Air Cargo Screening

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Abstract

An air security system is required for the planned Thames Estuary airport, intended to be built in the next decade to replace Heathrow airport. A combination of technologies provide a system that can detect all relevant threats currently posed to airports and air travel – both in passenger hold baggage and in commercial air cargo.

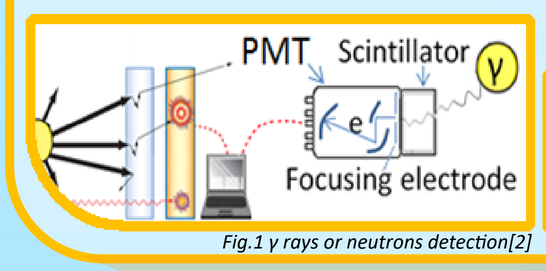
Radiation Portal Monitors

- Radiation portal monitors detect either gamma rays or neutrons. γ-rays are detected by a scintillator. [1]

$$\gamma + NaI \rightarrow NaI^{+} + e^{-}$$

- Neutrons are slowed and strike a conversion material.

$$n + He^{3} \rightarrow H^{3} + p + Energy$$

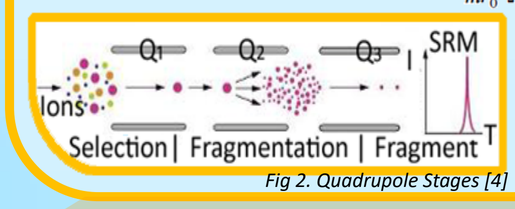


Throughput
180 LPH, 600 BPH
Cost Per Unit
£210,000

Fig.1 γ rays or neutrons detection[2]

Triple Quadrupole Mass Spectrometry

- Three sections of four parallel metal rods select a target ion, fragment it, and then investigate its composition. [3]
- From sample of air it will detect Illicit substances
- Mathieu equation, with stability parameters. $\frac{4}{\Omega^2}\frac{d^2u}{dt^2} + [a_u - 2q_u cos(\Omega t)]u = 0$ $a_x = \frac{8eU}{mr_0^2\Omega^2}$; $q_x = \frac{-4eV}{mr_0^2\Omega^2}$



Throughput
30 LPH
Cost Per Year
£14,195,456

Fig 2. Quadrupole Stages [4]

CO2 & 02 Detectors

- Monitors emit infrared radiation which is absorbed by C02 and then re-emit it in all directions. Absorption levels indicates CO2 levels. [5]

$$\upsilon_{photon} = \frac{hc}{\lambda_{abs}}$$

- Electrochemical oxygen sensor reject false alarms .

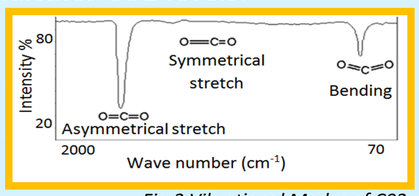


Fig.3 Vibrational Modes of C02

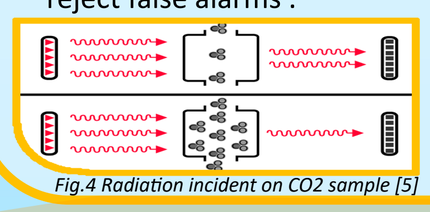
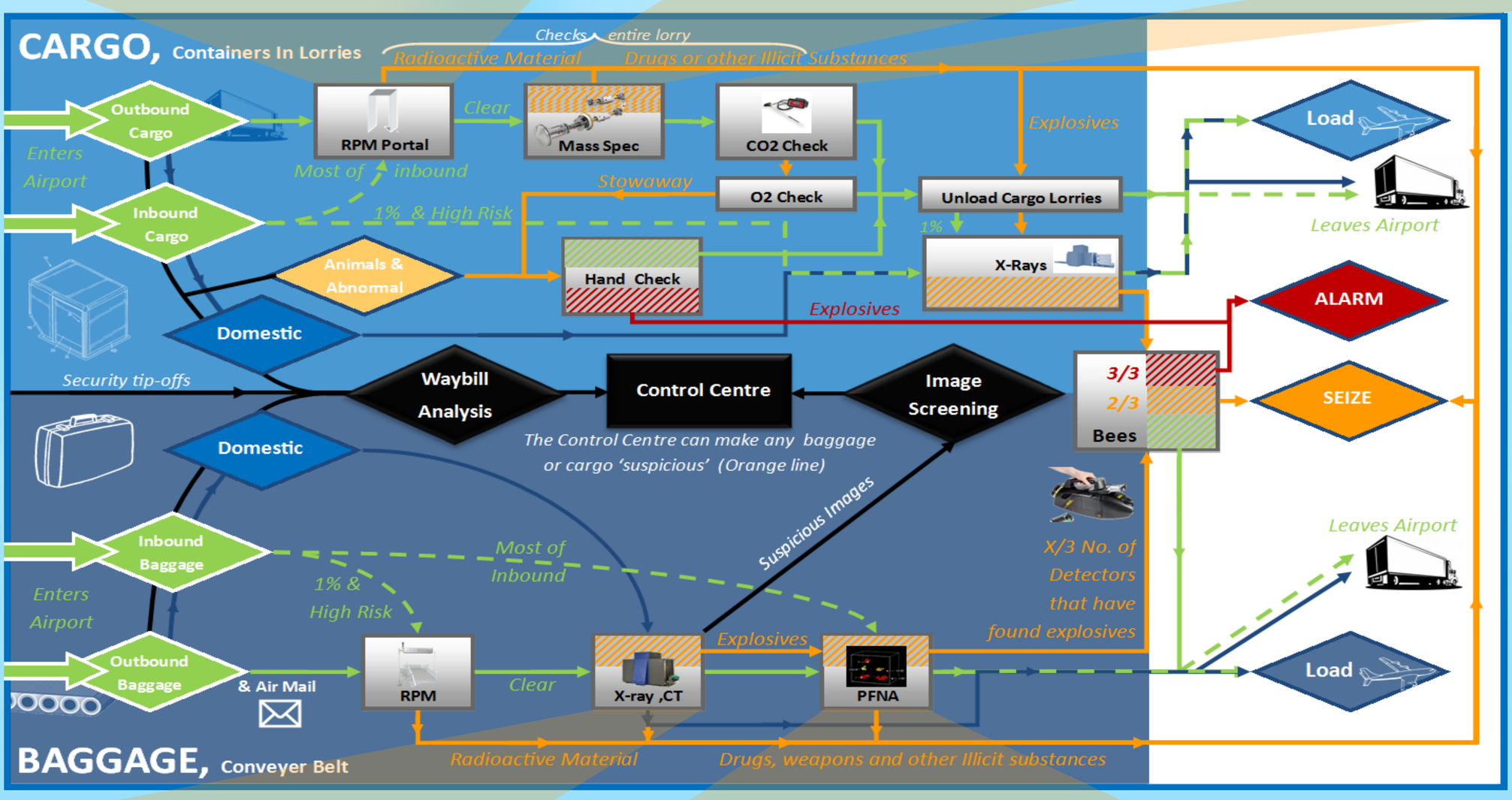


Fig.4 Radiation incident on CO2 sample [5]

Throughput
180 LPH
Cost Per Unit
£1500



Air Security System Key

- LPH - Lorries Per Hour
- BPH - Bags Per Hour
- PPH - Pallets Per Hour
- CONTROL DATA
- OUTBOUND (Safe)
- INBOUND (Safe)
- DOMESTIC (Safe)
- SUSPICIOUS
- DANGER

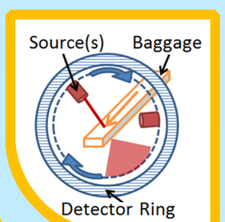
The **control centre** is a hub of skilled employees trained to respond to intelligence, analyse CT images, analyse waybills and mass spectrometry information on tobacco and alcohol presence, to detect smuggled Illicit substances.

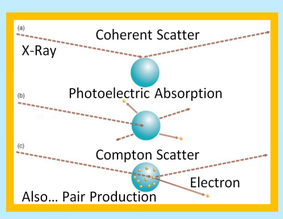
X-Ray Computed Tomography

•X-ray transmission, depends on Relative atomic mass Z_{eff}, Thickness T (>100Kv) and Density ρ . [6]

•Source rotates with respect to object. Attenuations α integrated & mapped for tomograms of all cross-sections.

•α f(ρ,Z_{eff}), resolved by multiple angles (or energies.)





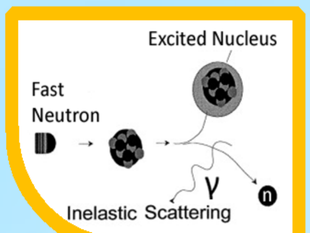
- Fig.6 Rotary CT scanner

Fig.5 X-ray Scattering [6]

Throughput
1800 B/PPH
Cost Per Unit
£1700000

Pulsed Fast Neutron Analysis

- Non-intrusive scan using inelastic scattering of pulsed fast neutrons 2.5 to 9.3MeV.[7]
- Characteristic gamma rays emitted from target. Elemental composition compared to signatures threats.
- ~2ns pulse time gives 3D image, threat location.[7]



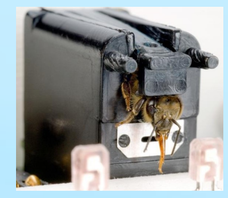
$$n_a + X \rightarrow n_b + \gamma$$

Fig.7 Fast neutron collision [7]

Throughput
360 BPH
Cost Per System
£7,700,000

Control centre & Sniffer Bees

- The control centre can decide to label cargo as safe, suspicious or dangerous depending on information it receives.
- Conditioned honey bees respond to specific substances up to 78 parts per trillion, their tongue triggers a light gate.
- If not viable, Sniffer Dogs will be used.



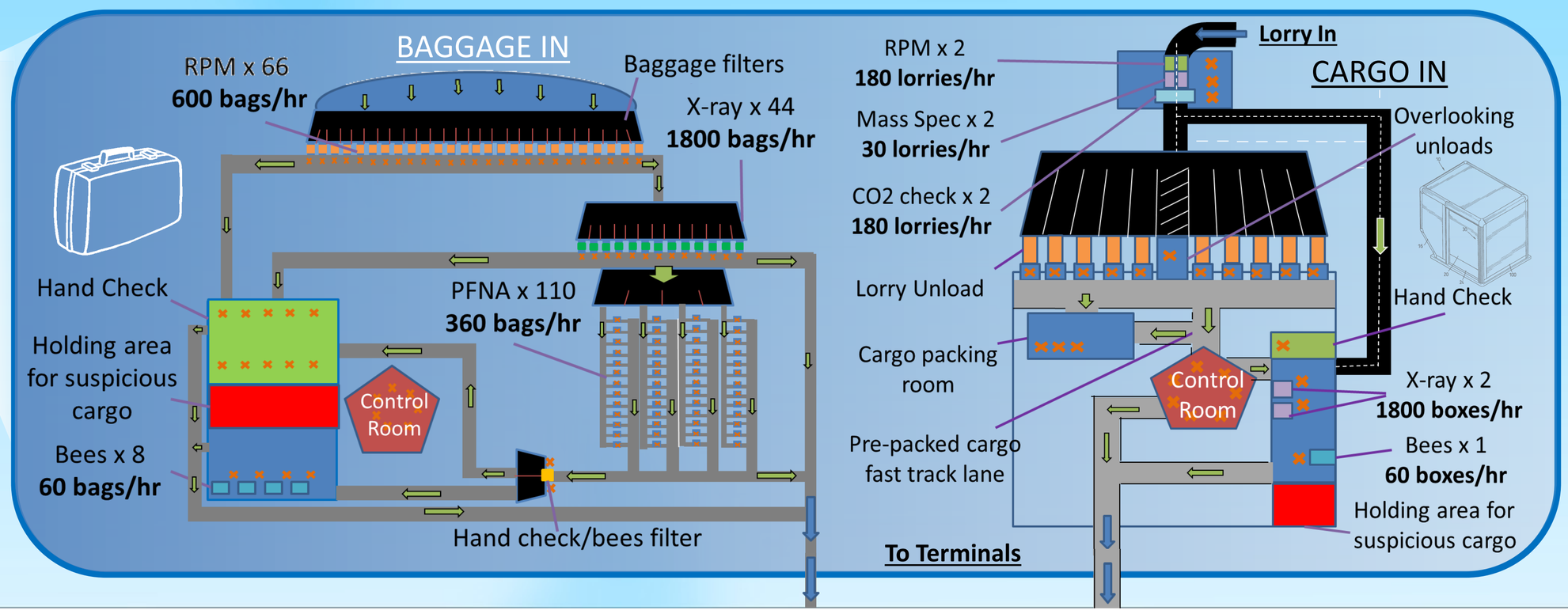
Throughput
60 B/PPH
Cost Per Year
£64000

Floor Plans & Overall Throughput

Estimated capacity 2023

Yearly passengers	Passengers on busiest day	Yearly cargo (metric tonnes)
78128349	241232	1681926

This system represents a cost effective, efficient and fully secure method of scanning an hours worth of predicted throughput in half an hour.



[1] RPM, http://www.stanford.edu/group/scintillators/ *Scintillator Materials Group, Stanford University 2009*
[2] Fig 1, Scintillator, http://gao.gov/assets/590/585514.pdf
[3] MS, March, R. E, *An Introduction to Quadrupole Ion Trap Mass Spectrometry. J. Mass Spectrom.*, 32: 351–369, 1997.
[4] Fig 2, Quadrupole, http://dx.doi.org/10.1016/j.cbpa.2009.09.014
[5] Fig 4, Capnograph, http://www.howequipmentworks.com/
[6] Fig 5, Scattering https://str.llnl.gov/June11/martz.html *Lawrence Livermore National Laboratory, 2011*
[7] Fig 7, PFTNA http://www.sciencedirect.com/science/article/pii/S0039914000005440, Western Kentucky University, Talanta Vol 54

References