Test Infrastructure Upgrades

Chem Bio Individual Protection Conference 2006

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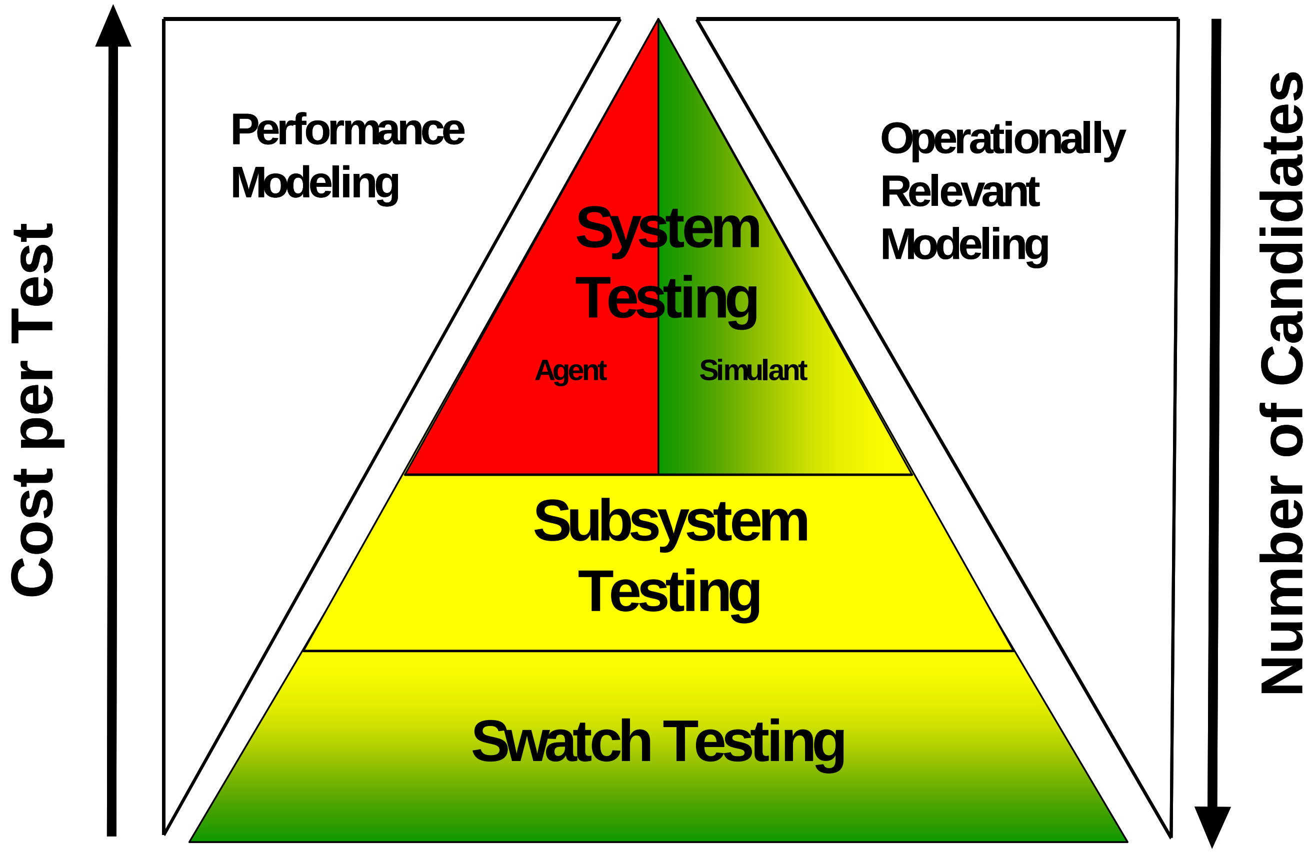
Dugway Proving Ground
March 9, 2006

Agenda

- Current Testing Protocol
- Improved Swatch Testing
  - Chemical Biological Agent Resistance Test (CBART)
  - Real Time analysis
- Improved System Testing
  - Real Time analysis of Man In Simulant Testing (MIST)
  - Improved Aerosol Testing
  - IPE Human Body Grid System
  - IPE Airflow Mapping
  - Protective Ensemble Test System (PETS)
- Conclusion

Evaluation Pyramid



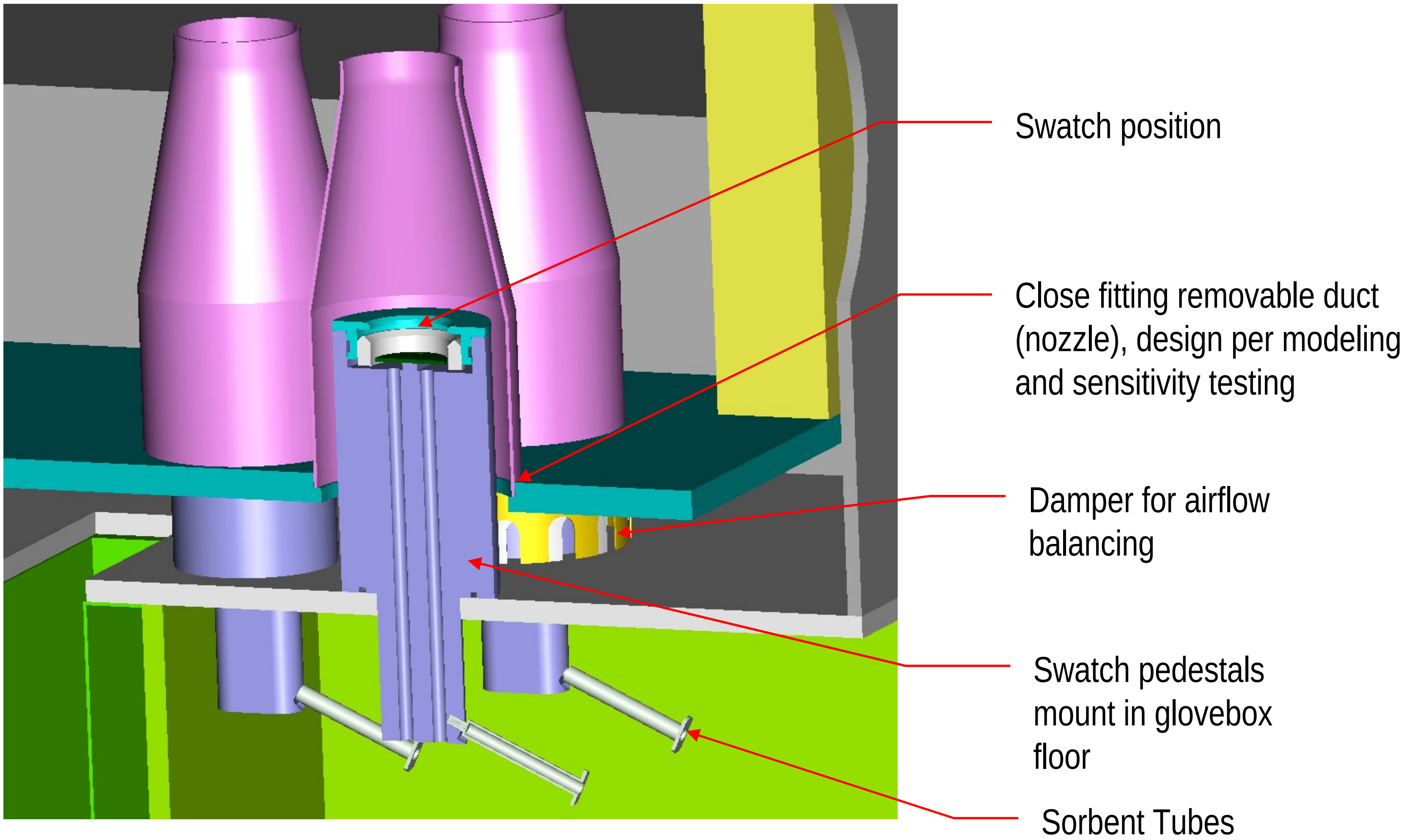
Swatch Testing Improvements

Increased Standardization—permeable fabrics tested differently than impermeable materials

	CBART	AVLAG
Test Types	Material Performance	Dual, Static & Convective flow
Flow Source	Wind Speed	Pressure Controlled
Types of data	1	3
Impingement Flow	Set @ wind speed-- No variability	Variable, based on swatch permeability
Config. Mgmt.	Built-in	None
	Single Test	Multiple Tests

Variable flow eliminated

CBART
(Chem/Bio Agent Resistance Test)
Conceptual Design



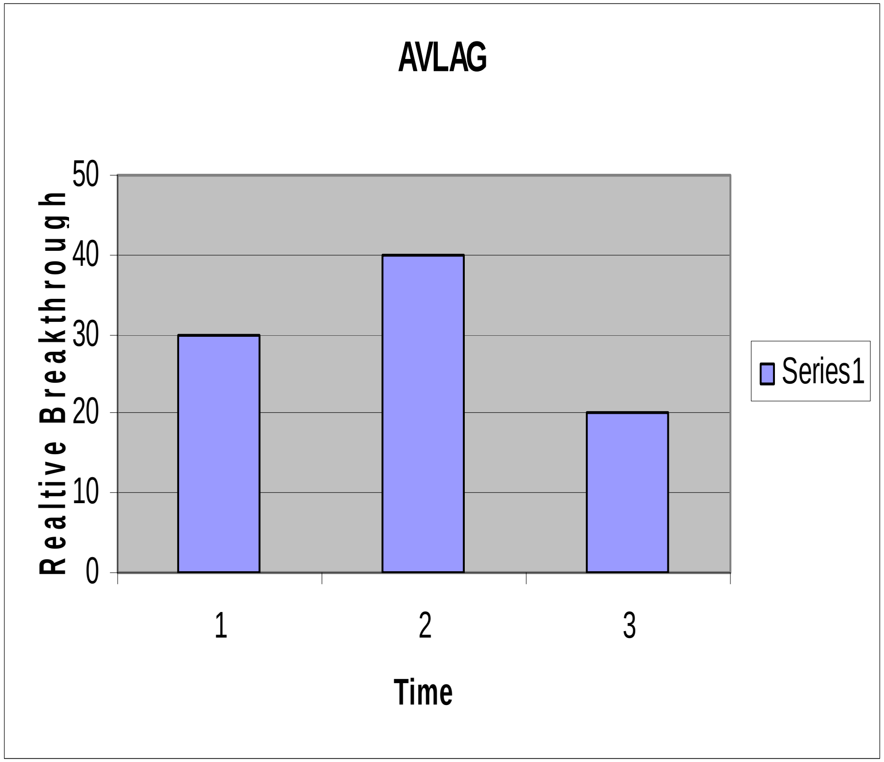
CBART

- Key Contributors
  - DPG, ECBC, SBCCOM, NSC, DTRA, DUSA-OR, JPEO, AEC, Natick, Battelle, Creare
- Limited JSTO funding this year
- Issues
  - Verification and validation of new fixture
  - Control parameters
  - Configuration Management

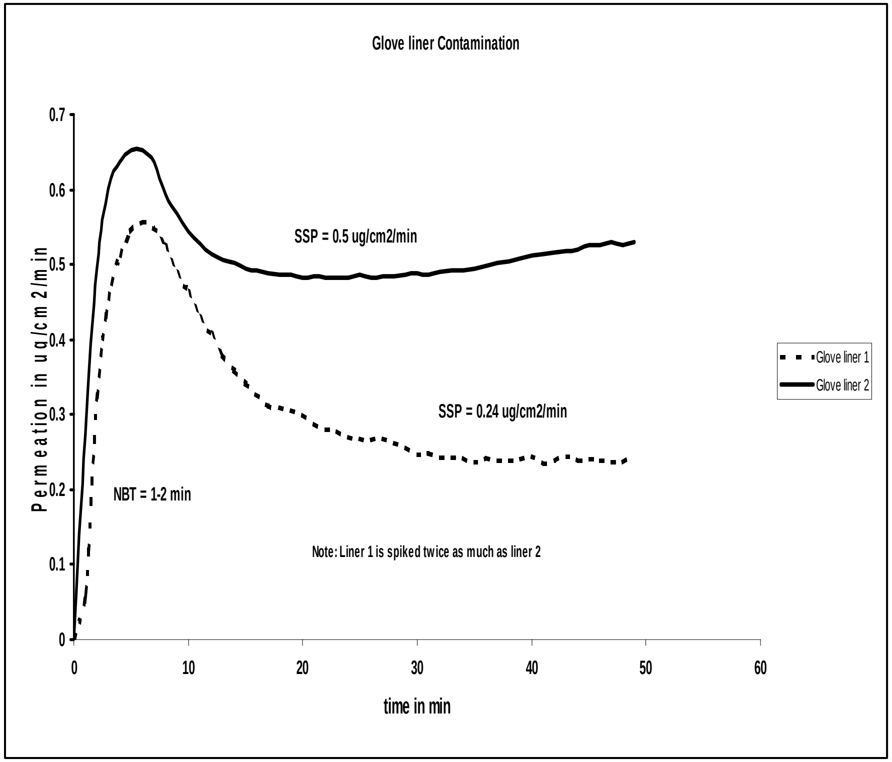
Swatch Real-Time Analysis

- Swatch testing has almost exclusively used bubbler samplers.
  - MINCAMS (>$30K each)
- Three bubblers per 24 hours gives 3 data points per sample/trial.
- Initial breakthrough time and steady state data unavailable.

Background

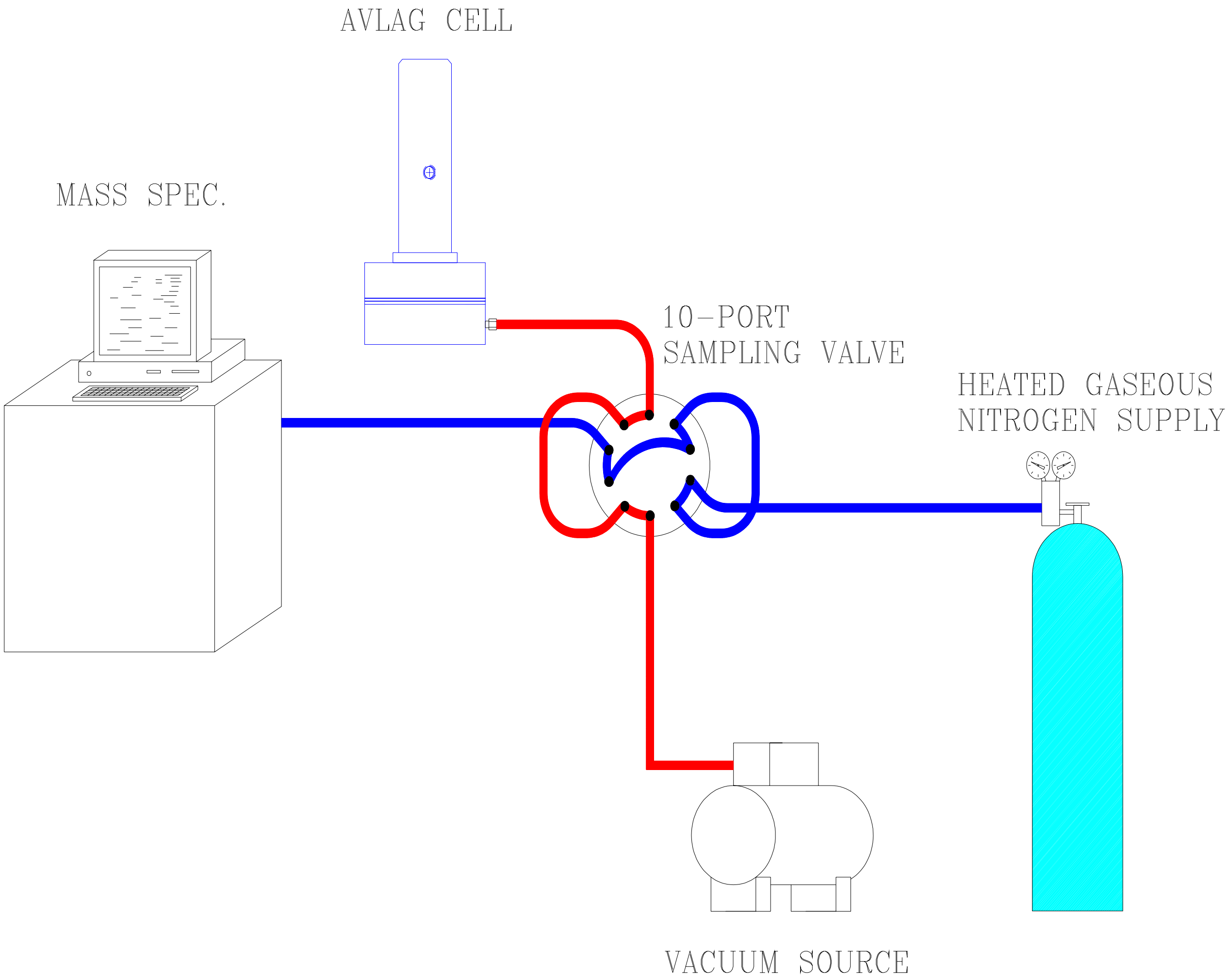


AVLAG
Realtive Breakthrough
50
40
30
20
10
0
1
2
3
Time
Series1



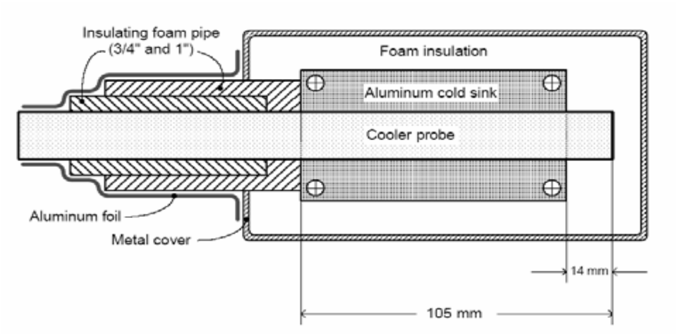
Glove liner Contamination
Permeation in ug/cm 2/min
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
40
50
60
time in min
SSP = 0.5 ug/cm2/min
SSP = 0.24 ug/cm2/min
NBT = 1-2 min
Note: Liner 1 is spiked twice as much as liner 2
Glove liner 1
Glove liner 2

Proposed Solution



Gradient Temperature Cyrogenic Pre-concentrator (GTCP)

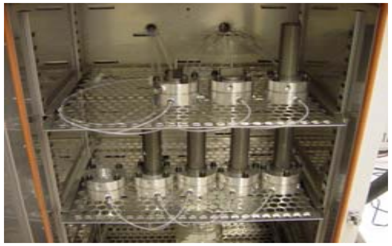
- GTCP ready to be integrated and tested with switching system (SS) and tested with agents.



The GTCP uses a two-stage refrigeration system, and eliminating problems typically associated with humidity concentration.

Cryofocusing Preconcentrator

Test chamber houses 10 AVLAG test cells. Using sequential switching, analyte from the permeate side of the test cell is transferred to the cryogenic prefocusing unit.

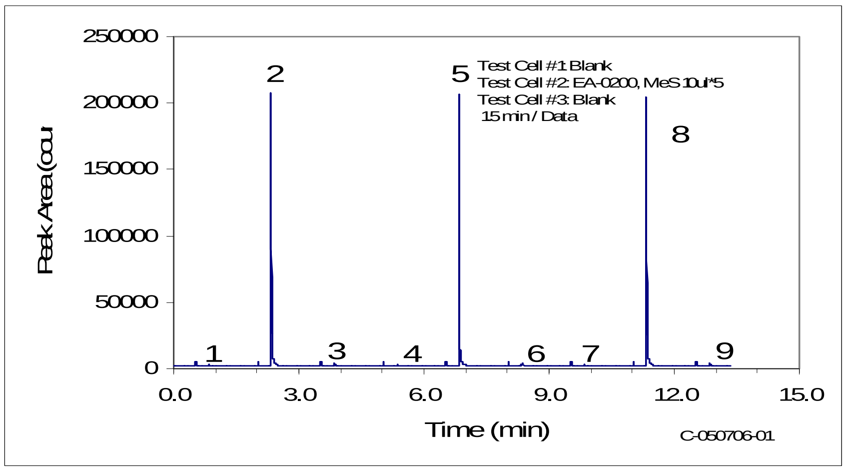


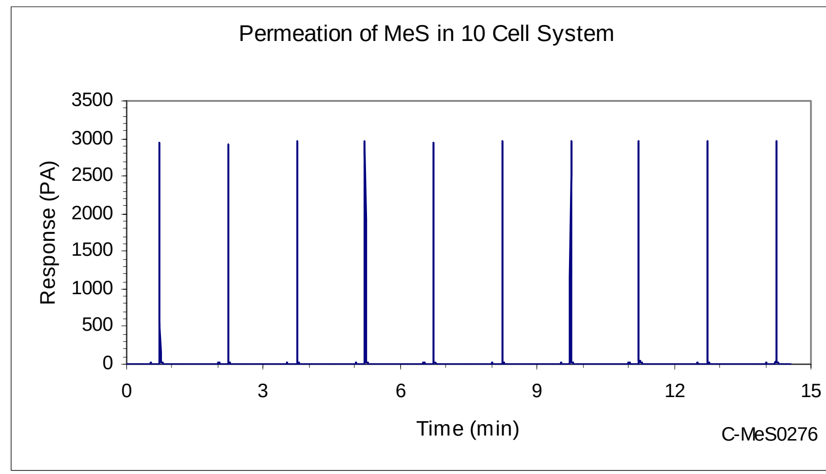
Test Chamber

Developed at SOUTH DAKOTA SCHOOL OF MINES & TECHNOLOGY

Status of Switching System (SS)

- SS ready to be integrated and tested with GTCP. Has been tested successfully with 10 cups.

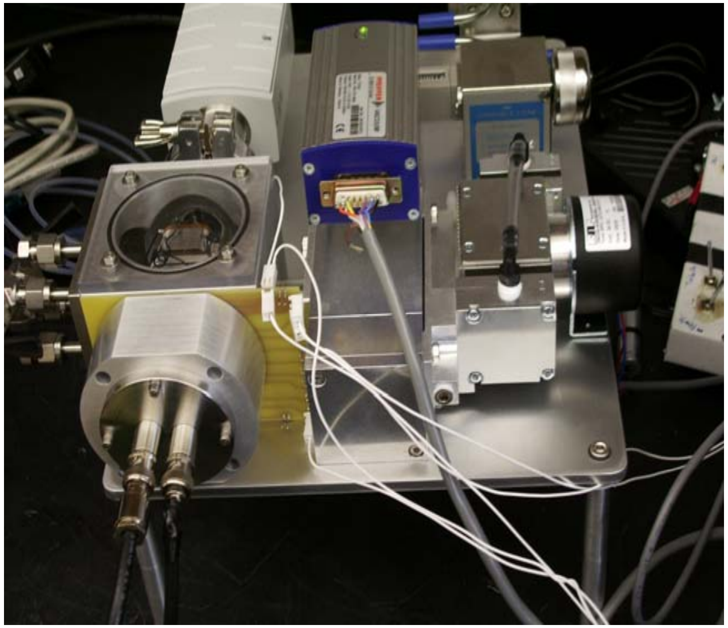


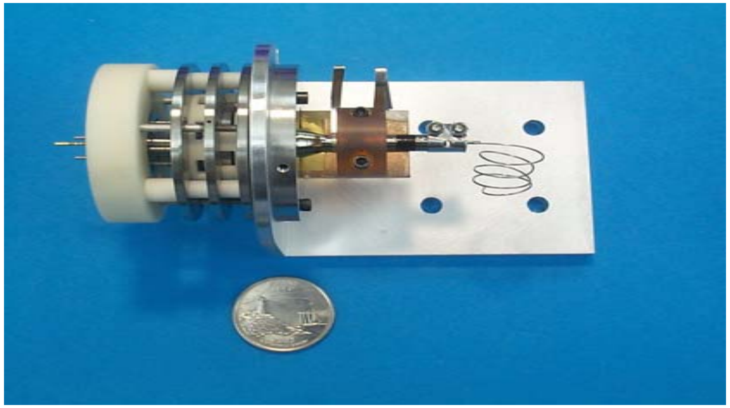


Sequential Switching using Fabric Swatches and Equal Amounts of Methyl Salicylate, with all Samples Spiked, then with Blanks to Demonstrate No Significant Carry-over

Miniature GC-MS

- GCMS has undergone dilute agent, TICs, and simulant testing at DPG.
- GCMS software fully developed beyond critical design.
- Seeing at least 1amu.
- Volume of toroidal trap a factor of x400 more trapping volume.
- Ready to be integrated onto the GTCP.
- Dugway will receive prototype this Spring.



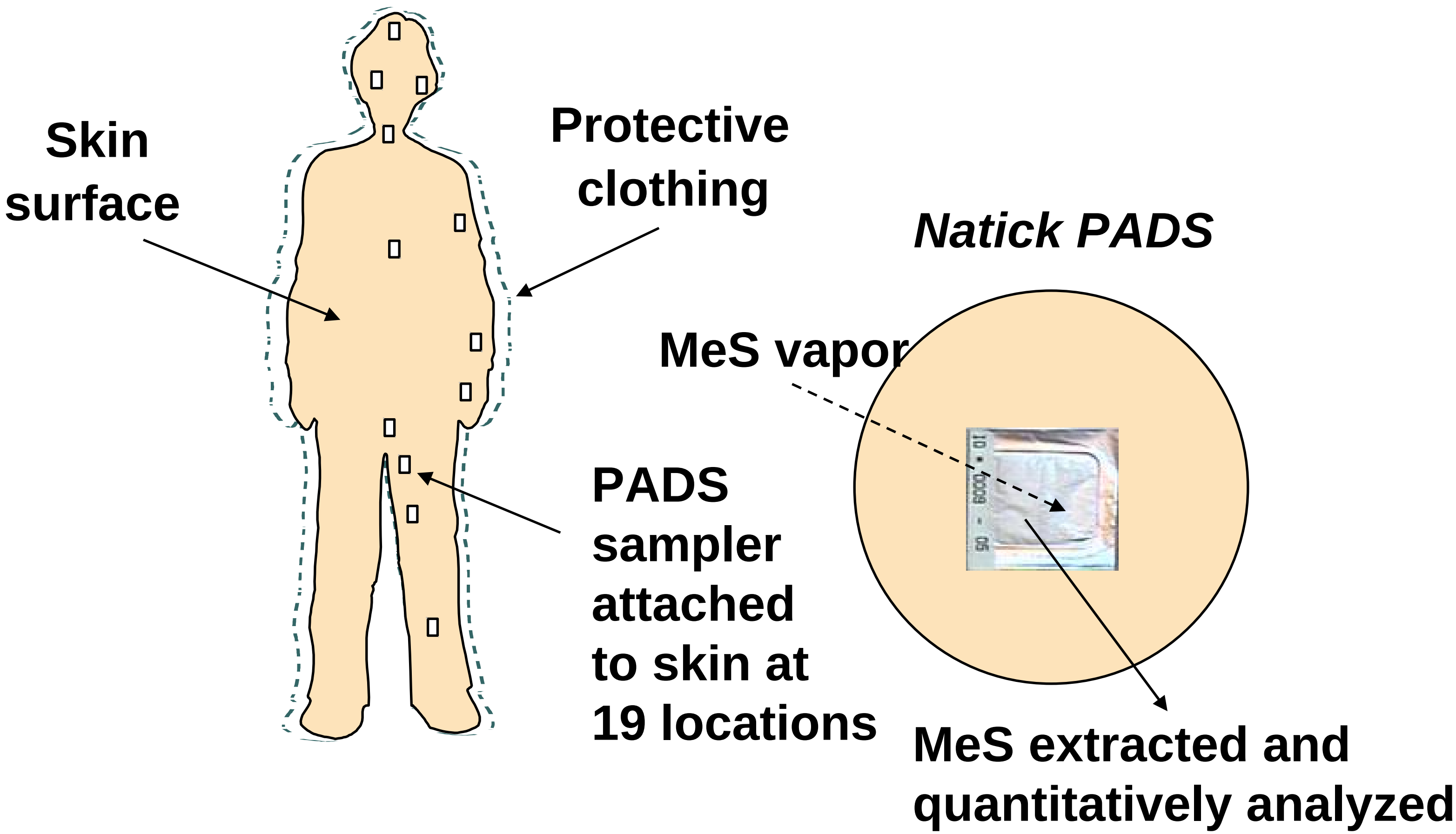


Developed at Brigham Young University

Swatch Real-Time Analysis

- Key Personnel
  - Nathan Lee/Dugway (Project Management)
  - Teri Corbin/ South Dakota School of Mines and Technology (Principle Scientist)
  - Milton Lee/Brigham Young University (Senior Scientist)
- JSTO funded beginning this year
- DTRA and Army Research Labs previously funded
- Issues
  - Verification and validation of 10 cup sample switching
  - Efficient separation of humidity from analyte
  - Swatch fixture available at Dugway and Battelle

Current MIST Sampling Procedure

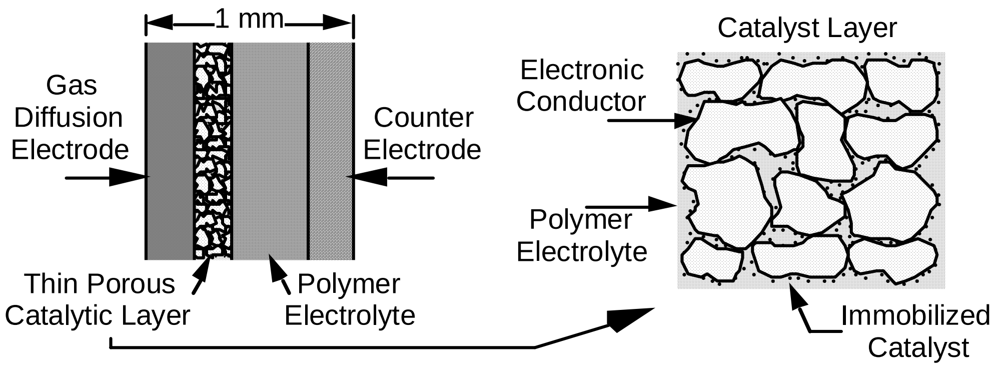


Real-Time MIST Sensor Requirements

- Size: 3 cm x 3 cm
- Concentration range: 10 ng/cm^2 to 100 mg/cm^2
- Wear duration: 2 hours
- Detect and clear time: 1 to 5 min
- Wireless
- Cost under $1000
- Selective to MeS
- Reject water/sweat
- Will be used for agent and robots later
- Technology selection in 5 months, operations capability in 1.5 years.

Potential MIST samplers

– Los Alamos National Laboratory (LANL) developed electrochemical fuel cell that has demonstrated sensitivity and selectivity for Methyl Salicylate.



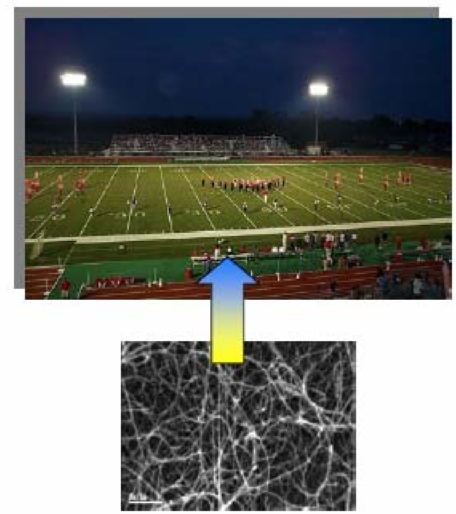
Electrochemical Fuel Cell Structure

Potential MIST samplers (cont.)

– NASA Center for Nanotechnology developed sensor array from single walled carbon nanotubes that has demonstrated sensitivity and selectivity for multiple chemicals.

Large surface area → large adsorption rates for gases and vapors → changes some measurable properties of the nanomaterial → basis for sensing

- Dielectric
- Capacitance
- Conductance

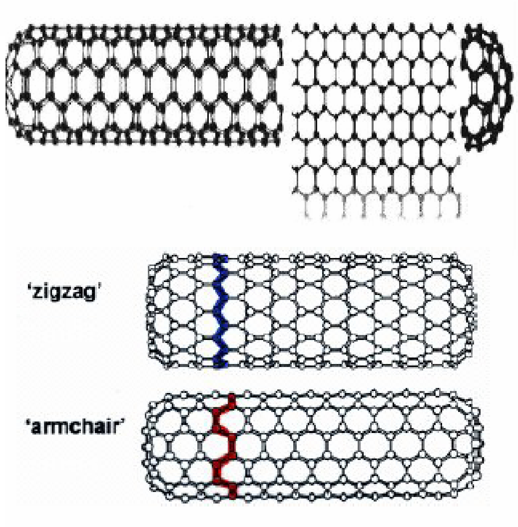


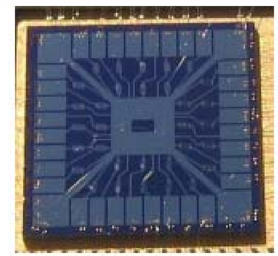
4 grams

Ames Research Center

Potential MIST samplers (cont.)

Nanomaterial + Chip (micro) ⟶ Macro sensing system





Array Chip

- Sensor array
- Chip < 1 cm^2
- Disposable or capable of integration

Operation:

1. The relative change of current or resistance is correlated to the concentration of analyte.
2. Array device "learns" the response pattern in the *training* mode.
3. Unknowns are then classified in the *identification* mode.

Real-Time MIST sampler

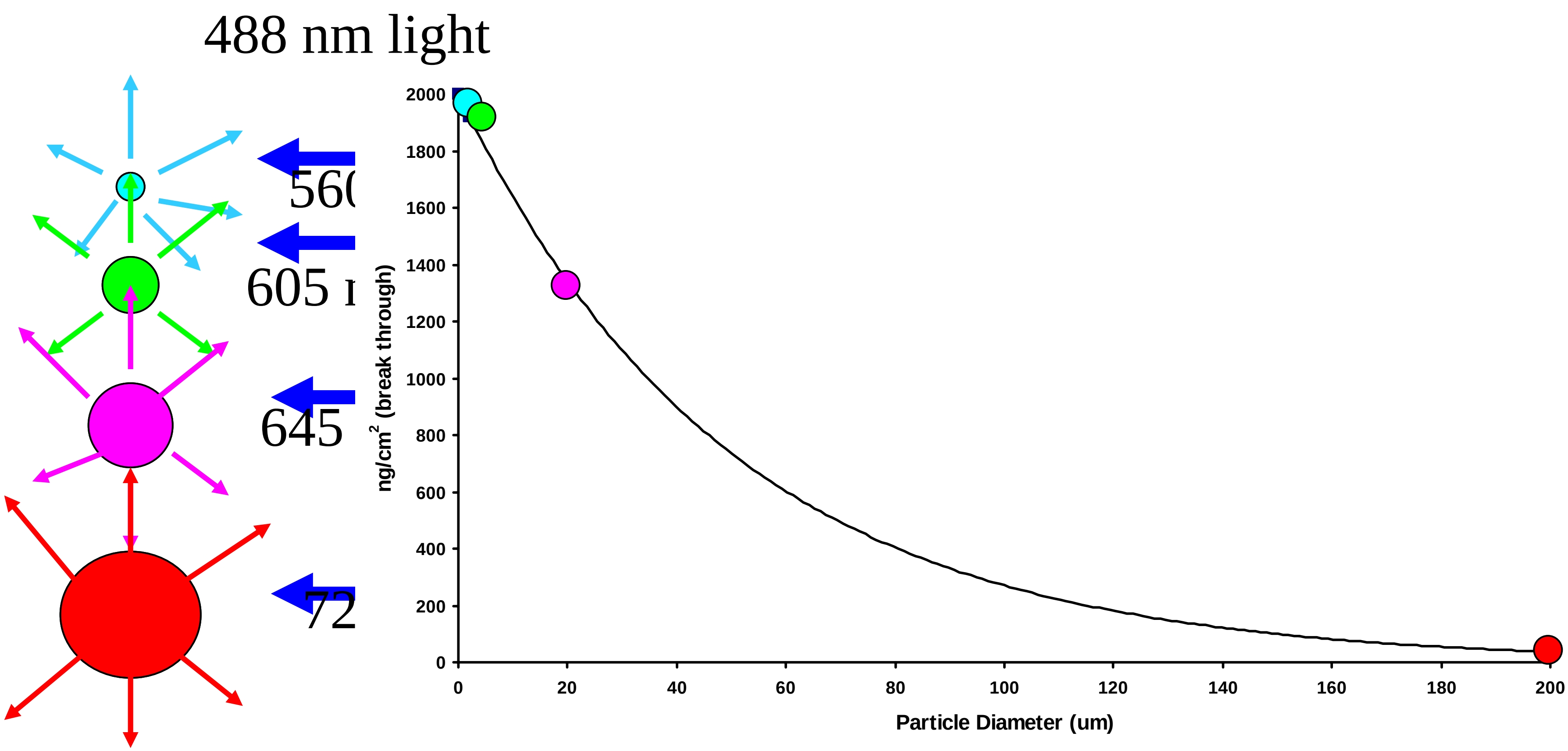
- Key Personnel
  - Andrew Neafsey, Jim Hanzelka – Dugway
  - Jon Kaufman – NAVAIRSYSCOM
  - Pam Gordon – AMTI
  - Alex Rodriguez – RDECOM
  - Karen Burke – RDECOM
  - Mike Vanfahenstock - Battelle
- JSTO funded beginning this year
- Issues
  - Verification and validation of technology
  - Attachment of sampler to body

Improved Aerosol System Testing

- Current aerosol testing utilizes 1-10 micron range particles
  - Exact size of penetrating particle unknown.
    - Solution: Selectively tag particle sizes of interest.
- Analytical procedure is laborious
  - Skin Rinsing to extract samples
    - Solution: Whole body aerosol scanner.

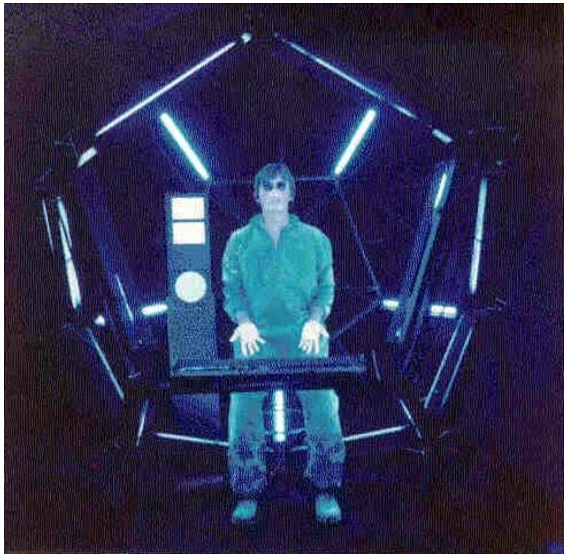
RTI Center for Aerosol testing in North Carolina
Photo courtesy of Jim Hanley

Basic Theory

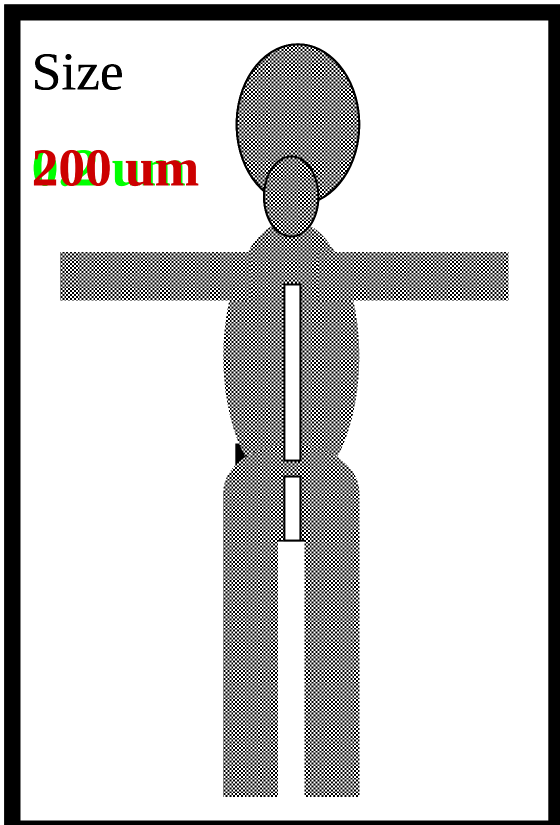


Whole Body Aerosol Scanner

- **The United Kingdom's Safe Training Systems has developed a whole body scanner that quantifies fluorescent tagged aerosols particles.**
- **PD-TESS has committed $500K to purchase one.**



Example Display



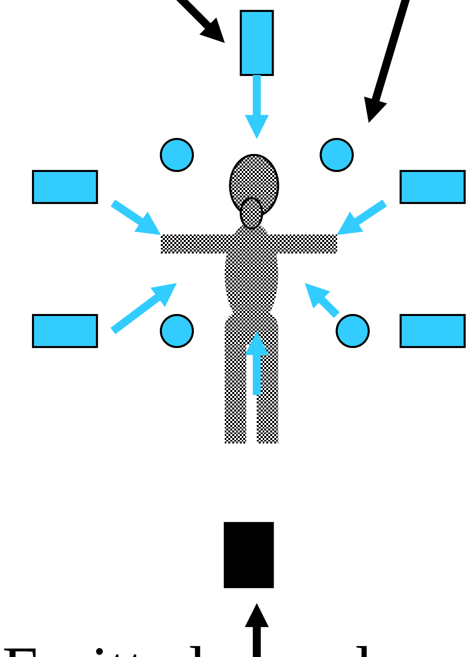
Wavelength
560 / 720

Avg density
1952

Profile
ng/cm2

White - 20
Yellow – 200
Black - 2000

Filtered Source 488 nm
When excited with 488 nm



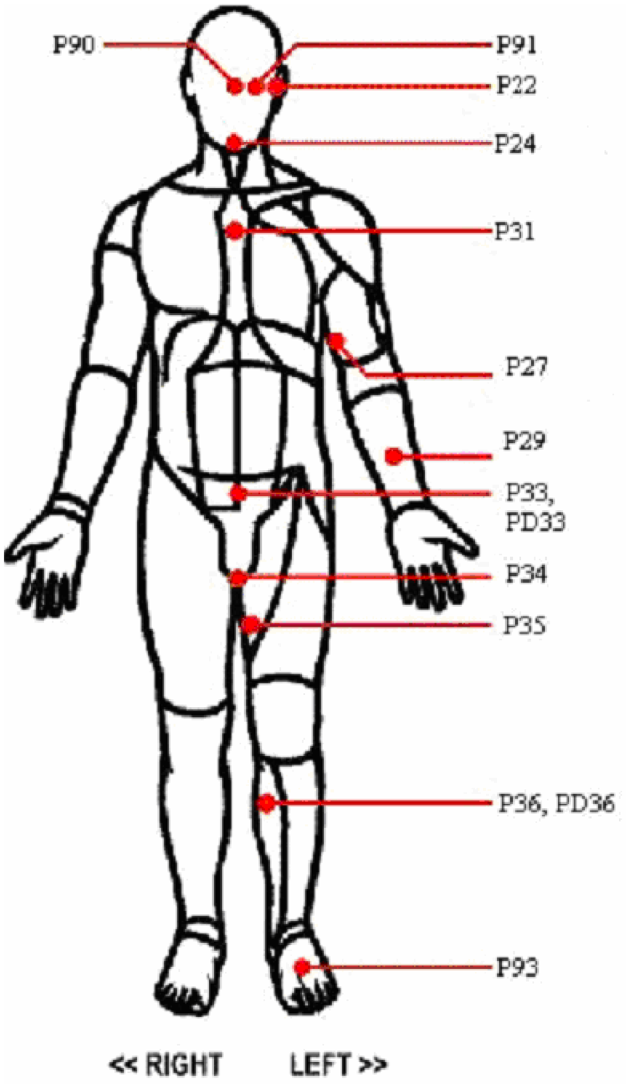
Filtered Camera
Emitted wavelength
are imaged
560, 605, 645, 720 nm

Aerosol Testing Improvements

- Personnel
  - James Hanzelka, Andrew Neafsey, Brad Rowland – Dugway
  - Jonathan Kaufmann – NAWC
  - James Hanley – RTI
  - Other members of the HWRW and nanoparticle working groups
- PD-TESS funded
- Issues
  - Particle tagging
  - Can be made mobile

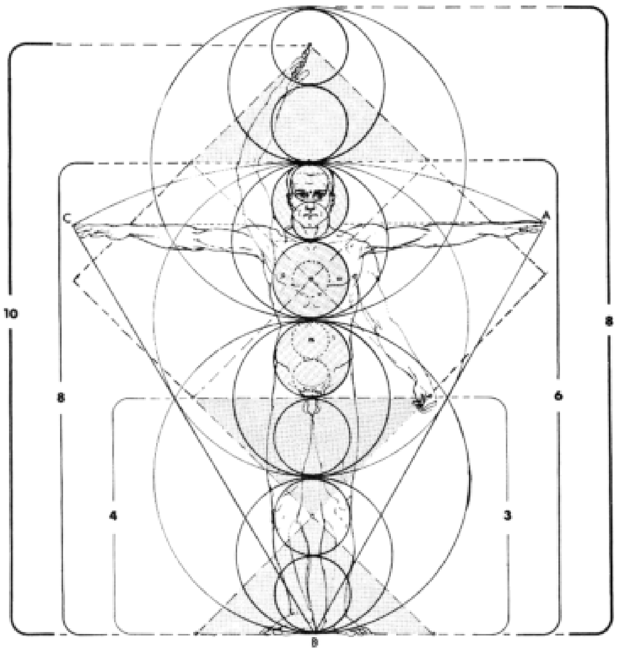
IPE Test Grid
Project Objectives

- Goal of program is to develop a standard method for marking the location of sampling on the body and successive layers of clothing for two purposes
  - Ensure repetitive placement of sampling for MIST, Aerosol and Swatch testing.
  - Provide a basis to relate data from MIST, Aerosol and Swatch testing (critical for overarching model effort).
- Use polar coordinates related to anthropometric landmarks.
- Joint effort between Natick Soldier Center and Dugway.



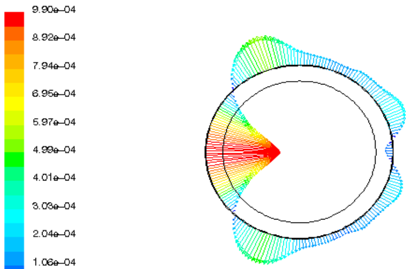
IPE Test Grid
Program Overview

- Key Personnel
  - Jim Hanzelka/Dugway – Project Management
  - Steven Paquette/Natick – NSC Anthropology Coordinator
  - Dan Blodgett/Dugway – Lead Statistician
- PD-TESS funded beginning this year
- Issues
  - Verification and validation of sampling sites to match current locations used for MIST and Aerosol Testing
  - Ease of use

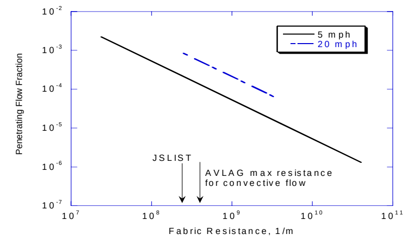


IPE Airflow Mapping

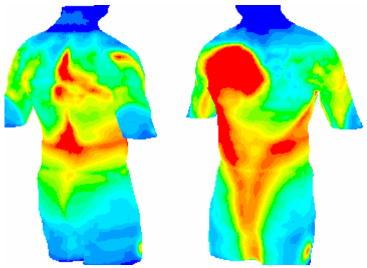
- Establish a validated model that describes the correlation between airflow and agent penetration through materials, interfaces and filters.
- Develop a grid for MIST sensor placement to reflect agent flows underneath suit.
- Standardize sensor placement
- Establish fundamental parameters that will be used in the Overarching IPE model.



Velocity Vectors Through Clothing Surface



Fraction of Flow Penetrating Garment



–Solve 3-D Mass/Momentum/Energy Equations for Airflow and Agent

–Volume-Averaged Porous Media Approach, Variable Properties

–Extend Commercial FLUENT® or Other modeling Software for Vapor/Liquid Physics in Fabric

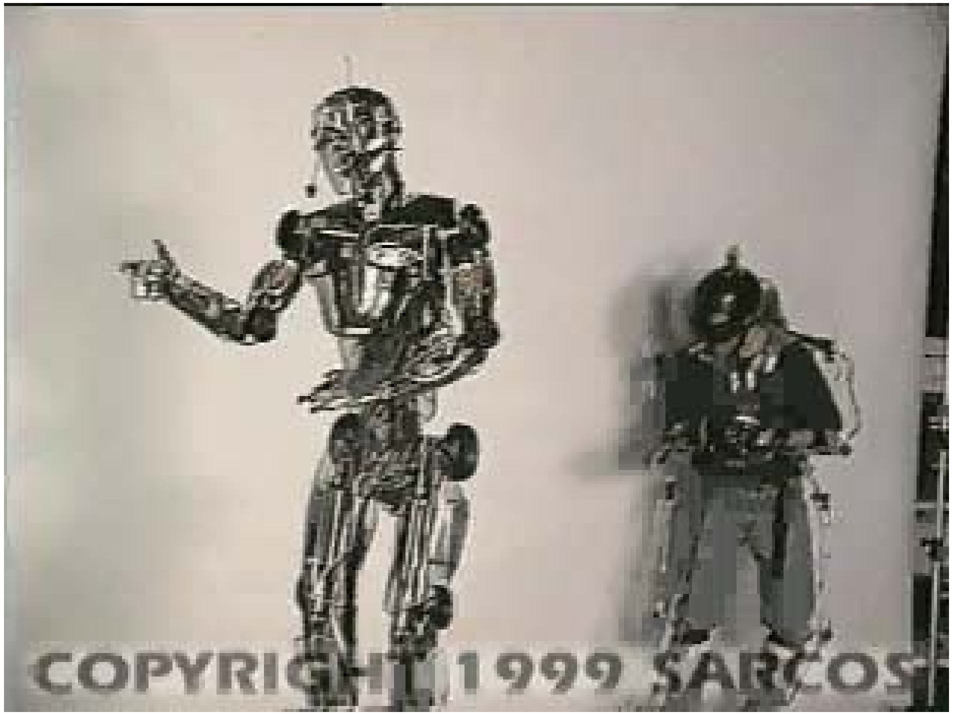
–Activated Carbon Model

IPE Airflow Mapping

- Key Personnel
  - Nathan Lee/Dugway (Project Management)
  - Phil Gibson/Natick (Principle Investigator)
  - Jim Barry/Creare (Senior Scientist)
- JSTO funded beginning this year
- Issues
  - Verification and validation of model
  - Control parameters

Protective Ensemble Test System (PETS) Objectives

- PETS will utilize a live agent facility that will incorporate robotic mannequins and support equipment for testing entire IPE ensembles under realistic use conditions.
- Design facility to accommodate various agents, simulants and environmental conditions.
- Design instrumentation to acquire real time data.
- Establish optimal sampling locations for test sampling.
- Verification and validation of live agent model, software and processes.



PETS

- Key Contributors
  - Dugway, ECBC, JPM-IP, Battelle, DTRA, DUSA-OR
- PD-TESS funded beginning this year
- Issues
  - Free standing or attached umbilical cord
  - Under-suit sampling locations
  - Analytical methods
  - Liquid, aerosol, vapor challenge test methods
  - Chamber Decontamination
  - Model and evaluation strategy

Conclusion

- Improved swatch testing protocols are needed to test next generation materials.
  - Chemical Biological Agent Resistance Test (CBART)
  - Real Time analysis
- Improved system testing needed to better characterize IPE performance.
  - Real Time analysis of Man In Simulant Testing
  - Improved Aerosol Testing
  - XYZ Grid System
  - Airflow Mapping
  - Protective Ensemble Test System