**Appendix `F'**

# SPECIFICATION FOR ON-LINE X-RAY BAGGAGE SCREENING SYSTEM

## 1. INTRODUCTION

The existing X-Ray machines installed at check in area to screen registered baggage are in stand-alone mode and not capable of detecting 100% explosives. Stand-alone machines occupy space at departure lounges and also cause big queues, which disrupt passenger flow during peak hours. Keeping in view the security threat, it is desirable that multi level in-line detection system is installed at major airports. The multi level X-Ray screening system has already been installed at various international airports abroad. The online hold baggage handling system (HBS) shall be integrated with airport baggage handling in order to provide complete hold baggage processing and screening system. It is recommended that installation of hold baggage screening system and X-ray BIS conveyer belt may be integrated and the work awarded as turn key project. Depending upon the passengers' peak hour density the level may be varied from three to four. Initially on line hold baggage-screening system shall be introduced at Delhi, Mumbai, Chennai, Kolkata, Ahmedabad, Calicut, Varanasi, Amritsar, Vizag and Srinagar airports. All new terminals and airports constructed in future will have only HBS. The priority of installation of HBS shall be decided by AAI in consultation with BCAS.

## 2. Conceptual System Design

The system designed for multi level screening process shall have the following features: -

### 2.1 Level 1

Level 1 screening is to be undertaken by a high speed multi view / computer sliced X-ray machine with automatic explosives detection facilities. The decision is to be fully automatic and the operator intervention is only required in start-up and shut down procedures. Un-cleared baggage will go to Level 2, and cleared bags will proceed to the baggage make-up area.

### 2.2 Level 2

2.2.1 Level 2 screening is remote workstations(s) whereby operator(s) can analyze the image generated by the Level 1 X-ray machine. The workstation is required to be equipped with enhanced imaging / manipulation systems to assist operator to diagnoses the screened image.

2.2.2 Typically 30-40% of all level-1 screened bags would be referred to level 2.

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2.2.3 Whilst the bag is being referred to level 2, it should be 'tracked' while it travels along the length of the conveyor such that its position and identity is known at all times.

2.2.4 In practice, it is usual to provide a conveying system that allows 15-20 seconds to queue and process the level 2 images.

2.2.5 In case of bigger airports (higher passenger density airport), a workstation 2B shall be introduced for longer time analysis. In this instance, there will be enhanced image manipulation capabilities; usually a more senior / experienced operator will view the image. In addition, the Level 2B screening would not be subject to time constraints as for level 2A. The analysis may be carried out between 40 to 120 seconds and 98% bags are expected to be cleared.

2.2.6 In systems with multiple level 1 machines, the Matrix type set-up of several level 1 and level 2 workstations will be linked together, enabling the next un-cleared level 1 image to go to next available level-2 workstation. The matrix data communication shall enable any of the Level 1 X-ray systems to send rejected bag images to any of the Level 2 workstations. The proposed matrix scheme must be flexible enough to accommodate future expansion. In all cases, any bag considered suspect by the operator are to be flagged and routed automatically to Level 3.

2.2.7 Cleared bags shall proceed to the baggage make-up area.

2.2.8 Any bag not cleared within a pre-determined time by the level 2 operators, are considered 'time-outs' and automatically forwarded to level 3. In addition any miss-tracked bags on the conveying system are defaulted to the level 3 area.

## 2.3 Level 3

2.3.1 There are several technologies available for level 3 screening, and the selection usually depends upon BCAS regulations and / or budget constraints. These include:

2.3.2 **Explosive Trace / Particle detection Check**. The un-cleared / suspected bags shall be checked with latest explosive trace detectors by using vacuum pump / specially designed filter papers for checking the presence of explosive substances.

2.3.3 **Explosive Sniffer Dogs.** The dogs being the most reliable explosive detection system, it is recommended that rejected bag at level 2 be sniffed by Explosive Detection dogs. The dogs to be deployed in pair, one for initial sniffing and second for confirmation. The pair of dogs' to be turned over every one hour. In an 8-hour shift, there should be minimum 4 dogs with handlers.

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## 2.4 Level 4

2.4.1 All un-cleared / suspected bags at level at level 3 are to be reunited with their owners for further inspection and interview. This process is normally manual and should be done in a safe area outside the boundaries of the baggage handling system.

2.4.2 The procedure shall be evolved whereby the passenger and the bag are brought together.

2..4.3 Any bag that is still deemed to be suspect after passenger interview, or if the passenger cannot be located, are normally handled according to the BCAS instructions till arrival of explosives experts. Bomb detection and disposal squad shall be summoned where available or the bag shall be shifted to cooling off pit.

## 3. System Throughputs

3.1 Normally a single on line HBS with Level 1& 2 X-ray machine and tracking would practically be able to sustain around 22 bags per minute (1300 bags/hour). This is a good design target. The recommended throughput is 1200-1800 bags per hours.

3.2 CTX/EDS machines with low throughput of 400-500 bags per hour may be installed as stand alone mode where traffic density is not high subject to availability of fund and space

## 4. Approval by Regulatory agent.

4.1 **Approval by International/ National regulatory agency**: - The X-ray BIS deployed at Level- 1 must be approved by at least three major regulatory agencies of civil aviation `Appropriate Authority' including the country of product manufacturer such as: -

a. Transport Security Administration (USA),
b. Department of Transport (UK),
c. Department of BKA,
d. ECAC – European Union.
e. Department of Transport (Australia)
f. Flughafen Police (Switzerland) and / or,
g. ENAC (Italy)

**4.2** Besides the product should be approved by the civil aviation regulatory authority of the manufacturing country

## 5. REQUIREMENTS FOR LEVEL- 1 X-RAY INSPECTION SYSTEM.

5.1 **Bag Size**. The x-ray system must be capable of scanning baggage up to 100 cm wide x 80 cm high x130 cm long.

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5.2 **Throughput**. The overall x-ray system must have a belt speed capacity of 0.5m/s in order to guarantee a throughput capacity of at least 1200 bags or more per hour (depending on the bag size).

5.3 CTX/Edts machine with low throughput of 400-500 bags may be installed as stand alone mode subject to availability of fund and space where passenger traffic density is not high

5.4 **Image Generation**. The X-ray system must generate at least four independent views of each bag. The images should be able to be selected in the factory design and options. All images should be able to be stored if required by the airport. The maximum storage period will be 14 days.

5.5. **Oversize Baggage.** Provisions to be made for an out of gauge (OOG) solution for large baggage and objects. The specification and detection parameters should be the same as for the in line systems. The OOG must be able to be data linked at a future time if required. This is an optional requirement.

6. **The HBS Management system shall:**

(a) Provide controls for start-up and power-down.
(b) Provide controls and displays for:

(i) Current system status.
(ii) User log-in management
(iii) System performance statistics.
(iv) Image recall capability.

7. **Detection Systems**

Multiple algorithm settings should be available and their approval /certification advised for the machines. These settings should be capable of selection under secure and regulator controlled arrangements. Vendor should explain the algorithm option and management systems available.

8. **Machine Statistics**

A display local to the level 1 X-ray is required. The local display should provide an image of the bag currently being scanned, as well as system statistics without requiring any action from the user (display is always visible). Critical statistics are as follows:

i. Bag Count (since Re-set and since power-up),
ii. Software version currently running on the X-ray scanner
iii. Data available to a user with 'special' access
iv. Alarm rate since re-set,
v. Error log

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A remote management Information system is required to provide statistical information regarding machine throughput, alarm rates and any error conditions. The management information System should provide this function for the level 1 and inspection processes as well as the level 2 Workstation.

9. **Detailed Requirement of Automatic level 1 X-ray Equipment**

| | | | |
|---|---|---|---|
| (i) | Throughput per unit | : | 1200 bags or more per hour continuous throughput |
| (ii) | Maximum distributed load | : | 150 kgs |
| (iii) | Conveyor belt height | : | 800 to 1000mm. |
| (iv) | Automatic detection of | : | 1. Bulk explosives<br>2. Sheet explosives<br>3. Density alert |
| (v) | X-ray source | : | Multiple X-ray fan beams |
| (vi) | System verification test | : | 1. True dual energy x-ray Generators<br>2. Automatic<br>3. Performed every 24 hours |
| (vii) | Power on indicators | : | Should be provided at both ends of the inspection tunnel |
| (viii) | X-ray "ON" indicators | : | Should be provided at both ends of the inspection tunnel |
| (ix) | Film safety | : | 2 passes of ISO 600 / 33 DIN high speed film |
| (x) | Resolution | : | 40 SWG tinned copper wire. |
| (xi) | Penetration | : | 30mm steel. |
| (xii) | Contrast sensitivity | : | 256 levels. |
| (xiii) | Overlay to highlight | : | Density Alert areas that are obscured by very dense material. |

(xiv) Threat objects must be identified with threat boxes.

(xv) Should be equipped with system emergency stop buttons on the machine and work station.

(xiv) Should have a modular construction so that system components can be changed easily with minimum downtime.

## 10. Level 2 Operator Workstations

### 10.1 General requirements for Level 2 Image Analysis Systems.

10.1.1 The level 2 image analysis workstations shall be located within the HBS control room. All HBS operations shall be controlled from this point.

10.1.2 The Workstation may be used to visually detect weapons, guns knives, and explosives to identify various components of improvised explosive devices, such as wires, detonators, explosives, timing devices and power sources, and to detect typically hidden contraband. The workstation interface

shall be ergonomically designed, provide for ease of use, and include imaging features that enables the operator to readily identify common items and clear most of the suspicious items.

10.1.3 Level 2 inspections shall be carried out while the level 1 uncleared bag is in transit through the baggage conveyor system. Each monitoring workstation shall be capable of storing up to 12 X-ray images waiting to be viewed by the operator.

10.1.4 The time limit available to the operator to view bags must be programmable, from 5 to 20 seconds. If this time is exceeded the bag image is classified as uncleared.

10.1.5 The system must be capable of transmitting an uncleared image to level 3 workstation complete with image data file.

10.1.6 The imaging system shall display data in a high resolution with threat objects outlined by a threat box.

10.1.7 The display shall be minimum 17 inch diagonal SVGA.

10.1.8 The monitor shall be adjustable via a tilt and swivel mechanism.

### 10.2 Level 2 Imaging Tools

Operators must be able to view bag images while accessing all imaging tools without looking down at the console. Imaging tools provided must be configurable by a supervisor with a key/password.

### 10.3 Level 2 Operator Workstation Minimum Specifications

#### 10.3.1 Display Monitor

a) Two monitors to display all image data.
b) Descriptive icon based toolbar for all imaging functions must be represented on screen.
c) High performance 24-bit video display processor.
d) 17” high-resolution colour SVGA video display monitor.

e) 60 Hz refresh rate.

f) Front panel for adjustment of contrast, brightness, vertical and horizontal alignment etc.
g) Display monitor should be affixed to a lockable console storage compartment.
h) Image display time.

10.3.2 **Imaging modes**

(a) Pre-set function with a minimum display of 5 seconds. The operator must be able to manipulate all imaging functions without looking down at the console. Imaging modes should include all of the following but are not limited to:

(i) Organic/inorganic/metallic in highly visible contrasting colour.
(ii) Pseudo-colour
(iii) Reverse video
(iv) Contrast adjustment
(v) Edge enhancement
(vi) Monochrome
(vii) Metal stripping
(viii) Continuously positional electronic zoom
(ix) Image enlargement
(x) Image storage

(b) Controls

(i) Control panel must be touch activated
(ii) A ‘Home Key’ to allow a single touch to revert to a user pre programmed default setting
(iii) Toolbar and imaging functions must be configurable by the end user.
(iv) ‘Reject’ and ‘Clear’ decisions should be discrete mechanical push-buttons with positive tactile feedback
(v) Workstation should be able to be switched on-line or off-line at any time without affecting the operation of other workstations or level 1 equipment on the same network.

10.3.3 **Power indicator**. A power-on indicator must be available with:

a) Operator console must have locking mechanism.
b) Access to system configuration must be a separate mode of operation for authorized personnel only.
c) Access to system configuration must require a mechanical key or electronic password.

10.3.4 **UPS**
a) Imaging Performance.
b) Integral Uninterruptible power Supply (UPS)

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10.4 **Additional Requirements Level 2**

10.4.1 A supervisor shall control system configuration with appropriate access. Image processing functions, operator time out functions and default image configuration shall all be controlled by the supervisor.

10.4.2 The system shall be based on an open architecture configuration and shall run on a PC platform. User operation at the system supervisor level shall be in a graphical User interface environment, based on the windows operating system. Access to the system shall be controlled by PIN and passwords. The system will be on line 24 hours per day, 7 days per week.

10.4.3 The operator via discrete mechanical push-buttons shall communicate reject and clear decisions.

10.4.4 Workstation on-line and off-line switch must be provided for use at any time without affecting the operation of other workstation or X-ray machines on the network.

10.4.5 It should have capacity for multiple workstations to be linked to a scanning machine.

10.5 **Image Printing**

A display printing facility must be provided to standard high-resolution colour printer. The system must be configurable to print any image rejected by a level 2 operator and/or level 3 operators.

11. **COMMUNICATION NETWORK**

11.1 Images generated at level 1, shall be digitally transmitted through server based preferably to selected level 2 image display workstation. The level 2 display workstations shall be located in the X-ray control room.

11.2 The matrix system shall comprise of switching equipment, which is able to support a fully redundant configuration. Redundant operation shall be configured in a hot stand by mode. In the event of a failure of the primary switch, the backup switch shall automatically take over operation. At no time shall any unclear bag image data be lost.

11.3 The system shall operate on a combined fiber optic/twisted pair copper network.

11.4 All computer equipment shall be protected by UPS system, to provide minimum 10 minutes power.

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### 11.5 **Matrix Configuration**

| | | |
|---|---|---|
| Communication network | : | Fiber-optic Ethernet network. |
| Network configuration | : | Fully redundant network configuration. The proposed expandable matrix scheme must be expandable to accommodate additional level 1 and level 2 systems in the future. |
| System electronics | : | Designed to facilitate the addition of industry standard peripherals such as above but not limited to these. |

### 11.6 **Mass storage**.

11.6.1 High-speed optical data networking, printing and communication devices

11.6.2 A colour printer will be attached to the Matrix network allowing the image of any bag rejected by either the level 2 operators or the level 3 operators or both to be printed.

11.6.3 The printer will be a colour laser type. Print speed will be a minimum of 6 pages per minute, at 300 DPI minimum resolution in colour. The printer spooler should be able to handle up to 10 images simultaneously.

## 12. **MANAGEMENT INFORMATION SYSTEM**

12.1 A dedicated network monitoring PC shall be provided which displays and logs information relevant to the level 1 and 2 systems. The Management information system shall have the following capabilities:

a) On-line monitoring of all control functions.

b) On-line event, alarm outputs and reports.

c) X-ray status and performance statistics

d) Workstation status and performance statistics

e) Hardware faults.

f) Image recall facility.

g) User log – in management system

12.2 The Management information system shall be able to compile and print reports summarizing the activity that has occurred on the Matrix network over a previously defined period of time. The system will allow data to be transferred to diskette for analysis on a separate PC.

12.3 A configuration program allowing the user to enter a header and a network name to appear at the top of each report is required.

## 13. **Data to be compiled**

(a) For level 1 X-ray
  i. Level 1 events (all)
  ii. Decisions
  iii. On line and off line activity
  iv. Faults (and the time at which they occur)

(b) For Workstations
  i. Workstation events (all)
  ii. Decisions
  iii. On line and off line activity
  iv. Faults (and the time at which they occur)

## 14. **Reports to be generated**

### **14.1 Level 1 X-ray Event Data**

14.1.1 This shall be a file compiled on a daily basis and shall be a summary report of the decision data for all X-ray machines connected on this particular network (i.e. there shall be a report collated for each network each day). It shall provide an hourly (on the Hour) summary of results for each mainframe, a fault log, and a result total for the entire network for the day.

14.1.2 Workstation event data shall be a file compiled on a daily basis and shall be a summary report of the event date for all workstations connected on this particular network (i.e. there shall be a report collated for each network each day). It shall provide an hourly (on the hour) summary of results for each workstation and a fault log for all workstations.

## 15. **Storage**

Event Report files (on each network) shall be stored to the Management information system local hard disk at the end of day. They shall be stored to a specific folder (for example 'HBS Report Data'). Each file shall be uniquely named. It should be possible to store log files for a complete year, at which point old log files shall be overwritten.

## 16. **Presentation**

It shall be possible to call up stored event files for viewing and printing from within the Management information system interface. The facility should allow the user to select the current log file or to select from a list of currently stored log files.

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17. **Retrieval and Offline Presentation**

17.1 There shall be a facility to allow a user to retrieve stored events files and copy to diskette for storage, viewing and printing on an offline facility. This should offer the user the option of copying the logs for the last day, last week, particular day, particular week, or all currently stored log files. The logs shall be stored in such a way that the printed copy resembles the on-screen image.

17.2 This feature shall offer the user the option of printing the logs for the last day, last week, particular day, particular week, or all currently stored log files.

18. **Threat Image Projection (TIP) for level 2 Operators**

18.1 A system shall be provided to generate and send images of virtual bags containing a threat object to the level 2-operator workstation. These systems monitor and assist operator performance. A range of threats must include military explosives, sheet explosives, commercial explosives, shielded devices and improvised explosives devices and other dangerous goods.

18.2 The TIP system shall transmit stored threat and false alarm bag images to the level 2 operator workstations, as time is available between 'live' bag images generated by the level 1 X-ray mainframes. The TIP system must provide a means for each operator to log onto the system and subsequently record each operator's decisions for later review by a supervisor.

18.3 A set of real 'bomb bag' as well as a set of false alarm bags will be stored in the TIP system memory. When time is available, the TIP system will choose an available workstation, send an image to that workstation, and log the operator's decision. The security supervisors can then use the data to monitor operator performance on a daily, weekly, or monthly basis.

18.4 The system must have the ability to perform the following tasks.

(a) Allow operators to log onto the system through the level 2 operator workstations.
(b) Maintain a database of individual operators with TIP statistics over a defined period.
(c) Present TIP bag images to any 'on-line' operator workstation on the network.
(d) Have the ability to select an individual workstation or send images out at a predefined rate.
(e) Log the operator's response. Log whether the bag was properly cleared or rejected, depending on whether the bag contained a real threat or a false alarm object.
(f) Alert the operator that they have just received a TIP image and whether they cleared or rejected the image appropriately.
(g) Prepare and print out reports which will allow the supervisor to monitor operator's performance.

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## 19. **Reports**

19.1 Summary reports must be able to be generated and printed out for an individual operator or for all individuals across periods of time.

i. The general report shall be the screeners log report.
ii. Details about individual screener's performance shall be presented in the individual screener performance summary report.
iii. Detailed information that compares multiple screeners shall be presented in the screener comparison report.
iv. The detailed information, regarding detection decisions for each fictional threat image shall be presented in the Threat Detection by Category Report.
v. Data reports shall be viewed by calendar month (example May 2004).

19.2 All report levels and the database shall be read only. Thus, users will not be permitted to modify or corrupt the information contained.

## 20. **TIP Bag Library**

Total Volume will be 12. Each volume to contain 150 Threat Bags and 50 False Alarm Bags (200 bags per volume, 2400 bags total). The images in these volumes must represent all explosives categories in the FAA / TSA / BCAS EDS certification standard

## 21. **Operating Conditions**

21.1 In addition to any specific safety devices stated elsewhere in the subcontract, the design of the system(s) shall ensure the safety of all operating and maintenance personnel together with others in the proximity of the equipment. Particular attention shall be given to the design of guards, belts, rollers and drives to eliminate all possibilities for trapping limbs, clothing etc.

21.2 Rotating and other hazardous components, even if housed within total enclosures, shall also be individually guarded. Guards shall be designed to be removable during maintenance but shall also incorporate access panels to permit routine lubrication without the removal of the entire guard assembles.

21.3 The systems shall be designed to prevent the possibility of human exposure to primary beams from X-ray devices. Radiation leakage from X-ray devices shall not exceed the limits set by the European community / Atomic Energy Regulatory Board of India.

## 22. **Electric Power Supply**

The level 1 machine shall be designed to operate from 415 volt, 50 Hz, 3-phase power supply, voltage fluctuation+/- 1%. All other equipment, shall be designed to operate from 240 volt, 50Hz. Single-phase power supply, voltage fluctuation +/-10%, frequency variation +/-1%. All electrical installations shall meet the VDE safety requirements.

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## 23. Maintenance

Mean-Time Between Failure (MTBF) and Mean-Time To Repair (MTTR) data for the systems offered is required and must indicate an average ‘uptime’ of over 99% under realistic operating conditions.

## 24. Option

24.1 The supplier shall include for a comprehensive maintenance service for 12 months after system acceptance.

24.2 This maintenance requirement shall include.

i. Preventive Maintenance.
ii. Routine Maintenance.
iii. Call-Out Maintenance.

24.3 Following every maintenance visit, the HBS contractor shall send a completion report to the engineer.

24.4 As an option, comprehensive maintenance for an additional five-year period after expiry of initial two-year maintenance period shall be offered.

## 25. Training

25.1 The supplier shall supply comprehensive documentation in plain English to allow the full and complete operation of the system.

25.2 A set of system verification test objects, on site and factory test procedures must be offered.

25.3 These objects when inspected must positively verify that the system is performing within published specifications and agreed detection levels.

25.4 A computer assisted training package must be offered. As a minimum this package must facilitate operator training and gauge training proficiency.

## 26. Climatic Conditions

The machine should be capable of operating between 0 to $40^{0C}$ temperatures, relative humidity between 0 to 95%

## 27. Design Loadings

For the purpose of the sizing of drivers, shaft sizes and bearing etc., the following live loads are considered:

(a) Belt Conveyors
- (i) Power calcs
- (ii) Structural loading

(b) Reclaim / make-up conveyors
(c) Horizontal Reclaim Carousel
(d) Walkways and Maintenance Platforms
(e) Super load

## 28. **Services**

Main supply 380V + 10%-6% 3 Ph, 50 Hz
Note the X-ray machine generally requires a conditioned power supply.

## 29. **Bag conditioning pre screening**

The HBS should ideally include a number of features that condition and present the bag to the x-ray in a separate, spaced and controlled manner. This should include: -

i. Check in operator discipline e.g. tie up trailing straps, use tubs as appropriate etc
ii. Window reservation techniques at check- in /collector conveyor
iii. Use of zoned belts at transfer in feeds
iv. Automatic baggage separation
v. Spacing and pitching of bags to suit the needs of the X-ray machine.
vi. Over-height detection
vii. Over-length detection

## 30. **Collector System – Window Reservation technique**

30.1 This feature is applied to those instances where by automatic checks in conveyors are provided to deliver bags on to collector conveyors.

30.2 A system known as “Window Reservation” is used to control the flow of bags. Effectively, the belt on the collector conveyor is split up into imaginary zones or “windows” each large enough to accept the bag and these are allocated to check –in desks on a demand basis such that all input have equal opportunity. This reduces passenger-waiting times, and also controls the flow of bags into the handling system right from the point of in-put.

30.3 As the allocated window approaches the desk, the Dispatch conveyor will automatically start up and the bag will be transferred onto the collector conveyor. This procedure is repeated until all bags in a single transaction are released in to the system.

30.4 It is preferential to arrange the conveyor speed such that the bags are fired across the collector conveyor without turning through $90^0$. This encourages the bag to lie flat and also decreases the cycle time. Obviously the conveyor width needs to be greater than the maximum bag length.

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## 31. Transfer In feed – Marked Belt

31.1 In those instances where bags are delivered to the HBS system via a transfer in feed line (or similar) it is much harder to control the input and flow of bags as this is operator dependant.

31.2 There should be discipline about the type of bag to be handled and also the orientation that the bag is placed onto the belt, such that it is in the most stable orientation for conveying and screening.

31.3 To help control the flow it is suggested that zones are marked onto the belt to indicate where handlers should load bags and where they shouldn't. In this way it is possible to encourage operators to correctly space bags from the outset, and also the throughput will be limited to be dictated by the belt speed and size of the zone.

## 32. Automatic Baggage separation

32.1 Whilst bags may be correctly spaced at point of input into the system, by the time they have been conveyed to the screening area, usually via inclines / declines, speed changes, merges / diverges, curves or drop – over etc bags can quite easily become entangled with others.

32.2 Singulation of baggage into the X-ray machine is essential for the efficient operation of the 100% HBS system. Also the correct pitch of baggage entering the machine is important. For downstream controls to be able to singulate and pitch baggage into the machine correctly each item must be separate and there must be a detectable gap between successive items – an automated baggage separation mechanism is required to achieve this.

32.3 Classically, there are 4 potential baggage patterns that can cause problems and hence should be detected and resolved via baggage separation i.e.

I. Bags caught up with each other, nose to tail, no overlap
II. Bags partially overlapped, left hand bag leading
III. Bags partially overlapped, right hand bag leading
IV. Bags fully overlapped, i.e. side by side.

32.4 Firstly, a series of sensors are required to detect the above sequence. Secondly, a series of queue conveyors, usually with inverter speed control and differing belt types are required. By varying the speed differential between them it is possible to separate baggage in the first 3 sequences above.

32.5 If it is likely that bags can be fully overlapped, then these bags can normally only be separated if they are transferred through at 90 degree T-junction such that they naturally become one of the first 3 sequences instead. In this case, 2 bag separation systems are to be provided, before and after the 90-degree junction. These are normally termed `primary' and `secondary' baggage separation systems, but are functionally similar.

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## 33. Over– Height Detection.

33.1 An over – height detector is required on a queue conveyor prior to the X-ray machine, mainly to prevent damage to the machine and the bag. Ideally this should be a mechanical flap with limit switch as these are not too sensitive to straps and labels etc. The use of photocells for this is not so efficient.

33.2 If the limit switch on the over height detector trips, then the bag is transported onto the next queue conveyor and stopped.

33.3 The oversized bag can now be removed or re-oriented. A visual warning beacon will flash and an audible alarm will pulse to alert the screening staff. To re-start the conveyor following rectification / removal of the bag the operator shall depress a button upon a locally mounted push – button station.

## 34. Over – length check

34.1 The length check is performed upon a queue conveyor prior to the X-ray. This ensures that bags that are too long are not allowed in the machine.

34.2 Whilst a bag is within the beam of the relevant photocell, pulses are counted from a star wheel / proximity cell arrangement upon the driven roller of conveyor. The number of pulses directly represents the length of the bag, assuming no slippage.

34.3 If the number of pulses received exceeds the pre-set quantity, then the bag is deemed over length. This rogue bag is allowed (subject to downstream dieback conditions) to continue onto the next queue conveyor following the length check and stopped. A visual warning beacon shall flash and an audible alarm pulse to alert the screening staff. After dealing with the bag the operator presses a `re-start' push button.

## 35. X-ray screening overview

### 35.1 Typical operation of screening line

35.1.1 Bags are spaced and pitched correctly prior to delivery into the x-ray machine, which is integrated into the baggage handling control system. Each bag is allocated a unique code number by the BHS control system to ensure communications between the x-ray machines and the BHS control system are always synchronized.

35.1.2 As the bag exits the x-ray machine, the Level 1 decision is made automatically by the x-ray machine indicating whether it is a clear or suspect bag. If the bag is declared as suspicious the X-ray image from the suspect bag will appear at the remote Level 2 workstation to await a manual operator decision. Typically around 60-70 % of bags will be cleared at this point with the remainder referred to level 2.

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35.1.3 The Level 2 x-ray image investigations will be conducted as the bag is being transported along the transport conveyor. This ideally needs to be at least 20 seconds for the level 1 and 2 decision to be made. The Level 2 decision should be made by the time the bag reaches the decision point, which is usually some form of diverting mechanism. If the operator does not make a decision, the system will automatically default the bag to the Level 3 screening areas for further analysis.

35.1.4 The diverted bag will allow cleared bags to proceed to the make up area and route suspect bags to the level 3 area for further inspection.

35.1.5 Cleared level 3 or 4 bags are usually entered into the system after the screening process. This can either be a manual or automated process.

35.1.6 Suspect bags at this point are referred to Level 4, which is a Security issue outside the HBS system.

35.1.7 Tracking errors are a function of both the mechanical system solution, and also the software and commissioning process. It will not be possible to achieve this target rate; if for example, the mechanical system is poorly designed in the first place. The following are guidelines to consider when designing the tracking conveyor systems.

I. Ideally keep all tracking lines straight and level whenever possible
II. Avoid changes in direction if possible
III. If unavoidable, use belt curves rather than drop-over 90 degree transfers
IV. If conveyors cannot be level, then a maximum 7 degree up or down should be considered
V. Keep conveying speeds to a minimum to avoid slippage, usually 0.5 to 0.6m/sec
VI. Keep speed changes to a minimum
VII. Ensure no snagging points on conveyor plate work
VIII. Careful selection of a diverter type for out sorting to level 3 area

## 35.2 Tracking Error Rates

35.2.1 The target rate for correct tracking is 99%. Tracking errors are defined as the percentage of all bags that are routed to level 3 because tracking information is lost such that it is no longer possible to securely associate the bag screening decision with the bag. In such cases the bag is routed to level 3 as a fail-safe measure. This error rate does not make provision for any bags
to reach the make up area that have not been specifically cleared by the screening process. The achievement of this must be 100%.

35.2.2 There is however some tracking error causes that are out of the control of the system and these mainly pertain to baggage types. The following examples are intended to illustrate types of baggage induced tracking errors.

35.2.3 Tracking errors result from apparent changes in length or position with respect to the conveyor belt, outside the defined tolerances as detected by photocells and pulse generators placed on the tracking conveyors.

35.2.4 This is an easily understood way of explaining how baggage characteristics can cause movement with respect to the belt, resulting in a tracking error. In this example bag 1 that stands on a conveyor on its wheels is likely to move with respect to the belt and thus change its position with respect to the belt. The other bag 2 indicates the possibility of its progress being interfered with by a protrusion such as a wheel holding the joint between conveyors; this would also move the position of the bag with respect to the belt and cause a tracking error

### 35.3 **Length Change**

The above example illustrate a way in which the length of a bag and the position of the bag can appear to change from the perspective of the photocells that detect the baggage

## 36. **Baggage position tracking**

36.1 The purpose of baggage tracking is to accurately reconcile routing decisions made by PLC control systems to real baggage travelling upon the conveyors. The software solution must provide fail – safe software philosophies for tracking baggage and routine actions whilst also being somewhat tolerant of the unpredictable travel characteristics inherent when conveying variable baggage types.

36.2 The bag position tracking technique shall be used for tracking bags on the conveyor with data attached to them inside the PLC System.

36.3 Each tracking conveyor is fitted with a pulse generator on a non-driven roller. The pulse generators generate a pulse per unit of the belt movement on the conveyor.

36.4 When a bag breaks the photocell on the first conveyor, which enters the bag into the tracking model, the bags unique PLC allocated tag is entered into a PLC register. This happens whilst the bag is obscuring the photocell. Thus a series of registers are created at the resolution of the pulse generator, which create a virtual image of the bag. The pulses received from respective conveyor causes the registers containing the bag tag to be moved. As such through these each tracking conveyor a bag is mapped to its own dedicated set of registers and the bag can be seen moving as the conveyor moves.

36.5 This technique allows the bag position to be monitored to the resolution of the pulse generator that would typically be 50 mm. Thus when the bag reaches the next photocell on the next conveyor its tracked image should also reach the photocell within a tolerance. This allows the tracking of the bag based on its position and is thus tolerant of bags being removed without causing a serial error to all succeeding bags.

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36.6 In high security applications the registered image also provides a length measurement of the bag to the resolution of the pulse generator. This can be used in addition to the positional check to give some ability to detect a bag being replaced with a different bag but of a different length within tolerances.

36.7 This technique gives rise to a degree of certainty of the bag currently at the photocell being the proper bag to which the data in the PLC relates. This level of certainty is determined by the tolerances. A bag that has moved with respect to the belt out side of the set tolerance but which is not within the tolerance of another bag is uncertain as to which bag it is.

36.8 A similar concept applies where length check is also used where the position is within tolerance but the length has changed outside of tolerance. When a bag becomes uncertain in this way it is termed as a miss track. Bags that are miss-tracked are handled according to a set default destination for miss-tracked bags.

36.9 This form of tracking control is to be utilized in the security element i.e. the 100% HBS.

## 37. **<u>Blockage Detection</u>**

37.1 Conveyor belt is required to be fitted with a photocell at its discharge end. For each of such conveyors a blockage detection algorithm checks for blockages or bag jams on the conveyor.

37.2 If the photocell is obscured for longer than a pre- set time period a blockage will be deemed to have occurred. The timer will not run whilst the conveyors / are stopped.

37.3 In the event of a blockage being detected, the conveyors / affected bag will be stopped and an alarm generated on the MIS if fitted.

37.4 The blockage must be manually cleared and the blockage reset function on the MIS of MCP operated whereupon the conveyor/s affected by the blockages will restart.

37.5 Conveyors upstream of the blockage will stop under dieback control as baggage reaches their respective photocells.

## 38. **<u>X-ray HBS Controls and Mechanical system HBS interface</u>**

38.1 The purpose of any `HBS' baggage handling' software solution is to accurately reconcile screening decisions made by connected systems to real baggage traveling upon the conveyor. The solution must provide fail-safe software philosophies for tracking baggage, reconciling decisions and routing actions, whilst also being somewhat tolerant of the unpredictable travel characteristics inherent when conveying variable baggage types.

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38.2 The very nature of HBS system suggests high accuracy tracking is paramount. However, although a control system solution may offer very tight tracking (where the accuracy is + / - one scan of the software) in reality baggage is not and cannot be conveyed with such precision 100% of time. With broad tolerances applied to checking routines within the software, the system can become very tolerant of the conveying inaccuracies. However, another fundamental feature of HBS control systems should be to identify (if possible), tampering with or exchanges of baggage. This feature requires the application of tight checking tolerances.

38.3 Thus, the situation exists where tighter the tolerances are made to satisfy \`security' requirements greater will be the volume of bags rejected as \`miss-tracks', conversely, opening up the tolerances will reduce reject rates but will reduce the level of security offered. BHS efficiency is defined in terms of acceptable levels of miss-tracks and miss-directs. In general, the target for this should be in the order of 1 – 2 %.

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