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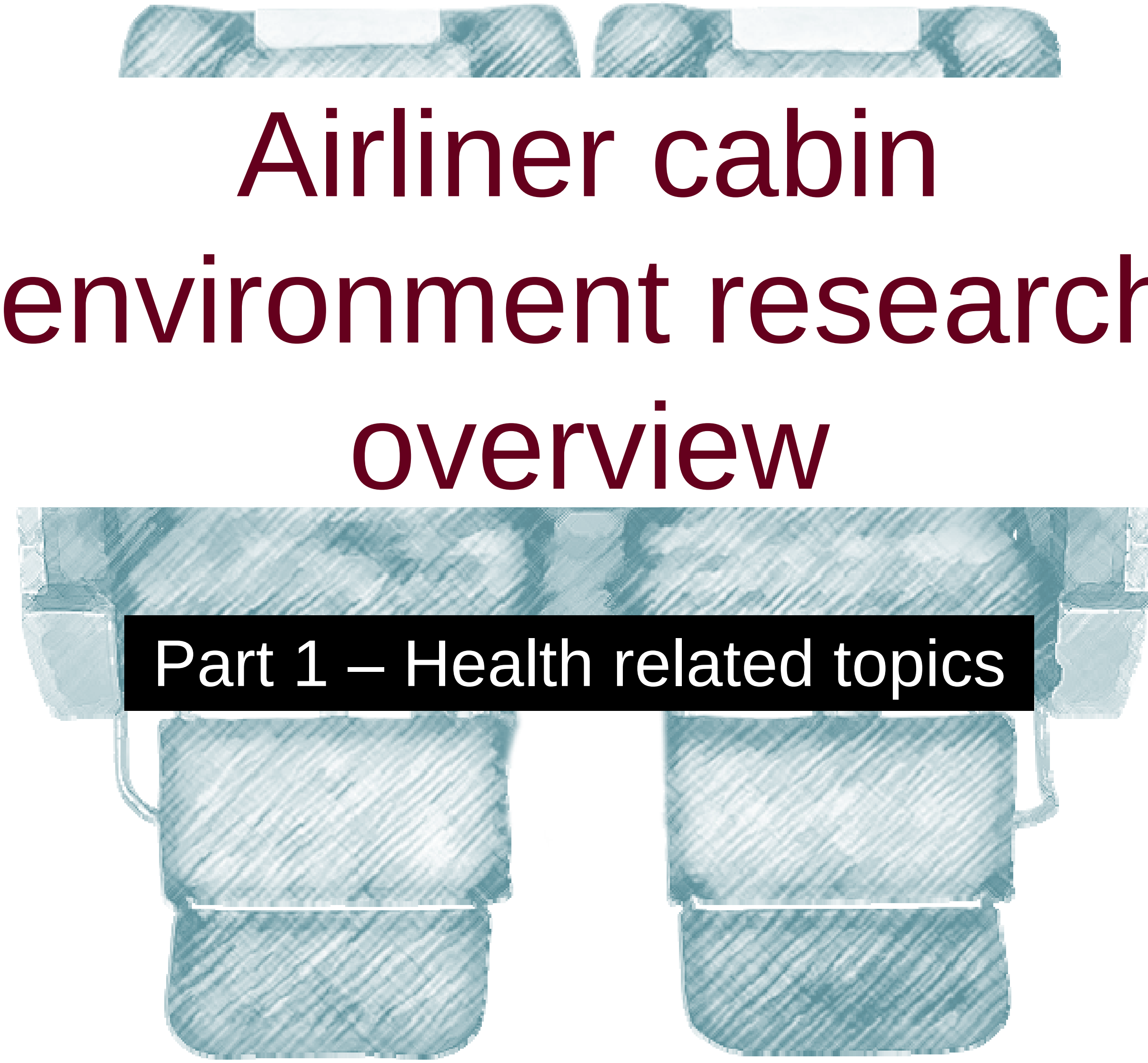
AIRLINER CABIN ENVIRONMENT RESEARCH

Airliner cabin environment research overview



Part 1 – Health related topics

William F. Gale
Auburn University

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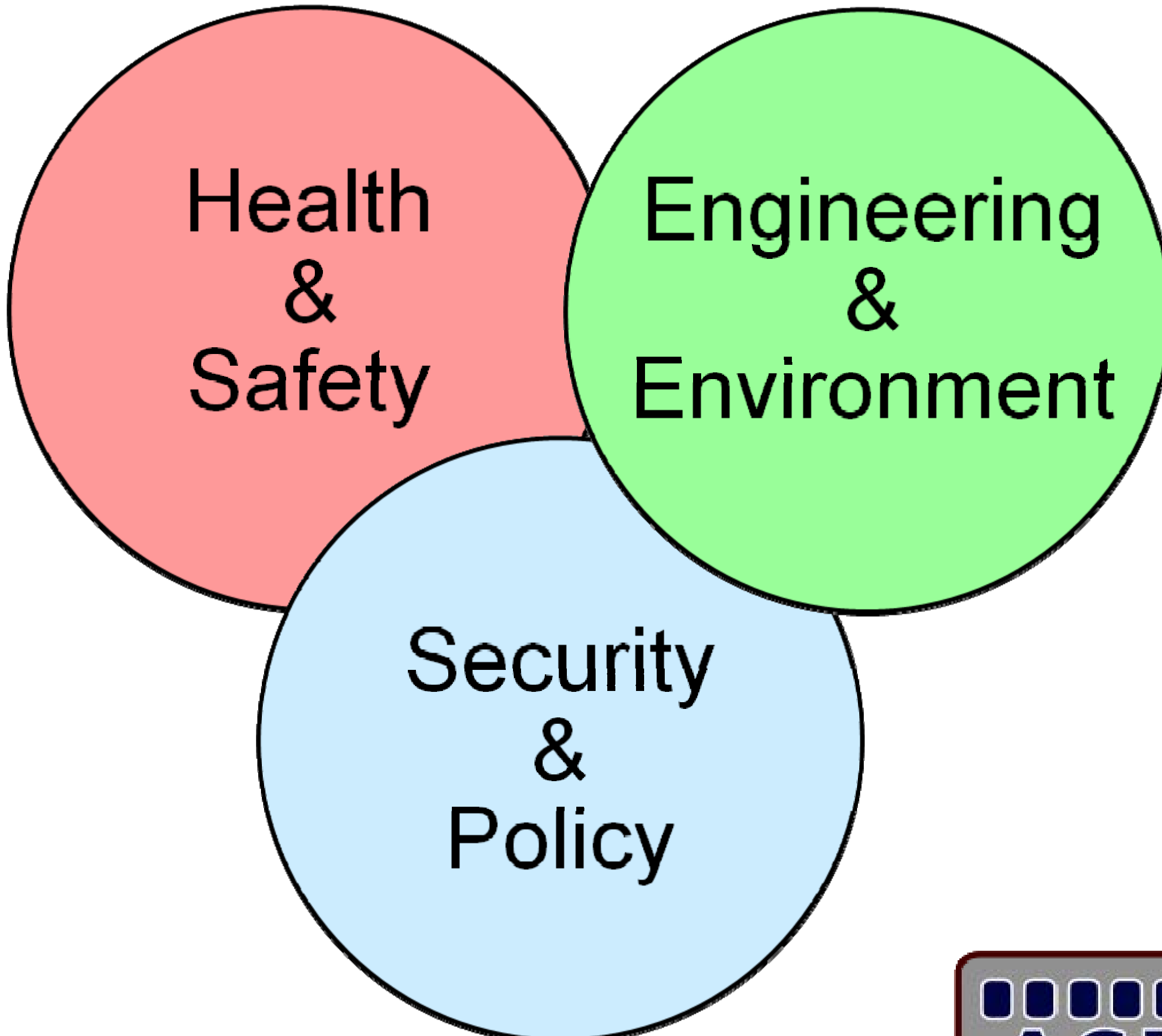
Cabin environment



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Cross-disciplinary team

- Lead
  - Auburn University
- Co-leads
  - Harvard University
  - Purdue University
- Core team
  - Boise State University
  - Kansas State University
  - U. of California Berkeley
  - U. Med. & D. New Jersey

Focus

Near-term
Interim & iterative approaches

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Industry collaboration

~ 40 industry partners

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Partnerships

- Manufacturers
- Operators/crews
- Security

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NASA TRL scale

Where do ACER & industry partners fit in?

TRL 1	Basic principles observed and reported	
TRL 2	Technology concept and/or application formulated	
TRL 3	Analytical and experimental critical function and/or characteristic proof-of concept	ACER
TRL 4	Component and/or breadboard validation in laboratory environment	ACER
TRL 5	Component and/or breadboard validation in relevant environment	ACER
TRL 6	System/subsystem model or prototype demonstration in a relevant environment (ground or space)	ACER
TRL 7	System prototype demonstration in a space environment	ACER
TRL 8	Actual system completed and "flight qualified" through test and demonstration (ground or space)	ind.
TRL 9	Actual system "flight proven" through successful mission operations	ind.

TRL descriptions from
John C. Mankins
Technology Readiness Levels, A White Paper
Advanced Concepts Office. Office of Space Access and Technology, NASA, 1995

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Integrated R & D program

- Ozone
- Pesticides
- Cabin pressure
- Air quality incidents & filters
- In-flight measurements
- Contaminant transport
- Sensors
- Decontamination
- Infectious disease transmission

Current New

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Ozone project

- ❑ Drivers
  - ➢ Industry need: want longer-life ozone converters
  - ➢ Public good: acceptable ozone levels?
    - How frequently do flights exceed FARs?
    - Are current FARs appropriate?
- ❑ Tasks
  - ➢ In-flight ozone sampling
  - ➢ Ozone chemistry
  - ➢ Human interactions

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Ozone tangible outcomes

- Lower maintenance costs
  - Ozone converter pre-filters to enhance converter life
  - Joint with manufacturers
- Informed basis for FARs
- Get rid of “the wrong stuff”
  - Byproducts worse than ozone itself
  - Need to target the right chemistry

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Pesticide project

- Drivers
  - "Disinsection" to protect public health/agriculture/ecosystems
  - Mandated by some governments
  - Most work is for buildings
  - Limited knowledge of exposure in cabin
- Tasks
  - Determine passenger/crew exposures & health implications
  - Develop guidelines

Pesticides tangible outcomes

- Reduced disinsection costs
- Reduction/elimination of pesticide use addresses crew concerns
- Make case to request relief from burdensome patchwork of regulations
  - Shows if disinsection harmful or not
  - Considers pesticide alternatives
  - Does disinsection actually work?

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Cabin pressure project

- Drivers
  - Chamber data is for healthy individuals
  - Aging population
  - Health-compromised passengers
- Tasks
  - Review Boeing funded OSU chamber study
  - Assess needs for new work
  - Chamber studies (restricted to rel. healthy)
  - Monitoring passengers

Pressure tangible outcomes

- Near term — physician guidance
  - Pretreatment for susceptible individuals
  - Suitable first response
  - Fewer disruptive health emergencies
- Longer-term — design data
  - OSU study probably already influenced choice of 787's cabin altitude
  - New post-787 ECS designs can be made compatible with aging population

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"Incidents" projects

- Drivers
  - Infrequent "smoke in the cabin" incidents
  - Possibility of bleed air contamination
  - Health concerns expressed by crews
- Tasks
  - Incidents (joint effort with OHRCA)
    - On-board sampling during "incidents"
    - Fight attendant cohort study
    - Air quality incident reporting system
  - Sampling of aircraft filters

"Incidents" tangible outcomes

- Objective data
  - Know what if anything is happening, how often and how significant?
  - Enables informed discussion
- Path to a fix (if there is a problem)
  - Distinguish causes of perceived incidents *e.g.* bleed air issues vs. smoldering wiring
  - Could localize to specific classes of equipment/operations enabling affordable fix

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In-flight measurements

Key enabling activity

- Drivers
  - Needed for most ACER projects
  - ASHRAE Phase I study was small-scale
- Tasks
  - Passenger surveys
  - Air quality sampling
  - Microbial sampling

Dec. # flights

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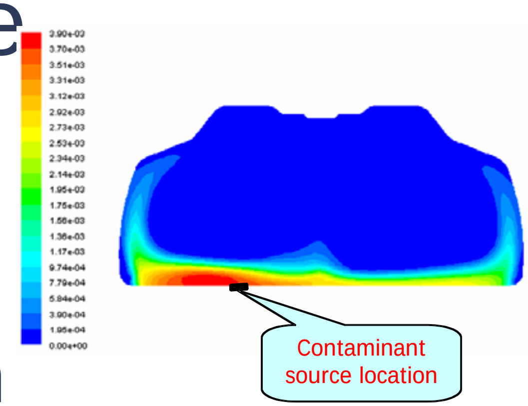
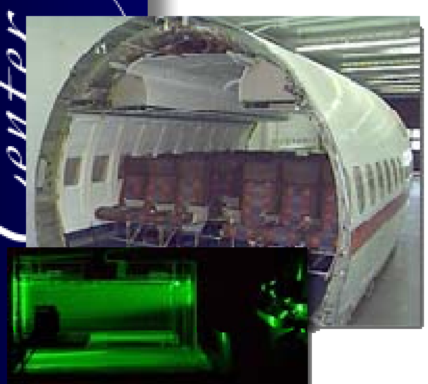
Contaminant transport

- Driver – where have all the (de)contaminants gone?
  - Correct location of sensors
  - Efficacious decontamination
  - Impact of air quality incidents, pesticides *etc., etc.*



- Tasks
  - Develop air distribution and transport models with predictive power
  - Experimental verification



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Contam. tran. outcomes

- Key enabling activity for other projects
- Forensic/epidemiological tools
- Design tools for future aircraft

Infectious disease transmission

- Drivers
  - Need to place civil aviation in the broader context of epidemiology
  - Distinguish between
    - Transport of infectious cases
    - Passenger to passenger transmission
    - Surface mediated transmission
- Tasks
  - Integrates relevant knowledge from other ACER projects
  - Aerosol studies & modeling

Image by ACER's Bill Nazaroff

Disease trans. tangible outcomes

- Replaces conjecture "I got sick when I flew to..." with hard science
- Identifies any changes needed to future generation ECS or cabin
- Key public health planning tool
  - Prioritize aircraft, versus terminal, versus other transportation modes *etc.*
  - Prioritize response within the cabin
  - Make best use of limited resources (esp. in epidemic)

Summary

- Key issues in passenger & crew health
  - Ozone
  - Pesticides
  - Cabin pressure
  - Air quality incidents
- Wider issues
  - Disease transmission
- Enabling activities
  - In-flight measurements
  - Contaminant transport

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Acknowledgments

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  - The ACER team
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Questions/Comments Please?

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Part 2 – Chem.–bio. response related topics

William F. Gale
Auburn University

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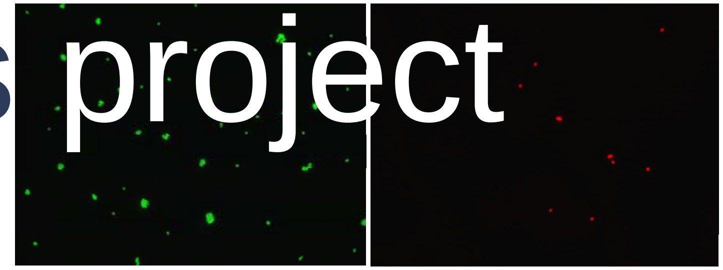
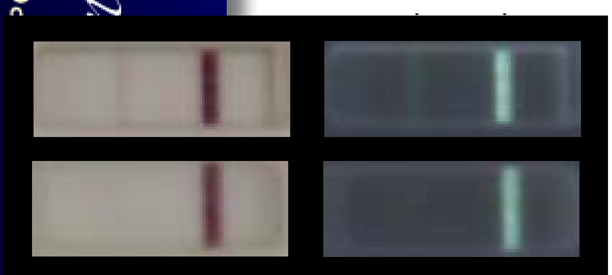
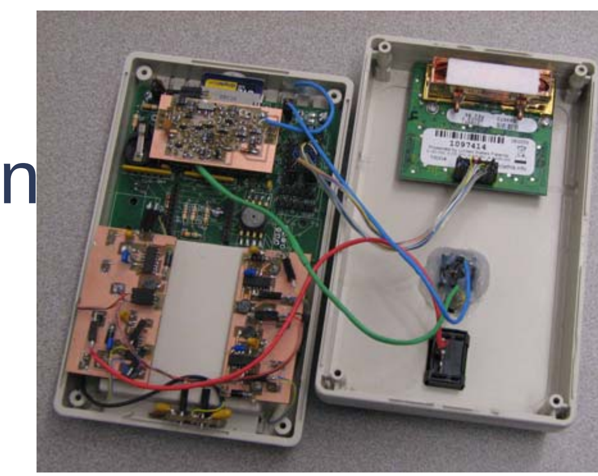
Sensors project



- Drivers

  - Response to epidemics
  - Defeat of chem.–bio. terrorism
  - Enables other ACER projects
- Tasks
  - Evaluation of COTS/GOTS/NM systems
  - Modification for airliner use
  - Sensor location
  - Integration into the cabin





Sensor tangible outcomes

- Defines what's practicable
  - Cuts through the sensor hype
  - Determines what works in civil aviation
  - Realistic expectations @ realistic $

- Unglamorous, but practicable sensors
  - Simple, low cost sensors in right locations
  - Use protocols recognize sensor limitations
- Sensor backbone
  - Small, fast, cheap & useful for any sensor
  - Practical to integrate into cabin

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Sensor "bread box"

- Supports a suite of sensors
  - Data processing/comms.
    - Modular/scaleable
      - Aircraft-ready
        - Affordable

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WHAT CAN WE DO?

Problems

- Costs too much
- Takes too long
- False positives
- Vol./mass/power

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Trigger sensor initiates sample capture

Normal landing

Hold at airport for PCR

Decon. project

- Drivers – respond to
  - Terrorism
    - DC anthrax attacks
    - Tokyo subway sarin attack
    - Chlorine tankers
    - Airliners favorite target
  - Epidemics/pandemics
    - SARS
    - influenza and AI
    - TB, plague *etc.*
- Tasks
  - Technology review
  - Lab evaluation
  - Full-scale demo.

Decon. tangible outcomes

- Ready when next pandemic hits
  - Evaluated efficacy of COTS hardware
  - Process tweaks have huge effect
- Enables response to bioterror
  - Delivery system that works for civil aviation
  - Knock down agents without risk to aircraft

- Overcome barriers to airline use
  - Safety issues
  - Cost and logistics

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Thermal decon. system

- AeroClave COTS technology
- Aircraft hookup
- Antiviral only

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Evaluation – thermal decon.

- T control/uniformity
- RH control capability
- Efficacy
- (Long-term effects?)

Limited scope for accel. lifing

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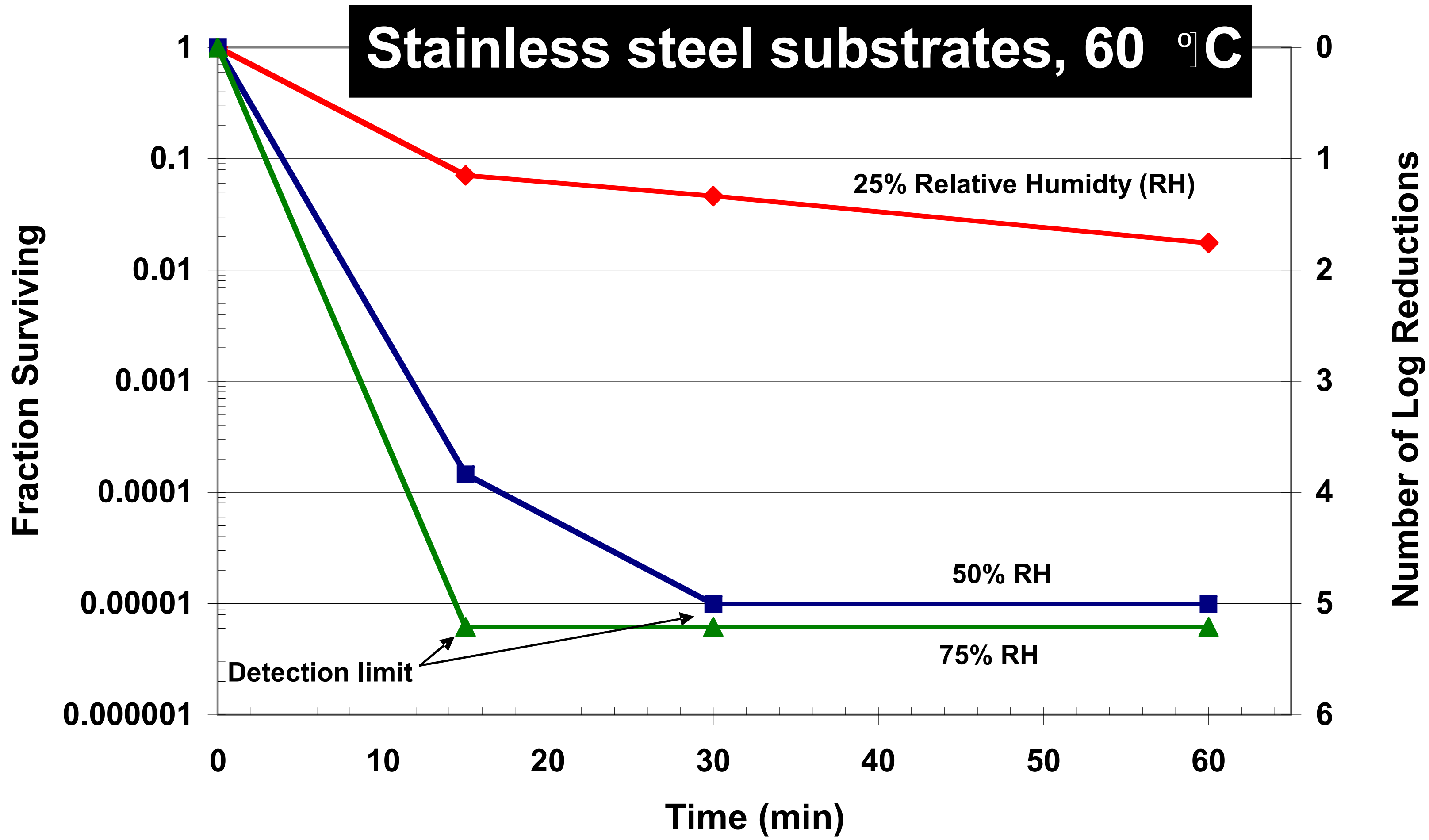
Efficacy data

Influenza



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Vaporized hydrogen peroxide (VHP)

- Efficacy against BWAs well known, but use very dilute against viruses?
- Materials compatibility?
- Best method of delivery?

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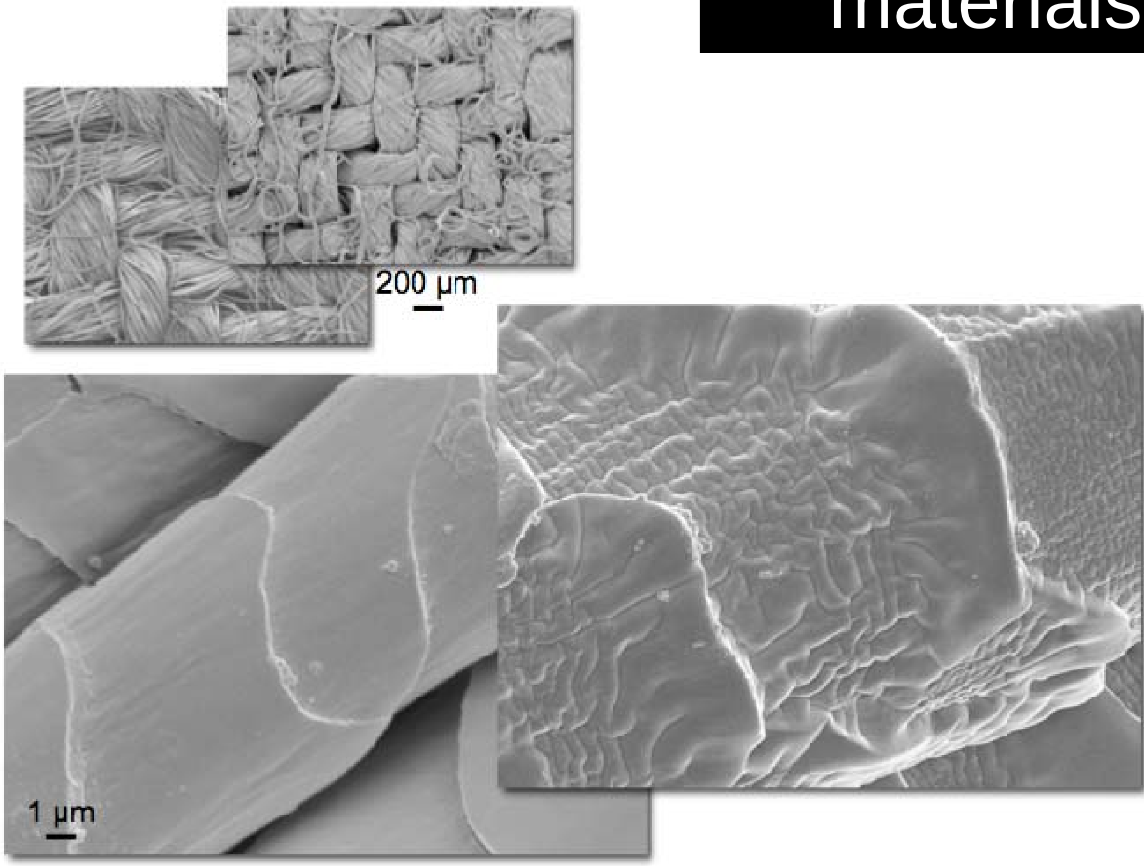
Materials/systems compatibility

Aircraft alloys, non-metallic materials & avionics



Single aisle demonstration

- Environmental conditioning (AeroClave)
- VHP injection (STERIS)

Decon. project

Wide-body demo

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Summary

- Chem.–bio. sensors
  - COTS/GOTS/NM evaluation
  - optimization and support systems
  - limited capabilities with current generation
- Whole airliner decontamination
  - efficacy
  - materials and systems compatibility
  - optimal delivery and full-scale demos
  - promising, but hurdles remain

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