Sensor Requirements for CBRNE Detection & Identification

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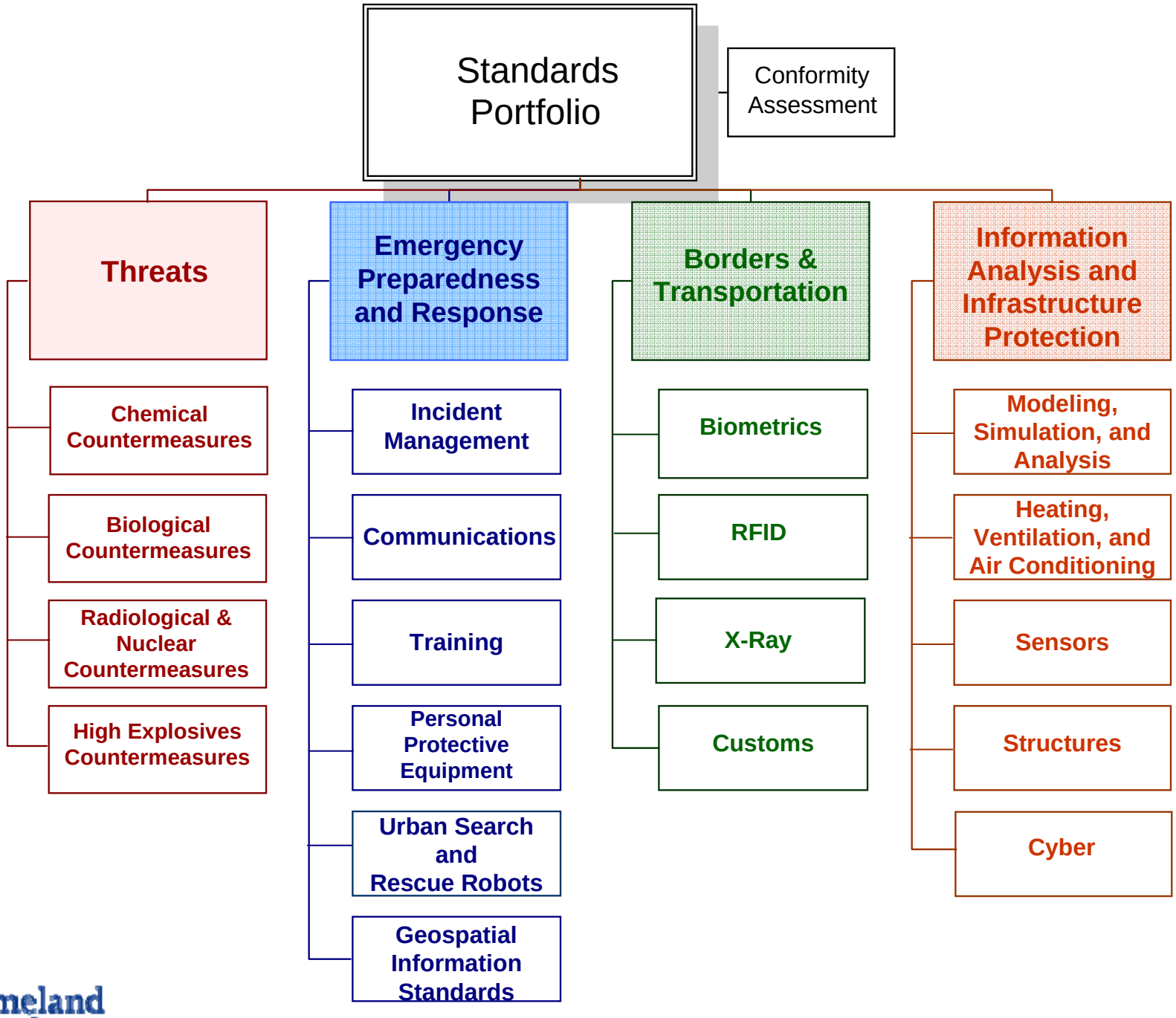

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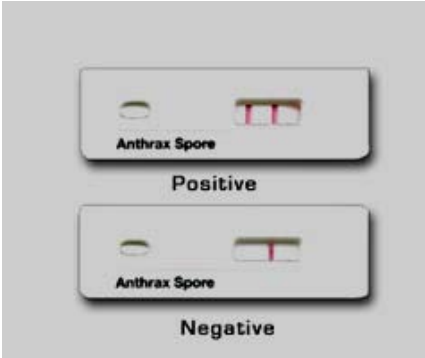
Equipment Standards Functional Areas

Respiratory Protection Equipment

Protective Equipment

Decontamination



Detection Equipment

Operational Equipment

HazMat Standards Requirements

- Personal Protective Equipment (NFPA, NIOSH)
- Radiation detectors (IEEE/ ANSI N42)
- Chemical agent detectors (ASTM E54)
- Explosives detection (ASTM)
- Biological agent detectors (AOAC)
- Urban search & rescue robots (ASTM)
- Communications equipment (SAFECOM)
- Incident management standards (NFPA)

Chemical, Biological, Radiological/Nuclear & Explosives Countermeasures Standards

HazMat Standards Requirements

- Radiation detectors
- Chemical agent detectors
- Explosives detection
- Biological agent detectors
- Urban search & rescue robots

Performance Standards for Radiation Detection Equipment

(Issued and available from IEEE)
http:/standards.ieee.org/getN42/index.html

Standard	Instrument Type
• ANSI N42.32-2003	Pagers, PRDs
• ANSI N42.33-2003	Portable Instruments (survey meters)
• ANSI N42.34-2003	Radionuclide Identifiers
• ANSI N42.35-2004	Portal Monitors

Writing committees consisted of users, manufacturers, field experts from National labs, and academia

First DHS Radiation Detector Standards

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ANSI N42 Standards Tests

- **General tests:** Display, controls, weight, size, batteries, alarms
- **Radiological tests:** exposure rate, background, false alarm, over range, accuracy, time to alarm, identification, neutrons
- **Environmental tests:** temperature, humidity, dust, sealing, temperature shock, water resistance
- **Mechanical tests:** mechanical shocks, impact test, vibration, drop test
- **Electromagnetic tests:** external magnetic fields, radio frequency, conducted disturbances (burst and radio frequencies), surges and oscillatory waves, electrostatic discharges

Radiation Instruments Data Format

Pagers and Survey Meters

- Data is a series of count and/or exposure rate readings
- Time of measurement

Radionuclide Identifiers

- A series of count and/or exposure rate readings
- Spectrum - source and background
- Results of the analysis of the spectrum
- Energy calibration
- Time of measurement - start and elapse

http://physics.nist.gov/N4242schema.

Radiation Instruments Data Format

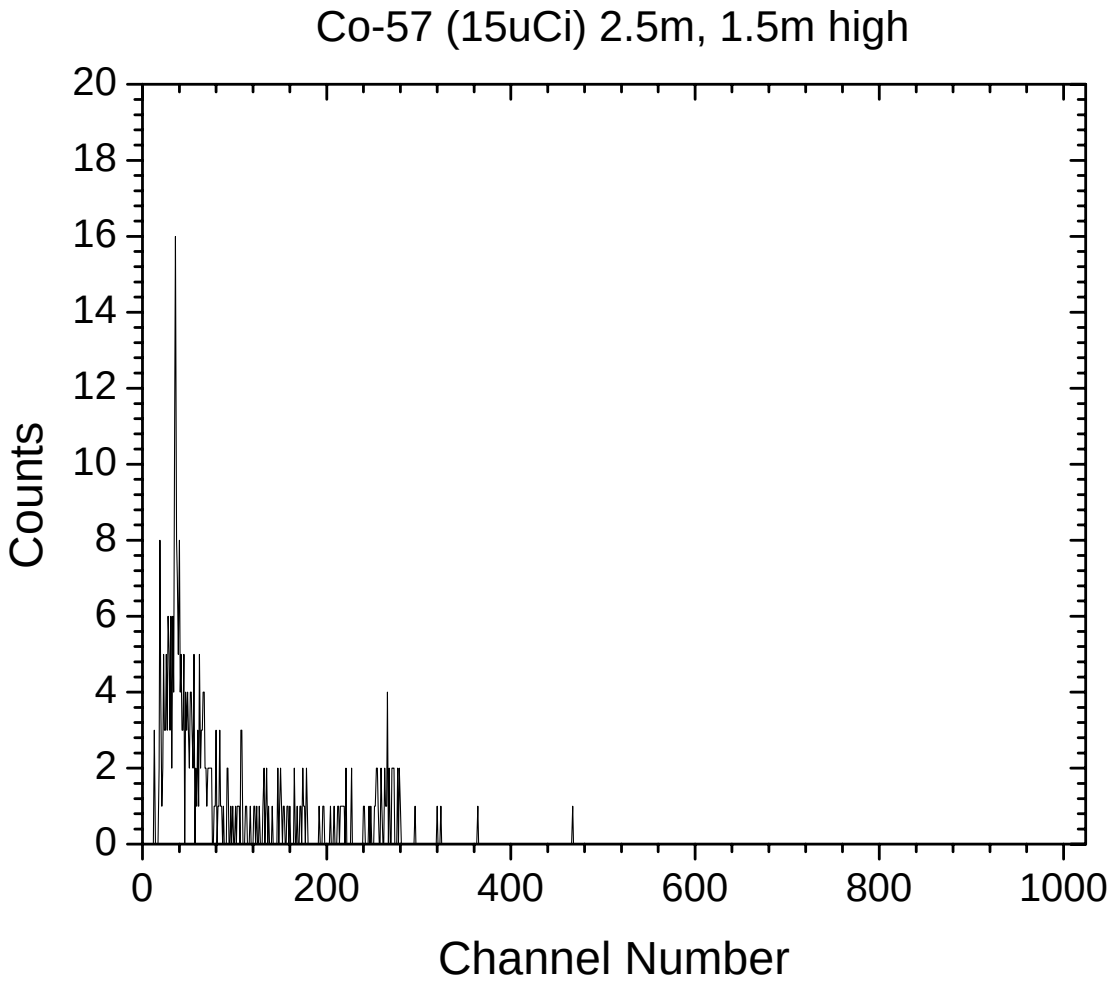
Plastic Portal Monitors

- Time of event
- Counts for gamma and neutron detectors
- Occupancy time

Spectroscopic Portals Monitors

- Time of event
- Counts for gamma and neutron detectors
- Occupancy time
- Spectrum - source and background
- Results of the analysis of the spectrum
- Energy calibration

Gamma-Ray Spectrum of Cobalt-57 obtained with Radiation Portal Monitor with NaI(Tl) Detector



Current Chemical Detection Technology for Field Use

Dynamic Range

Bulk

Trace

Draeger Tubes

- Chem detection paper (M8/M9)
- Enzyme tickets (M256A1)
- Colorimetric Tubes (Draeger)
- Ion Mobility Spectrometry (ICAM)
- FTIR (M21 RSCAAL)
- PID

ICAM - Improved Chemical Agent Monitor

M8 Detection Paper

Remote Chemical Agent Detection with IMS

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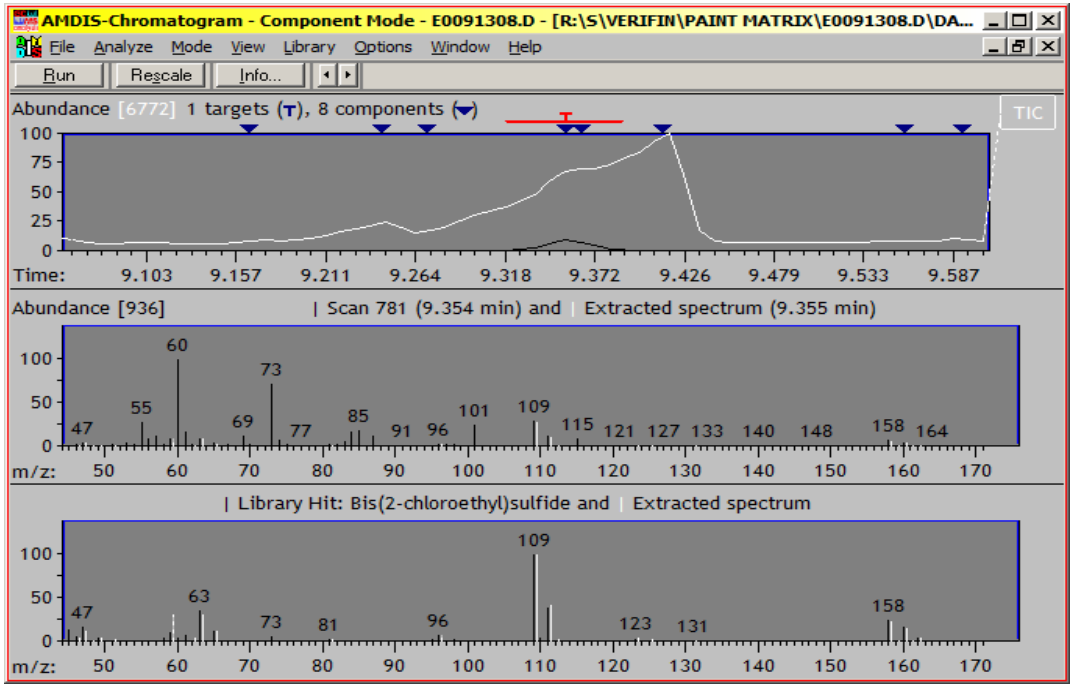
Mass Spectrometer Spectrum for TIC



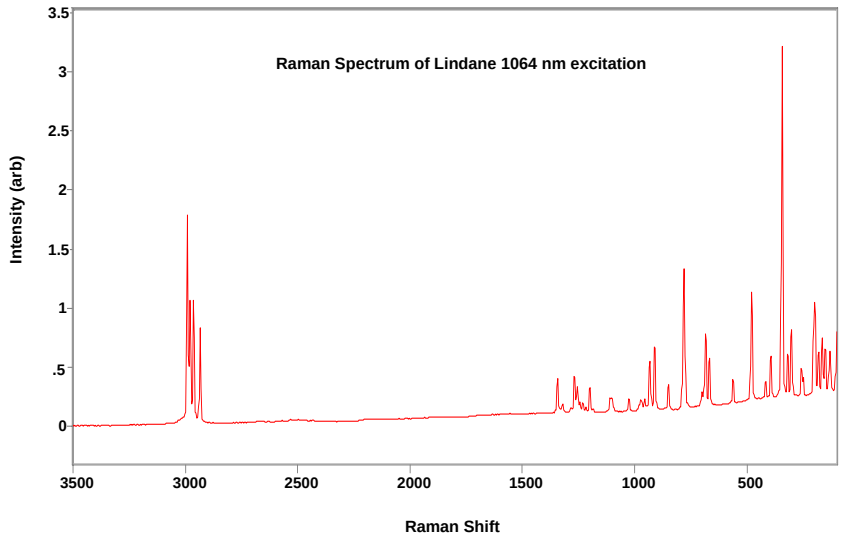
<u>Critical Instrument Parameters</u>

Mass range/Scan speed
Chromatographic speed and resolution
Mass resolution
Stability
Library of agents needed

<u>Critical Sample Parameters</u>

Purity (example very low purity)
Sample must be liquid/vapor
Minimum sample size 2 microliter
Minimum concentration down to
1 in 10^9 – lower in special cases

Raman Spectrometer Spectrum of Lindane

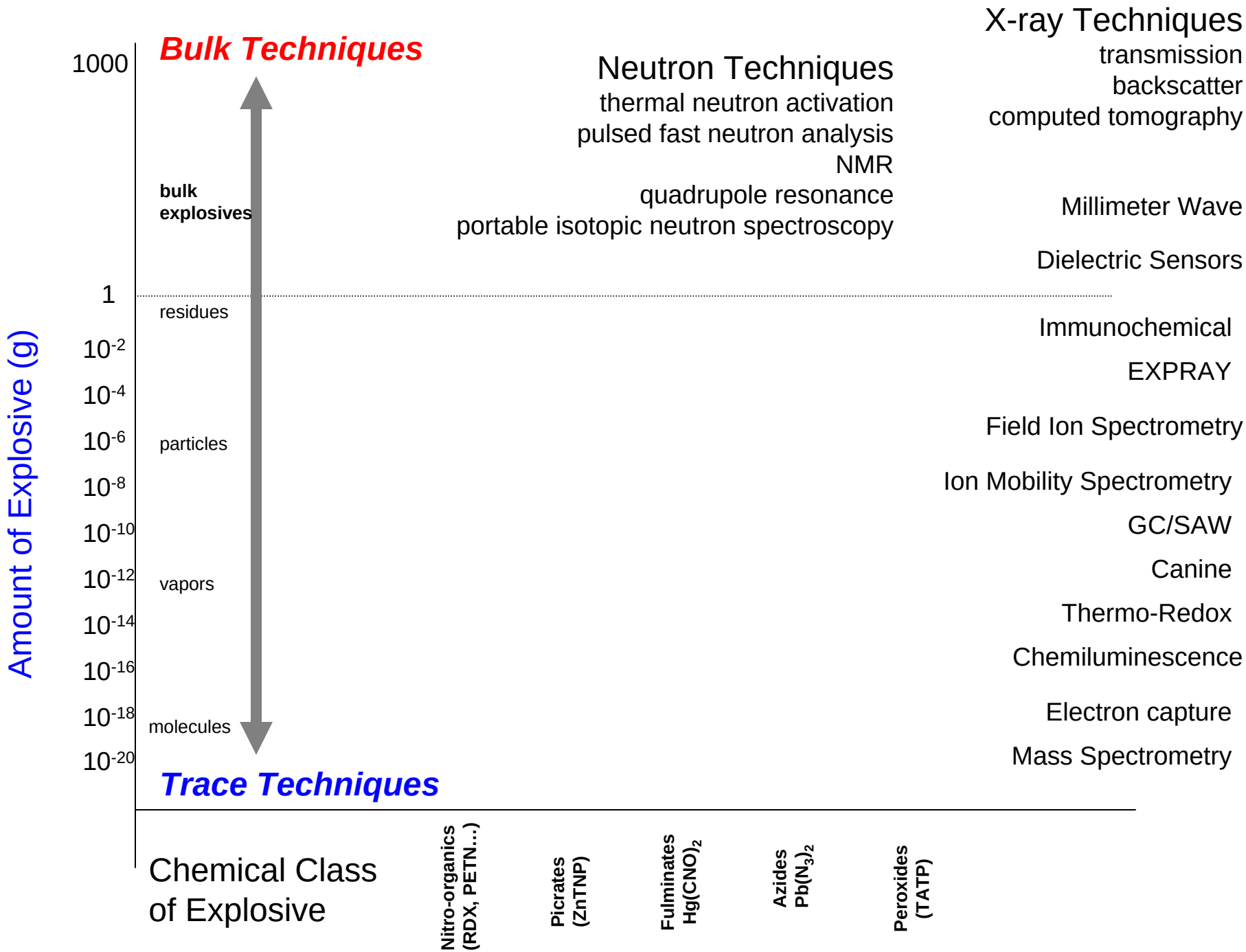


<u>Critical Instrument Parameters</u>

Excitation laser wavelength
Laser power at sample
Integration time (acquisition time)
Type of collection
Spectrometer type: dispersive vs. Fourier Transform
Resolution of the measurement
Calibration: x-axis , y-axis, both, or none

<u>Critical Sample Parameters</u>

Source of material
Location of sample
Time sample collected
Type of container (i.e. was the sample measured through the container?)
MSDS availability
Type of sample if known (forensic, toxic industrial chemical, pesticide, organic?)


Bulk Techniques
Trace Techniques
Amount of Explosive (g)
1000
1
10^{-2}
10^{-4}
10^{-6}
10^{-8}
10^{-10}
10^{-12}
10^{-14}
10^{-16}
10^{-18}
10^{-20}
bulk explosives
residues
particles
vapors
molecules
Neutron Techniques
thermal neutron activation
pulsed fast neutron analysis
NMR
quadrupole resonance
portable isotopic neutron spectroscopy
X-ray Techniques
transmission
backscatter
computed tomography
Millimeter Wave
Dielectric Sensors
Immunochemical
EXPRAY
Field Ion Spectrometry
Ion Mobility Spectrometry
GC/SAW
Canine
Thermo-Redox
Chemiluminescence
Electron capture
Mass Spectrometry
Chemical Class of Explosive
Nitro-organics (RDX, PETN...)
Picrates (ZnTNP)
Fulminates $Hg(CNO)_2$
Azides $Pb(N_3)_2$
Peroxides (TATP)

Trace Explosive Detection Devices

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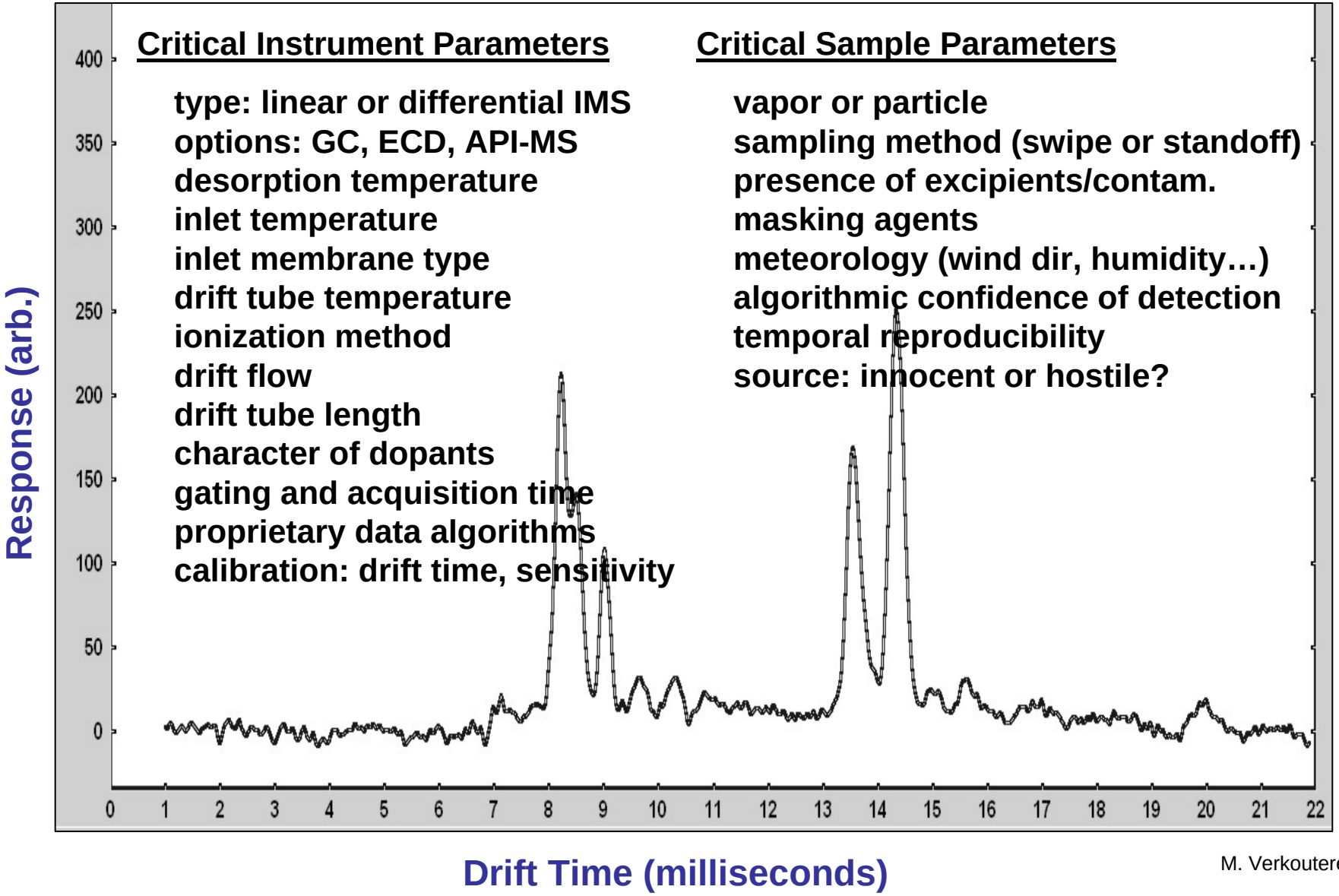
Ion Mobility Spectrum of RDX
(hexahydro-1,3,5-trinitro-1,3,5-triazine)

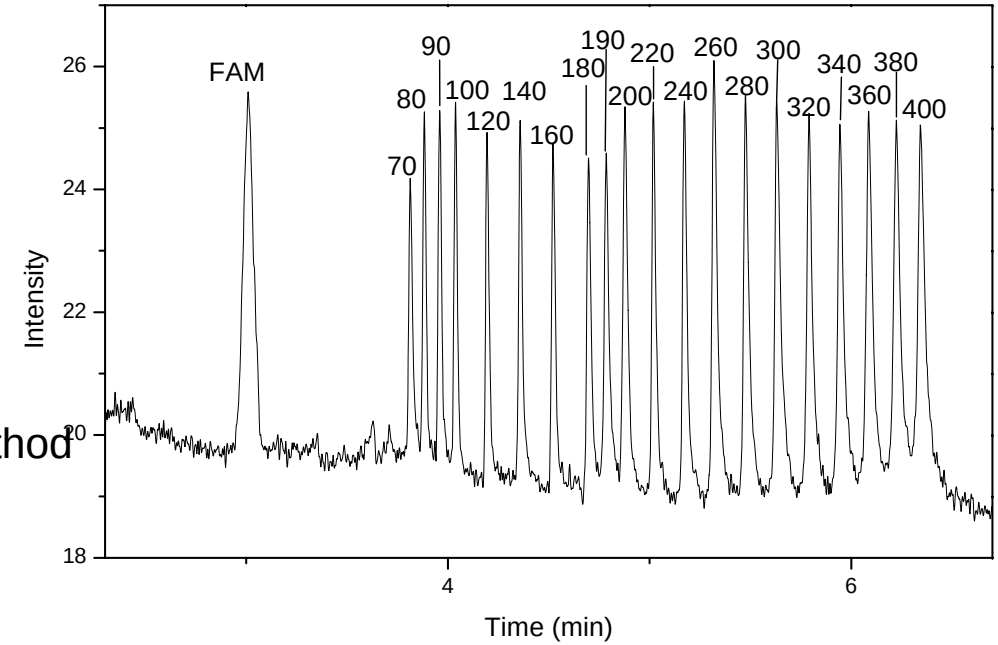


M. Verkouteren

Detection Technologies for Bacteria, Virus, and Toxins

- Molecular analysis
  - Spectroscopy (fluorescence, flame, IR…)
  - Mass spectroscopy (time of flight, MALDI…
- Antibody based
  - Immunochromatographic (lateral flow), electrophoretic, flow cytometry…
- Nucleic acid based
  - Real time PCR
  - Isothermal methods for amplification
  - Lab on a chip
  - Microarray

Forensic DNA Analysis using Capillary Electrophoresis



Critical Instrument Parameters

- Polymer matrix
- Spectral matrix
- Background electrolyte
- Capillary length
- Capillary surface modification method
- Capillary diameter
- Electrophoresis current
- Age of capillary
- Analysis temperature
- Injection time
- Injection electric field strength
- Separation electric field strength
- Excitation laser wavelength
- Emission wavelength(s)
- Calibration sample (DNA ladder)
- PHRED score (indication of resolution)

Critical Sample Parameters

- Sample matrix (e.g., fabric, chewing gum)
- Single or dual donor (e.g., buccal swab)
- Cell type
- Location of sample
- Sample extraction method
- Time sample collected
- PCR amplification conditions
- Post-PCR purification technique
- Age of material

ASTM E54.08.01
US&R Robot-borne Sensors

	Scenario A	Scenario B	Scenario C
Description	Upper stories of a multi-story pancake collapse	Subsurface voids	US&R Type II
Characteristics	Soft stories in the middle, undetermined stability, uneven terrain, sloped floor with holes, variable debris size, high hazmat potential, and poor visibility	Downwardly accessible void spaces, twisted/turning access (i.e., searchcam can't reach or turn necessary corners), variety of materials, complex orientations of support surfaces, sufficiently complex to cause spatial disorientation, hot, may be wet, high hazmat potential, and poor visibility	Rapid extraction of many non-ambulatory live victims from a contaminated (WMD / CBRNE) environment in a large urban area. This assumes that explosions or collapses have not compromised structures. Sample areas include malls, stadiums, several city blocks, etc. Teams may be pre-deployed.
Representative Image			

Three scenarios developed by FEMA responders to elicit US&R robot requirements.

ASTM E54.08.01: Hazmat Sensing Requirements for Robots

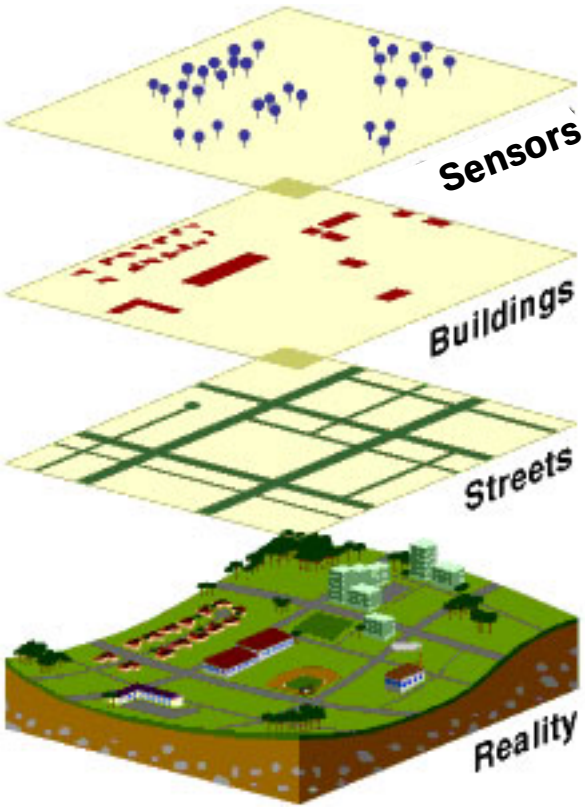
Requirement Number	Type	Sub-Type	Requirement	How Measured	Description
73	Sensing	Hazmat	Hazard Detection	Scale 1 - 5	Scale:1=ph + O2, LEL, CO, H2s, RAD; 2=+WMD and TIC detection;3=+WMD and TIC classification; 4=+Tentative WMD and TIC identification; 5=+WMD and TIC sampling. Detection capabilities must meet current capabilities as documented in industry standards. No latency.
83	Sensing	Passive Data Logging Onboard	Hazmat	Scale: 1 = Yes 0 = No	Automatically logs sensor data throughout mission

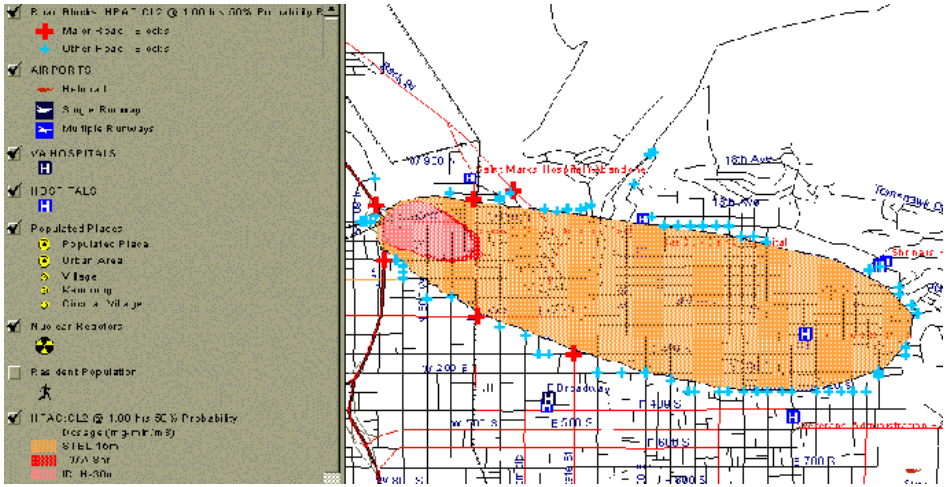
Metadata

Metadata, or data about data – is collected in parallel with sensor readings. It can include, but is not limited to:

- Time
- GPS location of the instrument
- Instrument characteristics, Status
- Data source, format
- IEEE 1451
  - The IEEE 1451 family of standards offers common interfaces for sensors, actuators, instruments and networks so transducers are interoperable and interchangeable.

Metadata





Metadata alignment allows compilation of various data sets – photos, maps, sensor readings, in layers – creating interactive geospatial information

Thanks to NIST Researchers

Radiological/Nuclear Detectors: Leticia Pibida

Chemical Detectors: Steve Choquette, Gary Mallard

Biological Detectors: Laurie Locascio, Wyatt Vreeland

Explosives Detectors: Gregory Gillen

Urban Search & Rescue Robots: Elena Messina

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