PRIME MINISTER'S OFFICE

Air Cargo Screening Requirements and Test Methodology

ISRAEL PRIME MINISTER'S OFFICE

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Background

1. Israeli cargo is divided into two main paths:
   1. Sea Ports: 99%
   2. Air Cargo: 1% - through three main cargo terminals
2. ~160,000 Tons (160 X 10^6 Kg) via aircrafts
3. ~60% by passengers aircrafts
4. IPMO is initiating a high priority program for Air Cargo Screening

Main Technical Requirements

- The system will not require disassembling the cargo on the pallet (1.1 X 1 X 1.6 m).
- The system will not require the opening or separation of an individual piece of cargo.
- The screening must in no way harm the contents of the commercial cargo
- False Alarms - Low percentage – Less than 0.5%

Main Operational Requirements

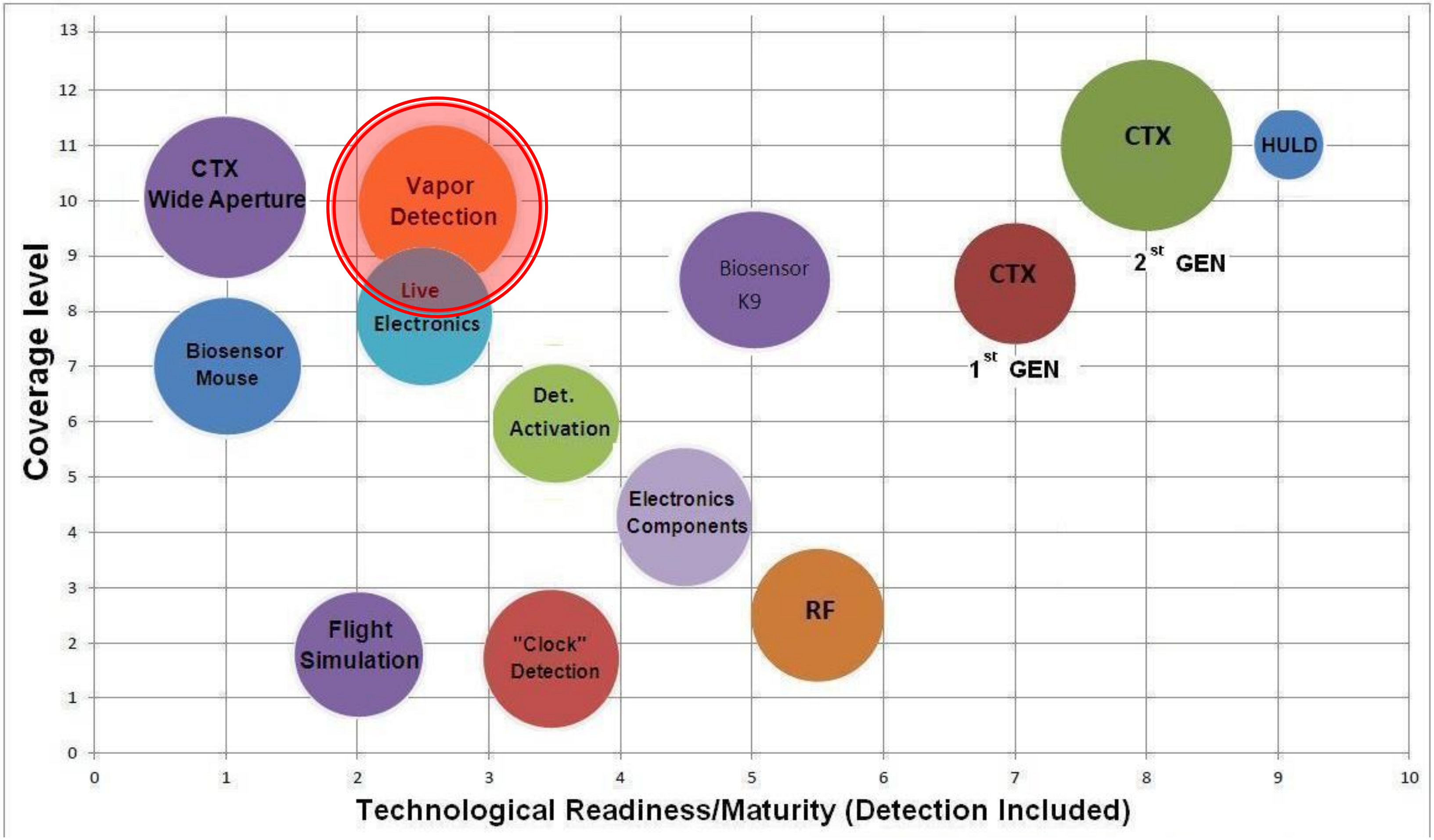
- Screening time - up to 10 minutes
- Mean time between screens - 5 minutes at the most
- Mean recovery time after alarm - no more than 15 minutes
- Time required to begin screening including calibration and checks – less than 30 minutes

Approaches and Principals

- **Trace Vapor Detection**
  - » HVS – Preconcentration – Analysis
  - » Direct sniffing

- **Detection of Initiation Device**
- **Bulk Detection**
  - » TBD (next ADSA?)

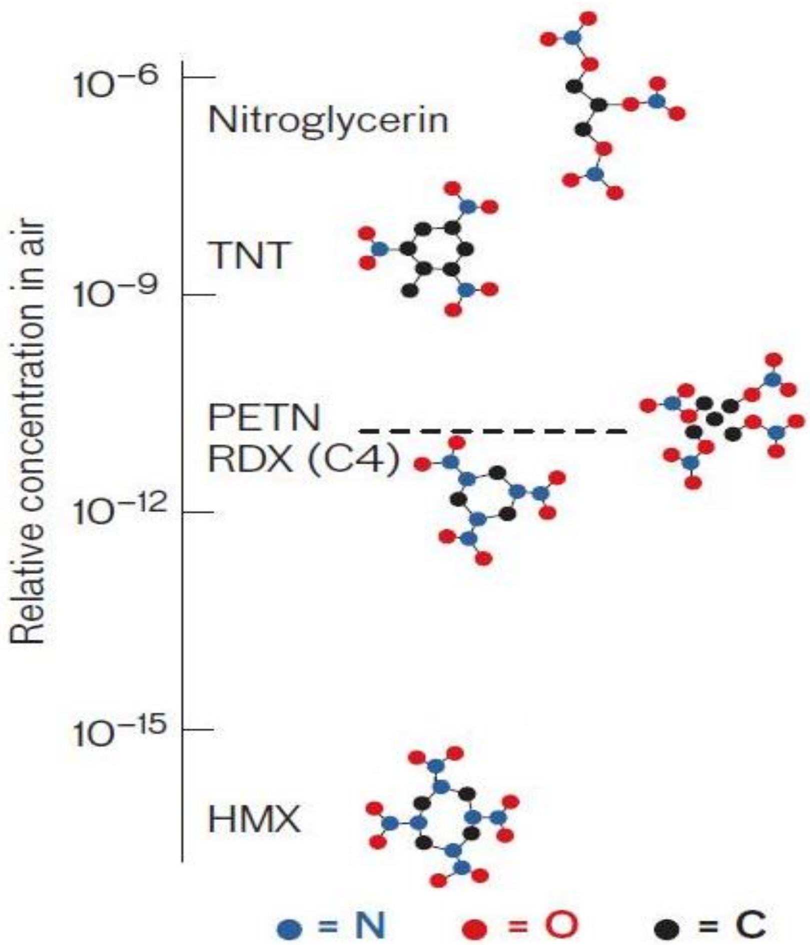
Technology Comparison



Vapor Pressure

Name	Vapour Pressure (rel. | Torr)	Preferred Trace Det.
TNT	7.7 ppb | $5.8 \cdot 10^{-6}$ (25 °C)	Particle (Vap.)
RDX	6.0 ppt | $4.6 \cdot 10^{-9}$ (25 °C)	Particle
HMX	3.95 ppt | $3 \cdot 10^{-9}$ (100 °C!)	Particle
Tetryl	7.5 ppt | $5.7 \cdot 10^{-9}$ (25 °C)	Particle
PETN	18 ppt | $1.4 \cdot 10^{-8}$ (25 °C)	Particle

Relative Conc. in Air



Novel Method for Remotely Detecting Trace Explosives
C. M. Wynn, S. Palmacci, R. R. Kunz, M. Rothschild

Well,

how much is it?

Basic Calculation

Vapor pressures are often expressed as **relative concentrations in saturated air, rather than in true pressure** units.

Usually expressed in units of ppm, ppb or ppt.

For an ideal gas we have the following relationship between the (vapor) pressure ***p*** *(in Pascal, with 1 Torr = 133 Pa), the volume* ***V*** *(m3), the quantity of gas* ***n*** *measured* in moles (e.g. 1 mole TNT = 227.13 grams), and the absolute temperature ***T*** *in Kelvin:*

pV = nRT => n/V = p/RT

With ***R*** *being the universal gas constant (8.31 J·mol–1·K–1).*

The TNT relative concentration at 25 °C for example amounts to 5.8·10–6 torr, or 7.7 ppb, **corresponding to about 0.07 ng/cm³**

An order of magnitude figure for *TNT of 0.1 ng/cc is often encountered*

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A potential for 1microgram / 10 liter saturated air

What can be done?

Look for other molecules?

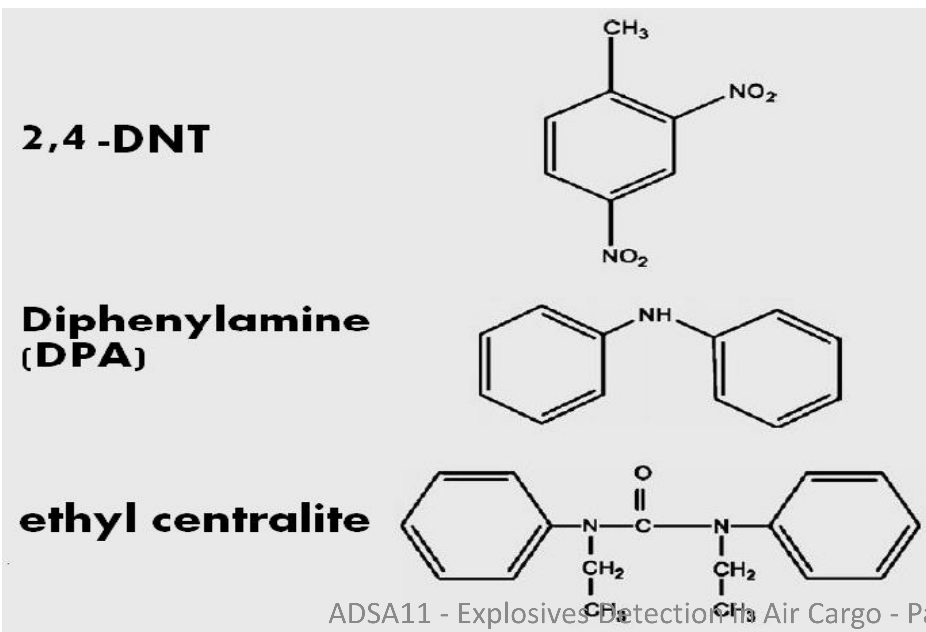
Preconcentration – integrated or separated for the detector

Better sensitivity? – are these available? (SPR, EC, TR…)

A combination is well preferred.

Other ingredients of Energetic Materials [smokeless powders]

The detection of **diphenylamine**, ethyl and methyl centralite, 2,4-DNT, diethyl and dibutyl phthalate by IMS is suggested as a method to indicate the presence of smokeless powders (Analysis of the headspace composition of smokeless powders using GC–MS, GC-μECD and IMS. [Forensic Science International (2010) **Almirall** et al]



DNT & DPA are 15-140 X 10^3 more likely to be found at vapor phase (vs. PETN or RDX)

Other ingredients of Energetic Materials [Explosives]

Two major groups of compounds can be found:

- Taggants (such as NG, EGDN, DMNB)

- Starting materials or additives (solvents, plasticizers, binders)

Trace Headspace Sampling with Cryoadsorption

	compounds in the headspace	recovered mass (ng/L) (20 °C)	recovered mass (ng/L) (40 °C)
semtex-1A	isophorone	102	440
	γ-butyrolactone	51.0	205
	DMNB	2240	8850
tagged-C-4	bis(2-ethylhexyl)adipate	1.1	17.5
	DMNB	4460	13560
detaflex	γ-butyrolactone	116	250
	tributyl acetalcitrate	37.3	367
detcord	γ-butyrolactone	0.35	4.07
	nitroglycerin	224	1110
	diethyl phthalate	0.0006	0.03

T.M. Lovestead, T.J. Bruno *Anal. Chem.*, 2010, *82* (13)

Characterization of Three Types of Semtex (H, 1A, and 10)

Comparison of SPME components for Semtex samples.

Component	1A	10	H
EGDN (detected as ethyl nitrate)[a)]	X	X	
4-Phenylcyclohexene[a)]	X		
Butyl benzoate[a)]		X	
2,6-Ditertbutyl-1,4-benzoquinone[a)]	X		
2,4-DNT			X
TNT[a)]			X
N′,*N*-Butylphthalimide[a)]		X	
4-Formyl-2,6-ditertbutylphenol	X		
3,5-Ditertbutyl-4-hydroxyacetophenone	X		
Ethyl centralite[a)]	X	X	
Dibutyl phthalate[a)]	X	X	X
i-Propylhexadecanoate	X	X	X
Hydrocarbons[a)]	X	X	X

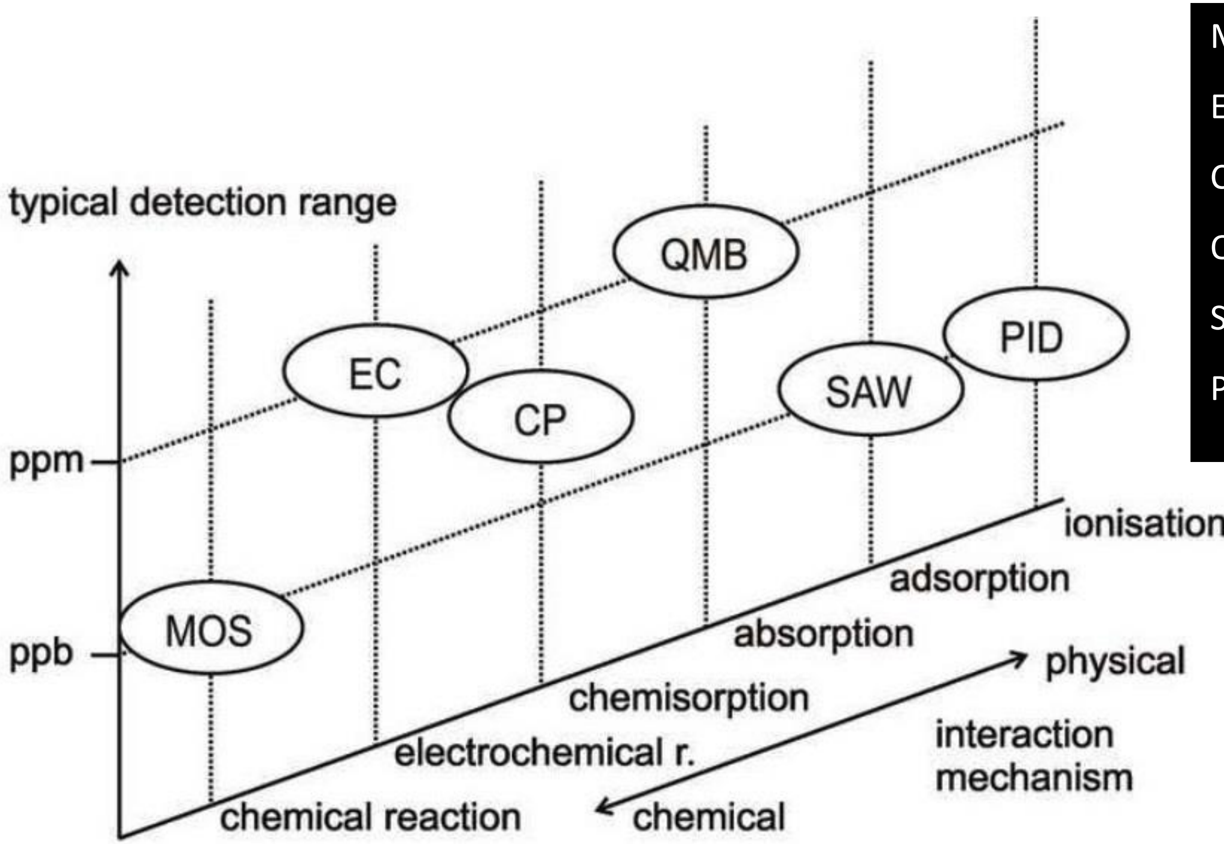
S. Moore, M. Schantz, W. MacCrehan *Propellants Explos. Pyrotech*. 2010, 35, 1 – 10

Pre-Concentrators

- COTS

- Tailored Made (usually it COST)

On 'Electronic Nose' Methodology



MOS: metal oxide semiconductor

EC: electrochemical cell

CP: conducting polymer

QMB: quartz micro balance

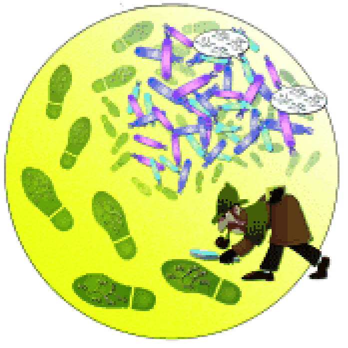
SAW: surface acoustic wave

PID: photo ionization detector

P. Boeker, On ‚Electronic Nose' Methodology
Sensors and Actuators B: Chemical (2014)

Vapor Detection - Program Schedule

- Q1/2014
  - Technology survey
- Q3/2014
  - 'First Impression' test – FAR oriented
    - 1st Detect – MS / Cylindrical Ion Trap (later this year)
    - Bruker – MS
    - SEDET – 3Q MS
    - PNNL – MS / Real-time vapor detection
    - Teknoscan – GC/IMS
    - Tracense – Silicon nanowires
- Q4/2014
  - Real Life Scenario (concealments)
- Q3-4/2015
  - Field test and Certification



Full access to filed/cargo terminal

Chemicals

Electronics

Fish

	LOD [pg]			UN type 1	FAR
	PETN	RDX	TNT		
Vendor 1	10-100	1-10	10-100	+++	<5%
Vendor 2	1000	100	1000	--	>5%
Vendor 3	1000	100	100	--	<5%
Vendor 4	1000	100	1000	+	>5%

Summary

- It's the tip of the iceberg
- But we are prepared for the hard way