SENSING

Anne Fischer, Ph.D. and Mark Wrobel, Ph.D., CHP

Discover DSO Day

June 15, 2017

DARPA

Distribution Statement "A" (Approved for Public Release, Distribution Unlimited)
Introductions
SIGMA
Cost-effective, operationally practical, continuous city-scale nuclear and radiological WMD sensing capability

Networked Systems
Multi-modal detection of potential hazards and threats pre-and post-event
**Chemical Systems**

**Spectral Combs from UV to THz (SCOUT)**
Enable chip-scale, quantitative detection of multiple trace species in real environments

**Folded Non-Natural Polymers with Biological Function (Fold F(x))**
Rapidly discover novel polymers for therapeutics and diagnostics

**Make-It**
Create fully automated chemical synthesizer for known and new small molecules

**Molecular Informatics**
Explore new approaches to store and process information with molecules
Building a DARPA Program

1. Request for Information (RFI)
2. Seedling Effort
3. Broad Agency Announcement
Building a DARPA Program

Today, we’re working on the far left of this progression
Heilmeier Catechism

• What are we trying to do?
• How does this get done, at present?
• What is new about our approach?
• If we succeed, what difference do we think it will make?
• How long do we think it will take?
• Can we transition?
• How much will it cost?
An Example

Molecular Informatics
We’re creating vast amounts of data

Past and projected global data growth
(1 ZB = 10^{21} bytes)

New foundations for information processing

Millions of molecules exist with unique properties that could be utilized to enable simplified, more capable storage and processing strategies

Structure, shape, size, charge, polarity, ...

Projected storage densities of $10^{18}$ bytes/mm$^3$

Projected processing speeds of $\sim 10^{20}$ reactions/s
With a richer feature space for physically representing and querying data, what new operations could molecules enable?

Vision: Explore new approaches to store and process information with molecules
Thought Experiment:

It is 2037, and we can now effectively track transport of chemical agents and explosives through a city.

What technologies were developed to enable this capability?
The Goal: Detecting and interdicting nuclear/radiological materials outside of regulatory

“No threat poses as grave a danger to our security and well-being as the potential use of nuclear weapons and materials by irresponsible states or terrorists.” - President’s Security Strategy, February 2015

- The nature of the threat:
  - Improvised Nuclear Device (IND)
  - Radiological Dispersal Device (RDD) – “dirty bomb”
  - Radiation Exposure Device (RED)

- The challenge:
  - Limited radiological signatures of some materials
  - Significant clutter and noise in the environment
  - Basic physics of radiation sensing
SIGMA: Cost-effective, operationally practical, continuous city-scale nuclear and radiological WMD detection capability

Automated threat detection and ID with Web based Command and Control

**Detectors**
- Increase efficiency & resolution via low cost, scalable methods
  - **Goal:** 10x cheaper, up to 10x faster spectroscopic $\gamma$ & $n$ detection. Buy & deploy 10k $\Sigma$ pagers, 200+ $\Sigma$ large detectors
  - **Achieved:** $\Sigma$ SPRD & 10k procurement at $400/unit, 200+ large detectors in production

**System Architecture**
- Build automated detector network. Increase sensitivity & reduce false alarms via algorithms & data fusion.
  - **Goal:** Continuous city-scale system w/ near-zero false alarm rate. Stream 10k detectors
  - **Achieved:** System able to stream & analyze >1k detectors at 1 Hz. Real-time ID algorithms in-place

**Deployment**
- Develop CONOPs. Execute pilots to transition real capability. Red team. Feedback to R&D.
  - **Goal:** Maximize scale-up, ensure operational viability & transition
  - **Achieved:** 10+ pilots, 4+ operational. Latest: DC 1000 Detector Exercise; DC FEMS

On-track to operationalize wide-area monitoring capability in 2017
1000+ D3S and ~50 vehicle detectors deployed: full system functionality without downtime
Unprecedented deployment of networked detectors and coverage of DC

(Oct, 2016)
Extended pilot with DC Fire demonstrated city-scale monitoring capability via SIGMA detectors installed on DC ambulance fleet.

Each vehicle covers average ~60 miles/day, with fleet of 37 traveling ~2000 miles/day – DC road network is ~1500 miles.

106,267 detector-hours with 380+ million spectra (at week 19 of operation)

Pilot helped build and confirm viable city-scale CONOPs.
New Fundamental Questions to be Answered

- **Design:**
  - How can this mission be supported in a completely “invisible” manner
    - Front line forces / law enforcement don’t even know their critically enabling this mission?
  - Critical Valley of Death issue for rare event missions
- **Complexity / Design:**
  - How do we multiply (multi-task) deployed sensors to support multi-threat detection?
  - How is ancillary / orthogonal data integrated to better support the mission?
Thought Experiment:

Water security