi-stage In-line U.S. certified EDS arrangement, relatively speaking, improves the bag screening throughput by approximately 100% over a stand-alone installation. But, that is not the end-of-the-story as bag processing speeds of 400 to 500 per hour per EDS unit are usually inadequate to handle peak hour baggage traffic at large international airports – without an exorbitant cost in EDS equipment. This processing rate certainly

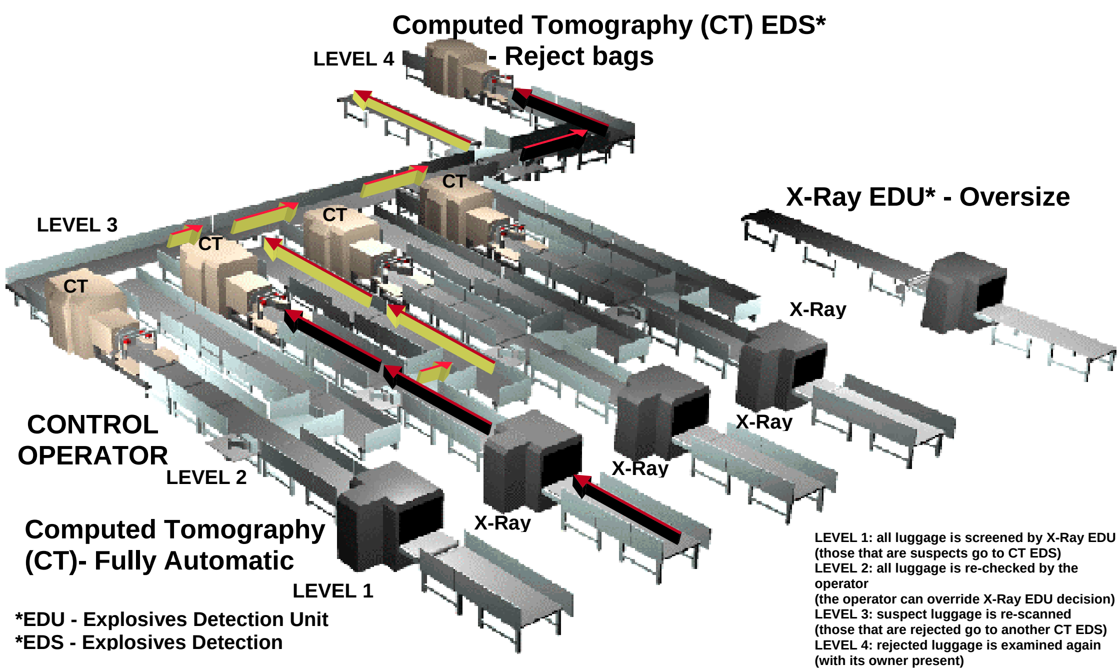
[35] GAO-05-365 *AVIATION SECURITY*, pg. 63 shows the cost of the installation per EDS unit running from $0 to 14 Million for nine airports with the average appearing to run approximately 4 Million each.

will put a strain on any future multiple near-simultaneous new generation large aircraft operations.

On the other hand if hundreds of millions of dollars are being spent to accommodate the new generation aircraft then what is the problem with spending hundreds of millions for EDS units to screen all bags for on-time departures? One answer is that the airports handling the new generation large aircraft are not the only airports involved as all airports are expected to have passenger growth in future years. The simple answer is that at processing rates of 400 to 500 bags per hour, and a cost of approximately $4 million per installed In-line EDS unit, it can become prohibitively expensive to accommodate a given airport's baggage screening requirements.

2.3 U.S. Multi-Stage EDS Installations

One major U.S. international airport has installed a multi-stage EDS unit In-line hold baggage screening system in their new international terminal. A multi-stage hold baggage screening system using only U.S. certified EDSs is an unusual configuration. It is unusual because of the cost of the system as each EDS unit costs approximately $1.2 million[36]. These are EDS unit costs and do not include the costs associated with the conveyor redesign, construction, installation, integration of the system, etc.



The first stage is a U.S. certified EDS unit, the second stage is an on-screen-review by an operator at a bag viewing station of the Stage 1 EDS images of uncleared bags. Bag

[36] 1.2 million is the approximate cost for units being deployed in the U.S. Units purchased outside the U.S. can run up to approximately $1.5 million U.S. depending on the options exercised.

viewing station on-screen-review operators either clear the alarmed[37] bags and send them to the loading/sorting carousel, or send them to the Stage 3 EDS unit. Stage 3 would be the second In-line installation of an EDS unit and this stage either confirms or clears an uncleared bag. Uncleared bags from the Stage 3 EDS unit are then subject to ETD examination and physical searches.

This multi-EDS stage system is still limited by the throughput of the Stage 1 EDS unit. With the Stage 1 EDS unit operating in a "hold-no-bags" mode, the maximum throughput of this stage is approximately 500 bags per hour. Unfortunately achieving and sustaining a 500 bag per hour is unlikely using the current EDS units as inefficiencies can also exist in the conveyor design, facility environment, mechanical breakdowns, number of input stations, queuing systems to feed the EDS units, etc.

Because of the operating parameters of the specific EDS unit used, the operating protocols require that all bags that alarm[38] in the Stage 3 EDS be retained (held) in the unit, i.e. usually referred to as the "Hold-on Alarm" operating mode. As a consequence the Stage 3's throughput is much reduced from that of a Stage 1 unit operating in the hold-no-bags mode. Therefore the number of Stage 3 EDS units required is calculated on the basis of the number of uncleared bags remaining after the Stage 2 Operator review.

2.4 U.S. EDS Lobby and Basement Stand-Alone Installations

Unfortunately the current situation at major U.S. airports is that the predominant installations of U.S. certified EDS units are in terminal lobbies or stand-alone basement installations – not In-line systems. This situation is even worse than the single-stage In-line EDS installations. The manual feeding of the lobby or basement located EDS units, reaction to system alarms, and the resolution of those alarms by physical searches or use of other technologies reduces the average baggage throughput to less than 200 bags per hour. This dilemma will exist for some years as the cost of designing, constructing conveyor systems, installing security screening control systems, etc. for U.S. airports is costing billions of U.S. dollars.

L-3 eXaminer 6500

Approximately half of the EDS units purchased by the TSA since the 9/11 attacks are ill suited for In-line installations[39] vis-à-vis later EDS units designed for In-line installation. This is, in part, because the images from a substantial number of the EDS units cannot currently be multiplexed to multiple baggage viewing stations. The TSA initially purchased both L-3 eXaminer 3DX 6000

[37] One has to be careful in this language because the use of "alarmed bag" can easily convey the impression that any alarm is an indication of an explosive. While this is a possibility, it is highly unlikely as these first/second generation EDS units have a false positive rate of approximately 15% in an operational setting.
[38] The competing US EDS supplier's unit operates slightly different and can be set to "hold-no-bag" that alarm – but the problem is then identifying and tracking (see Section 4.1) the bag that alarmed the unit – so most Stage 3 EDS units will probably be operated in a "hold-on-alarm" mode.
[39] GAO-05-365, *AVIATION SECURITY,* pg. 23, March 2005.

and InVision CTX 5500DS EDS units. The GAO-05-365 report shows the InVision CTX 5500DS In-line processing rate to be substantially lower than the competitive L3 3DX 6000 units and the later CTX 9000DSi sister unit - 250 versus 425 bags per hour. This restricts the flexibility of the systems and intensifies the labor requirements to operate the EDS units.

As noted earlier, stand-alone lobby and basement EDS unit installations are the norm in U.S. airports. This came about because of the Congressionally mandated requirement to install EDS units by December 31, 2002. This unrealistic deadline did not allow ample time to design, procure the equipment, construct the conveyor systems, etc. to properly implement In-line EDS installations. Moreover, U.S. designers, suppliers and contractors were generally inexperienced in the art of designing, integrating and building sophisticated hold baggage screening systems (see Section 6.0). The only alternative was to install the EDS units in airport terminal lobbies and basements. All of the inefficiencies associated with manually loading and unloading the units, responding to machine alarms, searching uncleared bags, etc. exacerbate the low throughput rate of the U.S. certified EDS units.

InVision CTX 5500DS

These stand-alone EDS installations are inefficient and screen bags at approximately 120 – 180 bags per hour[40] – with the usual maximum processing rate probably being closer to 150 bph. The primary reason for this slow processing rate is the difficulty of manually feeding the EDS units in an efficient manner.

3.0 European In-line Checked Baggage Screening Systems

HI-SCAN 10080 ED*t*S

The European, and the rest of the world's, aviation security baggage screening environment are generally quite different from those in the U.S. The European In-line hold baggage screening concept is a multi-stage system using non-U.S. certified Stage 1 high-speed

[40] GAO-05-365, *AVIATION SECURITY*, pg. 23, March 2005.

specialized X-ray units[41]. Stage 2 is an operator review of images for bags uncleared in Stage 1. Stage 3 EDS units can be either U.S. certified systems or X-ray units certified to the less stringent European EDS standards. As noted earlier, some European states have certified some of the specialized X-ray units as EDS for baggage screening although they would not meet the more stringent U.S. certification standards[42].

Heimann 10065 HDX

London Heathrow International Airport was one of the first airports, or perhaps the first airport, to explore the integration of X-ray screening systems in their baggage conveyor systems. This initiative came about, at least partially, as a result of the Pan American World Airways Flight 103 disaster on December 21, 1988. The initial exploratory efforts quickly became more sophisticated as lessons were learned about the complexities of integration, X-ray image review, remoting images to control rooms for greater efficiencies, etc. Other UK and European airports quickly followed Heathrow's lead, e.g. Manchester, UK, Brussels, Belgium, Schipol, Amsterdam, and others. A wealth of experience was gained in these efforts and the technology quickly moved from advanced X-ray units only to the integration of U.S. certified EDS units, such as at Manchester, in the late 1990s.

3.1 Probability of Detection Issues

InVision CTX 9000DSi

The question that becomes apparent is whether a U.S. EDS-only system versus that of the European concept of a non-U.S. certified high-speed advanced technology X-ray at Stage 1 are relatively equal in the probability of detection of explosives in the baggage being processed? No operational test or mathematical analysis of the difference in the probability of detection has been performed, at least none that has been published publicly[43]. Assuming that there is no significant difference, which may be a very large assumption, the more advantageous option would appear to be the European concept.

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[41] While explosive detection effectiveness is the paramount element in an In-line baggage screening system bag processing speed is an essential element of meeting airline on-time demands. These specialized Stage one X-ray units typically examine bags in excess of 1,200 bph.

[42] It should be noted that the European concept does comply with ICAO Annex 17 Paragraph 4.4.8 Standard.

[43] This may have happened as the Government Accountability Office (GAO) was tasked by Chairman Rogers of the Subcommittee on Homeland Security in early 2004 to study the U.S. Government's policy on the implementation of hold baggage screening. This resulted in GAO-05-365 *AVIATION SECURITY* report. This author met with the GAO Auditors and one of the suggestions offered was the need to do a formal mathematical analysis of the probability of detection between the U.S. versus the European concepts (this should be an operational test with real bags).

One of the arguments for the acceptance of the European concept of a high-speed advanced technology X-ray as a stage-one unit is that a parallel situation already exists with one of the U.S. certified EDS CT units. In this instance, the U.S. certified EDS unit uses an integrated X-ray to prescreen[44] incoming bags coming into the unit. The data from the "integrated stage-one" X-ray unit is then transferred to the Computed Tomography (CT) section of the EDS unit if a suspect area is identified by the X-ray. The CT then takes multiple slices of the suspect area before alarming or clearing the bag. The significant difference between screening bags in this U.S. certified EDS unit and a European high-speed X-ray is that the bag being examined in the U.S. EDS will always go through the EDS after examination by the integrated X-ray. In the European concept the bag may be cleared and go directly to the airplane without ever going through an EDS.

L-3 VIS 108

Generally speaking however, the advanced technology X-ray units used in stage one in the European designs are set with a broad-identification algorithm to try to include any possible explosive in those bags being sent on to stage two baggage viewing station on-screen-review and, possibly, the stage three EDS units. If these broad parameters are used, this can result in a much higher than desired false positive rate ranging from 40 to 60% in stage one units.

3.2 Baggage Processing Throughput Economics

A number of other factors figure into the selection of the U.S. concept versus the European concept. Perhaps principal among these is the question of the economic consequences of not being able to process the bags speedily enough for on-time departures. A second consideration is that the European design concept uses much less expensive X-ray equipment that costs approximately $200K to $600K per unit versus a U.S. certified EDS unit at $1.2 to $1.5 million per unit, with the exception of the newly certified Reveal Imaging unit discussed in Section 7 of this paper.

Yxlon XES 3000/3500

[44] This X-ray "prescreen" takes its raw feed and analyzes it with an algorithm that determines where the EDS slices should be placed – the X-ray prescreen does not clear the bag.

Obviously the primary goal of effectively screening bags for explosives must be met before the efficiencies of the system become paramount. To this end, one has to consider that the U.S. certified EDS units are not truly explosives detection technologies – they are largely density measuring mechanisms. An exception is the new Reveal CT-80 unit that combines density measurements with atomic number discrimination (dual energy) as well (see Section 7.0, New Entrant and Emerging Technologies). Another exception is the recently TSA certified Analogic AN6400 (see Section 7.1) that also combines atomic number discrimination (dual energy) along with CT density measurements. In other words, the U.S. and the European certified EDS units, with the exception of the CT-80, Analogic AN6400 and the Yxlon 3000 and 3500 units[45], are based on detecting the known densities of certain explosive compounds. As a consequence, a number of other substances can have similar densities and this results in approximately 15% false positive alarms[46].

On-screen-review (see Section 4.2) by an operator at stage two may clear the vast majority of these false positives with the remainder being sent on to the stage three EDS[47]. Assuming, again this is a large assumption, that the failure to identify any explosives at stage one is less than 10%, then the use of an advanced technology high-speed X-ray may be roughly comparable to the performance of a certified U.S. Computed Tomography EDS unit[48]. It is important to understand however that the advanced technology X-ray units are not detecting explosives – they are only selecting bags that contain items with broad characteristics typical of explosives – the down-stream processing of these uncleared bags will determine if explosives are actually present. The counter argument to this is that the U.S. certified EDS units that have been deployed are not specifically detecting explosives either; they are density measuring mechanisms (see previous comments on this subject).

Since advanced technology X-ray systems were first installed in European style In-line baggage screening systems in the early 1990s literally hundreds of millions of bags have been screened. No explosives have been found. This could mean that explosives have been present but missed being detected, or no explosives were present in any of the hundreds of millions of bags screened. Since the initial development of the European concept In-line screening system L-3 has introduced the Multi-View Tomography (MVT) unit that has a throughput rate of approximately 1,200 bags per hour. The L-3 MVT passed the TSA's rigid detection regime but failed U.S. certification on the basis of too

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[45] The TSA certified the GE Yxlon unit that uses X-ray Diffraction technology and is a "material specific" detector, i.e. it actually detects explosives. The Yxlon however is very slow and does not yet appear suitable for In-line installation except in a final stage unit, e.g. stage 5.

[46] Research continues, with some recent successes, in reducing these false alarms and the more optimistic persons believe future work may reduce the levels below 10%.

[47] The clearance level using OSR is dependent to some degree on the clarity of the X-ray or EDS images, stringency of the protocols used, etc. While the latest EDS technology images are considerably improved over first generation units they still lack the image clarity of comparable medical CT units. Some industry professionals argue that medical image clarity is not needed to be able to identify the TSA articulated threats.

[48] The actual detection effectiveness of the U.S. certified EDS units are classified.

high a false positive rate. The MVT is now being used in some In-line stage 1 units and adds a new dimension to the European style EDS.


L-3 MVT

In summary, the European In-line concept offers the distinct advantage over the U.S. In-line concept in processing speed. Some would argue that using the European In-line design only means someone is potentially putting bombs on airplanes faster. On the other hand, if a European concept design is properly done using an L-3 MVT at stage one and a U.S. certified EDS unit at stage three, along with operator on-screen reviews at stage two and four, it can be argued that there is no loss in explosive detection effectiveness. This statement notwithstanding, there are U.S. scientists who would and have disagreed with this assessment.

4.0 Variables Affecting Baggage Screening Throughput

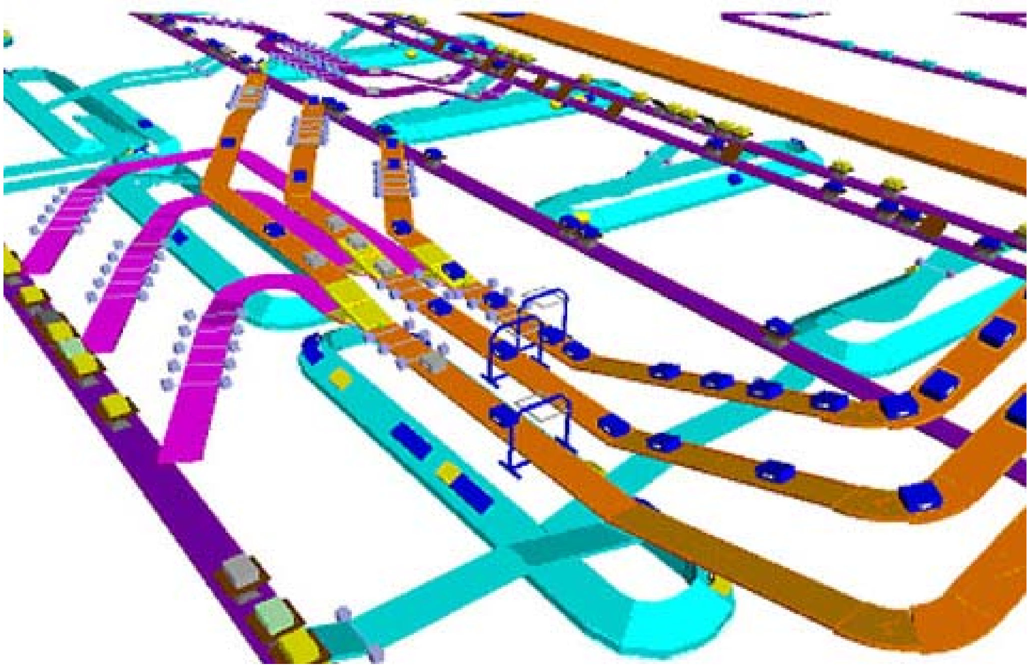
The limiting factors of a checked baggage screening system are the throughput of the X-ray or EDS unit(s), the facilities and staffing for on-screen-review, the efficiency of the process, any manual search, and the configuration of the conveyor systems. Other variables affect the processing rates of the numerous stand-alone lobby and basement installations, and the few In-line EDS installations in the U.S. These same variables and their impact apply to the European concept installations. Some of these variables are: inefficiencies of antiquated conveyor installations, lack of effective timing, inadequate queuing and metering conveyors, inaccuracies in the baggage tracking systems, mechanical breakdowns, EDS electronic restoration after a failure, physical layout of the passenger terminal (distance from the check-in counters and the EDS lobby installations), number of passenger check-in counters feeding a conveyor system, incompatibilities between conveyor systems and EDS conveyors, baggage screening staffing, conveyor and EDS entry jams, as well as other factors.

4.1 Airport Conveyor Systems Impact

One significant difference between the U.S. and the European, and for much of the larger international airports in the world, is the difference in the airport conveyor systems. Generally speaking, with one notable exception, the new Denver International Airport, U.S. airport conveyor systems are airline specific[49]. In most U.S. airport terminals there are multiple conveyor systems, each serving a specific airline, or a group of smaller airlines. Major airlines having the larger share of an airport's traffic generally have their own conveyor system serving their multiple-passenger check-in stations. In some

[49] Denver International Airport's conveyor system was initially constructed to serve as an airport-wide conveyor system and subsequently modified to accommodate specific airlines. The systems at some smaller airports, such as Jacksonville, FL and Harrisburg, PA are also airport wide and not airline specific.

instances airlines have their own terminals for their exclusive use[50]. Airlines with a smaller market share at the airport may share a conveyor system with several other competitor airlines.



At larger European, and many newer international airports worldwide, the conveyor systems tend to be either terminal-wide or even airport-wide installations. As a consequence these airports can achieve much greater levels of efficiencies in the processing of checked baggage through well-designed checked baggage screening systems. With a substantial number of passenger check-in stations feeding the overall conveyor system, and a well-designed integrated In-line checked baggage screening system, an airport can come closer to achieving the maximum throughput rate for all the capacity limiting components of the system, such as conveyors, high-speed Stage 1 advanced technology X-ray units, lower speed EDS units, etc. Larger systems handling a diversity of airline flight operations also generally have higher equipment utilization as flight departures tend to be more evenly distributed throughout the day.

4.2 Operator On-Screen Review (OSR) of Uncleared Bags

The Europeans were the first to develop and use on-screen-review of X-ray images of checked baggage from a remoted control room. As a consequence of this lead, they developed screening protocols and resolved their concerns in the 1990s involving on-screen-review of X-ray images, and, subsequently, for images from U.S. and European certified EDS units.

[50] A good example is British Airways exclusive use of Terminal 4 at Heathrow International Airport. When the new Terminal 5 becomes operational, BA will move their operations to the new terminal. Other examples are American Airlines at Dallas-Fort Worth and United at Denver and Chicago O'Hare.

Permitting an operator on-screen-review was a controversial process that generated much discussion within the FAA and, more recently the TSA. The controversy surrounding the use of on-screen-review was the reported difficulty of attaining a consistent satisfactory level of performance from EDS operators[51]. The specific details of the on-screen-review protocol determine the operator clearance rate and review time needed. Until relatively recently the on-screen review process remained unresolved as to whether it would be allowed in the overall U.S. EDS installations. In the interim on-screen-review remained a "grandfathered[52]" process at the SFO International Terminal EDS installation, Boston Logan International Airport EDS installations, and at a couple of other locations. This controversy has now been settled and the TSA began using on-screen-review system-wide in the U.S. in late 2004, albeit with a very conservative protocol.

On-screen-review usually results in a substantial increase in throughput for in an In-line EDS checked baggage screening system by reducing the number of bags that have to be hand-searched. In certain situations, on-screen-review can actually reduce throughput for the case where the EDS operates in "hold no bags" mode. This can happen when insufficient conveyor space does not accommodate the on-screen-review time before the bag reaches a default point, then some form of bag holding must be used with a resulting reduction of baggage throughput.

Under the European concept baggage processing rates in excess of 1,200 bags per hour at Stage 1 X-ray units can be achieved, and by using on-screen-review at Stage 2, a well-qualified team of operators can reduce the number of bags going to Stage 3 EDS units to approximately 10% of the overall baggage input. With a properly functioning Stage 3 EDS unit and on-screen-review at Stage 4, a well qualified team of operators can reduce the number of bags going to ETD and physical search to approximately 1-3% of the overall baggage input. On-screen-review at multiple levels comes at additional labor costs as some bags will be reviewed at more than one level. Bags that are uncleared at an early level will often fail later levels and be viewed at that level again without being cleared. Therefore, more review stations and operators may be required.

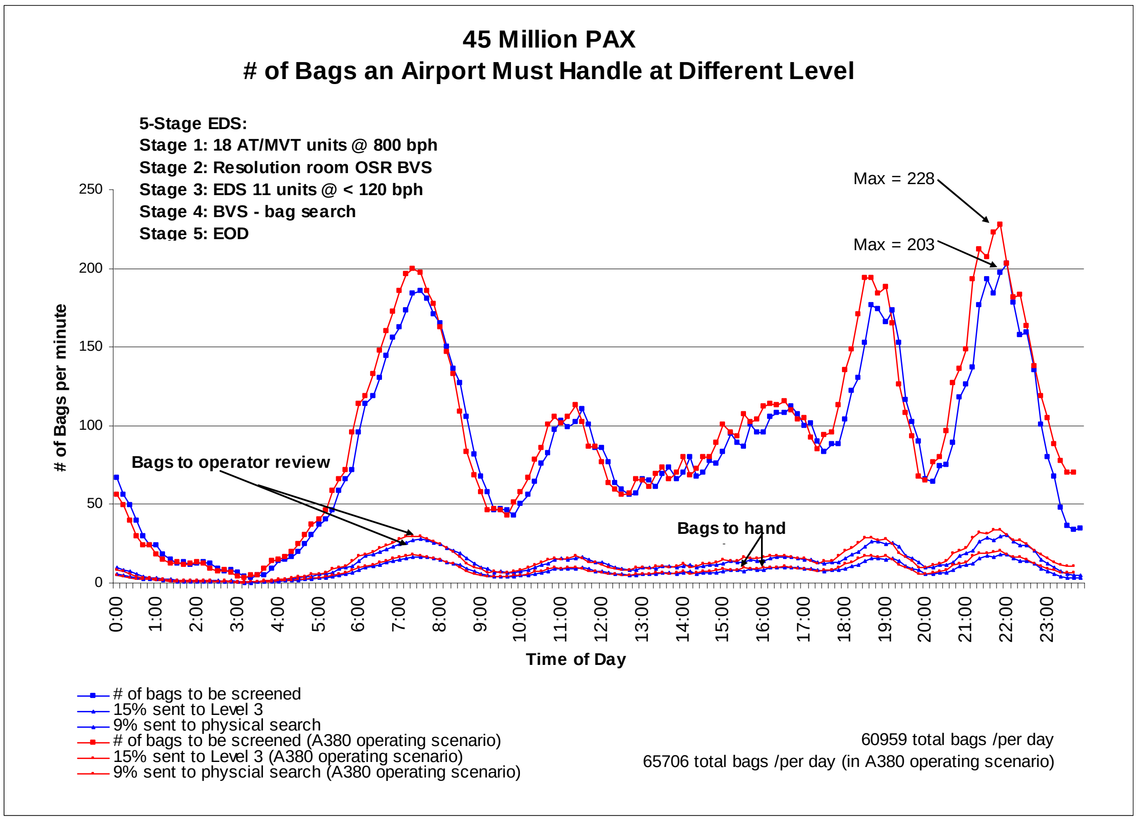
[51] On the other hand no terrorist bomb has ever been detected though the use of a U.S. certified EDS – or any other EDS. However there have been a couple of interesting associations with fireworks.

[52] Grandfathered is a term-of-art used to indicate a procedure or process is a hold-over from a previous time-period where the same process is not allowed, or is in question, under new rules.

Absent the use of on-screen-review, the efficiency of In-line EDS installations is considerably diminished as a 15 - 20% (and higher) false positive rate can raise havoc with the ability to process checked baggage. In this scenario, more hand search/ETD operators and facilities (tables, monitors, etc) must be provided. If these additional hand search stations are not provided, the result may be an impact on bag throughput because of the delay in completing any physical search of uncleared bag(s). These inefficiencies can result in delays to departing aircraft and these delays are cumulative as they can, in extreme cases, dramatically affect down-stream on-time departures throughout an airline's operating system. Again, as stated earlier, on-time departures of high-volume aircraft operations can be materially affected by an inefficient checked baggage screening system design.

4.3 Processing Efficiencies and Resolution of Uncleared Bags

Resolution of uncleared bags eventually results in the application of another technology or in a physical search of the bag accompanied by ETD examination of the contents that caused the alarm. Physical searches are time-consuming and labor intensive, and intrusive as far as many passengers are concerned. Many travelers since 9/11 have their own amusing or horror stories to tell concerning physical searches of their personal possessions. These stories are generally uncomplimentary to the security screeners, although one occasionally hears an amusing story of an encounter. At any rate, physical searches diminish the rate of throughput in the checked baggage screening system.

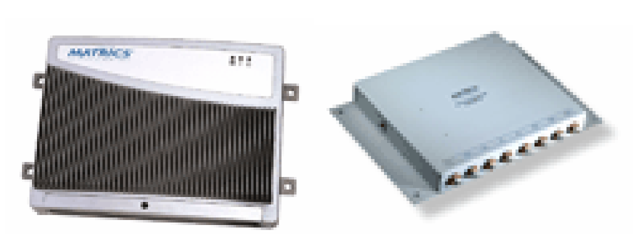


As noted elsewhere, most U.S. EDS In-line installations are single-stage EDS unit installations with images multiplexed to a Resolution Room where TSA operators view images at baggage viewing stations, or either lobby or baggage room stand-alone installations, not integrated into baggage conveyor systems. Of the single-scanner In-line U.S. EDS systems, Boston Logan International Airport and Jacksonville probably are the longest in operation and have the greatest amount of experience. Throughput rates in hold-no-bags mode typically run between 180 and 425 bags per hour,[53] with higher potentials claimed. The average throughput is probably more on the order of 350 bph because of the several variables involved.

Handling high volume baggage processing at airports of 30–45 million and higher passengers per annum is a serious issue.

The processing throughput rate looms large in the scheme of things to the airlines operating from these airports and their on-time departures. The TSA at one U.S. major airport recently discharged its Federal Security Director and his Deputy after earlier allegations of improper release of unscreened bags resulting from a failure of the airport's baggage conveyor system. TSA employees claimed that their supervisors directed them to release unscreened bags for loading onto airplanes after alleged pressure from the affected airlines[54].

4.4 In-line Baggage Tracking Technologies



Typical RFID Readers

Sophisticated baggage distribution systems are needed to support scan-center and multi-stage EDS operations and require an accurate baggage tracking system. Accurate baggage tracking for In-line security screening systems is a concern that is, as yet, not fully resolved. The solution is known but has not been adopted by the International Air Transport Association (IATA), the principal standard setting organization, along with ICAO, for international airline operations. The current IATA bag tag tracking system is based on bar-code technology. IATA adopted this standard in the late 1980s and it is not a trivial undertaking to change.

The current state-of-the-art technology favorite to replace the bar-code standard is Radio Frequency Identification Device (RFID). RFIDs can either be active or passive devices[55] and can be integrated into tags similar to the current bar-code airline bag tag. Unfortunately, RFIDs are currently in the $0.25+ price range per tag and are too

[53] GAO-05-365, *AVIATION SECURITY*, pg. 23, March 2005.

[54] Houston Chronicle, *Hobby security chiefs resign ahead of report Federal probe is said to expose breaches with unscreened bags*, Oct. 14, 2004. Oct. 14, 2004.

[55] Active technology emits a signal continuously while passive technology emits a response only when interrogated by an electronic signal.

expensive to use system-wide at this cost. The good news is that billions of tags are needed for the world airline system and the price per-tag will probably be less than $.05 U.S. when and if RFID is adopted as a worldwide industry standard.

Some airports have already begun to use RFID tags for tracking bags in their In-line baggage screening systems. RFID tags generally obtain read-rates in the high 90% range, while the present bar code standard tags are lucky to reach a mid-80% accurate read-rate. Bags that are lost to the tracking system are usually automatically re-routed by the baggage control system to a redirection station. Manual intervention is then required by an individual to read the bar code with a scanner or read the printed information on the tag in order to redirect the bag to its proper destination. Some U.S. In-line installations do not have redirection stations and any bag that is lost by the computer tracking systems is automatically routed to the baggage search station. Operating protocols usually require that these lost bags be searched and this significantly adds to the workload of the baggage search staff.

These bag tracking inefficiencies reduce the bag throughput rate and require additional manpower to run the In-line system. In the end, the reduced manpower costs from the elimination of the manual redirection stations required in bar-code bag tracking systems, and the increased accuracy of the RFID read-rate, will probably reduce overall costs to more than compensate for costlier RFID tags. Given the current state of RFID technology and the myriad problems of tracking bags in a conveyor system with bar code technology, it is high time that the International Civil Aviation Organization and the International Air Transport Association undertook actions to adopt RFID as the baggage tracking standard.

4.5 Baggage Content Variability and Its Effect on Screening

Another variable is the size and contents of bags. In the San Francisco International Terminal[56] there is a considerable problem with the size of some of the bags used by travelers from some Far East countries that are too large for the tunnel opening in the EDS units. These oversized bags must be screened using other technologies and/or physically examined. There is also a considerable difference in the contents of some bags of travelers from the Far East from bag contents of Western business or pleasure travelers.

A noticeable difference occurs between travelers to the Philippines and the Republic of Korea and travelers from other countries. The travelers from the Philippines and the Republic of Korea pack large amounts of foodstuffs on their return to their home countries and as these are organic substances with characteristics similar to explosives, they tend to generate a higher number of false positives. A similar situation occurs on the U.S. East and Southern Coasts with travelers to the Middle East, the Caribbean, and countries in Central and South America. Similar situations exist at airports in other areas of the world, such as Middle East, Africa, etc.

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[56] This is not a problem that is unique to San Francisco as the same problem exists at numerous airports worldwide.

4.6 Conveyor "Jams" and Their Effect on System Throughput

Another problem is that some bags, even though they are actually small enough to go through the EDS tunnel, become mis-aligned on the conveyor input to the EDS unit and jam the entrance to the EDS tunnel. Once these jams occur, a number of bags can pile up behind the mis-aligned bag, or the system automatically senses the jam and shuts down, or the whole system stops while the jam is being cleared. A considerable amount of attention has been given to this problem and it appears that the extent of the problem has been substantially reduced. A problem often misdiagnosed as a jam results when a bag slips on the conveyor within the EDS scanner causing an image misread. When this occurs, the bag involved must be rescanned or directed to manual search.

Some major new airports, and some older international airports such as Frankfurt, Germany, have invested in conveyor systems that provide the maximum flexibility to airlines. The conveyor must be designed and constructed to provide: continuity of service, minimal periodic maintenance, effective baggage tracking, and effective and efficient movement of baggage to any destination in passenger terminals. Some of these airports have dual-racetrack conveyor systems that offer the flexibility to reach any point in the baggage distribution system, even if one conveyor racetrack is shut down for maintenance or has failed for some mechanical or electrical reason. Obviously, older antiquated conveyor systems that lack the flexibility of these better systems will have greater difficulty achieving efficient operation when In-line baggage screening systems are added.

Irregular baggage inputs from passenger and curbside check-in areas can also result in throughput inefficiencies. This occurs when there is insufficient baggage input to selected conveyor systems and/or the conveyors lack metering and queuing conveyors to regulate the input and flow of baggage into the In-line system. Likewise a surge of bags within a short time span can overload an In-line EDS checked baggage screening system.

4.7 Impact on Future Modifications to Existing EDS units

The GAO study reports that stand-alone EDS units "can screen 120 to 180 bags per hour[57]." In another part of this same GAO study on page 23 they show the following data:

Bags Per Hour Screened by Stand-alone and In-line EDS Machines and ETD		
Type of Equipment	Stand-Alone	In-line
CTX 2500 – Stand-alone only	120	NA
CTX 5500	180	250
CTX 9000 – In-line only	NA	425
L3 6000	180	425

[57] GAO-050365 *AVIATION SECURITY*, pg. 44, March 2005.

Elsewhere in this paper it is acknowledged that some suppliers are claiming EDS processing rates in excess of 500 bags per hour. Such rates require nearly perfect presentation of bags by the conveyor system with lateral alignment, orientation and axial spacing that is nearly impossible under actual airport conditions. We also note that it is unlikely that these high processing rates can be consistently maintained for a variety of reasons previously listed, such as conveyer failures, bag jams, EDS unit failures, etc.

InVision CTX 2500

The good news is that the efficiency of the EDS units is likely to improve as the systems are enhanced by future software modifications. These expectations notwithstanding, it is highly unlikely that improved versions based upon the current mechanically constrained GE InVision and L-3 EDS units will ever sustain processing rates much higher than the 500 – 600 bags per hour range in In-line installations and will have negligible bag throughput improvements in stand-alone installations.

On the other hand, the life cycle of the GE InVision and L-3 EDS units are probably in the 5 – 10 year range and the machines will have to be replaced relatively quickly, particularly in heavy-use environments where mechanical failures may become a problem. Future EDS replacement units and/or technologies will hopefully substantially improve the detection effectiveness as well as baggage throughput efficiencies (see Section 7.0 – New Entrants and Emerging Technologies for more comments on this).

5.0 EDS System Costs

Denver International Airport

Checked baggage screening systems require a considerable amount of capital investment. As noted in Section 2.4, one relatively modest airport EDS system cost approximately $5 million U.S. per EDS unit after all costs were calculated. This is one of the moderately expensive per-unit U.S. installations[58]. The U.S. Government, under Letters of Intent (LOI) promising to fund 90% of the installation costs of airport hold baggage screening systems, has committed $1.276 billion for just 8 major U.S. airports:

[58] Ibid., pg. 63, March 2005.

TSA Letters of Intent to Fund 90% of In-Line Installations[59]			
Airport	Millions	Airport	Millions
Atlanta Hartsfield-Jackson	$125	Las Vegas McCarran	$125
Boston Logan	$116	Los Angeles/Ontario	$342
Dallas/Fort Worth	$139	Phoenix	$122
Denver	$ 95	Seattle/Tacoma	$212
Total LOI for 90% funding for Eight U.S. Airport In-line Installations			$1.276

Adding the 10% that the airports have to pay brings the total for these 8 airports to $1.418 billion – not an inconsiderable sum of money. As former U.S. Senator, Everett Dirksen is reported to have once remarked "A billion here and a billion there, pretty soon it adds up to real money[60]".

A number of the remaining 429 U.S. commercial airports are clamoring for assistance from the U.S. Government in funding the installation of In-line hold baggage systems. Miami, for instance, is having considerable difficulty even getting the U.S. Government to commit to a LOI for their installation needs. Furthermore, none of these funds involve the actual acquisition of the EDS units – these are, or at least up to this point, provided by the U.S. Government at approximately $1.2 million each. Thus far the TSA has purchased approximately 800 CTX-9000/5000/5500/2500s and approximately 500 L-3 3DX6000s for deployment at U.S. airports[61].

InVision CTX 5500DS

L3 eXaminer 3DX 6000

5.1 Overall Costs of U.S. In-line EDS Installations

Overall, the cost of the EDS units, engineering design, civil works, redesign or replacement of conveyor systems, integration of In-line EDS systems into U.S. airport conveyor systems, and associated other expenses has been estimated to top $12 billion[62]. The Reason Foundation based this figure on the purchase and deployment of 6,000 EDS

[59] Statement of David Z. Plavin, President, Airports Council International-North America (ACI-NA) on behalf of ACI-NA and the American Association of Airport Executives (AAAE) before the House Aviation Subcommittee Hearing on Financing/Deployment of Explosives Detection Systems, July 14, 2004.
[60] Senator Everett Dirksen, U.S. politician (1896 – 1969). As an ASI member notes "Billions soon to be revised to Trillions".
[61] *Government Security News*, pg. 16, April 4, 2005.
[62] Reason Foundation http://www.rppi.org/071102.html (2002).

units – a wildly speculative number of EDS units. The Reason Foundation was one of the more rational post-9/11 assessments. A number of pundits, with little detailed knowledge of the U.S. aviation system and even less access to sensitive information, but with a great deal of enthusiasm, came forth with a number of forecasts and sensational projections in the months following the 9/11 terrorist attacks.

Based on the recent GAO Report[63] and some other assessments, a more realistic figure would probably be in the vicinity of 3,000 to 3,500[64] EDS units when all U.S. airport systems have been purchased. The GAO Report states "Total costs of In-line EDS Baggage Screening Systems are unknown." The GAO Report also states that "the total cost of installing in-line systems is—a rough order-of-magnitude estimate—from $3 billion to more than $5 billion." Based on the author's estimate of roughly 3,000 to 3,500 total EDS units, and an estimated average installation cost of $1.5 to $2 million for each unit (probably $4 million each for purchase and installation), we arrive at a range of $4.5 to $7 billion total cost for the entire U.S EDS In-line and standalone EDS system. This is still a considerable sum of taxpayer and aviation industry funds.

Sadly this is probably still a low figure – sadly, because it is necessary, not because of the cost. A TSA 2002 projected budget of $6.8 for EDS deployment may still be low by several billion when and if the U.S. EDS program is completed in future years. The U.S. Congress, after a relatively supportive start, has now become overly cost-conscious and is "nickel and dimeing" the allocation and appropriation of funds to enable the construction of a U.S. wide In-line EDS system. This miserly allocation and appropriation of funds will exacerbate the existing and future installation problems, and add to the overall cost of the U.S. EDS system. Given the consequences of the 9/11 attacks where the world economy was dramatically impacted and the U.S. aviation industry critically affected, the Congress' position is mystifying.

5.2 EDS In-line Life-Cycle Costs

Capital costs are not the end of the matter as parts, maintenance, and equipment operation costs may, in the long run, dwarf the initial capital costs. The extent to which this happens is dependent on a number of variables, the most important of which is the mean time between failure (MTBF) of the mechanical components of the EDS units and the associated conveyor units[65]. GE InVision, Inc. won a $36 million contract and L-3 Communications obtained a $28 million contract with the TSA to provided maintenance for approximately 800 and 500 EDS of their units respectively on March 14, 2005. These two contracts run thorough September 30, 2005, and each has a four-year option for renewal[66]. These figures indicate it will cost approximately $50,000 per U.S. EDS unit per year ongoing maintenance cost for the EDS units alone.

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[63] See GAO-05-365 entitled "*AVIATION SECURITY*, GAO-05-365 March 2005.
[64] Author's calculations from personal knowledge and available public data.
[65] Particularly the queuing, sequencing, timing, etc. conveyors.
[66] GSN Government Security News, pg16, April 4, 2005.

This considerable capital investment and the associated maintenance issues now beg the question whether these units were the right choice given today's situation. Are the investment and the anticipated benefits worth the life-cycle costs? The answer lies in one's perspective. Perhaps the best manner of determining the worth of what the U.S. is doing is to review the lesson of the 9/11 terrorist attacks.

5.3 Cost-Avoidance versus Cost-Consequences

During the deliberations of the now famous, or infamous as to one's viewpoint, Gore Commission[67] in late 1996 and early 1997, one of the Commissioners, Ms. Victoria Cummock made the suggestion that $4-$5.00 per ticket, the price of a quick meal[68] at a fast-food outlet, be levied on passengers to support aviation security improvements. Mrs. Cummock's suggestion was roundly rejected by most of the other 21 Commissioners. Had this been adopted and the 9/11 attacks been prevented, which is a huge assumption, the result of cost avoidance of the $4-$5.00 per passenger security charge would have been dramatic.

It has been variously calculated by differing organizations that the 9/11 terrorist attacks cost the U.S. economy $639 billion through 2003[69]. The impact on the world's economy is even harder to determine, but it is variously estimated to be between $1 to 2 trillion or more. The cost of the $4-$5.00 levy for the years between the Gore Commission's demise on February 12, 1997[70] and September 11, 2001, would have been approximately $10.4 to $13 billion. This is based on the number of revenue passenger enplanements of 2,559,028,000[71], or, for the benefit of this analysis – 2.6 billion passengers. The benefit cost ratio using these rough-order-of-magnitude figures would have been a startling 60 to 1, using the $10.4 billion security assessment and the New York State Senate Finance Committee's $639 billion estimate, or 154 to 1 using the $13 billion security assessment and a cost consequence figure of $2 trillion.

These are immediate short-term direct and indirect impacts of the 9/11 attacks. The medium- and long- term impacts, although highly uncertain, affect industries' capital bases. It has been estimated that the medium-term impacts will primarily affect five main areas: (1) insurance – an estimated increase in property and liability insurance rates of 30%; (2) airlines – a loss of 20% in the industry's relative value; (3) tourism and other industries associated with travel – relative equity values in hotels and leisure facilities

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[67] President Clinton's *White House Commission on Aviation Safety and Security*, Executive Order 13015, August 22, 1996.

[68] Or, a quickie meal, as stated by Ms. Cummock at the time.

[69] The New York State Senate Finance Committee, GAO-02-700R, *Impact of Terrorist Attacks on the World Trade Center*, pg. 32.

[70] Actually the calculations used are from September 1997 as it would take at least that much time, even on an expedited basis, for any assessment to have been passed into law by the Congress and signed by the President.

[71] Department of Transportation Bureau of Transportation Statistics, www.bts.gov/programs/airline_information/indicators/airtraffic/annual/1981-2001.html .

reduced by 15%;(4) shipping – underlying transportation rates increased; and (5) increased defense/security expenditures[72].

In doing research on the cost-consequences of the 9/11 attacks, one is struck by the indefinite findings of the papers on the subject. Moreover, the further one recedes from the date of the attacks, the more uncertain the amount and extent of the cost-consequences become. As the 9/11 attacks get mixed with the already diminishing U.S. economy at the time of the attacks, as well other subsequent events such as the Severe Acute Respiratory Syndrome (SARS) outbreak in Southeast Asia, the more difficult it gets to accurately assess the extent of the impact of the attacks. In the end, one has to accept the fact that there is no satisfactory way to directly and accurately determine the full extent of the economic consequences of the attacks.

As unlikely as it seems, there are positive economic consequences as a result of the 9/11 attacks in that it created an increase in the security and defense industries' output in equipment, R&D, new technologies, increased security and defense employment, etc. One can just as easily argue, however, that these economic benefits, for the most part, are consequences that also add to the burden of the world's commercial environment through the increased cost of the production of goods, their transportation, etc. In any event, any positive economic consequences are far out-weighed by the negative cost consequences of the attacks.

No scientific support for these figures is claimed, but the reader will get the point. Sometimes the choices we have are not pleasant, but there is no substitute for doing the job right the first time. This would appear to be the case in the checked baggage EDS system – we can gamble, as we have been doing in the years prior to the 9/11 attacks, or we can do the job right. In any event, the potential consequences are most unpleasant if we fail – particularly if we do so a second time.

One aspect of cost-consequence is that one never knows in advance what the ultimate price will be for not doing something. One can speculate on a worst-case scenario – but it is still speculation. In the failure to adopt Ms. Cummock's suggestion to levy a $4-$5.00 fee for security on each passenger the calculation of the cost, including projections, is relatively easy. However, one does not know in advance if it will prevent a disaster from occurring, or the consequences of a disaster if it does occur. In this instance, the consequences were horrendous – will the next consequence be the result of a chemical, biological, nuclear or a radiological dispersal device (RDD - a dirty bomb)?

5.4 Psychological Consequences

The monetary costs are not the only thing at issue. The psychological loss the U.S. suffered as a nation, and similar losses to other nations as a result of the vulnerabilities exposed are incalculable – but real. It takes decades for a nation to establish a sense of invulnerability and, although the U.S. had breaches in its aviation security system, it was

[72] Robert Looney, Economic Costs to the United States Stemming from the 9/11 Attacks, *Strategic Insight*, August 5, 2002.

looked on as relatively terrorist-proof – that is until this myth was destroyed on 9/11. This sense of invulnerability was in itself a level of protection, and many of the U.S. adversaries believed it as well. But many of the professionals in the aviation security system knew its "warts" and were not as sanguine about its invulnerability.

The U.S. failure to prevent the 9/11 attacks, or to prevent a part of them, empowered its adversary. It now appears that individuals and groups with like-minded views were emboldened and may attempt to attack the U.S. in the future, something that they would never have considered doing so absent the successful 9/11 attacks. The U.S. is still addressing these potential adversaries, and will probably have to contend with a halo effect for decades. All of this is because the U.S. was not vigilant enough to ban the admission of "edged weapons" on commercial airplanes. As the saying goes:

> "*for the want of a nail the horse shoe was lost, for the want of a shoe the horse was lost, for the want of the horse the rider was lost, for the want of the rider the message was lost, for the want of the message the battle was lost, for the want of the battle the war was lost, for the want of the war the kingdom was lost, and* ***all for the want of the horse shoe nail***." Benjamin Franklin

What better symbolism than that of 9/11 – *for the want of a security system that detected and prevented the use of* ***4 inch blades****, etcetera, etcetera*.

Once a major breach occurs in an otherwise vaunted system, it is nearly impossible to re-establish the sense of invulnerability. The U.S. is now in that position of trying to re-establish our supposed invulnerability and protection against bombings as one of the key defensive areas. The U.S. cannot afford to fail, given the horrendous impact a second failure would have on the U.S. and the world aviation community. So, based on these considerations, perhaps the price now being paid for protection from explosive devices being placed on airplanes may be small indeed.

6.0 Pre and Post 9/11 U.S. Government Technology Installation Activities

In the four years preceding the 9/11 terrorist attacks, the U.S. FAA established a Security Equipment Integrated Product Team (SEIPT) for the procurement, engineering, and installation of checked baggage screening equipment. That mandate evolved for the SEIPT to address Walk-Through Metal Detectors, passenger Threat Image Projection (TIP) X-ray screening equipment, and ETD as well as checked baggage screening systems. The SEIPT began its activities in late 1997 from a location in FAA

Headquarters. The SEIPT operations were eventually moved to Herndon, VA, in the summer of 1998.

The FAA, through the SEIPT contractual process, selected Raytheon to do engineering studies, develop specifications, and oversee the installation of a variety of security equipment funded by the U.S. Government at selected U.S. airports. Over a period of four years leading up to the 9/11 terrorist attacks, Raytheon went through a learning-curve working with the SEIPT and selected U.S. airport and other officials. When the 9/11 attacks occurred, it would have logically appeared that everything was set for a rapid deployment and implementation of the EDS hold baggage screening equipment, new TIP-ready carry-on article X-ray screening units, more sensitive walk-through metal detectors, etc. But, this was not to be.

Shortly after the 9/11 attacks, the DOT, in all its wisdom, decided to re-advertise the functions of the Raytheon SEIPT contract. The DOT, again in all its wisdom, selected the Boeing Service Company led consortium for the $508 million award through December 21, 2002, to take over the functions that had been so hard-learned by the Raytheon team. Rumors were rife that the Boeing Service Company[73] won out of sympathy to Boeing because of the trauma to Boeing growing out of the 9/11 attacks where all-Boeing aircraft were used. This appears to be rumor only as there is no concrete evidence, or at least none that has been forthcoming to this point, that this was the case. Others, in a more knowledgeable position, assert that these rumors have no basis in fact and that the Boeing Service Company team simply provided a much better proposal. These same persons wonder whether Raytheon was over-confident since they already had a contract and just presumed that it would continue.

The net result in the change from Raytheon to the Boeing Service Company team was a considerable amount of confusion, delay, consternation, and frustration on the part of the SEIPT members and the affected airports. Numerous complaints were heard from airport managers and engineers who repeatedly asked, "Who are these idiots showing up asking dumb questions---what happened to the Raytheon team to whom we explained all this two years ago?" In any event, for whatever the reason that the contract was changed to the Boeing Service Company team, it created additional stress on the system by bringing in another organization that had to go through a considerable learning curve during a major recovery from a crisis situation.

These problems were subsequently compounded by the Boeing Service Company group having to do the training, initiation, and implementation of the hold baggage screening process, e.g. baggage search, alarm resolution, etc. by December 31, 2002, and,

[73] Boeing Service Company contract included several subcontractors: Siemens Dematic Corp., Dallas TX; DMJM Aviation, Deal MD; Corgan Associates, Inc. Fort Worth, TX; Leo A. Daly, Los Angeles, CA; TransSolutions, Fort Worth, TX; Preston Aviation Solutions, Inc., Marietta, GA; Cage, Inc., Irving, TX; Advanced Interactive Systems, Inc., Renton, WA; The Multitech Group, Inc., South Plainfield, NJ; Turner Construction Co., Farmington Hills, MI; Ricondo & Associates, Chicago, IL; Hanscomb, Houston, TX; Zuckert Scoutt & Rasenberger, Washington, DC: and Aergo, Dallas, TX. Transportation Security Administration Press Release TSA-18-2, Friday June 7, 2002.

subsequently, by December 31, 2003[74]. The initial training of the EDS operators[75] in regard to review of bags that were not automatically cleared by the EDS was to just open and search the bag. Therefore, after the initial installation of stand-alone EDS equipment, most EDS units were initially operated without any on-screen-review – whenever a bag alarmed the unit the search team did not even bother to look at the EDS screen, they just opened the bag. Lack of training? – Yes. Lack of skill? Of course. Contributing to this situation was the discovery in the pre-9/11 environment by the FAA's Red Team[76] that the operators on the existing EDS installed systems were not consistently applying good judgment in their on-screen-resolution of uncleared bags. As a consequence, the FAA suspended the use of on-screen-resolution except for a couple of locations.

The Boeing Services Company contract came up for review in early 2004 and many of the SEIPT [by now changed to the Security Technology Deployment Office (STDO)] members were reportedly elated when it appeared that the Boeing Services Company group would not have their contract renewed. It was renewed at a price of $198 million through December 31, 2004, to the dismay of many, reportedly because the Bush Administration feared the political consequences of denying Boeing workers this contract in an election year – go figure? Again, there is no concrete evidence that this was the case, but there clearly was a great deal of unhappiness in the performance of the Boeing Services Company team in the first two years after the award of the contract.

The familiarization of the new Boeing Services Company teams with the existing U.S. airport baggage handling systems and the nuances of the new EDS equipment and environment, in retrospect, was an unnecessary burden on the U.S. aviation system when speed and clarity were needed. Raytheon had acquired this knowledge and experience during its contract over a four-year period and presumably could have reacted quickly and appropriately in the post 9/11 emergency period. Bringing in a new contractor who had to re-learn what was already known to a previous contractor created an unnecessary burden by the U.S. Government authorities who made this unwise decision.

According to a Boeing News Release on February 10, 2004, and a TSA release of August 24, 2004, the contract to Boeing was extended to December 31, 2004. The August 24th TSA release also stated: "Over the next few weeks, TSA will solicit information from the private sector regarding multiple contracts for deployment, installation and maintenance for the post December 31, 2004 period." The TSA did indeed solicit information on bids from the private sector and awarded maintenance contracts to both InVision as well as L-3 for their respective deployed units. The TSA also extended the Boeing Services Company contract through March 10, 2005, but did not extend it beyond that date. The Boeing Services Company announced on March 10, 2005, that it had successfully completed its contract with the TSA.

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[74] Aviation and Transportation Security Act (ATSA) (Public Law 107-71, 115 Stat. 597 November 19, 2001). This deadline was subsequently extended to December 31, 2003 (Homeland Security Act of 2002, Pub. Law No. 107-296, 116 Stat. 2135).

[75] The Boeing Service Company team had to train a total of 21,500 federal baggage screeners – but not all of these necessarily for on-screen-review of EDS images.

[76] A generally accepted term to define a group of people whose job is to test systems, usually covertly.

The TSA's June 7, 2002, news release (TSA 18-02) stated: "the Boeing Service Company will install up to 1,100 EDS machines and between 4,800–6,000 ETD machines. In addition the company will manage the installation of the EDS and ETD machines into the airports, provide for continuous improvement of the equipment including innovation and retrofit, manage maintenance of the equipment and provide training for a minimum of 21,500 federal baggage screeners to operate the equipment." The TSA's August 24, 2004, news release stated that "The original contract . . . led to the successful deployment and installation of more than 7,000 pieces of explosive detection equipment to the nation's 450 (sic) commercial airports." GAO-05-365, page 20 reflects the following EDS and ETD status as of June 2004:

	Number		
Airport Category	**Airports**	**EDS Machines**	**ETD Machines**
X	**21**	**679**	**2,833**
I	**61**	**467**	**2,401**
II	**50**	**71**	**695**
III	**124**	**9**	**744**
IV	**190**	**2**	**473**
Total	**446**	**1,228**	**7,146**

This is an impressive accomplishment in one sense, but a questionable accomplishment in another, i.e. how many EDS systems were installed in an In-line configuration during this time? Given the amount of expenditure, $706 million for deployment[77] of this equipment, this amounts to $84,308.57 per individual piece of equipment deployed – very little of which was installed In-line.

Where, what, and to whom were these funds expended? Presumably a substantial amount was spent on engineering studies having to do with positioning the lobby and basement stand-alone EDS units. Also, presumably a good deal of money was spent on strengthening airport lobby floors to accommodate the floor-load weights of the GE InVision CTX5500DS, CTX2500s and the L-3 eXaminer 3DX 6000 EDS units. How much was spent on re-learning the airport/airline and the aviation system? How much on training 21,500 baggage screeners? But, at $84K per EDS/ETD deployed, was this $706 million expenditure justified?

All this begs the question whether the U.S. taxpayer and passengers on airlines operating from U.S. airports received good value for the taxpayer funds and passenger revenue charges spent. It also begs the question of just how many developing or under-developed countries, or for that matter any country, can afford such extravagance.

[77] The TSA (U.S. Government) purchased the equipment from separate appropriations.

7.0 New Entrant and Emerging Technologies

There does not appear to be any major breakthroughs forthcoming in the immediate future to replace the existing computed tomography as the primary technology for non-intrusive bulk explosives detection. The latest TSA certified unit is Analogic's AN6400 EDS unit. The AN6400 is a third generation EDS with improved detection capabilities and a significant reduction in false positive alarms. Reveal Imaging's CT-80, is another recently certified third generation EDS unit and appears to be a substantial advance over the existing InVision and L-3 EDS units as it eliminates a substantial mechanical part of these competing units. The Reveal Imaging CT-80 and the Analogic AN6400 units add atomic number discrimination (dual-energy X-ray) to the density measuring capability of the predecessor CT EDS units.

Another new entrant, SureScan, has not yet been certified, but does potentially offer additional enhancements and development of EDS technology. SureScan is on the verge of submitting their SureScan™ x1000 to the TSA for testing. SureScan is currently preparing for bag data gathering, probably at the John F. Kennedy International Airport in New York. These actions are a prelude to the TSA certification testing at the TSA's Laboratory in Atlantic City, New Jersey.

7.1 Analogic AN6400 EXACT™

Analogic, the manufacturer of the computed tomography generator of L-3'S eXaminer 3DX 6000 and 6500 units, has developed the Analogic AN6400 CT EDS unit. The Analogic computed tomography AN6400 was certified by the TSA on April 27, 2005 and is what can best be described a third-generation + EDS.

Analogic AN6400

The Analogic betters the L-3 Xaminer 6500 EDS unit by adding dual energy atomic number discrimination, better internal air conditioning, a significantly improved workstation, and has better networking capability. The L-3 eXaminer's 3DX6500 workstation had already been substantially improved and the graphics was considered to be the best of the existing EDS units - the new Analogic unit graphics is reported to be even better, perhaps approaching that of current medical CT technology.

Because of the close working relationship between L-3 Communications' Security and Detections Systems and Analogic, L-3 will market the Analogic AN6400, perhaps as the L-3 eXaminer 3DX6500D (for dual-energy). The size and weight of Analogic's newly certified EDS is similar to that of L-3's eXaminer 3DX6500.

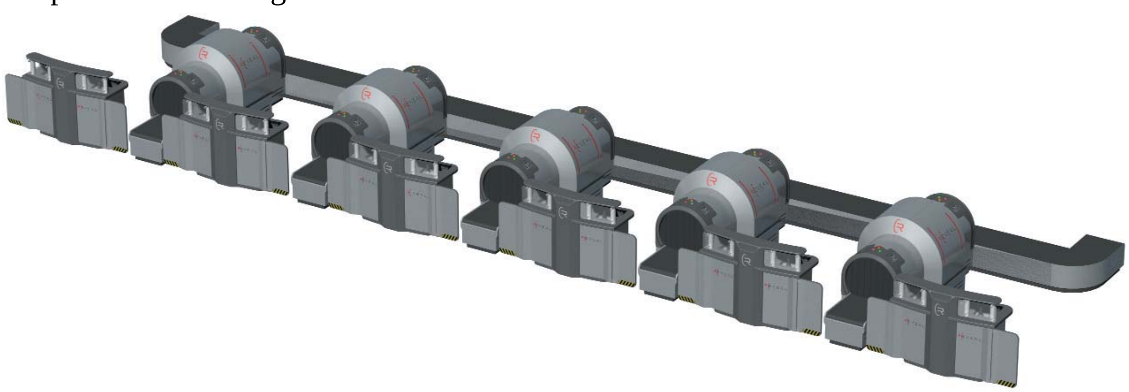
Unfortunately, Analogic's AN6400 still uses a mechanical gantry and the throughput is estimated to be approximately 500 bags per hour. However, with its improved networking capability, improved workstations, dual energy atomic number discrimination, and reportedly substantially reduced false positive rate, the AN6400 represents a significant advancement over the currently deployed EDS units.

7.2 Reveal Imaging CT-80

Reveal Imaging's CT-80, as a newly U.S. certified EDS unit, represents a major advance in Computed Tomography in that the unit has been designed with an electronic, rather than mechanical, gantry, thereby substantially reducing the mean-time-between-failure rate of the competitive EDS units. This new EDS unit[78] was certified in December 2004 and adds to the dimensions and options available to checked bag screening systems.

The CT-80 is arguably a third-generation CT explosive detection system using dual energy X-ray for material atomic weight discrimination rather than being capable of only measuring density (attenuation) variations in baggage under test. The CT-80 is significantly smaller and less expensive per-unit than other certified EDS equipment. Additionally, the design of the unit allows it to be installed in the check-in ticket area as well as In-line or stand-alone. This also allows the screening of the bag(s) in the presence of the passenger. The CT-80s can also be networked to provide some of the same labor savings as traditional in-line systems.

The CT-80 is approximately the same size as an Advanced X-ray unit and costs approximately the same or perhaps a bit more than some at $350 to $400K. Installed in a check-in kiosk and integrated into a discharge conveyor system, the CT-80 has the same electronic integration capability with an airport's baggage handling system as its competition, the GE InVision and L-3 EDS units. Said another way, the CT-80's Program Logic Controller communicates with the airport's conveyor baggage handling computer for full integration.



On the downside the CT-80 is far slower than its competitors at approximately 80 bags per hour. A straight comparison of throughput rates between the CT-80 and its competitors would require approximately 4-6 CT-80 units to handle the same throughput as one InVision CTX 9000DSi or L-3 eXaminer 3DX 6500 EDS unit. This, however, is not a true reflection of the situation as the CT-80 throughput rate should be able to easily handle the baggage check-in rate at individual check-in stations. In fact, one CT-80 should be able to easily handle the combined input from two and perhaps three check-in

[78] Reveal Imaging CT-80 www.revealimaging.com .

desks. In other words, for serving multiple check-in counters, at the normal rate of passenger check-in processing, the CT-80 may be a very efficient unit.

If the CT-80 units are not "clustered" in one location and are not networked, one of the unintended consequences of the CT-80 may be a higher labor cost per unit screened. This may not hold true, however, if the images from the CT-80 units are networked to a baggage viewing station control room and the on-screen-review operator staffing is adequate to accommodate the number of uncleared bag images. With systems in the check-in counters, it is possible to have the passenger present in case there is a problem with the bag. The labor associated with resolving any alarms on uncleared bags would then require that a security screener be available near the ticket counters to search the bags. The level of labor expenditure for these physical searches and whether this would be a problem, would depend on the number of installed CT-80s, their proximity, and the alarm rate of the units.

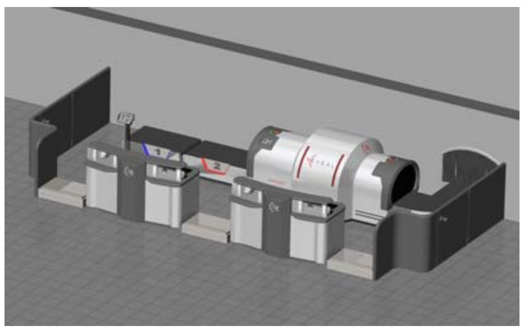
The CT-80 is not really designed for an In-line conveyor installation as reflected in this paper, although Reveal Imaging advertises it as In-line capable. In essence, the CT-80 can be installed "in-line," but at the front of the line instead of the middle. Reveal Imaging's perspective of an In-line CT-80 installation is that the unit would discharge screened bags into the airport conveyor system from an installation behind-the-check-in-counter. This can be either an advantage or disadvantage depending on the environment in which the units will operate. For example, there is less likelihood of mistracked bags arriving in a resolution room with an unknown status. Because bags are bar code read by the ticket agent, bag images and the tag numbers can be locked together for 100% tracking and reconciliation. A simple bar code read of a Reveal Imaging scanned bag should retrieve the images and the alarm status.

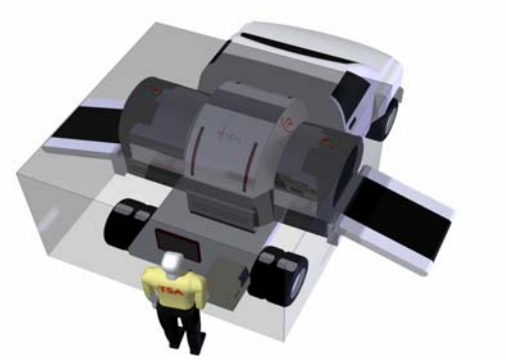
One concern in using the CT-80, however, will be the availability of space for the installation of multiple EDS units in the ticketing and check-in areas. On the positive side, the Reveal unit may be ideal for installation in smaller airports, at airports where there are limited multiple conveyor systems, etc. These check-in installations will normally require new check-in kiosks and associated engineering modifications of the check-in counters. This option considerably improves the aviation industry's installation choices, but the CT-80 check-in counter installations may also add to an airport's ticketing and check-in area congestion[79].

Reveal Imaging claims that the check-in desk is only one of many types of installations for this machine. Other types of installation include:

- Standalone – lobby
- Behind a bank of desks or kiosks
- Simple inline (low volume middle or end of line integration)
- Mobile

[79] See www.revealimaging.com/products_CT-80.html .





Whether the elimination of the mechanical gantry makes a dramatic difference in the mean-time-between-failure of the CT-80 versus GE InVision’s and L-3’s units is yet to be determined. Should this happen, a major life-cycle cost burden could be mitigated, and this would add to the attraction of the Reveal Imaging CT-80 unit.

7.3 SureScan Emerging Technology

One new emerging entrant potentially offers additional enhancements and development to the existing computed tomography EDS technology. SureScan, a wholly owned subsidiary of the Endicott Interconnect Corporation, is on the verge of submitting their SureScan™ x1000 to the TSA for testing. SureScan is currently preparing for bag data gathering, which will probably be accomplished at John F. Kennedy International Airport in New York over the next few months. These actions are a prelude to TSA certification testing at the TSA Laboratory in Atlantic City, New Jersey. An aspirant to the TSA certification testing does not get this far without first having passed some preliminary scrutiny by TSA scientists.

SureScan, while based on computed tomography, also adds the atomic number discrimination to its multiple-energy density measuring algorithms. The SureScan unit also eliminates the mechanical gantry by using more than two dozen separate X-ray source generators in its electronic gantry to acquire data. The SureScan™ x1000 unit can use up through 5 energy levels but the company will only say that it is using more than two energy levels. SureScan believes that these features, along with the added energy levels, will enable it to pass the TSA certification trials with a false positive level of less than 10%.

SureScan hopes to be able to have a bag throughput of between 700 and 1,000 bags per hour at a 10% false positive rate. SureScan, like most new entrants, takes a very optimistic view of their new equipment's potential performance. Most such new entrants never achieve their initial optimistic goals. However, if SureScan does successfully achieve TSA EDS certification, they offer a baggage throughput promise not seen in the current four certified EDS suppliers.

Should SureScan realize their goals, it will offer a dramatic improvement in the performance of U.S. certified EDS systems. At 700 to 1,000 bags per hour, with a 10% false positive rate, it may quickly become the best In-line EDS unit available. This could then validate the U.S. EDS philosophy of a single stage EDS system, with on-screen-operator review and become the industry leader. One cannot assume, however, that the current industry leaders, GE InVision and L-3, are blind to these potential developments.

7.4 InVision and L-3 S&DS R&D

The GE InVision and L-3 industry leaders are accelerating their R&D to produce similar advances in their EDS units to those of the new and emerging entrants to: 1) reduce the level of their false positives, 2) improve their detection levels, and, 3) increase bag throughput and eliminate the mechanical gantry.

L-3's R&D on new EDS technology is articulated in their 2004 Annual Report: "The TSA Awarded Analogic $1.5 million as the first phase of a multi-million dollar grant under its *Phoenix* Category 3 program to design a new generation of advanced, networkable EDSs with significantly higher throughput and detection capabilities, targeted for delivery in fiscal 2007. And "Under a second TSA grant Analogic is designing a new generation of EDSs targeted for deployment by the end of calendar 2006. This large-bore system is being designed to scan up to 1200 bags per hour, provide high-resolution projection images, and further reduce the false-positive rate and alarmed-bag resolution time.[80]" "Early in fiscal 2005, the TSA also awarded Analogic a cooperative agreement as part of its new *Manhattan II* program to identify and develop revolutionary technologies into deployable systems that will significantly enhance automatic threat detection and discrimination capabilities for checked baggage for aircraft and other applications."

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[80] Analogic Annual 2004 Report.

GE InVision is launching multi-platform technology upgrades of all its EDS units. Some of these technology upgrades are also being partially funded through a grant from the TSA *Phoenix* program. These technology upgrades will essentially be accomplished in two phases, within 2-3 years and within 5-6 years. These phases are product-delivery timeframes, not R&D units. These new systems will have dual-energy atomic number discrimination; however, the first phase systems will retain the mechanical gantry. The GE InVision units will have full 3D high-resolution imaging workstations sufficient to deal with the identified threat specified by the TSA. GE InVision is planning on producing an electronic multi-source stationary (non-rotational gantry) running at 1000 bags per hour with a 5% false positive rate. GE InVision, like their competitor L-3 has a TSA grant under TSA's *Manhattan II* program to develop future EDS technology units out to the 2010 timeframe. GE InVision's perspective is to eventually produce a fourth generation EDS with a throughput of 1000 bags per hour.

Under the *Phoenix* program the TSA is providing grants to enhance and further develop the current CT technology. This program is running in two parts in the first phase with the intent to demonstrate the capability of enhancing the current technology in the first part and actually produce the technology in the second part. The objectives of the *Phoenix* program are to improve the detection capability of the existing EDS units, reduce the false positive rates, and improve baggage processing throughput. A second part of the Phoenix program is to explore combining other technologies, such as Quadrupole Resonance, with computed tomography to enhance detection of explosives as well as reduce the false positive rate even further.

The TSA's *Manhattan II* program is to promote the development of future technology that may eventually replace computed tomography as the primary technology used in bulk non-intrusive explosives detection. The *Manhattan II* time frame is looking more to 2010 and beyond.

All in all, we may see a dramatic improvement in the EDS industry within the next three to five years.

7.5 FAA/TSA Argus Small EDS R&D Initiative

Before we examine the wisdom of the choices made over the past few years, it is prudent to also look at some other developments in the EDS arena. In the 1999/2000 timeframe the FAA initiated a research and development program known as Argus to develop a smaller EDS non-intrusive unit. The objective of this R&D program was to produce EDS units more suitable for deployment in smaller airport lobbies and/or basement installations where high baggage processing rates were not necessary. This resulted in R&D funds being allocated to InVision, Vivid Technologies, and L-3 Communications' Security and Detection Systems division (L-3 S&DS).

After the 9/11 attacks, the whole Argus program seemed to go into limbo while the U.S. government was trying to get its house in order to prevent any further attacks. Shortly thereafter, the TSA was formed in February 2002 and the leadership of this new organization appeared to lack technological sophistication and did not appear inclined to put any great effort into picking up the technology cudgel[81], or baton if you prefer, and run with it.

L-3 VividCT Argus

The Vivid VCT-30 unit was the first EDS produced under the Argus initiative and achieved TSA certification in May 2002. Some security technology experts in this field have described the VCT-30 as a second generation computed tomography technology. In the interim, L-3 was in the process of acquiring Vivid Technologies and, thus, acquired the newly certified Vivid Argus unit. At that point it appeared that L-3 ceased, or slowed, the development of their efforts to produce a competing Argus unit. However, L-3 subsequently submitted their 3DX1000 EDS unit developed under the Argus initiative for certification and it was certified by the TSA as an EDS in August 2003.

At first InVision appeared to be dragging their feet in the Argus program and some persons speculated that this was because they were producing a smaller EDS unit they chose to name the CTX 2500, a smaller version of their CTX-5500 series units. InVision, however, did eventually submit its CTX 1000 developed under the Argus initiative for certification testing and the TSA certified it as an EDS unit in mid-2004.

Very few of the Argus units were ever sold. One Argus unit was eventually deployed to Portland, Maine, for a field operational test of their use – but the Argus units were essentially a forgotten option by the TSA leadership. At the time of the wholesale TSA purchases of the InVision CTX 5500 and the L-3 eXaminer 3DX6000 units, it appears that a wise choice would have been to have purchased a number of the newly certified Argus units for deployment at a number of the smaller 429 U.S. commercial airports. That opportunity was missed, possibly because of the technology blindness of the new TSA leadership and a failure to assess the needs of the smaller airports and their lower traffic loads. Presumably, had the TSA done so the burden on the U.S. taxpayer would have been a bit less. In the end, with the recent certification of the Reveal Imaging CT-80, it may be that it was best that the Argus units were not purchased anyway.

Other reasons for the TSA not taking advantage of the availability of the smaller Argus initiative EDS units may have been that it took almost as long to make these new smaller units as it did to produce the larger InVision and L-3 EDSs. Given the rush to produce

[81] The TSA leadership likewise missed the opportunity to take advantage of the fully developed Threat Image Projection (TIP) software development that is now used to test the alertness and detection abilities of X-ray screening operators. The TSA was subsequently shamed into updating the walk-through metal detectors at all major U.S. airports by articles in the media reporting the TSA's failure to replace these units.

hundreds of the InVision CTX5500DS and L-3 3DX6000 units, the TSA SEIPT may have elected to concentrate on the production of these larger units to avoid additional confusion in responding to tight time frames for EDS deployment by December 31, 2002. There was also the improbability of the Argus EDS units being produced in sufficient numbers within 2002 to supply the smaller airports. As it eventually happened, the smaller of the U.S. 429 commercial airports received Explosive Trace Detection (ETD) units as an interim measure – and they are still in use today[82]. Added to this situation was the possibility that InVision and L-3, as the sole suppliers of the larger certified EDS units, may not have been too eager to produce the smaller Argus units because of the reduced profit margins.

7.6 Other Emerging Explosive Detection Technologies

Other considerations that have been on-going for several years have been to combine technologies for improved explosives detection. One of these is Quadrupole Resonance (QR) that was being explored by InVision and a couple of independent corporations, one from Australia. The development of QR as an independent detection technology appears to be progressing as well. The TSA reportedly "will soon begin trials with QRSciences Quadrupole Resonance (QR) EDS at an as yet unspecified number of airports.[83]" According to Jane's Airport review,[84] Moscow's Sheremetyevo International Airport is also "to trial" a quadrupole resonance (QR) advanced explosive-detection system from QRSciences of Australia.

8.0 Considerations


L-3 MVT

In Subsection 3.1 the possibility was raised that the probability of detection of explosives would be no less using a European multi-stage EDS with a high-speed L-3 MVT at Stage 1 with U.S. EDS units at Stage 3. If that analysis is undertaken, and should it be determined that there is no substantial difference in the explosive detection effectiveness between the two approaches, then the obvious question is: Which approach is the most appropriate for an individual airport environment and which is most cost beneficial? Should the European approach make more sense, both from a cost standpoint as well as a much higher baggage processing rate, then perhaps this should be the preferred design standard to be applied for future installations.

The issue is not settled at this point as a number of other variables will have to be addressed, the first of which is: Has the U.S. already purchased all the EDS units needed

[82] GAO-05-365, *AVIATION SECURITY*, pg. 20, March 2005.
[83] Jane's Airport review, April 2005 Vol 17 Issue 3, pg. 20.
[84] Ibid, pg. 18.

in the U.S.[85]? In other words, does it matter any more since the U.S. may no longer need to purchase any additional U.S. certified EDS units? In order to determine this, TSA would have to go back and reevaluate its plans for deployment of existing EDS units vis-à-vis individual airport requirements. In order to determine individual airport requirements, a re-assessment would have to be made to see if an airport could make beneficial use of a European multi-stage design. Airports that could benefit from this design would then need to be provided with the necessary high-speed MVT[86] front-end units. However, purchase of the MVT units would now add to the cost of the overall system and may not make sense unless the high-speed baggage processing rates are needed.

L-3 eXaminer 6500

The current situation may very well be beyond the point where it would make any sense to consider going back and re-assessing each airport's needs. If any of the developments mentioned earlier in EDS technology, such as if SureScan becomes a reality, the difference in the U.S. versus European EDS concept becomes passé. If, however, an analysis does determine that there is a need for some European multi-stage MVT/EDS designs, this may free-up a number of already purchased EDS units for deployment elsewhere. Or, the U.S. Government may not need to purchase additional EDS units as, under the European concept fewer numbers of these expensive units may be necessary.

InVision CTX 9000DSi

Another consideration at this time would seem to be the purchase of a number of Reveal Imaging CT-80 for deployment at airports that can accommodate these units[87]. The technical considerations would center around the space available for integration of these units in the ticket-counter environment, processing rates required, manpower considerations vis-à-vis an In-line EDS installation, etc. Provided the U.S. does not already have an excess of EDS units, it would appear that the Reveal CT-80 would be the best selection for a number of our smaller commercial airports and perhaps in some situations at some locations in a number of the larger U.S. airports.

[85] This presumes we don't need a higher baggage processing rate than that of the current U.S. certified EDS unit(s).

[86] The L-3 MVT is specifically named because of its unique standing, i.e. it passed the FAA/TSA detection regime but failed its certification because of its unacceptably high false positive rate. A competing unit from another manufacturer recently failed its TSA certification regime, including the failure to meet the TSA explosives detection standards.

[87] The purchase of the CT-80 units would probably have to await the completion of the currently planned operational trials of the TSA's initial purchase of five of these units.

9.0 U.S. Government Accountability Office (GAO) Study

On February 18, 2005, the U.S. GAO Director of Homeland Security & Justice Issues forwarded Draft Report GAO-05-365[88] to Representative Harold Rogers, the Chairman of the Subcommittee on Homeland Security of the U.S. House of Representatives. GAO auditors were busy on this study for the several months and met with U.S. airlines, the airlines' trade association - the Air Transport Association, TSA officials, airport officials, equipment suppliers, designers of In-line systems, and other interested parties. The GAO's public report in March 2005 noted that it had also provided the TSA with two other reports, one that was classified and a third that was unclassified but contained sensitive security information (SSI). The stated objective of the GAO study was "To Assess efforts by the Transportation Security Administration (TSA) to screen checked baggage for explosives using explosives detection system (EDS) and explosives trace detection (ETD) equipment."

Hopefully, the GAO study will assist Chairman Rogers and Congress in addressing a number of problems they have in determining authorization and appropriations levels for U.S. checked baggage screening systems. However, as noted in this paper, there are a host of variables and a number of unresolved issues associated with the U.S. checked baggage screening issues. As noted in the GAO report, the TSA needs to address several planning issues before some semblance of order can be restored to the U.S. aviation security system. Clearly, one of these is the need to take a comprehensive look at the TSA's checked baggage screening concepts and its associated policies. Actually, the TSA needs to persuade the Congress to review its mandate in the ATSA that requires the TSA to use only U.S. certified EDS equipment[89]. As Congressman Mica recently proclaimed:

> "Congress is the one that mandated this," Mr. Mica said. "But we should have done more research and development on the technology and put this in gradually[90]."

This raises an interesting point, in this instance the Congress dictated the "solution" to the Executive Branch of the U.S. Government when it mandated the use of U.S. certified EDS. Under the U.S. Constitution and its separation of powers the Legislative Branch is supposed to enact laws that specify requirements and the Executive Branch is supposed to find ways to implement the legislative requirements, in other words, find *solutions*. It can be argued that the Legislative Branch overstepped its bounds in the ATSA and entered the Executive Branch's arena when it dictated the use of U.S. certified EDS. As a consequence the Congress now find themselves in the untenable position of trying to grapple with a burdensome technology issue that properly should have been left in the hands of the Executive Branch of the U.S. Government.

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[88] The public version of GAO-05-365 *AVIATION SECURITY* was subsequently released in its final form in March 2005.
[89] Aviation and Transportation Security Act (ATSA) (Public Law 107-71, 115 Stat. 597 November 19, 2001).
[90] New York Times, *Assessing Security Screening Efforts*, Eric Lipton, May 8, 2005

It is also clear that with the differing philosophies about an acceptable standard in the worldwide aviation security checked baggage screening system, we will continue with a confused situation for some time. While this exists the new generation large aircraft will begin operations. It will complicate the current confused situation even further. In the midst of all this confusion, we must remember that our job is NOT to put bombs and hijackers on airplanes faster, that is: the efficiencies of the processing system. Our job professionally is to ensure the safety and security of the aviation industry, the effectiveness of the security system. Said another way, the first objective is to ensure the safety and security of the aviation transportation system – once that is assured then our collective attention can then be turned to the facilitation of persons traveling in world aviation.

Given the International Civil Aviation Organization's requirement to screen all checked baggage by January 1, 2006 the foregoing review begs the questions of whether the U.S. and the rest of the world can benefit from the U.S. accomplishments, avoid its errors and mistakes, and provide the level of security the current terrorism threat demands. And, given the continued increase in passengers in aviation, illustrated by the advent of the new generation large aircraft, can we meet the demand and avoid an unacceptable impact on facilitation of passenger movements?

10.0 Where do we logically go from here?

From a checked bag screening standpoint, as noted in sections 7.0 and 8.0, the future U.S. course of action in baggage screening would appear to depend on any assessment on whether the European (as modified by using an L-3 MVT in any stage one unit) or the U.S. approach make the most sense. This determination depends on whether there is a substantial difference in the effectiveness of the detection of explosives between the two systems. One thing is certain, and that is that these two competing systems have resulted in a split in the world aviation community's approach to checked baggage screening systems. If the world aviation community is to reconcile these differing approaches, it essentially has two choices: 1) make a change to one or the other in a logical analytical process, or 2) wait and hope that with the continued advancement of EDS technologies over the next decade that the two concepts will merge.

From the non-U.S. standpoint, it would appear that the approach to screening checked baggage will not be as strict, or as expensive, as the U.S. approach. As an example, one U.S. airport with 26.140 million passenger annual enplanements in 2004 has a total of 44 U.S. certified EDS units in a single-stage installation[91]. A non-U.S. international airport with 30.350 million annual enplanements in 2004 has installed a multi-stage European concept checked-baggage screening system with 30[92] high speed Advanced Technology Stage-one X-rays with 8 down-stream U.S. certified EDS units. The rough-order-of-magnitude equipment-cost comparison between the U.S. airport and the non-U.S. airport

[91] This single-stage EDS unit is then followed by an OSR from a bag viewing station and then an ETD/physical of all uncleared bags.
[92] Some of these are L-3 MVTs.

is: $41.8 million versus $18.5 million[93]. This dilemma is further illustrated by the recent release by a major nation's tender request for a checked baggage screening systems that is obviously based on the European concept and technology.

A number of non-U.S. airports are under pressure from the U.S. government to install EDS units using the U.S. concept. These airports have either originating or direct flights of U.S. airlines as well as non-U.S. airline flights from these airports to the U.S. The U.S. influences the security on the flights to the U.S. by imposing U.S. screening standards on the airlines that operate these flights. There is little that these non-U.S. airlines can do other than comply with the U.S. restrictions. The U.S. Government sends a message of its expectations by periodically inspecting these airports' security measures under the U.S. International Security Development and Cooperation Act of August 8, 1985[94]. The U.S. expectation is further enhanced by the message it sends when it requires the re-screening of all transfer checked baggage on arrival in the U.S. using U.S. protocols (see Section 2.0).

From an accommodation of the new generation large aircraft and the continued growth of the aviation industry, the aviation industry must achieve aviation security productivity gains while it continues to improve its record of safety as well as protection against terrorism. These are not necessarily incompatible goals, provided the aviation industry is: prudent in its choices, design of airports and associated facilities; governments provide national security funding to protect national, regional, and international interests; and the aviation industry commits itself to this program.

[93] These figures do not include installation costs.

[94] This act requires the U.S. to periodically assess the adequacy of aviation security being provided at airports where U.S. airlines operate as well as foreign airlines that operate flights to the U.S.

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CHECKED BAGGAGE SCREENING GLOSSARY

1. AAAE	American Association of Airport Executives
2. ASI	Aerospace Services International, Inc.
3. ATSA	Aviation and Transportation Security Act
4. AVSEC	Aviation Security
5. BOS	Boston Logan International Airport
6. BPH	Bags Per Hour
7. BVS	Baggage Viewing Station
8. CBSS	Checked Baggage Screening System
9. CT	Computed Tomography
10. CTX	InVision Computed Tomography units
11. DHS	Department of Homeland Security
12. DOT	Department of Transportation
13. EDS	Explosive Detection System
14. EOD	Explosives Ordnance Disposal
15. ETD	Explosive Trace Detector
16. FAA	Federal Aviation Administration
17. GAO	Government Accountability Organization
18. GE	General Electric
19. HBSS	Hold Baggage Screening System (see also CBSS)
20. IATA	International Air Transport Association
21. ICAO	International Civil Aviation Organization
22. JAX	Jacksonville International Airport
23. LAX	Lon Angeles International Airport
24. LOI	Letter-of-Intent
25. MTBF	Mean Time Between Failure
26. MVT	Multi-View Tomography
27. NGLA	New Generation Large Aircraft
28. OSR	On-Screen-Review
29. QR	Quadrupole Resonance
30. RDD	Radiological Dispersal Device
31. R&D	Research and Development
32. RFID	Radio Frequency Identification Device
33. SEIPT	Security Equipment Integrated Product Team
34. SFO	San Francisco International Airport
35. SSI	Sensitive Security Information
36. STDO	Security Technology Deployment Office
37. TBIT	The Bradley International Terminal
38. TIP	Threat Image Projection
39. TSA	Transportation Security Administration
40. T-5	Terminal 5 – Heathrow International Airport