Sensing Biological Warfare Agents Onboard Commercial Aircraft

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MSR

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Problem

- Each year over 600 million passengers fly to and within the United States, via 7 million flights, through 67 hub airports.
- The air transportation system is vulnerable to deliberate biowarfare attacks.
- Infection need not be deliberate to raise public health concerns: the avian influenza virus has the potential to cause a pandemic.
- Onboard biosensor systems may mitigate risk and improve quarantine strategies.

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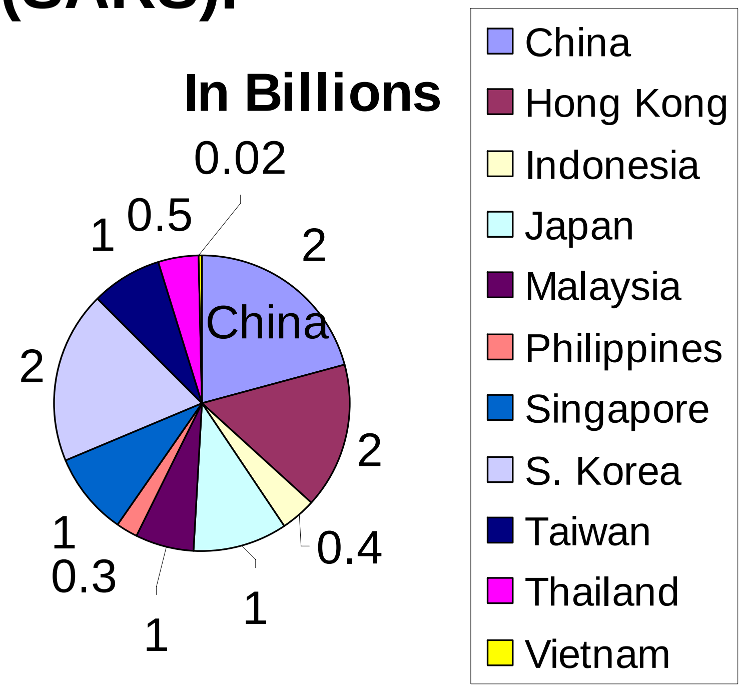
Background

- **Commercial airline flights are known vectors for the global spread of the severe acute respiratory syndrome (SARS).**
  - 5 continents
  - 18 countries
  - >8,096 cases
  - 774 fatalities



- **Cost of SARS: $11B**

Data from Far Eastern Economic Review, Dow Jones monthly magazine on Asia. (http://www.feer.com / 4/24/2003).

Objectives

- **Generate biosensor system specifications**
  - Probability of false alarm (pFA) < 10^{-6}
  - Probability of detect (pD) > 0.999
  - Minimize liquid reagents
  - Small footprint (< 4" X 4" X 3")
  - Affordable in mass production quantities (<$2K)
- **Perform analyses to establish acceptable Type I & II error rates**
  - Constrain design: detection time, reagent-use, pFA, pD, weight, power, number of sensors needed
- **Prototype a biosensor for onboard bio-anomaly event identification**

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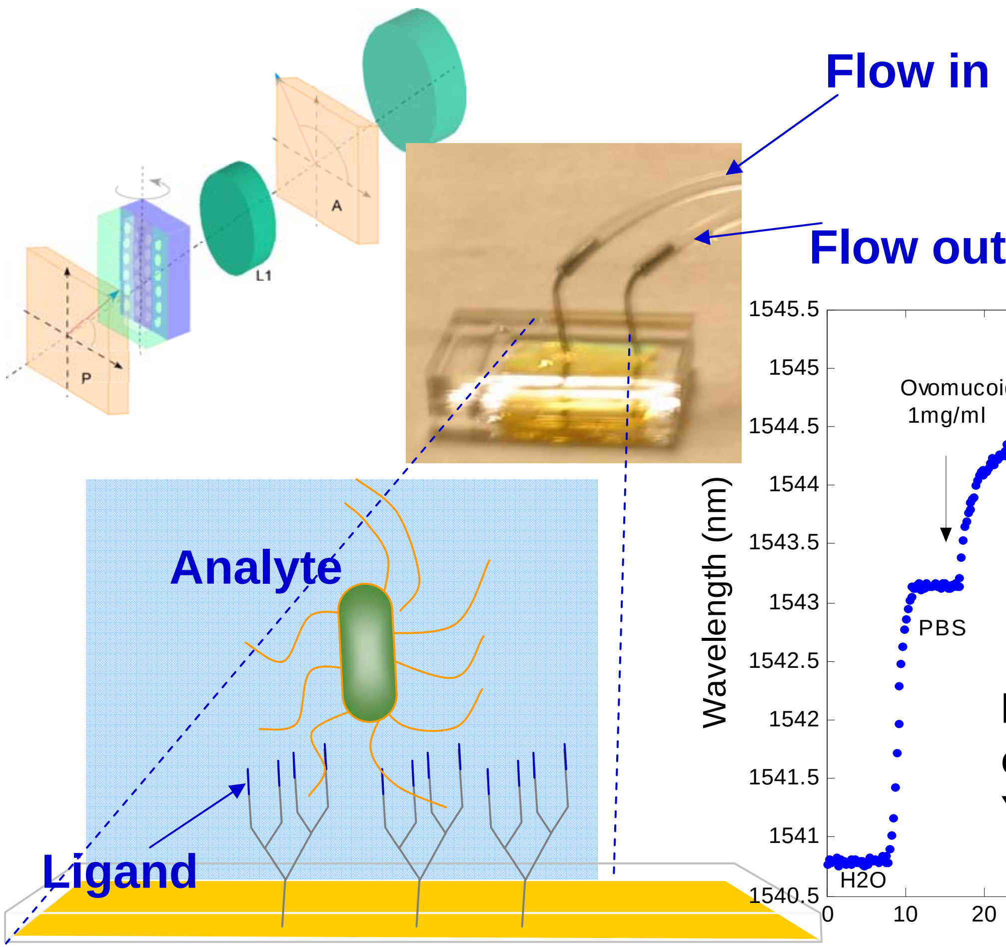
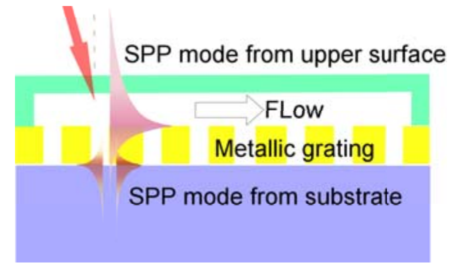
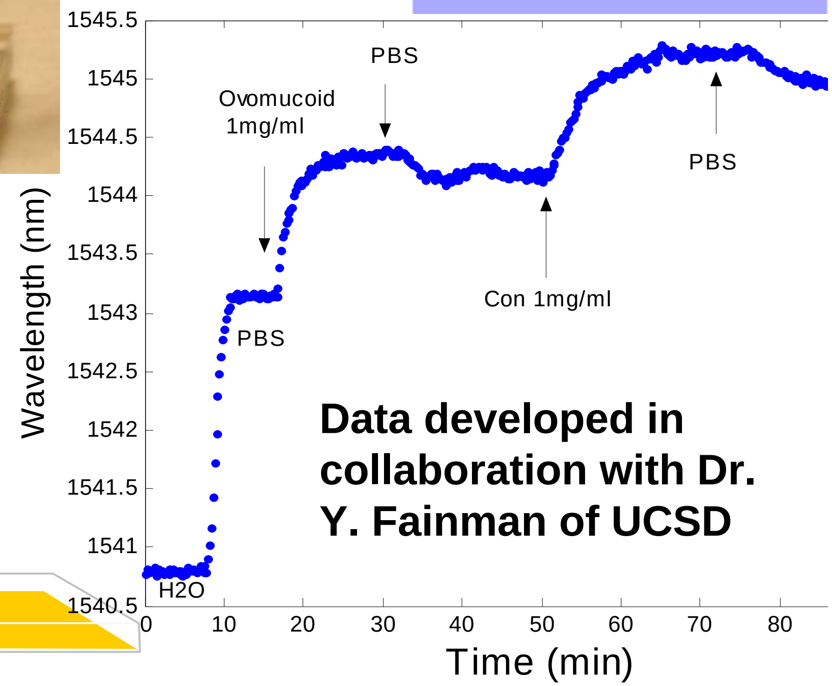
Activities

- ☑ Calibrate a surface plasmon polariton (SPP) breadboard for bio-detection
- ☑ Characterize aerosol collection technologies
- ☑ Perform platform configuration assessment
- ☑ Design a multi-modal SPP/Surface-Enhance Raman scattering bio-detector

Demonstration







Data developed in collaboration with Dr. Y. Fainman of UCSD

Highlight

Assumptions:

Initial concentration,

C_o = 0.3 [CFU/liter]

Collector efficiency, ε = 0.5

Concentration factor, ϕ = 1

Loss fraction, γ = 0.2;

Viability fraction, υ = 0.1;

Relevant fraction, ρ = 0.2;

No missed detection

No false alarms

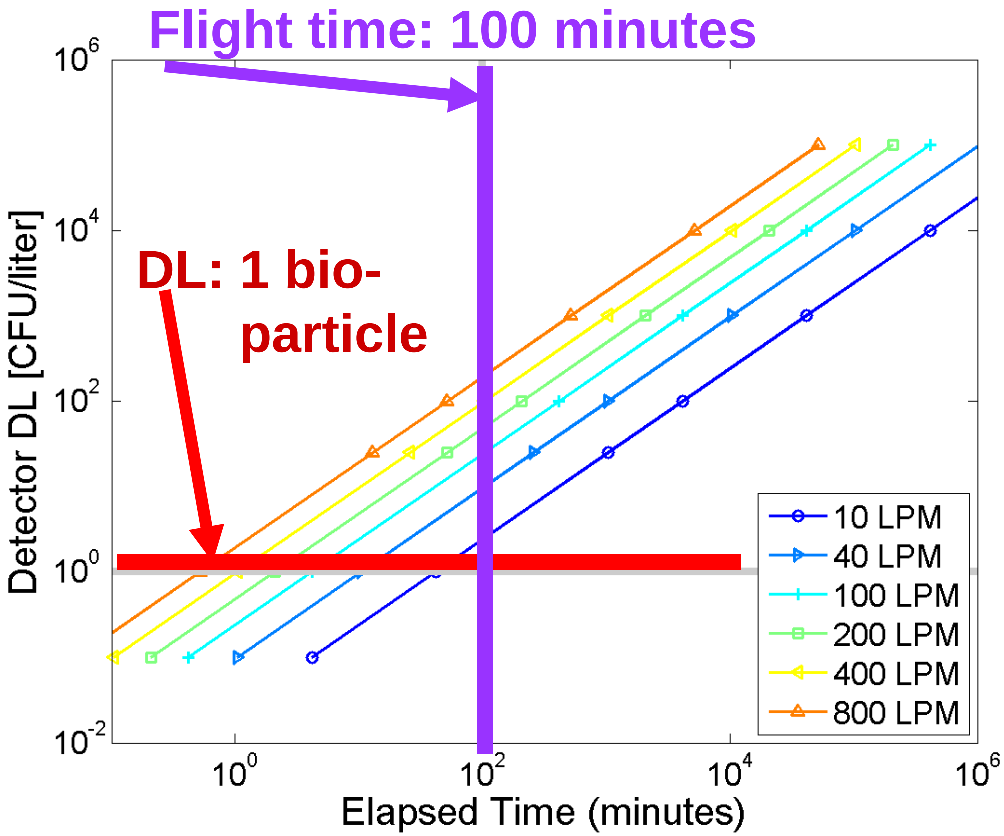
Variables

Sampling velocities in liters per minute, **V** [LPM]

Elapsed time, **t**, [minutes]

Detection limit (DL) in CFU/liter

$DL = C_o * V * t * \varepsilon * \phi * \upsilon * \rho * (1 - \gamma)$



Impacts

- Rapid, reliable, onboard bio-threat sensing technologies will improve border security, making it possible to respond to threats in real time
- Bio-threat aircraft warning system will allow authorities to take appropriate actions to reduce the potential impact of biological weapon attacks and pandemic outbreaks
  - Enable targeted quarantine strategies
- Effort should be of interest to the FAA, DHS S&T, and CDC

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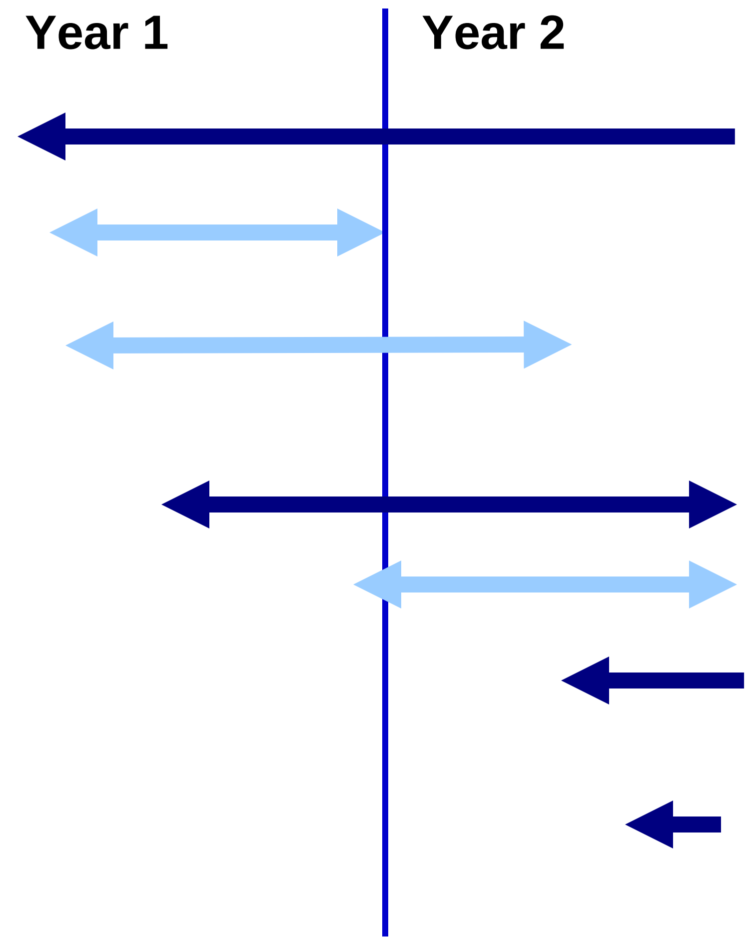
Future Plans



End-to-End Systems Analysis

- **Biosensor Model/Microbial Diversity Database**
- **Fluidics Infrastructure / Optics Breadboard**

Epitope-ligand Investigation

- **Establish Detection Limits**

Expand Novel Capture Surface for Viral Agents

Miniaturize and Test in B767 Mock-up (Yr 3)

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