THE COLLABORATIVE ARRANGEMENT FOR THE PREVENTION AND MANAGEMENT OF PUBLIC HEALTH EVENTS IN CIVIL AVIATION (CAPSCA)
AFRICA BUREAU

CAPSCA AFRICA
11th CONFERENCE
NAIROBI, KENYA
1–5 DECEMBER 2025

From Past Pandemics to Future Preparedness: Applying CAPSCA Lessons and the Swiss Cheese Model for Strengthening Africa's Pandemic Defense

05 December 2025

Dr. Kris Belland
DO, MPH, MBA, MSS, CPE, FAsMA, FAsHFA, FCAMA, FAOCOPM
President / CEO Aerospace Medicine Strategic Consultation (AsMSC), PLLC

Disclosure Information

Dr. Kris M. Belland

I have the following financial relationships to disclose: (No Conflict of Interest)

- **AeroClenz**; Chief Medical Officer, UV-C to reduce in flight disease transmission. Will discuss scientific aspects, not products
- **TrekSecure**; Chief Medical Advisor: Integrated Information Technology Processes for Infectious Disease Pandemic Response

I will not discuss off-label use and / or investigational use in my presentation
This Presentation Represents My Personal Opinions and not the US DOD, ICAO, WHO or Any Other Organization

Three Decade Career Pursuit ASM Passion

Training USNA, PCOM, USUHS, USAFAWC SunTzu, WGU DO, MBA, MSS, MPH: ASM and FM Boarded

1980-18 USN AMDD F/A-18 Hornet, F-14 TomCat, T-45 Goshawk, TopGun, DSDS

C3&4F (9-11-Bio, Haiti Earthquake USNS MERCY) One Team, One Fight! Train like you Fight

CNAF & C7F Op Tomodachi, Trifecta – Earthquake, Tsunami, Nuclear Meltdown

CBRN, PRK/LASIK, EID, SIQ-P (Neg Pres & UV-C), Bio Collection Drone

2015-16 Aerospace Medical Association (AsMA) President

2018-20 American Airlines CMO / Global Corporate Medical Director: IATA MAG

2020-21 Pilot and Flight Attendant Union Medical Representative: APA & APFA

2020-22 US FAA Deputy Regional Flight Surgeon & Senior AME – COVID-19 ATC's

Today President / CEO AsMSC, PLLC: CMO AeroClenz & TrekSecure

CAPSCA AsMA Rep, WHO-PRET - COVID-19

TOPGUN Admirals

★★★★

2016-18 Commander Pacific Fleet
CNO F/A-18, T-45 PE CR

Shut Down USN/USMC Flt Train, Politics, Risk Comms

★★★

2009-13 Commander Naval Air Forces
Vietnam Veterans Agent Orange Exposure

Politics, PACT Act-Burn Pits, Other Toxic Substances

★★

1996-2000 NSAWC / TOPGUN
Fallon Childhood Leukemia Cluster

CDC/ATSDR,Childhood Leukemia ClusterRisk Coms

Warlock (Charles Parnell)
Cyclone (Jon Hamm)
Iceman (Val Kilmer)

In Real Life: Dick, Killer and Notso


T-45 GOSHAWK
CARRIER-CAPABLE TRAINER
NAVY
600
NH
NAVY
D55

Few in Number, Yet Profound in Impact: The Remarkable DO Aerospace Medicine Specialists

Physicians (Two Federally Recognized):
Allopathic MD
Osteopathic DO

Dr. James D. Polk

Chief Health and Medical Officer

Dr. JD Polk, DO, MS, MMM, CPE, FACOEP, FAsMA, is the agency chief health and m
Administration (NASA) located at NASA Headquarters in Washington. He began s

Dr. Polk is the former dean of medicine for Des Moines University's College of Ost
University, Dr. Polk was the assistant secretary (acting) for health affairs and chie
Security (DHS), assuming this post after serving as the principal deputy assistant
officer. Before coming to DHS, Dr. Polk was the chief of space medicine for NASA
state emergency medical services medical director for the state of Ohio and form
is a fellow of the American College of Osteopathic Emergency Physicians, fellow
Extreme and Wilderness Medicine.

Dr. Polk received his degree in osteopathic medicine from the A.T. Still University
emergency medicine with the Mt. Sinai hospitals via Ohio University and complet
Texas Medical Branch. He is triple board certified in emergency medicine and ae
Medicine, the American Osteopath Board of Emergency Medicine, and the Ameri
holds a master in science in space studies from the American Military University,
Southern California's Marshall School of Business, and a master's certificate in pu

LIEUTENANT GENERAL (DR.) DOUGLAS J. ROBB

Lt. Gen. (Dr.) Douglas J. Robb is the Director, Defense Health Agency (DHA), Defense Health Headquarters, Falls Church, Virginia. He leads a joint, integrated Combat Support Agency enabling the Army, Navy, Air Force, and Marine Corps medical services to provide a medically ready force and ready medical force to Combatant Commands in both peacetime and wartime. In support of an integrated, affordable, and high quality military health service, th
services to include the health plan (TRICARE), pharm
acquisition, education and training, public health, me
resource management, and contracting. The DHA ad
worldwide medical, dental and pharmacy programs
members, retirees and their families. The DHA exerc
inpatient facilities and their subordinate clinics assig
Directorate and also manages the execution of polic
for Health Affairs.

General Robb entered the Air Force in June 1979 as
board certified in aerospace medicine. He has spent
support of Air Force, joint, and coalition aviation forc

Biography

National Guard Bureau

General Officer Management Office, Arlington, VA

MAJOR GENERAL BRETT A. WYRICK

Ronak Shah, DO, MBA, MPH · 1st

Director, Aerospace Medicine

The University of Texas Medical Branch

Houston, Texas, United States · Contact info

500+ connections

J. Timothy LaVan, Gary Beven, and 92 other mutual connections

Message More

Daniel Berry DO, PhD · 1st

Regional Flight Surgeon at Federal Aviation Administration

Federal Aviation Administration

Olathe, Kansas, United States · Contact info

219 connections

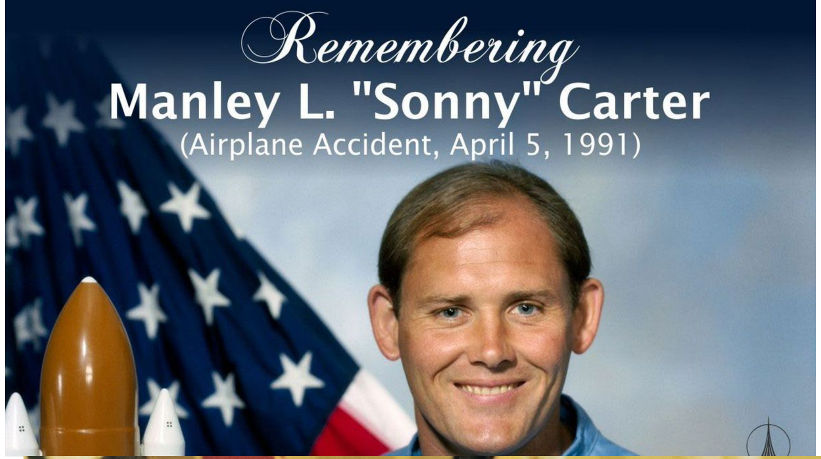
Dwight Holland, MD, PhD, Warren silberman, and 80 other mutual connections

MURRAY GOLDSTEIN DO, MPH SPECIAL ADVISOR

SHARE

For the period 1953-1993, Dr. Murray Goldstein was a commissioned medical officer in the United States Public Health Service (USPHS) and a member of the staff of the National Institutes of Health (NIH); for the final 13 years at the NIH he served as the Director of the NIH National Institute of Neurological Disorders and Stroke. He was an Assistant Surgeon General in the USPHS with the 2 star rank of Rear Admiral. Following his retirement from the USPHS, he served as Director of the United Cerebral Palsy Research and Educational Foundation from 1993-2005 and medical consultant to the United Cerebral Palsy Association. He is now a medical research consultant to several national organizations and the US government.

- President Biden and Trump Physicians are / were DO’s



NASA Connection

- US Navy Astronaut Candidate
- USN AMDD's
  - Dr. David Brown
  - Dr. Sonny Carter

Richard “Rick” Scheuring, DO - NASA Artemis Flight Surgeon

What is *Aerospace Medicine*?

- **International leader in aerospace medicine and human performance**
- **Mission to Advance the Art and Science of Aerospace Medicine**
- **2,250 Members, Every Country with Aviation and Space Programs**
- **Physicians (Every Specialty), Nurses, PhD, Physiologists, Administrators, Executives, Dentists, and More**
- **Not All ASM Trained / Boarded, But Movement towards MD/DO Board Certification (i.e. NASA)**

The Aerospace Medical Association

Centennial 2029-30

AsMA.org

Aerospace Medicine Specialists Physicians – Like Other Medical Specialties Where We Serve - FUTURE IS BRIGHT

- General Service Areas: Clinical, Research, Admin, Leadership, Executive, Education
- Military – Support Aviation, Aircrew, Squadron Members, Family
  - Army
  - Navy
  - Air Force
  - Space Force
  - US Marine Corps
  - US Coast Guard
- Government
  - Regulators – FAA, CAA, etc
  - Policy – Government / Congress – Laws and Funding
- Civilian
  - ComAir - AA, UA, DA, Qatar, New Zealand, Air Australia, China, South Korea, Japan, KLM, More
  - Space - Space X, Blue Origin, Virgin Galactic, Boeing, (Many, Many Countries and Growing)

Aerospace Medicine Boards (MD / DO’s)

- American Board of Preventive Medicine (ABPM) / American Osteopathic Board of Preventive Medicine (AOBPM) - Key is Preventive and Occupational Medicine
  - Preventive Medicine
  - Occupational Health
  - Correctional Medicine
  - Aerospace Medicine
  - Undersea and Hyperbaric Medicine

Aerospace Medicine International Community

AsMA	Aerospace Medical Association
CDC	US Centers for Disease Control
EASA	European Union Aviation Safety Agency
ECDC	European Centre for Disease Prevention and Control
ESAM	European Society of Aerospace Medicine
FAA	US Federal Aviation Administration
IAASM	International Academy of Aviation & Space Medicine
IAMA	International Airline Medical Association
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
CAPSCA	Collaborative Arrangement for the Prevention and Management of Public Health Events in Civil Aviation
SOFRAMAS	Société Française de Médecine Aérospaciale
WHO	World Health Organization

IATA MAG (Paulo) Dr. David Powell, Dr. Rui Pumbal: Physicians
AA, Portugal, France, KLM, British Airways, New Zealand, Australia, China and South Korea

Introduction to Aerospace Medicine

When the human body is exposed to environments outside of our evolved tolerances, it does not always behave as expected

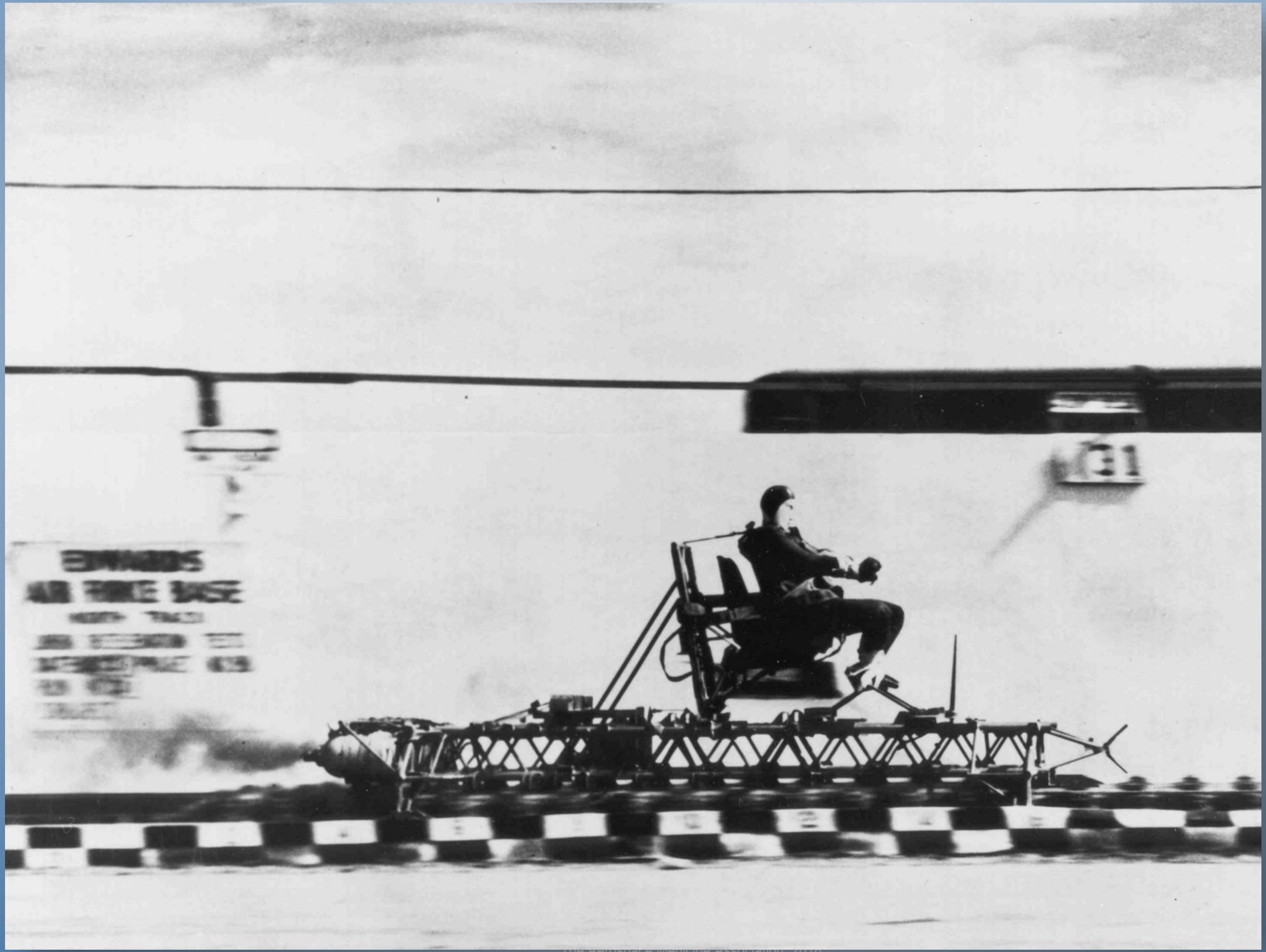
Humans evolved in a specific environment

- **Constant Gravity of 9.8 m/s^2**
- **Atmospheric Pressure near 760 mmHg**
- **21% oxygen, 79% nitrogen and some trace gases**
- **Temperature near 24^{o}C**

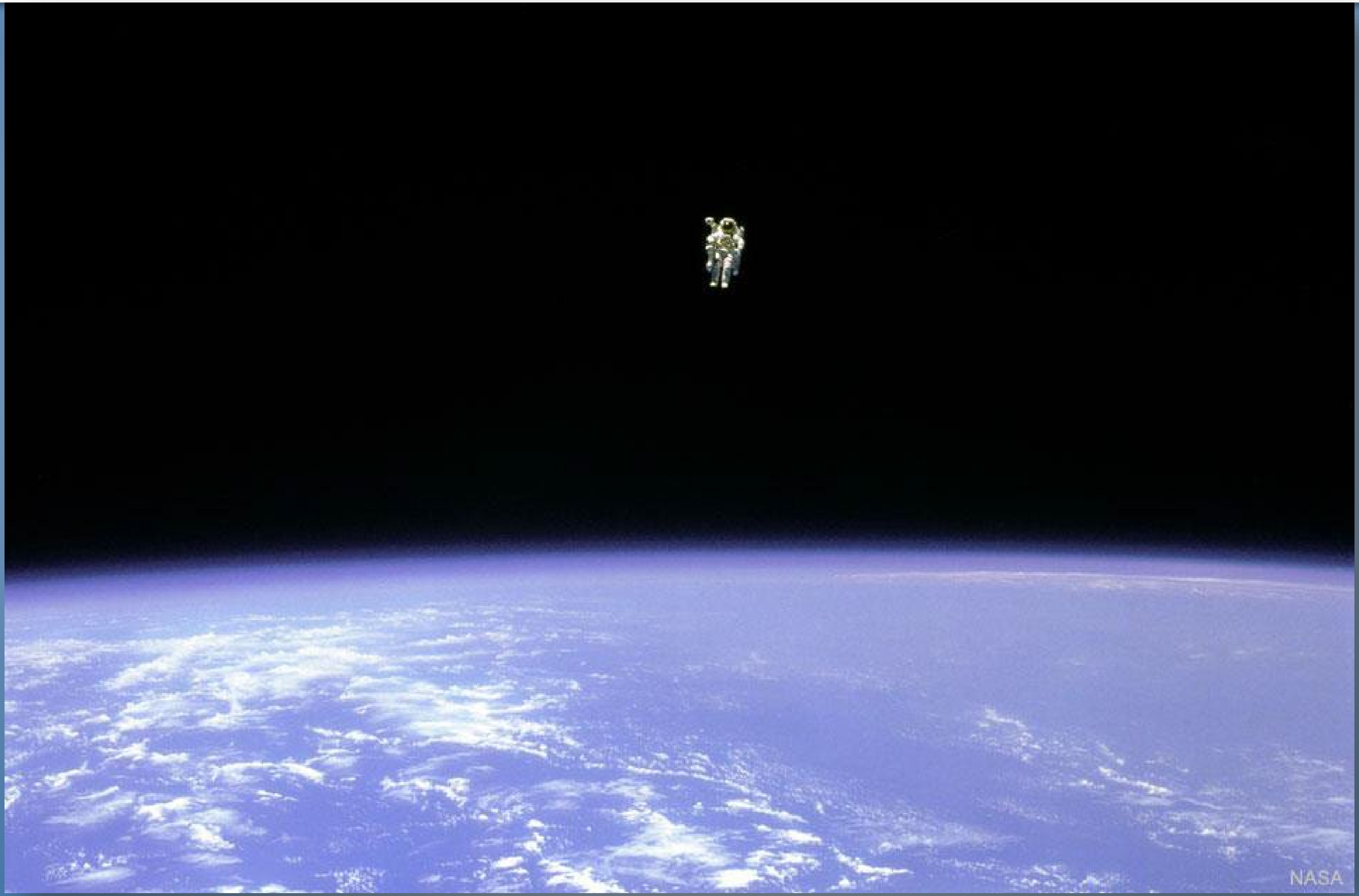
These are the conditions at sea level on Earth

We have traveled to where the force of gravity cannot be perceived…

… and have experienced when that force is equivalent to over 40 times Earth's gravity



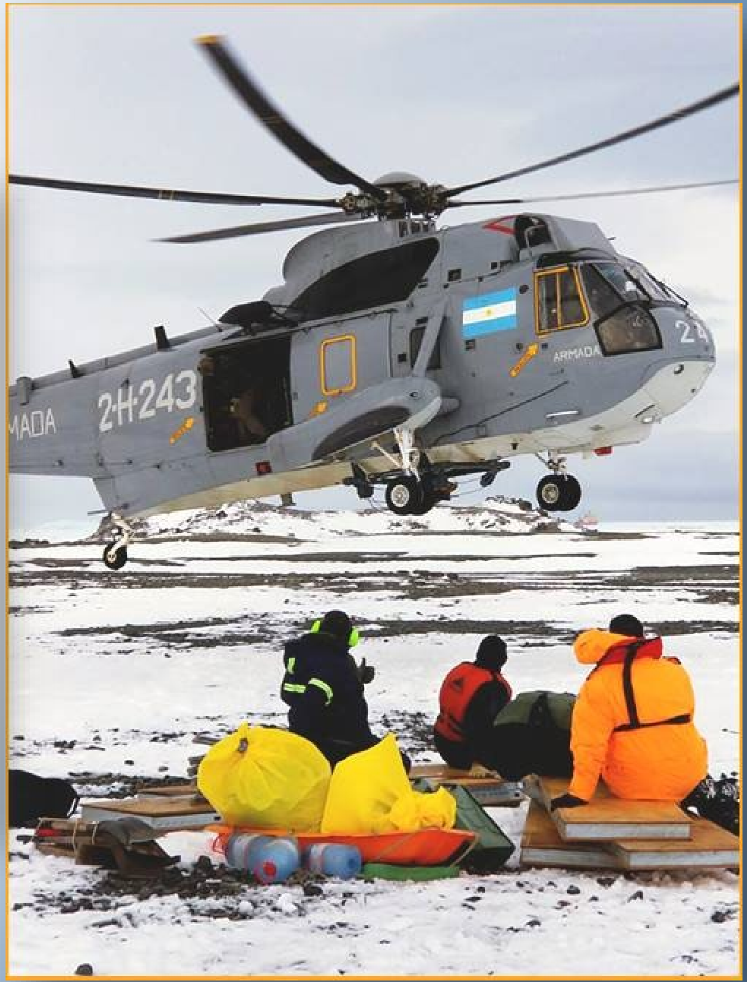
To where ambient pressure is zero…



… and where it is 1,000 times that at sea level.

To extreme altitudes where supplemental oxygen & pressure are necessary.

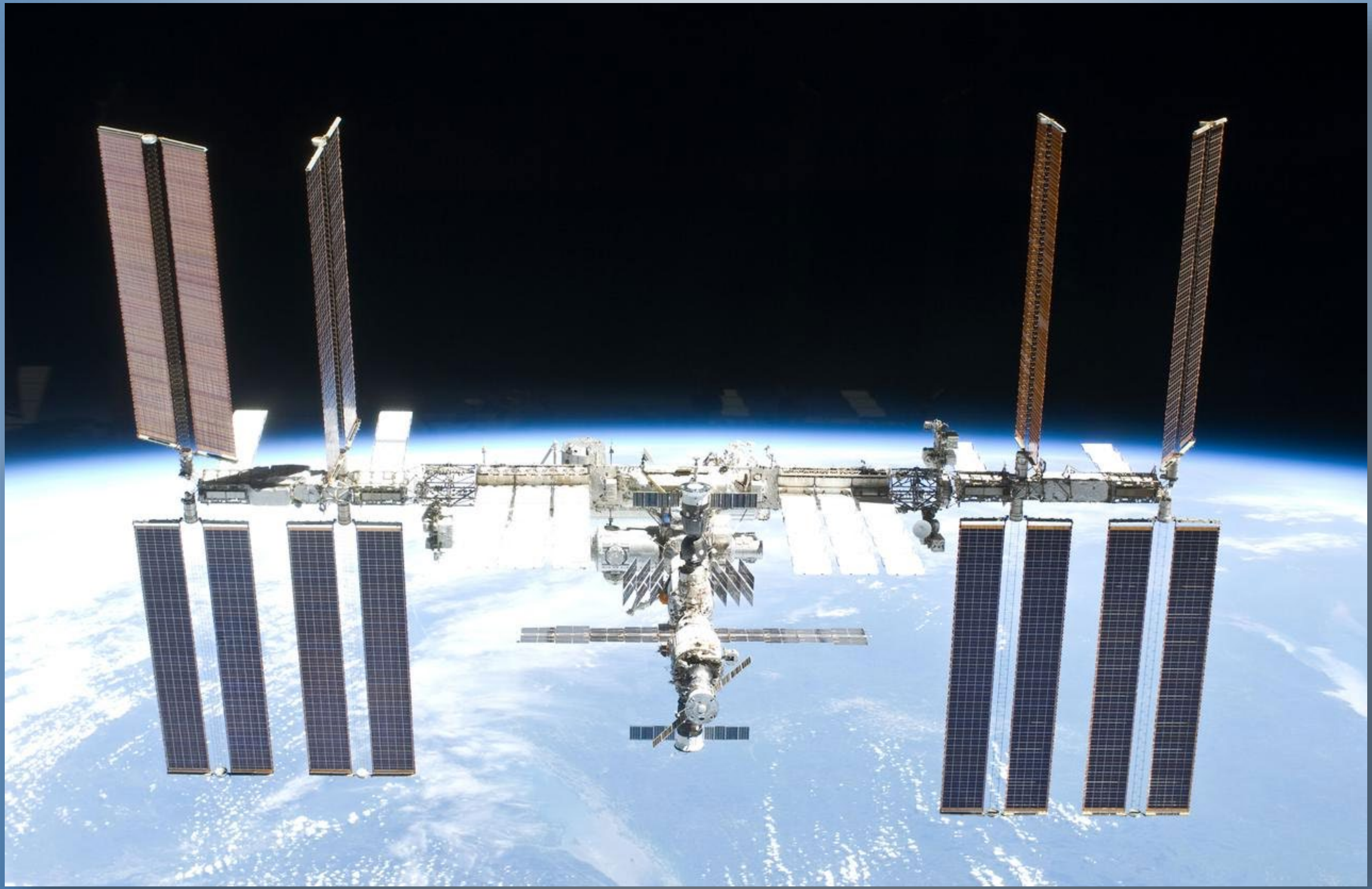
To where temperatures are way below zero…



… and where the temperature is hot enough to melt a spacecraft.

Our practitioners care for people in every corner of the globe…

… and beyond it.



Aerospace Medicine Specialists

- Aerospace Medicine specialists draw from the full range of medical specialties
- Working with professionals from dozens of other disciplines, Aerospace Medicine Specialists keep people healthy in Earth's atmosphere and beyond
- Aerospace Medicine primarily encompasses four key areas:
  - Clinical
  - Research
  - Education
  - Policy

Aerospace Medicine Specialists work with:

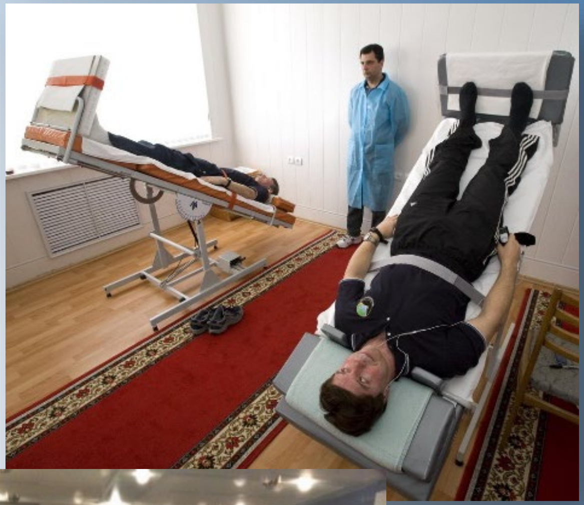
- Engineers
- Nurses
- Pharmacists
- Medics
- Doctors
- Astronauts
- Pilots
- Civilians
- Military

Clinical Aerospace Medicine

- Contingency/Emergency Response
  - Remote Medical Care in the Field
  - In-Flight Telemedicine
  - Orbital and Interplanetary Telemedicine
  - Search and Rescue
  - Disaster Preparedness
  - Accident Investigation
- Screening and Prevention
  - Pilots and Air Crew
  - Astronauts
  - Air Traffic Controllers
  - Flight Controllers
  - Health maintenance
  - Occupational Health and Wellness

Aerospace Medicine Research

- **Human Factors:**
  - Habitability
  - Survivability
  - User Interfaces
  - Control Surfaces
- **Environmental Effects and Mitigation:**
  - High Altitude
  - Hyperbarics and Hypobarics
  - Non-standard Gravity
  - Radiation Countermeasures
- **Human Physiology:**
  - Sensory Effects of Unusual Environments
  - Spatial Disorientation
  - System Specific responses
- **Behavioral Health and Performance:**
  - Crew Selection
  - Crew Resource Management
  - Fatigue Management
  - Social Isolation
  - Operations and Contingency Planning
  - Autonomous Health Systems
  - Search and Rescue techniques
  - Life Support Systems
  - Fitness for Duty Criteria



Aerospace Medicine Education

- Pilots
  - Military
  - Civilian
  - Students
- Doctors
  - General Practitioners
  - Specialists
  - Aviation Medical Examiners
  - Continuing Medical Education
  - Researchers
- Nurses
  - Clinical practice
  - Administrators
  - Researchers
- Paramedics
  - Flight Medics
  - Critical Care Medics
  - Public Health Practitioners
- Professionals
  - Engineers
  - Students
  - Civilian
  - Military
- Graduate Students
  - Multiple Disciplines
- Other Training:
  - Aerospace physiology courses
  - Online courses
  - University Affiliated Courses
  - Aerospace Medicine Residencies

Aerospace Medicine Policy

- Civil and Military Aviation Health
- Defense Health
- Transportation Health
- Accident Investigation & Prevention
- Training Requirements
- Government Space Activities
- Commercial Space Activities
- Behavioral Health Issues:
  - Addiction
  - Fatigue
  - Mental illness

Physician Training Path and Opportunities

- **What it Takes to Become an Aerospace Medicine Specialist**
  - **Undergraduate degree**
  - **Medical School, MD / DO (HPSP, USUHS)**
  - **Residency training (RAM)**
  - **Subspecialty training**
  - **Additional masters or doctorate level training**
- **Aerospace Medicine Residency Programs and Other Education Opportunities**

Where Aerospace Medicine Specialists Work

- Civilian government (NASA, FAA)
  - Civil aviation authorities
  - Civil space flight agencies
  - Accident investigation boards
- Military (US Army, Navy, Air Force, Marine Corps, Space Force)
  - Every military and branch that has pilots / UAV operations, needs aerospace medicine specialists
- Private sector
  - Commercial aviation
  - Commercial spaceflight: SpaceX, Virgin Galactic, Blue Origin. Axiom, etc.
  - Travel medicine
- Academic medicine
  - Academic medical centers
  - Universities
  - Research organizations

Aerospace Medical Association (AsMA)

- International leader in aerospace medicine and human performance
- Apply and advance scientific knowledge to promote and enhance the health, safety and performance of those involved in aerospace and related activities
- AsMA members are in every country that flies and every country that has a human spaceflight program

AsMA.org

Vital Nature of Board-Certified Physicians in Aerospace Medicine

- US Commercial Airlines. To save money, reduce litigation have been outsourcing medical support including CMO roles.
  - 100 Internal Medical to Outsourc Contracting
  - Aeromedical input into the organization was not optimal
  - COVID-19 happened
  - Billions in bailouts for US Airlines
  - AsMA Resolution followed
- Due to COVID-19 ComAir (UA, Delta) are Hiring Back ASM Specialists

Aerospace Medical Association Resolution 2020 - 01

Title of Resolution: Vital Nature of Board-Certified Specialists in Aerospace Medicine

Authors: Kris M. Be
Hernando

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SUBJECT: VITAL NATURE OF BOARD-CERTIFIED PHYSICIANS IN AEROSPACE MEDICINE

Aerospace Medical Association

President
James R. DeVoll, MD, MPH, Asma
McLean, Virginia

Executive Director
Jeffrey C. Sventek, MS, CAsP, F AsMA
Association Headquarters Office

320 South Henry Street
Alexandria, VA 22314-3579
Phone: 703-739-2240
Fax: 703-739-9652
www.asma.org

April 8, 2022

American Medical Association
Dr. Gerald E. Harmon, President
515 N. State Street
Chicago, IL 60610

SUBJECT: Vital Nature of Board-Certified Physicians in Aerospace Medicine

Dear Dr. Harmon,

On June 8 2021, the membership of the Aerospace Medical Association (AsMA) passed a resolution to highlight the continued need for physician leadership on clinical teams. As physicians represent the highest level of training and certification in any specialty, their replacement by mid-level providers lacking this level of expertise is inappropriate. AsMA will continue to advocate against any non-physician expansion of practice that reduces a physician's role in leading medical care.

The background for the resolution is as follows:

- Aerospace Medicine is an internationally recognized, unique specialty of medicine with advanced education requirements supporting all domains of aviation and space flight.
- In over a century of support, the Aerospace Medicine Team, led by Aerospace Medicine physicians have advanced the art and science of every human flight endeavor, resulting in improved safety, reduced mishaps, and enhanced mission accomplishment.
- Aerospace Medicine physicians are required to maintain their professional knowledge and standing with State medical licensure, current Specialty Board certifications, continuing medical education activities, and ongoing privileging; and have extensive knowledge, skills, and professional self-regulation in the full and total range of the practice of Aerospace Medicine.
- In an effort to reduce costs, outsource work, and pass-on legal liability, there has been a trend in Managed Medical Care, US commercial airlines and in the US Governmental Departments to replace Aerospace Medicine physicians with non-aerospace medicine mid-level providers (protocol driven, lack of specialty training / experience), resulting in significantly increased risk and reduced safety margins.
- 193 state parties are signatories to the Convention on International Civil Aviation ("Chicago Convention"), which obliges the governments to reciprocally implement certain international regulatory standards, including physician responsibility pertaining to medical fitness of license holders, prevention of ill health and management of public health events in aviation.

The AsMA resolution states:

- World legislative, regulatory and rule-making bodies codify Aerospace Medicine specialty practitioners and the unique leadership roles of Aerospace Medicine physicians.
- AsMA recognizes the unique contributions and advanced qualifications of Aerospace Medicine professionals; and specifically opposes all efforts to remove, reduce or replace Aerospace Medicine physician leadership in civilian, corporate or government Aerospace Medicine programs and aircrew healthcare support teams.
- AsMA advocates against other mid-level provider scope of practice expansions that threaten the safety, health, and wellbeing of aircrew, patients, support personnel and the flying public.

Thank you for your kind consideration of this important effort to enhance the safety of global Aerospace Medicine operations. Please feel free to contact the Aerospace Medical Association at (703) 739-2240 x105 if we can be of assistance.

Sincerely,

Jeffrey C. Sventek, MS, CAsP, AsMA, FRAeS
Executive Director

ive Medicine

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AsMA an AOA Resolutions (AMA President Supportive):
Vital Nature of Board-Certified Specialist in Aerospace Medicine

World legislative, regulatory and rule-making bodies codify the Aerospace Medicine specialty, practitioners and the unique leadership roles of Aerospace Medicine physicians

Recognizes the unique contributions and advanced qualifications of Aerospace Medicine professionals; and specifically opposes any and all efforts to remove, reduce or replace Aerospace Medicine physician leadership in civilian, corporate or government Aerospace Medicine programs and aircrew healthcare support teams

Advocates against other further Aerospace medicine mid-level provider scope of practice expansions that threaten the safety, health, and wellbeing of aircrew, patients, support personnel and the flying public.

American Board of Preventive Medicine (ABPM) offers international aerospace medicine certification

- March 2026: A New Pathway for International Medical Graduates (IMGs)
- Specialty: Aerospace Medicine focuses on the care, research, and operational support for air and space vehicle crew members, passengers, and support personnel.

American Osteopathic College of Occupational and Preventive Medicine

Colleges: ACOEM /AOCOPM

- Specialty College
- Professional Membership Organization
- CME Provider
- Teaching Entity
- Separately Incorporated 501(c)(3) organization

Boards: ABPM /AOBPM

- Certifying Board
- Part of the American Osteopathic Association
- Administers primary Board Exams (PH, AM, OM)
- Also administers sub-specialty exams (Correctional Medicine, Undersea/Hyperbaric Medicine) and the Occupational Medicine Certificate of Added Qualification (CAQ)

COVID was no anomaly. Another pandemic is inevitable.

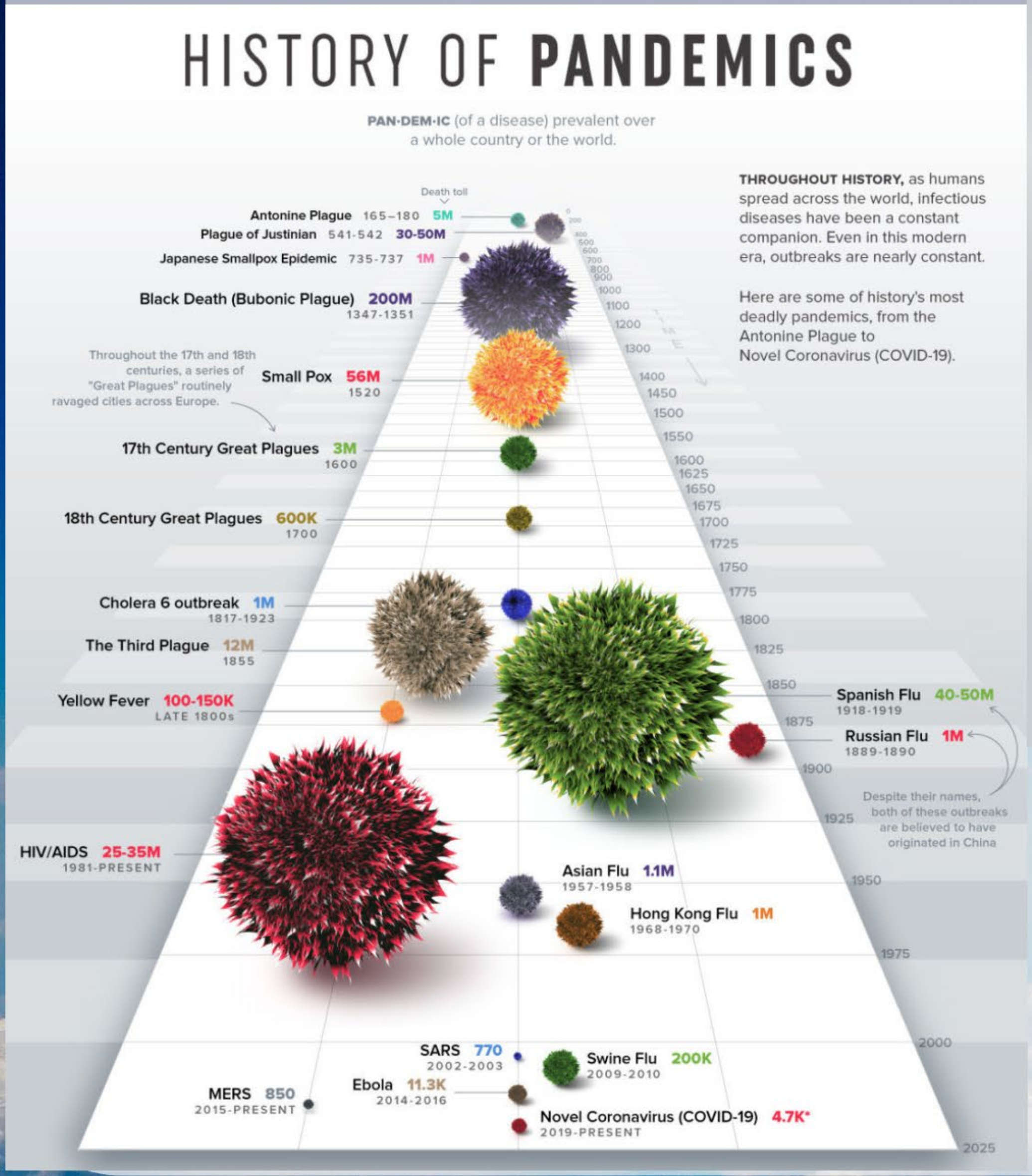
World ‘woefully unprepared’ for a biological incident, simulation exercise finds

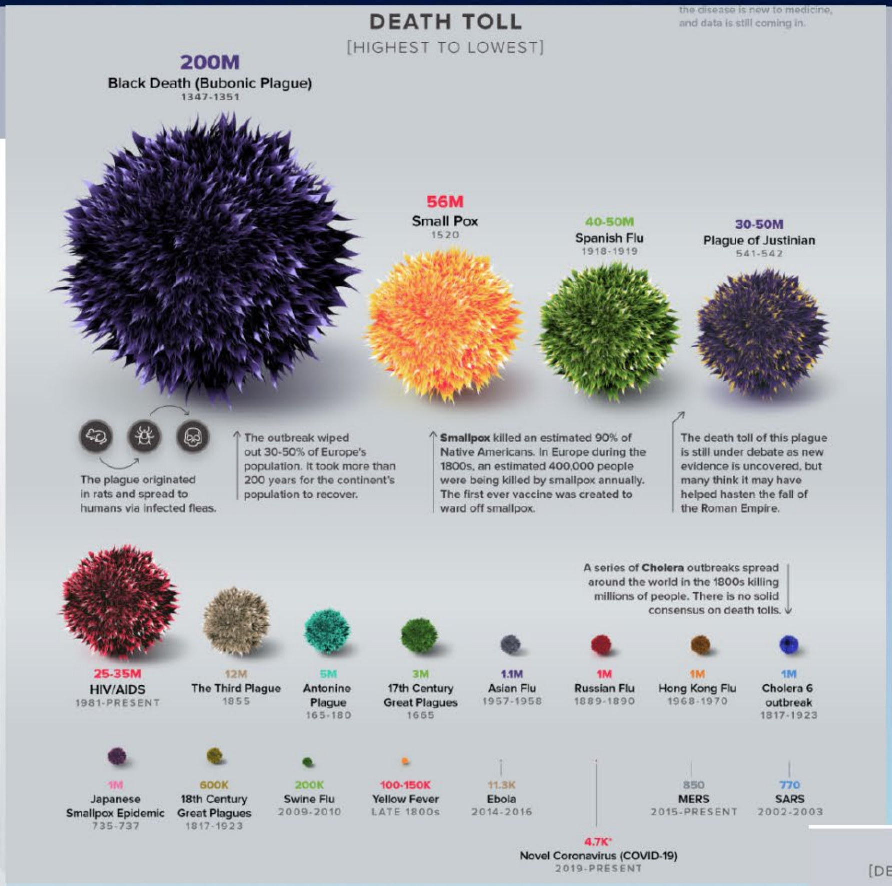
Warning that existing systems would not address current and anticipated future biological threats

By Harriet Barber, GLOBAL HEALTH SECURITY REPORTER
30 May 2023 • 4:47pm

World Wide Transmission / Translocation

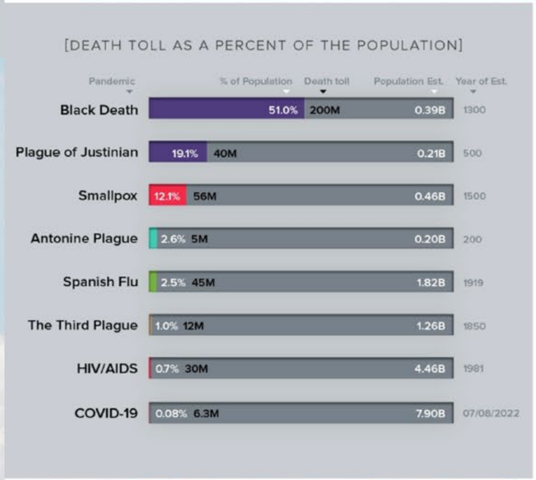
Pandemics in Context



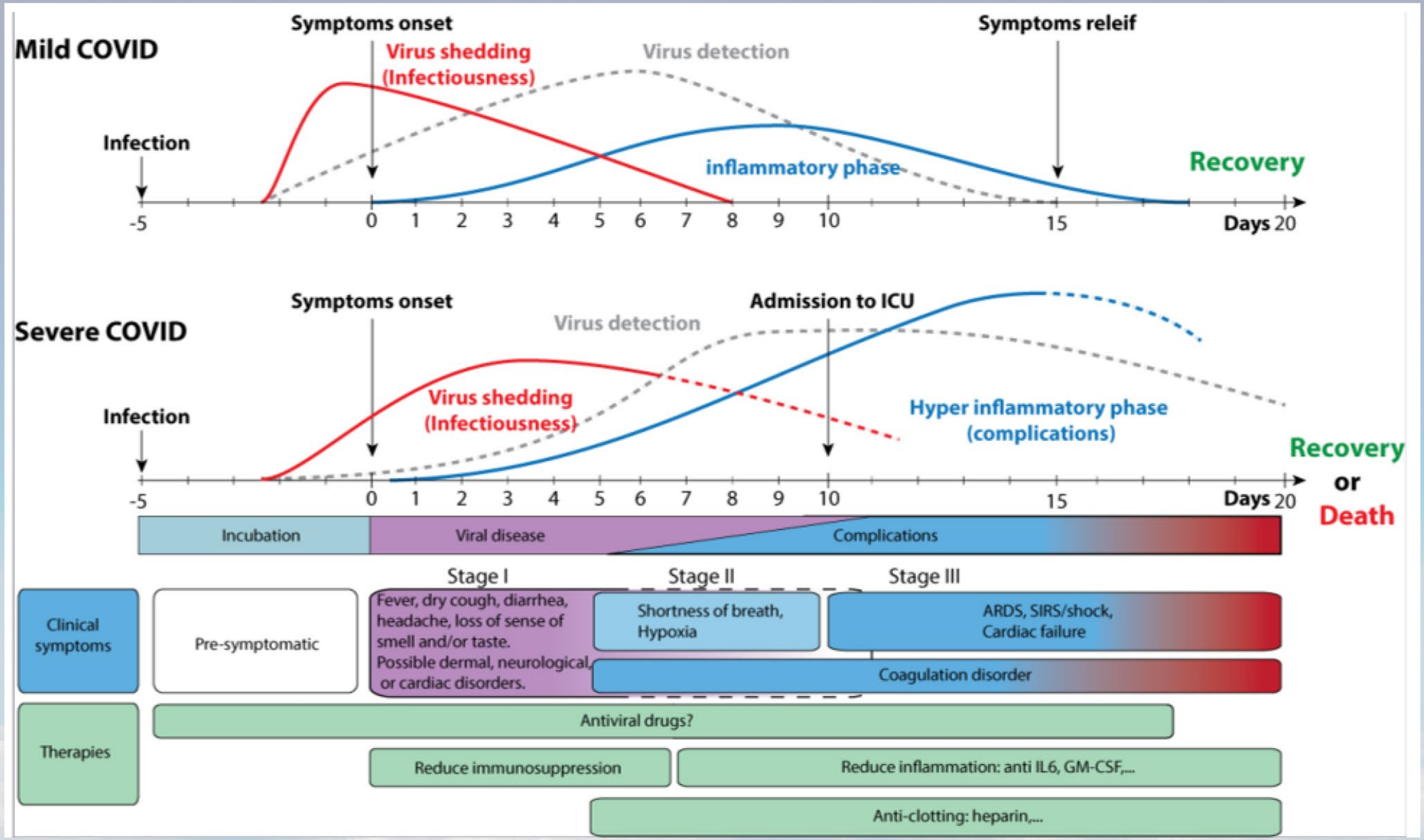


If COVID's death rate mirrored the Plague, *4 billion deaths* would occur

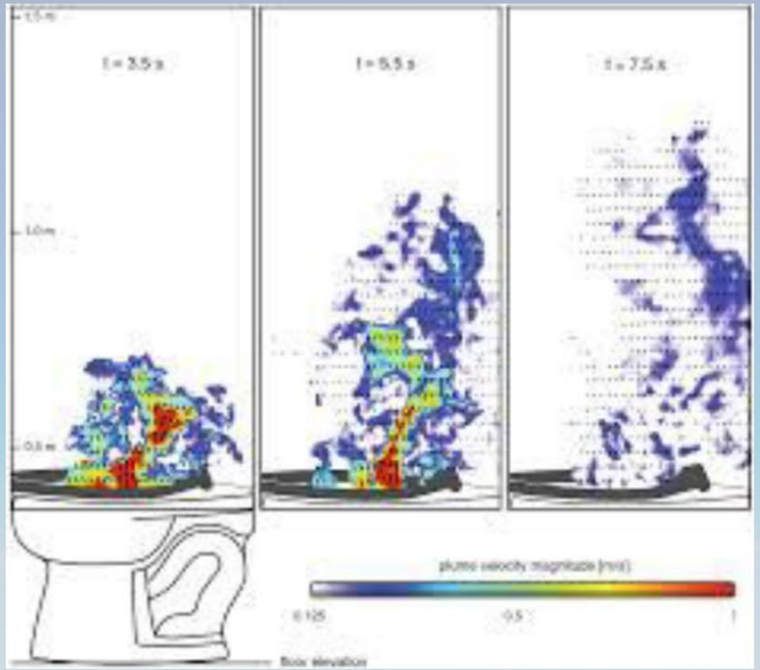
Preparing for the worst case scenario is <u>necessary</u> to prevent critical loss of life

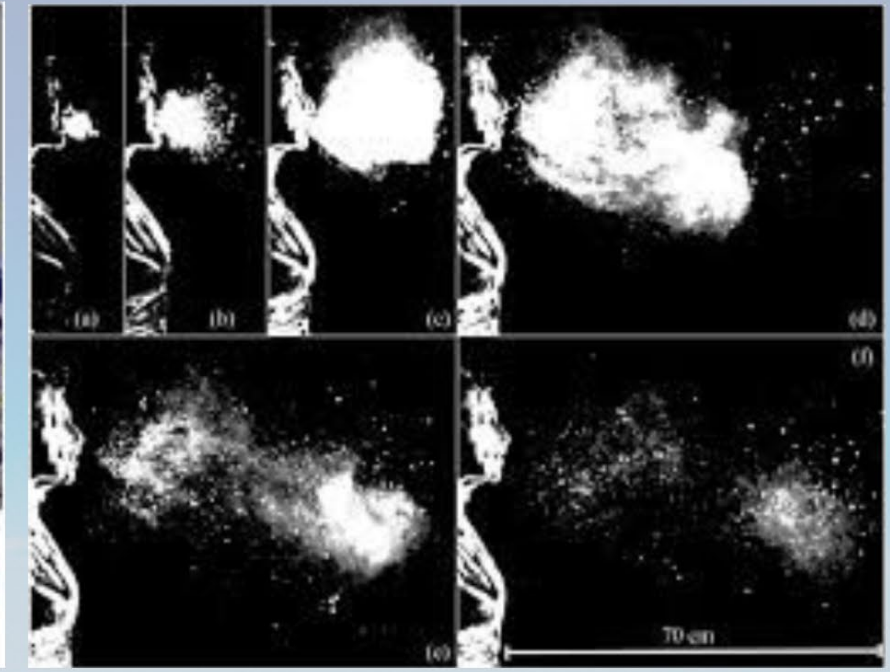


COVID–19 Transmission Timeline

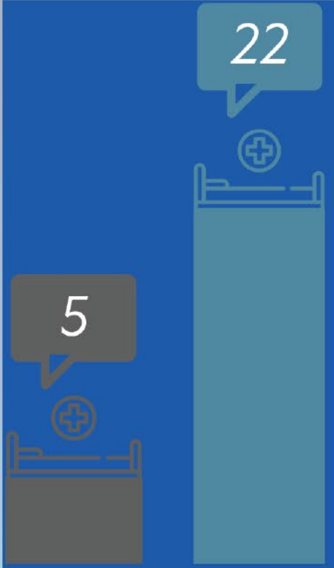


Aerosolization – The Omnipresent Challenge





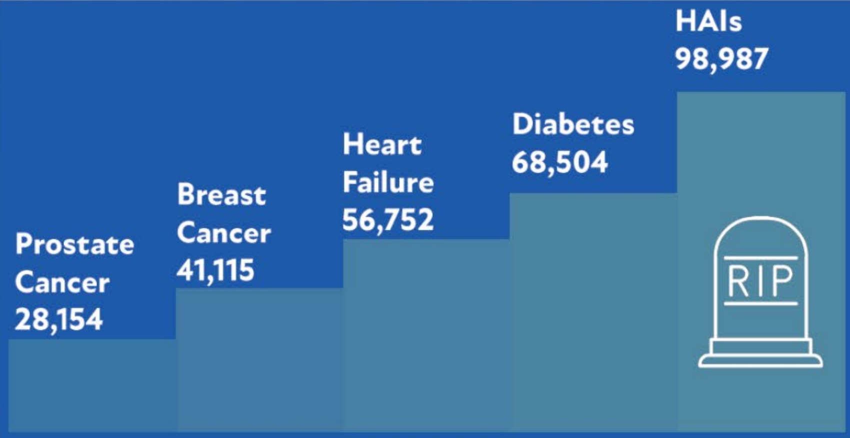
HAIs Pose a Major Threat to Hospital Networks:



Your average length of stay in the hospital increases by

17.6 days

if you get an HAI.



HAIs account for ***~99,000*** deaths in the U.S annually -

More than Breast Cancer & Prostate Cancer ***Combined***.

1 in 31 US hospital patients has an HAI at any given time.

One out of every 10 patients who acquire an HAI will *die* as a result.

HAIs cost U.S. hospitals at least **$28.4 billion** annually.

Sources:
HAIs: Reports and Data, CDC Nov. 2024
Prevalence and Burden of Healthcare Associated Infections (HAIs), 2016-2021, Melissa A. Miller, Oct. 2024

Prior Room Occupancy Increases Risk For HAIs

Study	Healthcare associated pathogen	Likelihood of patient acquiring HAI based on prior room occupancy (comparing a previously 'positive' room with a previously 'negative' room)
Martinez 2003[1]	VRE – cultured within room	2.6x
Huang 2006[2]	VRE – prior room occupant	1.6x
	MRSA – prior room occupant	1.3x
Drees 2008[3]	VRE – cultured within room	1.9x
	VRE – prior room occupant	2.2x
	VRE – prior room occupant in previous two weeks	2.0x
Shaughnessy 2008[4]	*C. difficile* – prior room occupant	2.4x
Nseir 2010[5]	*A. baumannii* – prior room occupant	3.8x
	P. aeruginosa – prior room occupant	2.1x

1. Martinez *et al. Arch Intern Med* 2003; 163: 1905-12.
2. Huang *et al. Arch Intern Med* 2006; 166: 1945-51.
3. Drees *et al. Clin Infect Dis* 2008; 46: 678-85.
4. Shaughnessy. ICAAC/IDSA 2008. Abstract K-4194.
5. Nseir et al. Clin Microbiol Infect 2010 (in press).

Multiple Studies Confirm Inflight Transmission / Translocation Occurs and Commercial Toilets Emit Energetic and Rapidly Spread Aerosol Plumes

Micro-particle aerosolization

- Probable transmission could be through flatulence by infected patients, although no such published data has been found. But, according to several existing investigations, flatus does have the tendency to carry micro-particles which have the capacity to spread bacteria (55). However, additional research is still warranted to estimate the intensity of such infections; presence of undergarments/ clothing would however, lower the risk of transmission through this passage. The same was claimed by the Chinese Centers of Disease Control and Prevention that pants do act as a hindrance in the transmission of disease via flatulence that contains the SARS-CoV-2 virus (56).

HEALTH / DISEASES / COVID-19

Airplane toilets are a surprisingly good place to track COVID outbreak

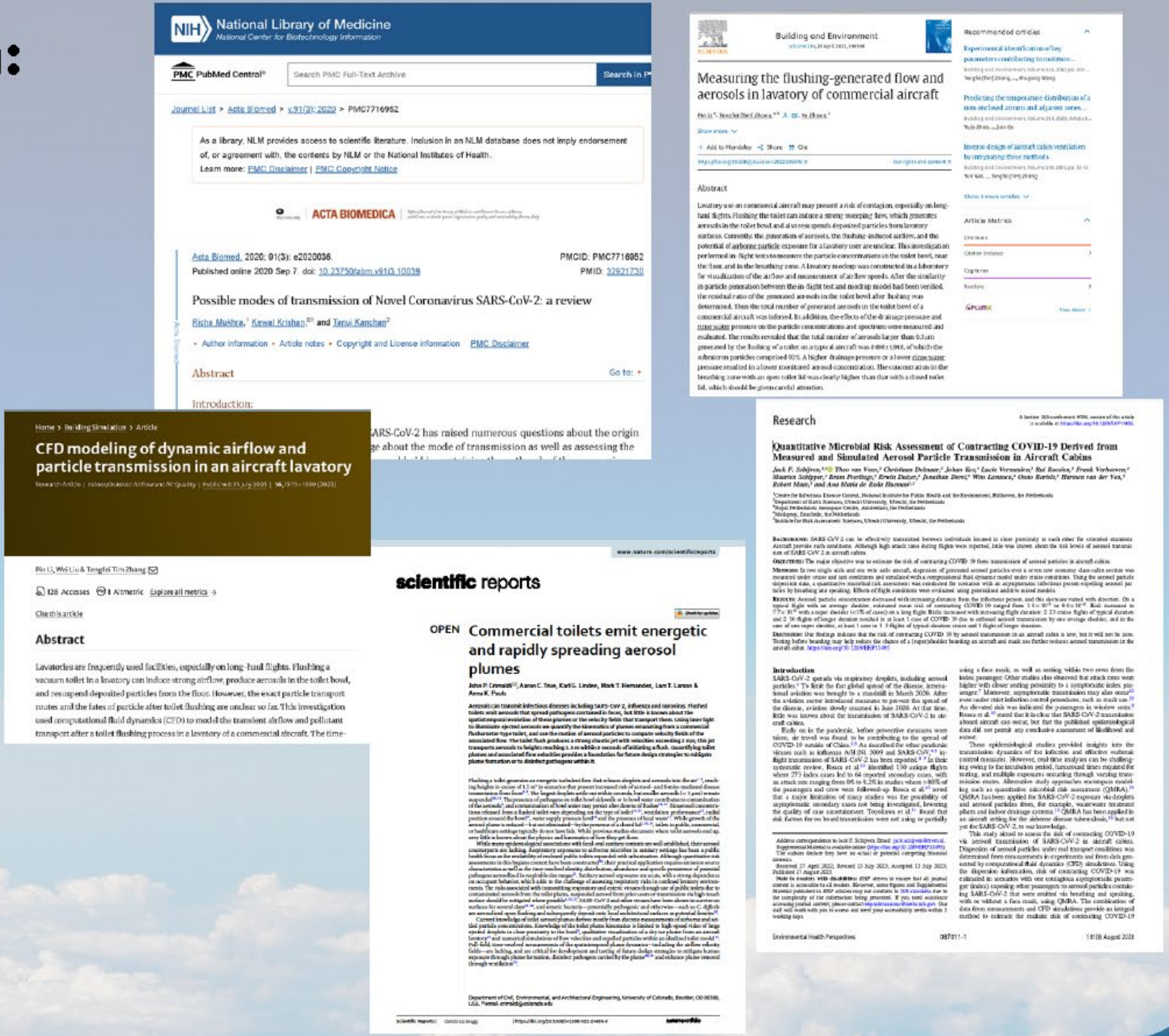
CDC researchers found the virus in 81 percent of wastewater samples from long haul flights last year.

BY LAURA BAISAS | PUBLISHED FEB 24, 2023 11:00 AM EST

A small trial from the CDC shows that testing airplane wastewater is an effective and inexpensive way to detect viruses.

Multiple Studies Confirm:

- Longer the Flight, the Higher the Transmission Rate
- No Mask, Higher Transmission Rate
- Lav's Emit Energetic Rapidly spreading aerosol plumes
- Increased Concentration of Aerosol with Raised Lid
- Micro aerosolization Flatus Occurs
- Particles May Remain Suspended More than Five Minutes
- Closed Lav = Greater Particles on Lid and Seat



Does 2x2 airplane passenger contact tracing for infectious respiratory pathogens work?

A systematic review of the evidence

Meta-analysis - 165 flights investigated

- 72 (43.7%) Evidence In-Flight Transmission
- 27 investigations assessed High Level Evidence
- 23 as medium
- 22 as low
- 1/3rd Beyond 2X2 Seating Area

We suggest that for emerging pathogens, in the absence of pathogen-specific evidence, the 2x2 system should not be used for contact tracing.

Instead, alternate contact tracing protocols and close contact definitions for enclosed areas, such as the same cabin on an aircraft or other forms of transport, should be considered as part of a whole of journey approach.

Meta-Analysis > PLoS One. 2023 Feb 2;18(2):e0264294. doi: 10.1371/journal.pone.0264294. eCollection 2023.

Does 2x2 airplane passenger contact tracing for infectious respiratory pathogens work? A systematic review of the evidence

Anna C Rafferty [1,2], Kelly Bofkin [3,4], Whitney Hughes [3], Sara Souter [3,4], Ian Hosegood [3], Robyn N Hall [2], Luis Furuya-Kanamori [5], Bette Liu [6], Michael Drane [7], Toby Regan [8], Molly Halder [8], Catherine Kelaher [2], Martyn D Kirk [1,2]

Affiliations + expand

PMID: 36730309 PMCID: PMC9894495 DOI: 10.1371/journal.pone.0264294
Free PMC article

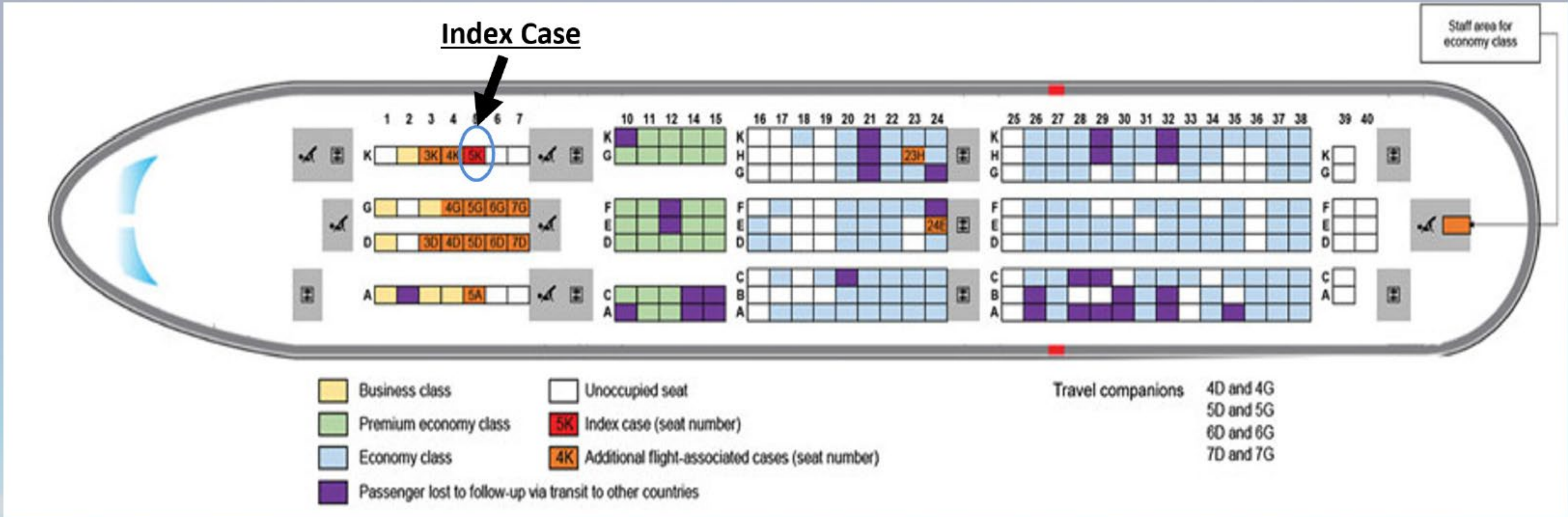
Abstract

We critically appraised the literature regarding in-flight transmission of a range of
infections to provide an evidence base for public health policies for contact tracing
the limited pathogen-specific data for SARS-CoV-2 currently available. Using Pub
and other databases including preprints, we systematically reviewed evidence of ir
of infectious respiratory illnesses. A meta-analysis was conducted where total num
board a specific flight was known, to calculate a pooled Attack Rate (AR) for a ran
The quality of the evidence provided was assessed using a bias assessment tool d
flight transmission investigations of influenza which was modelled on the PRISMA
Newcastle-Ottawa scale. We identified 103 publications detailing 165 flight investi
43.7% (72/165) of investigations provided evidence for in-flight transmission. H1
had the highest reported pooled attack rate per 100 persons (AR = 1.17), followe

Pathogen	Number of investigations and evidence level		
	Low	Medium	High
SARS-CoV-2	3	8	10
H1N1 influenza A virus	2	4	7
Mycobacterium tuberculosis	0	3	4
Measles virus	14	3	5
SARS-CoV	0	4	0
Mumps virus	1	0	0
Neisseria meningitidis	2	0	0
Seasonal influenza virus & ILI	0	1	1
Total	22	23	27

https://doi.org/10.1371/journal.pone.0264294.t002

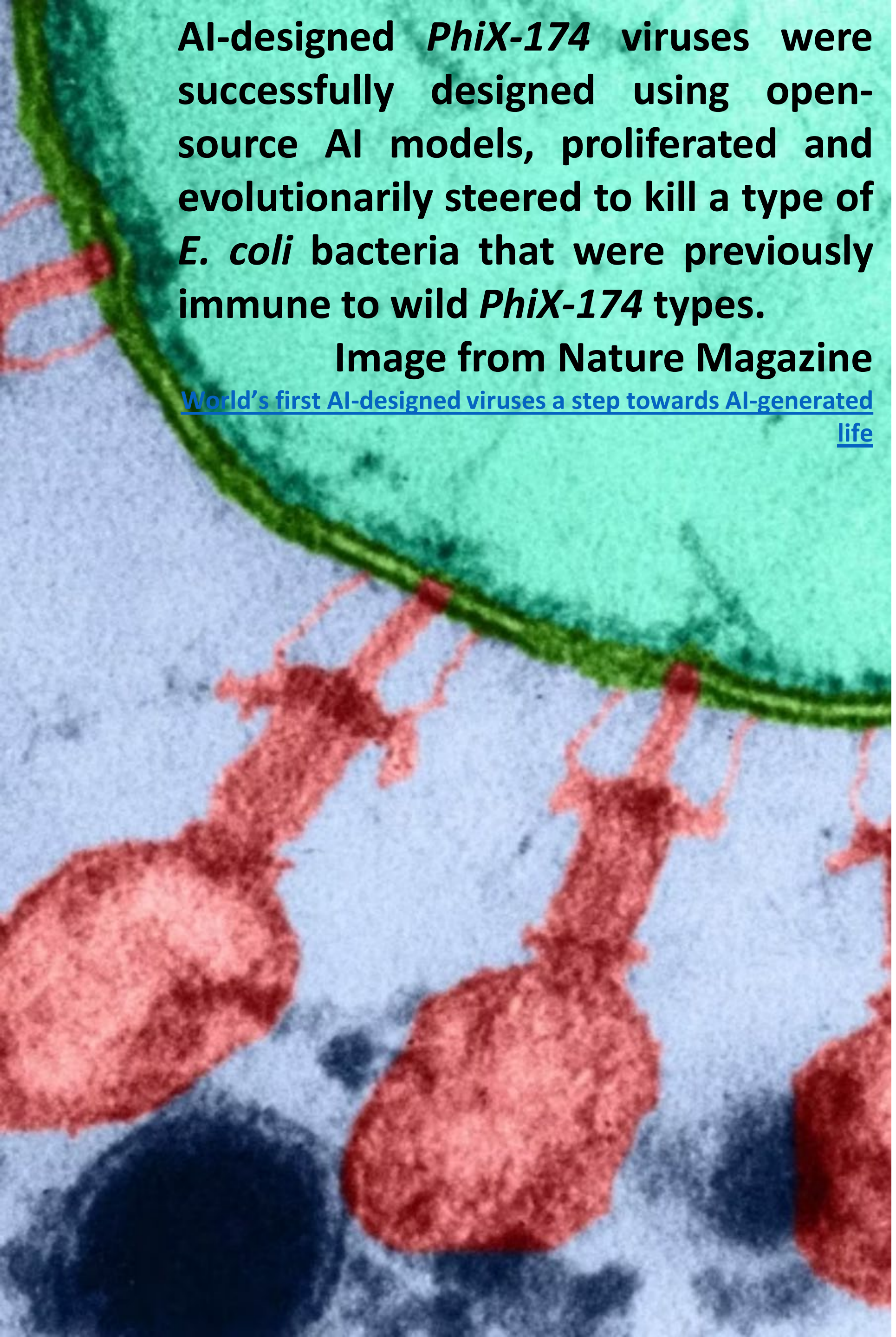
Vietnam Airlines flight 54 from London, UK, to Hanoi, Vietnam, 02 March, 2020



Airline crew often use business class toilets while on board, which might explain the case among the crew serving in economy class, for whom no other potential source of infection could be established

Khanh N, Thai P, Quach H, Thi N, Dinh P, Duong T, et al. Transmission of SARS-CoV 2 During Long-Haul Flight. Emerg Infect Dis. 2020;26(11):2617-2624. https://doi.org/10.3201/eid2611.203299

Threshold Crossed: AI-Designed, Viable Viruses Reality



AI-designed *PhiX-174* viruses were successfully designed using open-source AI models, proliferated and evolutionarily steered to kill a type of *E. coli* bacteria that were previously immune to wild *PhiX-174* types.

Image from Nature Magazine

[World's first AI-designed viruses a step towards AI-generated life]

19 Sep 2025: Paper submitted to Nature

- Arc Institute, Stanford University
- Demonstrates first end-to-end design, synthesis & revival Novel, functional viruses using open-source AI model (Evo 1/2)
- New viral species were then evolutionarily steered to infect and kill a targeted type of bacteria, which was originally immune to the unaltered virus
- Consequence: Creating novel pathogens

  little constraints

  Faster than countermeasures respond

  Low Cost AI and Lab

<u>Lessons Learned</u>:
USN, Aviation (HRO), Top Gun, United Nations ICAO and CAPSCA

COMTHIRDFLEET Today

-Speed, Agility, Precision, Persistence –

20 JUNE 2005

Presented by CDR Kris Belland
THIRD Fleet Surgeon

Sea Trials

- SECNAV
- CNO
  - Sea Enterprise
    - Project Coordinator VCNO
  - Sea Warrior
    - Project Coordinator CNP / CNETC
  - Sea Trial
    - Lead Agent CFFC
      - Project Coordinator NWDC
    - Sea Strike
      - Operational Agent C2F
      - C5F
    - Sea Shield
      - Operational Agent C3F
      - C7F
    - Sea Basing
      - Operational Agent C2F
      - C6F
  - FORCE net
    - Director N6/7
      - Project Coordinator NNWC

CBRNE Defense

- CNO Tasker # 25
- CNRSW / DTRA / Federal / State / Local
  - Bio-Watch -JPM Guardian
  - Quarantine TTX 07 Dec 2004 (First in Nation)
  - BIO-NET San Diego TTX 25 May 2005
- CNO's Operational Agent for Experimentation and Innovation
  - Shipboard Surgical System (SSS)
  - Shipboard Isolation & Quarantine Program (SIQ-P)
  - Biological Combat Assessment System (BCAS)

NAVSEA WARFARE CENTERS DAHLGREN

Shipboard Isolation and Quarantine

Concept Experiment Final Report

9 May 2011

JOINT REQUIREMENTS OFFICE FOR CBRN DEFENSE

Distribution limited to U.S. Government agencies only. Other requests for this document must be referred to:

Joint CBRN Combat Developer for Experimentation
Joint Experimentation and Analysis Division
401 MANSCEN Loop, Suite 2023
Fort Leonard Wood, MO 65473-8929

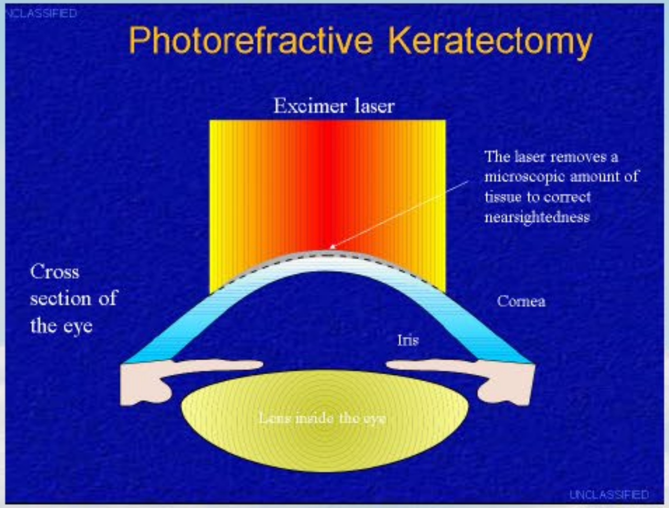
SHIPBOARD CHEMICAL-BIOLOGICAL-RADIOLOGICAL PROTECTION BRANCH

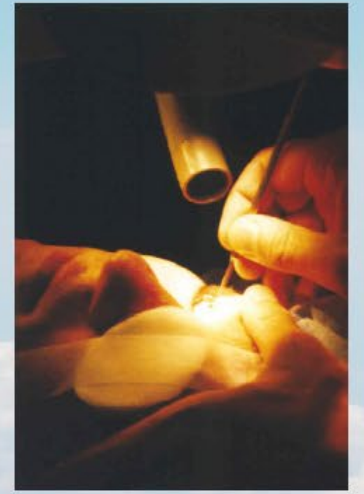
CVN-76 SHIPBOARD ISOLATION QUARANTINE (SIQ)

OPERATION, DESIGN, TEST PLAN, AND RESULTS

USN Laser Eye Surgery Retention Study

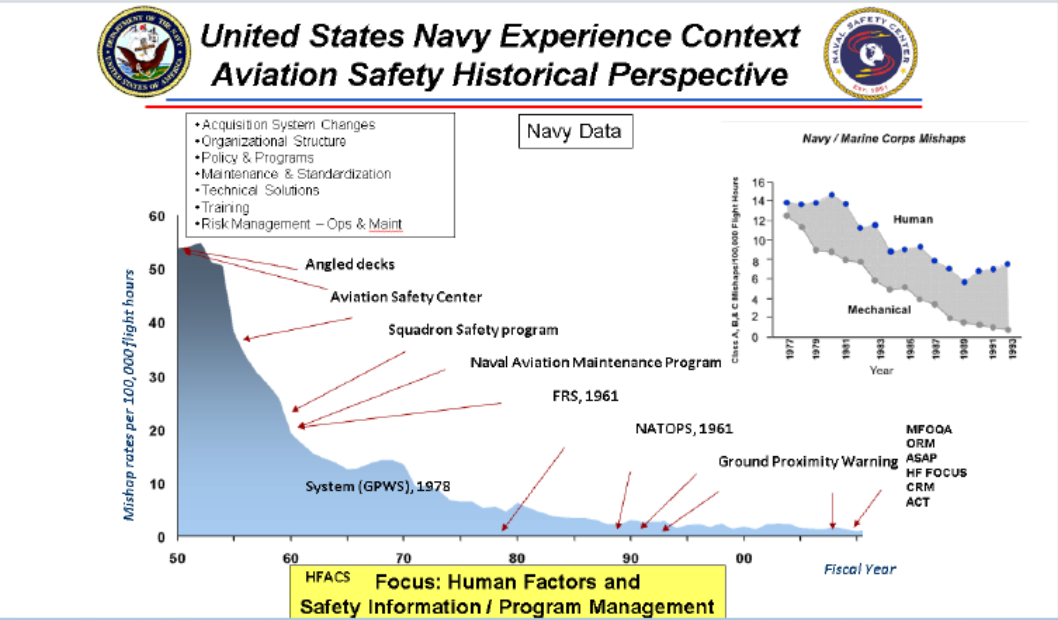
- UV-C Similar Level of Acceptance
- Contact Under "G"
- VISX Excimer Laser
  - Non Ionizing Radiation
  - Does Not Detach Electrons from Atoms / Molecules
- More Energy vs. UV-C

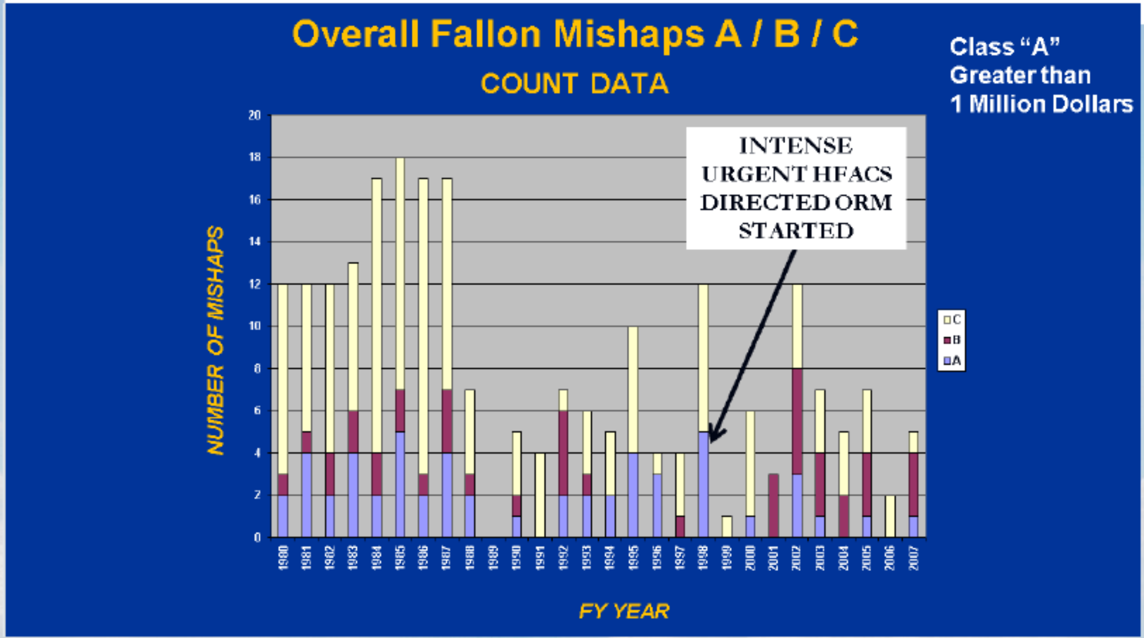


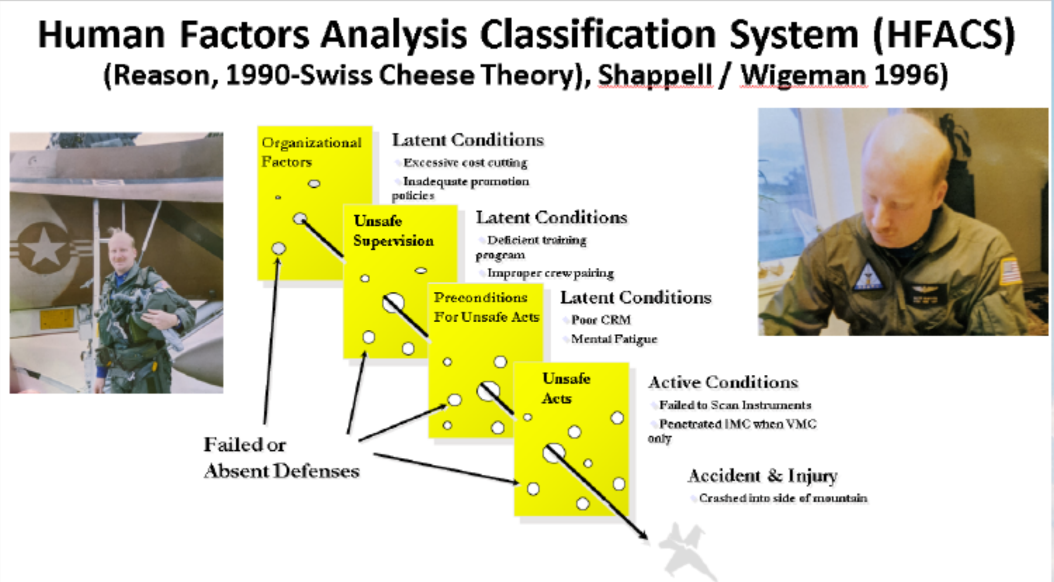


Fallon Nevada Naval Air Facility
Naval Strike and Air Warfare Center
NSAWC / TOPGUN 1996-2000


Fallon Nevada Naval Air Facility
Naval Strike and Air Warfare Center
NSAWC / TOPGUN 1996-2000
NAWDC
UNITED STATES NAVY FIGHTER WEAPONS SCHOOL

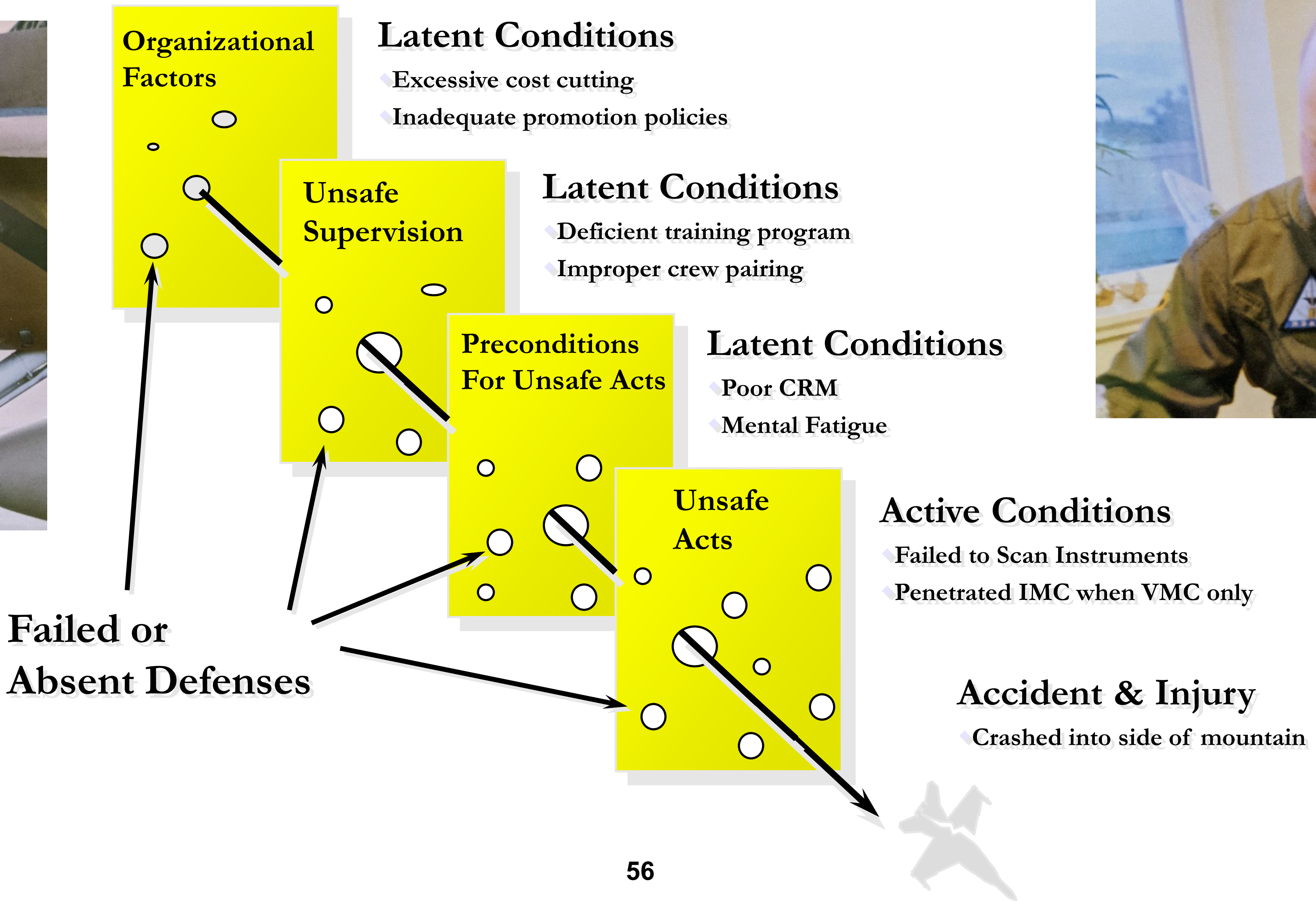

United States Navy Experience Context
Aviation Safety Historical Perspective
•Acquisition System Changes
•Organizational Structure
•Policy & Programs
•Maintenance & Standardization
•Technical Solutions
•Training
•Risk Management – Ops & Maint
Navy Data
Navy / Marine Corps Mishaps
Human
Mechanical
Year
Angled decks
Aviation Safety Center
Squadron Safety program
Naval Aviation Maintenance Program
FRS, 1961
NATOPS, 1961
Ground Proximity Warning
System (GPWS), 1978
MFOQA
ORM
ASAP
HF FOCUS
CRM
ACT
Mishap rates per 100,000 flight hours
Fiscal Year
HFACS
Focus: Human Factors and
Safety Information / Program Management

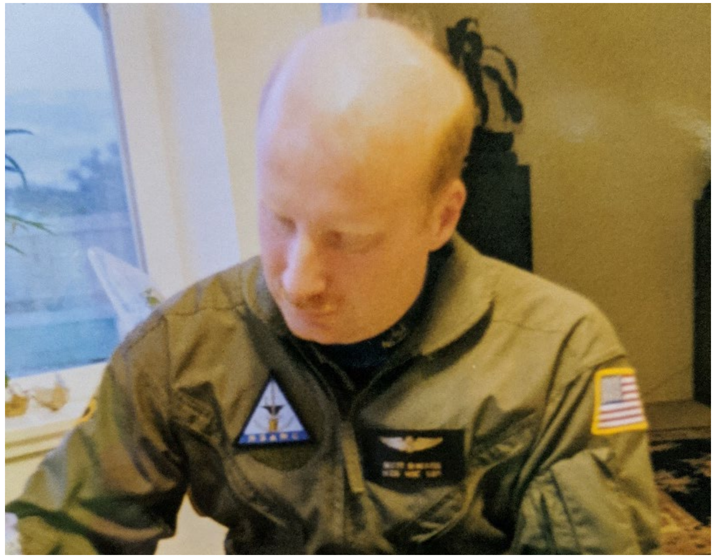

Overall Fallon Mishaps A / B / C
COUNT DATA
Class "A"
Greater than
1 Million Dollars
INTENSE
URGENT HFACS
DIRECTED ORM
STARTED
NUMBER OF MISHAPS
FY YEAR
C
B
A


Human Factors Analysis Classification System (HFACS)
(Reason, 1990-Swiss Cheese Theory), Shappell / Wigeman 1996)
Organizational Factors
Latent Conditions
Excessive cost cutting
Inadequate promotion policies
Unsafe Supervision
Latent Conditions
Deficient training program
Improper crew pairing
Preconditions For Unsafe Acts
Latent Conditions
Poor CRM
Mental Fatigue
Unsafe Acts
Active Conditions
Failed to Scan Instruments
Penetrated IMC when VMC only
Accident & Injury
Crashed into side of mountain
Failed or
Absent Defenses

Human Factors Analysis Classification System (HFACS)

(Reason, 1990, Shappell / Wigeman 1996)





Interventions

- Personal Navy Message from 00
- ORM In-Brief
- Raised Safety Awareness
  - CAPT Skip Lind, Cultural Workshops
  - Safety Surveys
  - Flight Surgeon / Safety Department Briefs

Credibility in Both Worlds?

- Dual Designated Naval Aviator and Flight Surgeon
  - 30 Mishap Investigations
  - 12 Ejection Seat Investigations
- Experience seeing patients
  - Osteopathic Family Practice and Aerospace Medicine Board Certified
  - The Difference a DO Makes
    - Bed Side Manner, Ability to Connect, Holistic approach
- Did We Make a Difference?

Naval Strike and Air Warfare Center
NSAWC / TOPGUN
Carrier Air Wing
Mishap Reduction

Kris M. Belland DO, MPH, MBA, MSS, FAsMA
CAPT MC USN (NA/FS/SWMDO)
In Partial Fulfillment of MPH requirements
Uniformed Services University of the Health Sciences

UNIFORMED SERVICES UNIVERSITY
of the Health Sciences

Results

- Statistical Analysis
  - Poisson Regression Method
  - STATA for Windows® (10.0) software

Results

	Incident Rate Ratio	Incident Rate Reduction	P-Value	Confidence Interval
TOTAL	0.73	27%	*0.017	0.57 – 0.95
Fleet	0.79	21%	0.073	0.61 – 1.02
NSAWC	0.16	84%	*0.015	0.04 – 0.70
Fleet * NSAWC	0.20	80%	*0.038	0.04 – 0.91

FLEET*NSAWC Incident Rate Ratio was 80% lower at NSAWC than the rest of the Fleet indicating a significantly greater reduction in mishaps.

Conclusion

- Significant Carrier Air Wing Mishap Reductions Occurred at NSAWC When Comparing 10 Years Pre HFACS ORM and 10 Years Post
  - Strong Case for Intervention Contribution
    - Temporal Relationship and Plausibility
- Potential Applicability / Crossover to World of Medicine
  - High Reliability Organizations (HRO)

Public Health Significance
Applicability to Medicine

Plenty Room for Improvement

- Still lose 1-2 DoD Mishap Lives / Week, 70-90% Human Errors
- Few Peer Reviewed Studies on Mishap Reduction Efforts

2000 To Err is Human: Building a Safer Health System

- Institute of Medicine Committee Study - Quality Health Care in America
- 98,000 Human Deaths/Yr due to Preventable Human Error = 268 PER DAY!
- 747 (max cap 660) = 148 Fully Loaded 747's Worth of People Lost / Yr!
- Approx Three Fully Loaded 747's per Week / Month / Year / Decade

High Reliability Organizations (HRO):

- Aviation, Nuclear Power, Special Operations…Not Medicine!

2016 Johns Hopkins Medicine, Department of Surgery 01 May

- 251,454 / year – Understatement as Outpatient deaths not included
- Greater than One 747 PER DAY!
  - #2 Cause of Death After Heart Disease

Carrier Air Wing Mishap Reduction Using a Human Factors Classification System and Risk Management

Kris M. Belland, Cara Olsen, and Russell Lawry

Belland KM, Olsen C, Lawry R. *Carrier air wing mishap reduction using a Human Factors Classification System and risk management.* **AviatSpac eEnvir onMed2010;81: 1028–32.**

Introduction: In 1998, the Navy's center of excellence for advanced air wing combat operations, namely the Naval Strike and Air Warfare Center (NSAWC), had a spike in Class A flight mishaps. The spike triggered an intense review of prior mishaps and current mishap-reduction practices using the Human Factors Analysis and Classification System (HFACS). The review resulted in NSAWC instituting a comprehensive multifactorial mishap reduction plan applying Operational Risk Management (ORM) precepts. ***Methods:*** This is a nonrandomized investigational study with use of a historical comparison population. The Class A mishap rate per flight hour covering 10 yr prior to the mishap reduction efforts was estimated and compared to the Class A mishap rate per flight hour for the 10 yr after implementation using Poisson regression. ***Results:*** Combined Fleet and NSAWC data shows a 27% reduction in mishap rate, but the 21% reduction in the Fleet alone was not statistically significant. The mishap reduction at NSAWC was statistically significant with an 84% reduction. Fallon carrier air wing mishap rates post-ORM mishap reduction efforts are approaching those seen in the Fleet, but are still elevated overall (3.7 vs. 2.4). ***Conclusion:*** The incidence rate ratio was 80% lower at Fallon than the rest of the Fleet, indicating a signifi-

making tool which includes risk assessment, decision making, implementation of risk controls (to accept, avoid, or mitigate risk), and continuous monitoring of outcomes. The goal of effective risk management is not so much to minimize particular errors and violations as to enhance human performance at all levels of the system(2,10).

HFACS is a way to study and categorize mishaps in order that interventions can be instituted to reduce human errors (8,11,13–15). HFACS is based on earlier research published in 1990 by Reason (9), who described active versus latent failures that humans made during nuclear accidents and shipboard mishaps. This theory was further developed by Shappell and Wiegmann to address aviation-specific mishaps (11,12). HFACS can be effectively used to assess risk as the first step of ORM (risk assessment) as well as a tool for continuous monitoring of outcomes (mishaps and mishap rates).

Aerospace Medicine Specialists Collegial Friendships
(Partial List)

- **International: Common relationship thread connecting many key ... s**
  - **AsMA:** Dr. Joe “Bugs” Ortega, Dr. Chuck DeJohn (D.O.), Dr. James DeV... ...ventek, Dr. Rui Pumbal, Dr. Ian Hosegood (ATM Committee), Dr. Paulo Alves, Dr. Diego Garci... ...os Salicrup and many others
    - Sen Jeff Merkley ltr in response draft legislation “Maintaining Imp... ...tance During Lengthy Epidemics (MIDDLE)
    - JAMA Article Air Transport Medicine Committee, IATA, IAMA ... Patient COVID-19 Info Page to be published
    - Mental Health working group completed draft Mental H... ...ition Paper, Stressors on Aircrew and Industry
  - **IAASM:** International Academy of Aviation and ... ...edicine
  - **EASA:** Dr. Cristian Panait
  - **IATA: International Air Transport As...** **Dr. David Powell,** (Rui and Ian also Members), more later
  - **ICAO:** **Dr. Johanna “Ansa” Jorda... ...k STAR!, more later**
    - **CAPSCA: Dr. Jarnail Singh (...** Dr. Nigel Dowdell, Dr. Carlos Salicrup, Dr. Diego Garcia, Dr. Paulo Alvez, and Too many to mention all
    - **CART:** Council Avi... ...very Taskforce, **Take Off Guidance**
    - **TFHIOA:** Tas... Health Issues Outbreaks in Aviation (Annex 9 Facilitation). The establishment and maintenance of Intern... ...ndards and Recommended Practices (SARP’s) as well as Procedures for Navigation (PANS) - fund... ...enets of Chicago Convention
  - **WH... ...ttedly Little to No internal Aerospace Medicine Expertise –**
    - **...y on Dr. Jordaan ICAO - CAPSCA / CART / TFHIOA / AsMA**
    - **ICAO Dr. Powell IATA**

TOO MANY AsM SME / ACCOMPLISHMENTS TO MENTION ALL!

ICAO International Civil Aviation Organization

Dr. Johanna "Ansa" Jordaan

- **193 Nations-Funded & directed** to support diplomacy & cooperation **in air transport** as signatory to Chicago Convention (1944)
  - **Core function** - Maintain expert administrative bureaucracy (the ICAO Secretariat) supporting these diplomatic interactions, and to research new air transport policy and standardization innovations as directed and endorsed by governments through the ICAO Assembly, or by the ICAO Council
    - Industry and civil society groups, and other concerned regional and international organizations
- **Soverign Rights**
- **Harmonization Goal and Challenge**


CONVENTION
ON
INTERNATIONAL
CIVIL AVIATION
DONE
AT CHICAGO
ON THE
7TH DAY OF DECEMBER
1944

CAPSCA Collaborative Arrangement for the Prevention and Management of Public Health Events in Civil Aviation

Dr. Johanna "Ansa" Jordaan

Established in 2006, Voluntary cross-sectorial, multi-organizational collaboration program managed by ICAO with support from WHO. It brings together international, regional, national and local organizations to combine efforts to improve preparedness planning and response to public health events that affect the aviation sector such as:

- **Communicable diseases (pandemic influenza, Zika, Ebola, Coronavirus); Disaster management (natural or man-made disasters);** Chemical events (nuclear power-plant accidents); Bioterrorism; Volcanic ash; Water and food safety; Hygiene and waste management; Drones in humanitarian operations. **Dr. Jarnal Singh, Dr. Claude Thibeault**

The objectives of CAPSCA are:

- **Public health protection, ensure safe and economically viable air transport, with minimal effect on international travel and trade (Chicago Convention);**
- **Capacity building**
- **Facilitate multi-sector collaboration and cooperation (civil aviation authorities, public health authorities, airports, air traffic services, airlines, immigration, customs, security and handling personnel) - a mechanism for pooling and sharing expertise, resources and best practices;**
- **Assess State readiness**

- **Meet Weekly: Products to CART, ICAO Counsel and Coordinate with WHO**

Applying Reason Swiss Cheese Theory to COVID-19 and CAPSCA Discussions

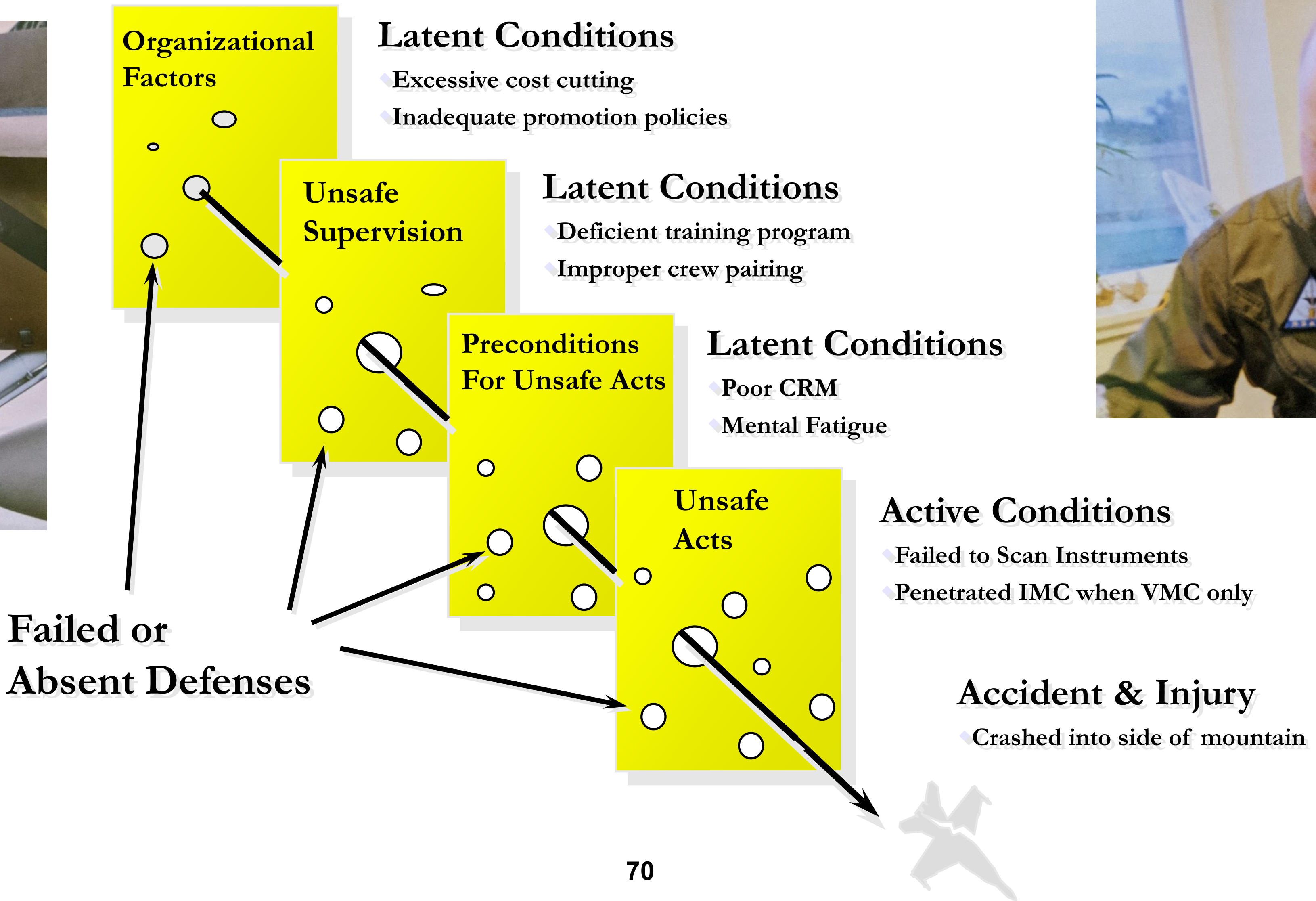
- CAPSCA discussing risk-mitigation and Aviation Layered Defense
  - COVID-19 Science Advisory Group
  - We were able to apply Aviation Risk Mitigation Strategies to COVID-19 and future Emerging Infectious Diseases
  - Evolutionary vs. Revolutionary

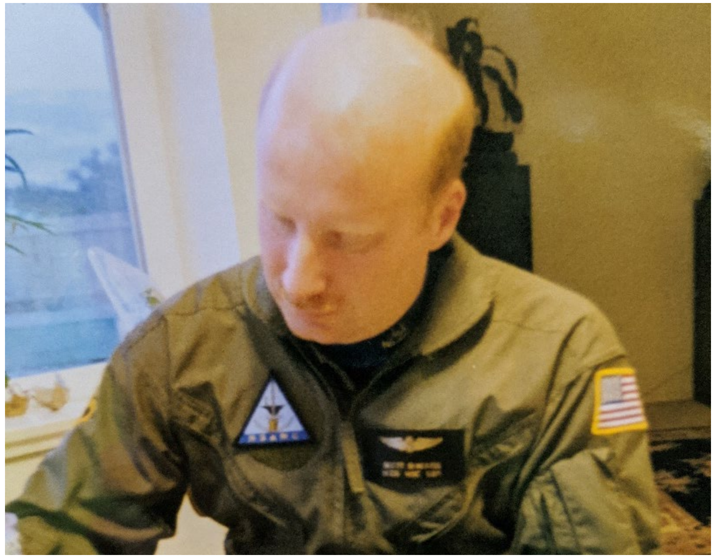
The Solution:

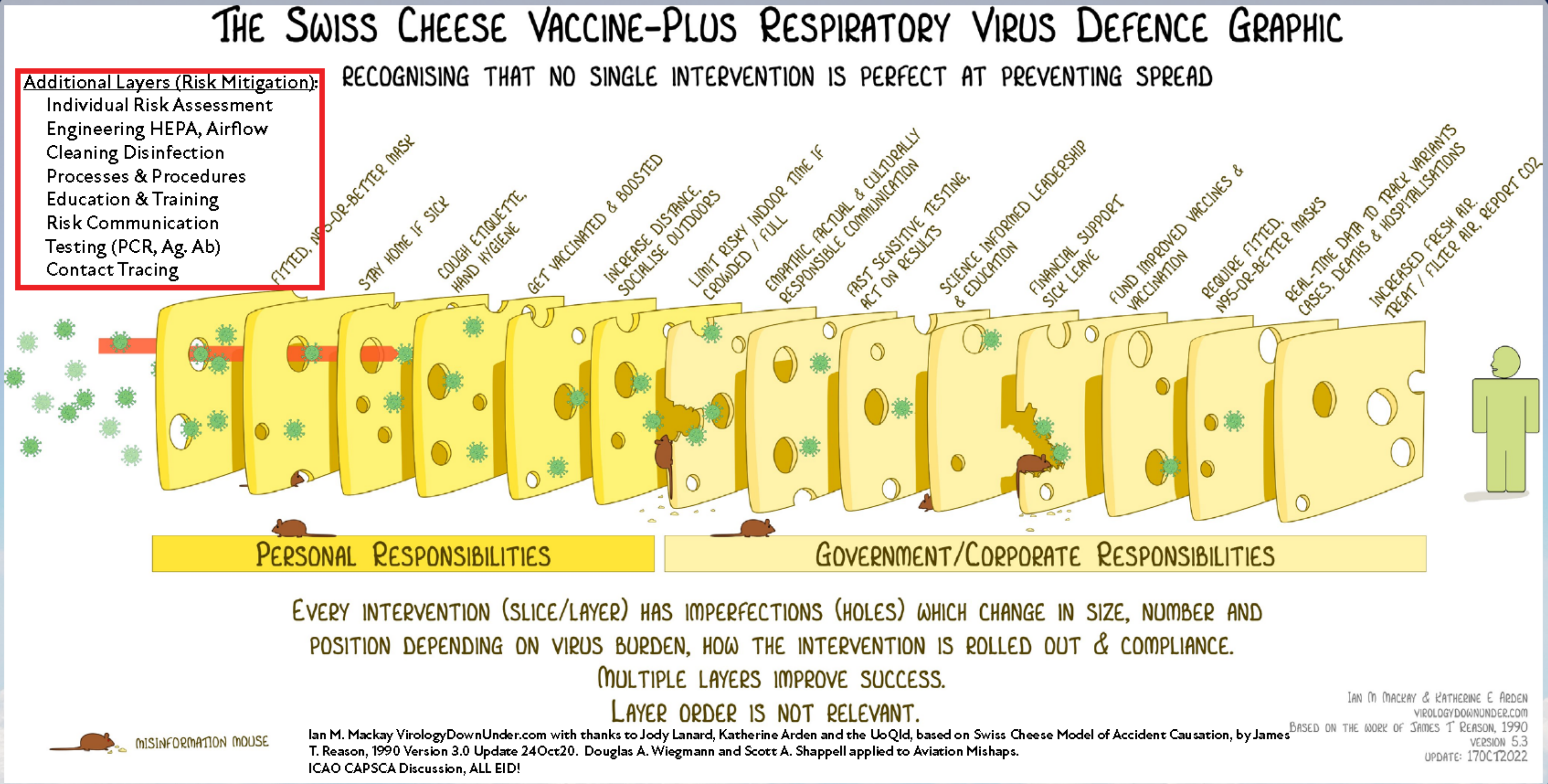
Multi Layered Risk Mitigation (Reason Swiss Cheese Theory) and UV-C as an Additional Layer

Human Factors Analysis Classification System (HFACS)

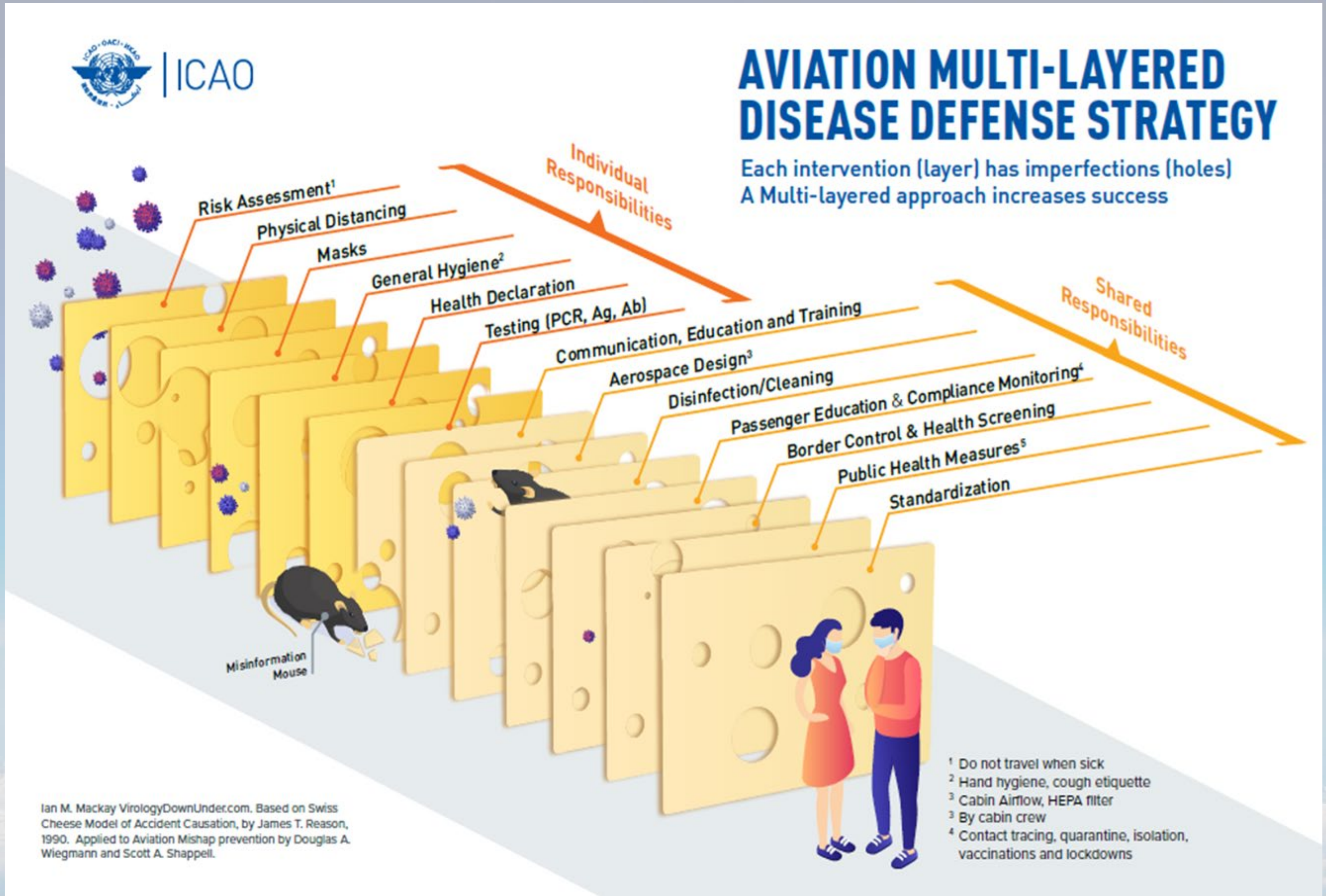
(Reason, 1990, Shappell / Wigeman 1996)






The Swiss Cheese Vaccine-Plus Respiratory Virus Defence Graphic
RECOGNISING THAT NO SINGLE INTERVENTION IS PERFECT AT PREVENTING SPREAD
Additional Layers (Risk Mitigation):
Individual Risk Assessment
Engineering HEPA, Airflow
Cleaning Disinfection
Processes & Procedures
Education & Training
Risk Communication
Testing (PCR, Ag, Ab)
Contact Tracing
FITTED, N95-OR-BETTER MASK
STAY HOME IF SICK
COUGH ETIQUETTE, HAND HYGIENE
GET VACCINATED & BOOSTED
INCREASE DISTANCE, SOCIALISE OUTDOORS
LIMIT RISKY INDOOR TIME IF CROWDED / FULL
EMPATHIC, FACTUAL & CULTURALLY RESPONSIBLE COMMUNICATION
FAST SENSITIVE TESTING, ACT ON RESULTS
SCIENCE INFORMED LEADERSHIP & EDUCATION
FINANCIAL SUPPORT SICK LEAVE
FUND IMPROVED VACCINES & VACCINATION
REQUIRE FITTED, N95-OR-BETTER MASKS
REAL-TIME DATA TO TRACK VARIANTS CASES, DEATHS & HOSPITALISATIONS
INCREASED FRESH AIR. TREAT / FILTER AIR, REPORT CO2
Personal Responsibilities
Government/Corporate Responsibilities
Every intervention (slice/layer) has imperfections (holes) which change in size, number and position depending on virus burden, how the intervention is rolled out & compliance.
Multiple layers improve success.
Layer order is not relevant.
Misinformation Mouse
Ian M. Mackay VirologyDownUnder.com with thanks to Jody Lanard, Katherine Arden and the UoQld, based on Swiss Cheese Model of Accident Causation, by James T. Reason, 1990 Version 3.0 Update 24Oct20. Douglas A. Wiegmann and Scott A. Shappell applied to Aviation Mishaps.
ICAO CAPSCA Discussion, ALL EID!
Ian M Mackay & Katherine E Arden
virologydownunder.com
Based on the work of James T Reason, 1990
Version 5.3
Update: 17OCT2022

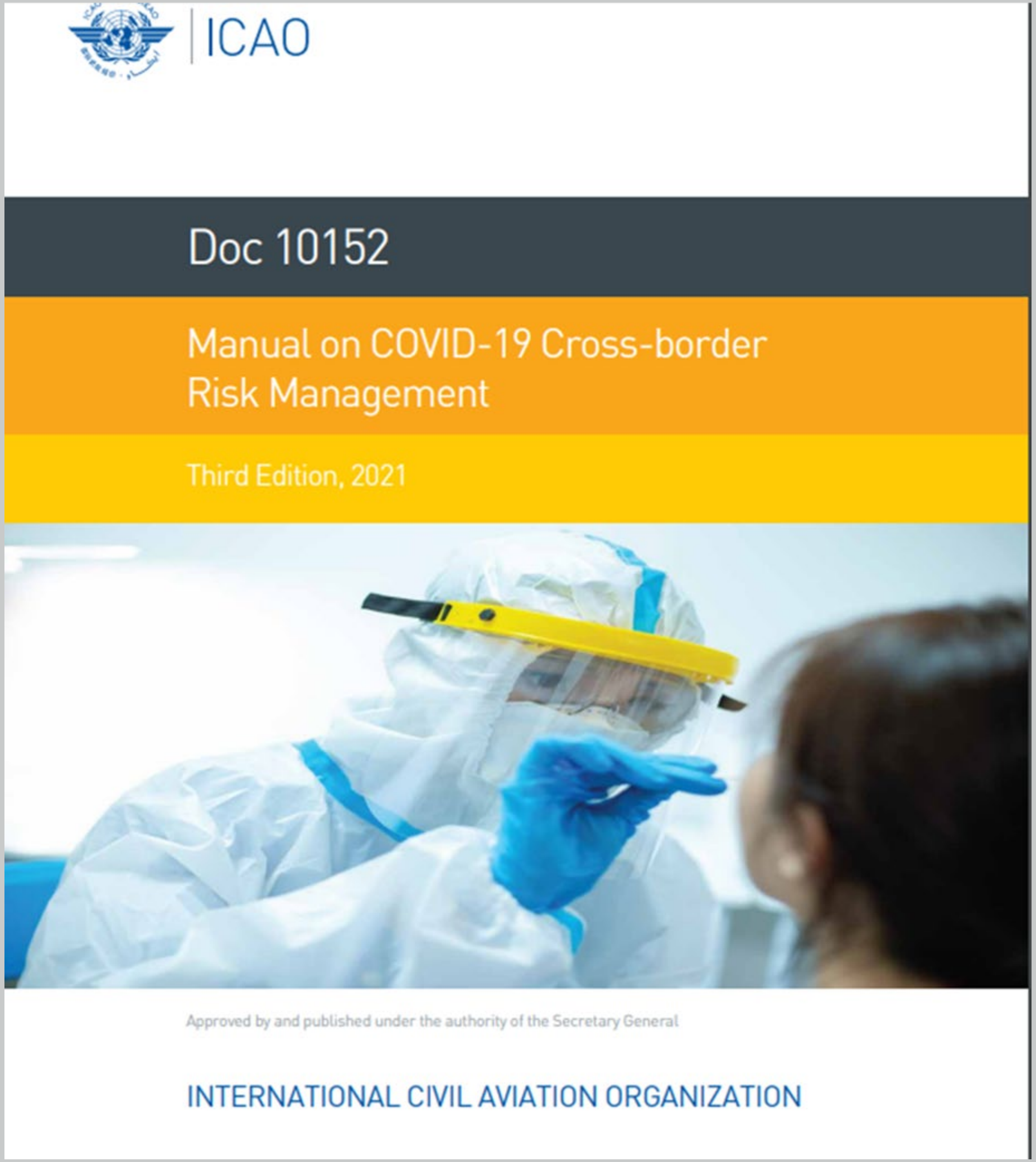
Apply HRO Aviation Mishap Reduction – (James Reason Swiss Cheese Model) To COVID-19 and Future Pandemics



Many ASM Members Directly Contributed

Testing and Cross-border Risk Management Measures Manual (3rd Ed) - 2021 ICAO Doc 10152

Chapter 1	Introduction
Chapter 2	General Risk Management Principles Applied to Air Transport
Chapter 3	Testing Vaccination and Cross-Border Risk Management Measures
Chapter 4	Implementation Model Multi-Layered Assessment and Mitigation
Chapter 5	Public Health Corridor
Chapter 6	Transitioning from Crisis Response to Routine Operations
	Primer
	Estimated Effectiveness of Individual Risk Mitigation Measures



What We Did Well: AsMS Responding and Educating

Wayne Gretzky, Hockey Player:
Skating to Where the Ice Hockey Puck Will Be

20MAY2021, First AsMA Webinar

COVID-19 Update

Chairs: Dr. Ortega, Dr. DeJohn

Dr. Kris Belland

Dr. "Ansa" Jordaan

Dr. David Powell

Dr. Susan Northrup

Dr. Rui Pombal

Dr. Aunon-Chancellor

Dr. Ian Hosegood

29AUG2021, Denver

No Panel- AsMA CNX

23May 2022, AsMA Reno

Controversies Lessons Learned

Dr. Pombal, Dr. Wilkinson

Dr. Rui Pombal

Dr. Wilkinson

Dr. "Ansa" Jordaan

Dr. David Powell

Dr. Susan Northrup

Dr. Kris Belland

22Sept 2022, ICAM Conference

Next Pandemic Top 10 Lessons

Dr. Northrup, Dr. Wilkinson

Dr. Kris Belland

Dr. David Powell

Dr. Rui Pombal

Dr. Ben Johnston

Dr. Johann Wium

Dr. Jonathan Monin

All ICAM constituent orgs rep

>50% IATA MAG

05/21/23 AsMA, New Orleans

World Health Organization

PRET
Preparedness and Resilience for Emerging Threats

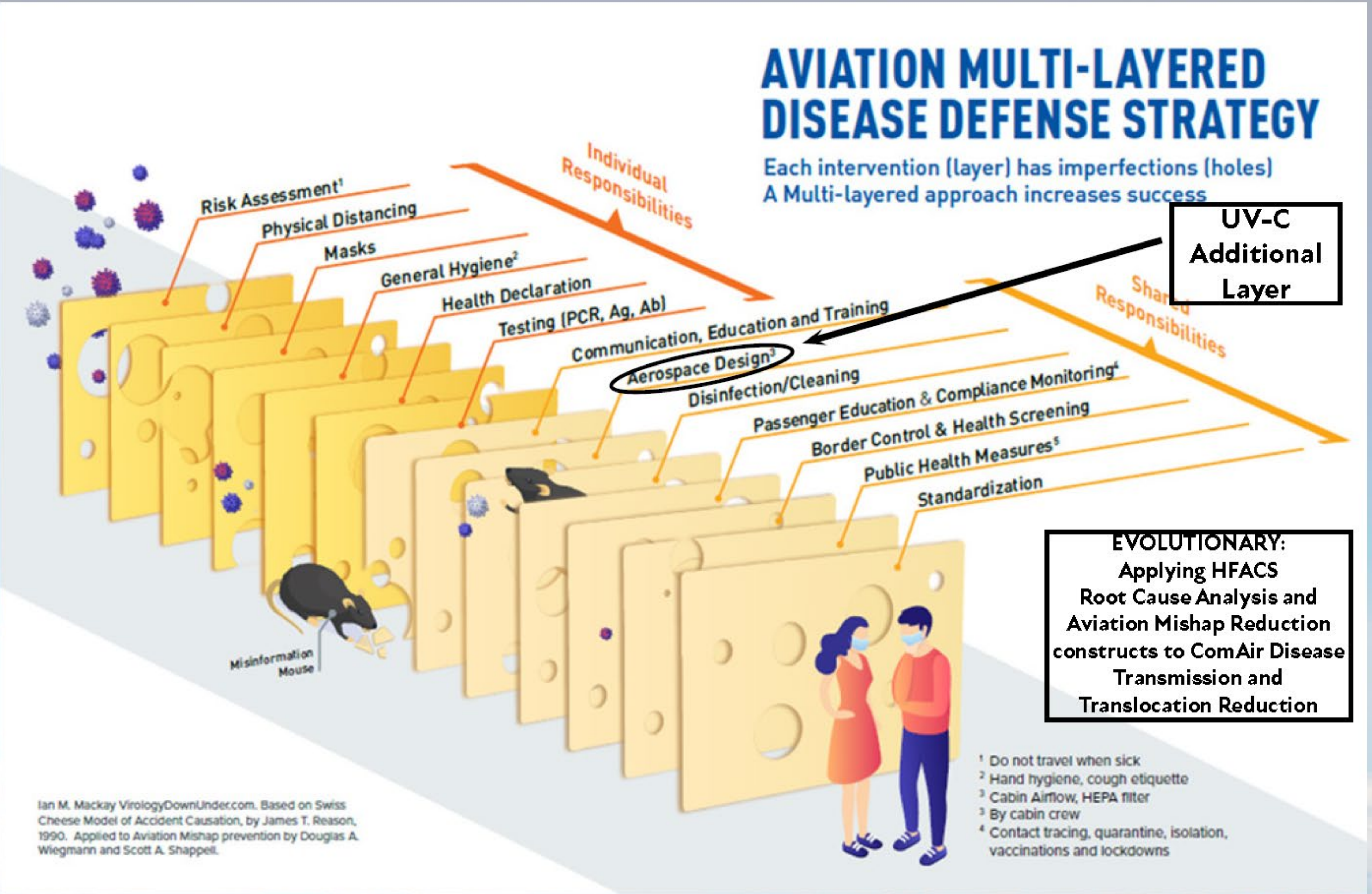
WORLD HEALTH ORGANIZATION
R-PEF PARTNER PRESENTATION

Commercial Airlines and Aerospace Medical Association (AsMA): Applying COVID-19 Lessons Learned in Preparation for the Next Pandemic

22 February 2024

Kris M. Belland, D.O. MPH, MBA, MSS, CPE, FAsHFA, FAOCOPM, FCAMA, FAsMA
President-Elect, American Osteopathic College of Occupational and Preventive Medicine
President / CEO: Aerospace Medicine Strategic Consultation, PLLC (AsMSC)

A New Risk Mitigation Layer
UV-C


AVIATION MULTI-LAYERED DISEASE DEFENSE STRATEGY
Each intervention (layer) has imperfections (holes)
A Multi-layered approach increases success
UV-C Additional Layer
Individual Responsibilities
Shared Responsibilities
Risk Assessment[1]
Physical Distancing
Masks
General Hygiene[2]
Health Declaration
Testing (PCR, Ag, Ab)
Communication, Education and Training
Aerospace Design[3]
Disinfection/Cleaning
Passenger Education & Compliance Monitoring[4]
Border Control & Health Screening
Public Health Measures[5]
Standardization
Misinformation Mouse
EVOLUTIONARY: Applying HFACS Root Cause Analysis and Aviation Mishap Reduction constructs to ComAir Disease Transmission and Translocation Reduction
1 Do not travel when sick
2 Hand hygiene, cough etiquette
3 Cabin Airflow, HEPA filter
3 By cabin crew
4 Contact tracing, quarantine, isolation, vaccinations and lockdowns
Ian M. Mackay VirologyDownUnder.com. Based on Swiss Cheese Model of Accident Causation, by James T. Reason, 1990. Applied to Aviation Mishap prevention by Douglas A. Wiegmann and Scott A. Shappell.

Bringing Controlled Sunlight Indoors

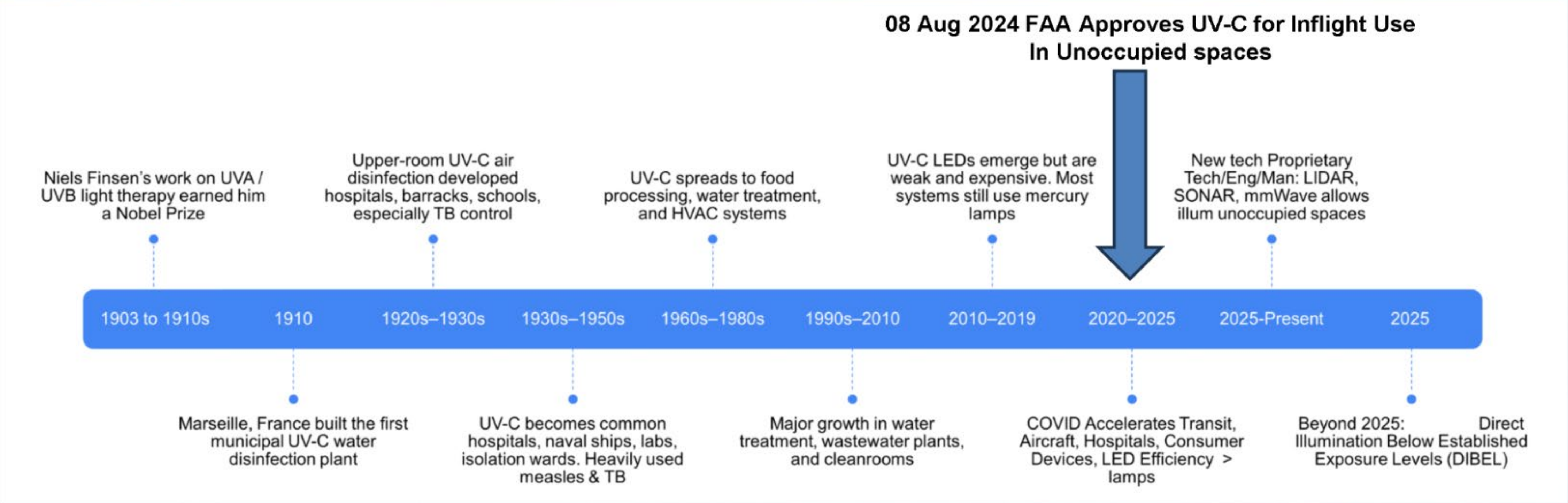
Safe and Effective, Over 50 years of Hospital / School Use

Reduces Transmission / Translocation of Disease

Cutting Edge Technology, Engineering and Manufacturing

We Can Control Air Flow, Humidity, Compression, Pressure and now Light

BLUF: UV-C Used for 115 Years!
Internationally, 90-plus for Air Disinfection



The Dose Makes the Poison

Use Science, Engineering and Technology to Tame: Dose (Energy + Wavelength + Time) = Effect

Aerospace Engineering
- Wind Flow over a lifting wing
- PV = NRT
- Flight (Air and Space)

Fluid Dynamics / Hydraulic fluid
- Actuators

Oxygen / Nitrogen
- OBOGS

Why Not Light Energy? Sunlight
- UVA, UVB, UVC

Foundational Tox Concept Paracelsus (1493-1541):

- "All things are poison, and nothing without poisonl only the dose permits something not to be poisonous."
- Any substance can be toxic at a high enough dose
- Tox substances are often harmless/therapeutic at low enough levels:
  - Water: too much leads to fatal water intoxication
  - Botulinum toxin: Used safely in botox treatments
  - Radiation, oxygen, vitamins, etc.

Modern Risk Assessment and Safety Margins

Low or Insufficient	Beneficial Amount	High or Too Much
No photosynthesis	Life/Photosynthesis	Glare / HA
No or low effects	Healthy Vit D, Circadian Rhythm	Sunburn / Heatstroke
Visibility Decreased (NVG)	Tx Psoriasis, Eczema, Vitiligo	Dehydration
Sleep Easier	Sight PRK / LASIK / SMILE	Cancer
Seasonal Affective Disorder	Antibacteria Disinfection	Premature Aging
Death	Sterilization Disinfection	Eye / Skin Damage
	Engineered Effects	Immune Suppresion
	Cross Linking	DNA / RNA Damage
	Teeth Whitening	Death

The Solution: UVC is Physics, Not Guesswork

UVC light physically disrupts DNA/RNA or protein, inactivating pathogens with very broad applicability

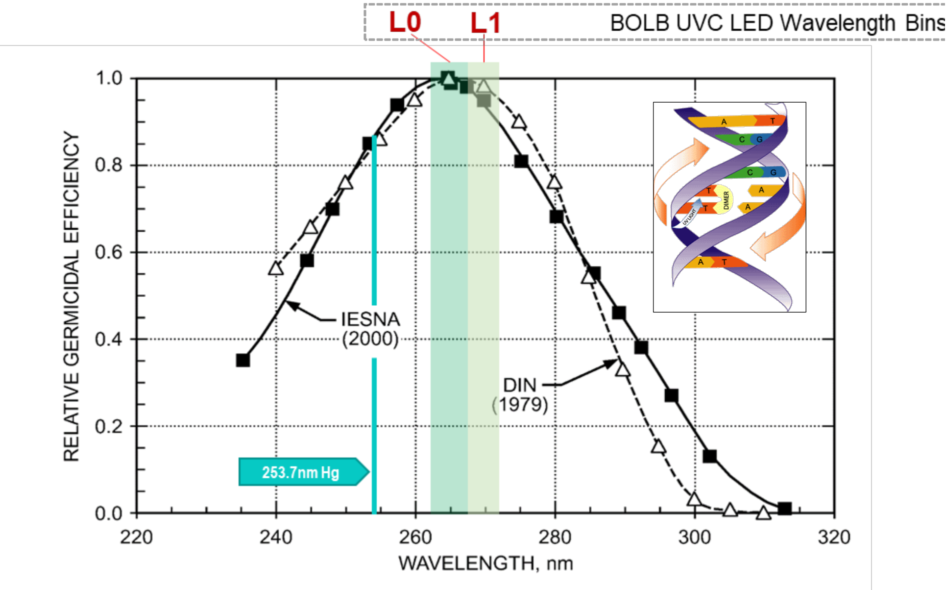


Fig. 1 Relative UV-C Germicidal Efficiency

Reference: ASHRAE HVAC Handbook Chapter 17 page 1

A Physics -Based, Non -Evolutionary Defense That Pathogens Cannot Evade

01

Mechanism

UVC photons physically break DNA/RNA molecular bonds, making replication impossible. Efficacy is determined by dose and geometry, not by a microbe's strain.

02

Proven & Universal

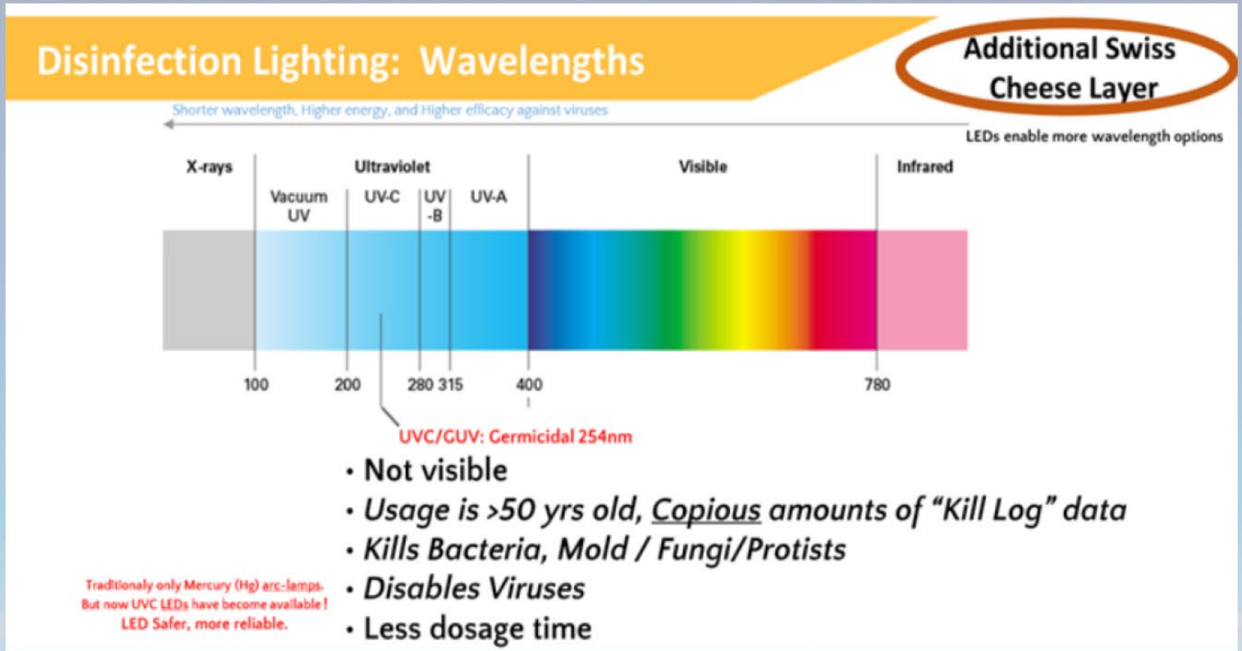
This method is tested and proven to eliminate a wide range of viruses, bacteria, and molds, including SARS-CoV-2, H1N1, and MRSA. It is practically universal in efficacy against micro-organisms.

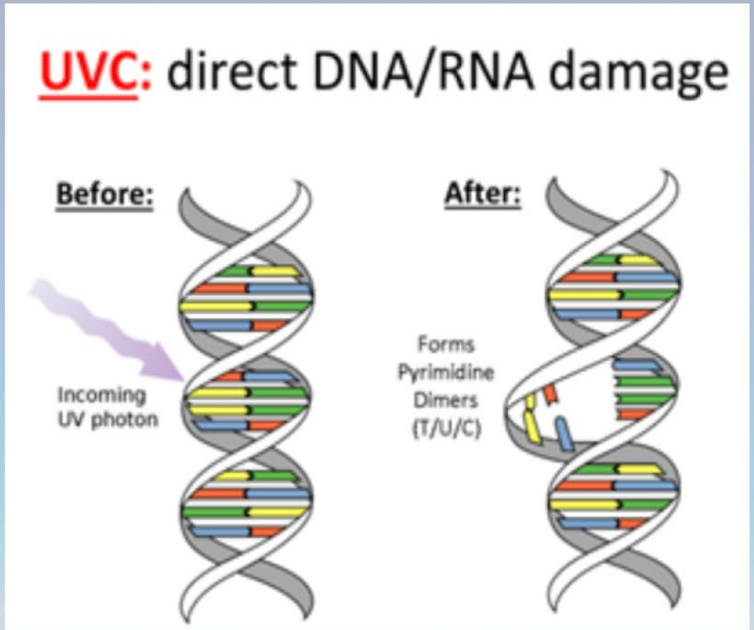
No "Mutation Chase"

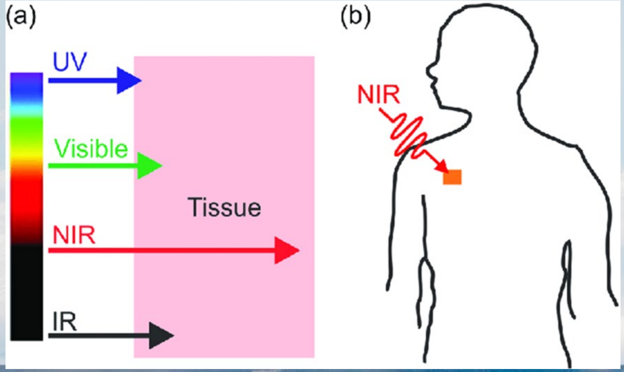
03

Pathogens can't "mutate away" from UVC photophysics. We counter physical margins with engineering (dose, airflow), not by racing to develop a new molecule.

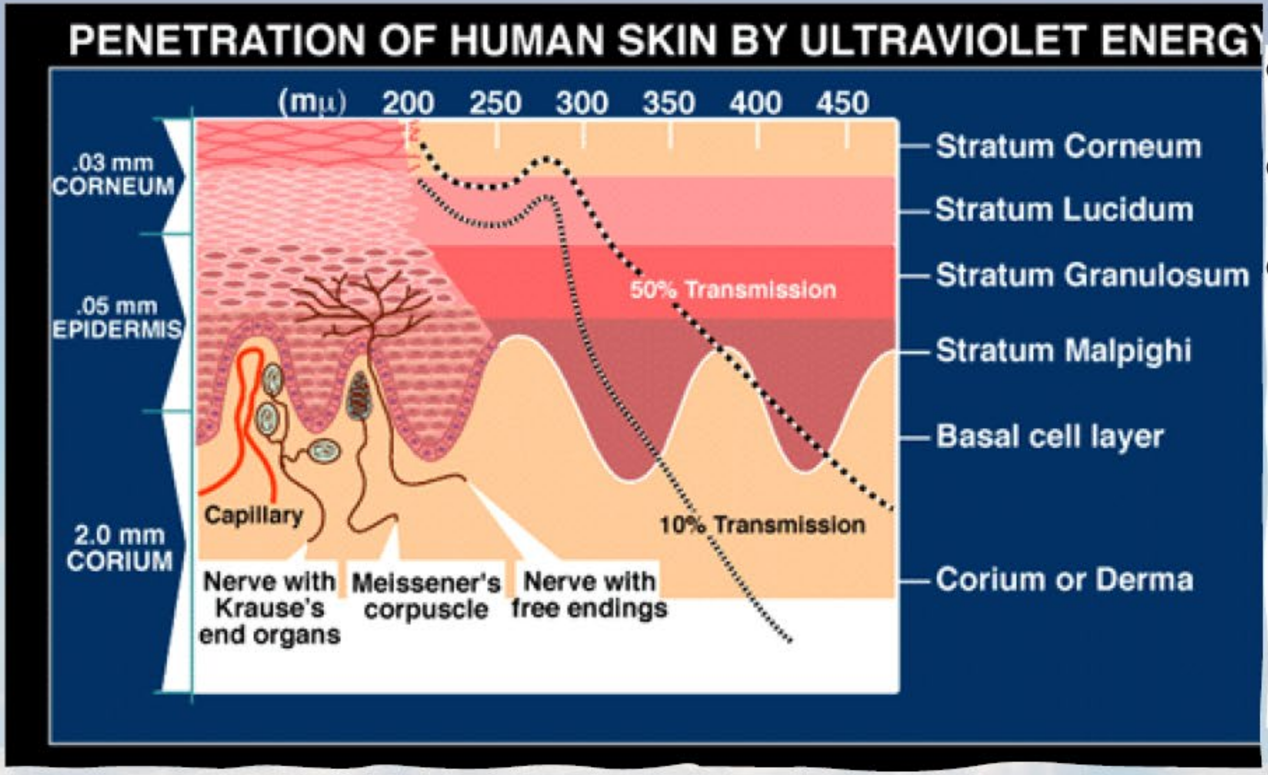
Applying HRO Aviation Mishap Reduction – (James Reason Swiss Cheese Model) To COVID-19 & Future Pandemics

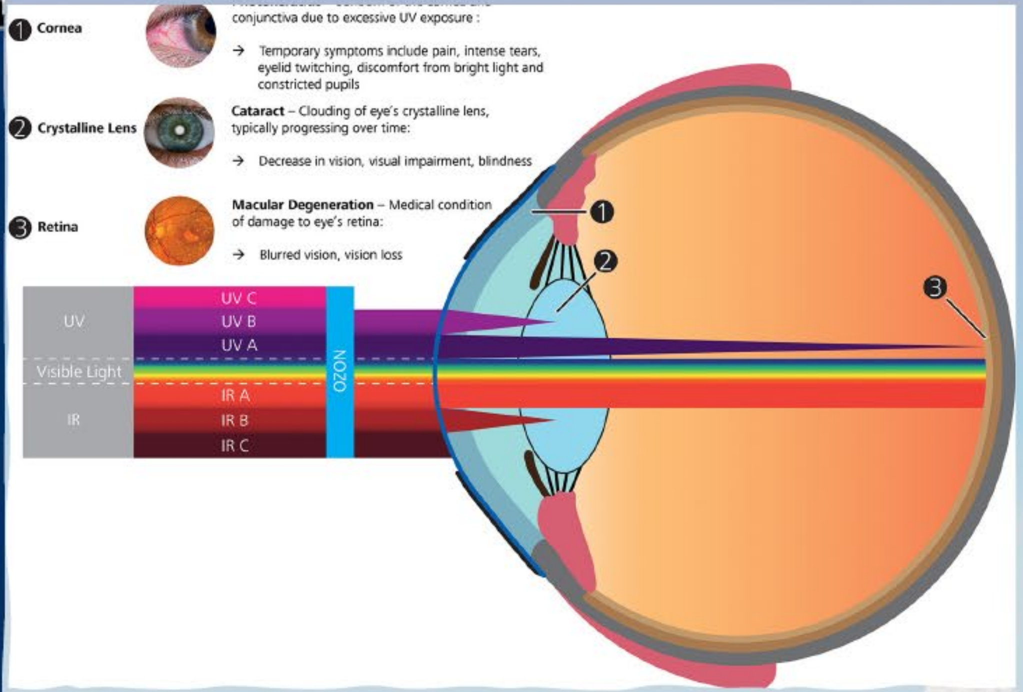






Depth of UV-C Penetration





Classifications of DNA/RNA Virus Families:

Virus classification (the Baltimore system)

Stephen P. Glaudel 2-May-2020; rev 7-Aug-2020

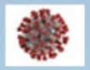
All Viruses: Good UV-C Efficacy
BEST TO ADDRESS EID / MUTATIONS / Next Pandemic
Faster than making vaccines!

I: dsDNA viruses
(e.g. Herpesviruses, Poxviruses, Polyomaviruses, Adenoviruses, Papillomaviruses (e.g. 'warts').
Double-strand DNA viruses.

II: ssDNA viruses (+ strand or "sense") DNA
(e.g. Anelloviridae, Circoviridae, & Parvoviridae)
Single-strand DNA viruses.

'Non-Enveloped' Viruses (i.e. some UVA Efficacy on these)

III: dsRNA viruses
(e.g. Reoviruses, including the Rotaviruses)
Double-strand RNA viruses contain from one to a dozen different RNA molecules, each coding for one or more viral proteins.



IV: (+)ssRNA viruses (+ strand or sense) RNA
(e.g. Coronaviridae, Flaviviridae (incl. Hepatitis-C, West-Nile, Dengue, Zika), Arteriviridae, Astroviridae, Togaviridae, Picornaviridae – Enteroviruses (incl. Rhinovirus & Polio), Caliciviridae – Norovirus).
Positive-sense ssRNA viruses have their genome directly utilized as mRNA, with host ribosomes translating it into a single protein that is modified by host and viral proteins to form the various proteins needed for replication. One of these proteins is RNA-dependent RNA polymerase (**RdRP**, or **'RNA replicase'**), which copies the viral RNA to form a double-stranded replicative form. In turn, this dsRNA directs the formation of new viral RNA.

V: (−)ssRNA viruses (negative−strand or 'anti-sense') RNA
(e.g. Orthomyxoviridae - Influenza, Arenaviridae, Paramyxoviridae, Hantaviridae, Filoviridae, Rhabdoviridae - Rabies, Pneumoviridae (e.g. Human Syncytical Virus)).
Negative-sense ssRNA viruses must have their genome copied by an **RNA replicase** to form positive-sense RNA. This means that the virus must bring along with it the enzyme RNA replicase. The positive-sense RNA molecule then acts as viral mRNA, which is translated into proteins by the host ribosomes.

Constantly Mutating, Vaccines 'at-risk'

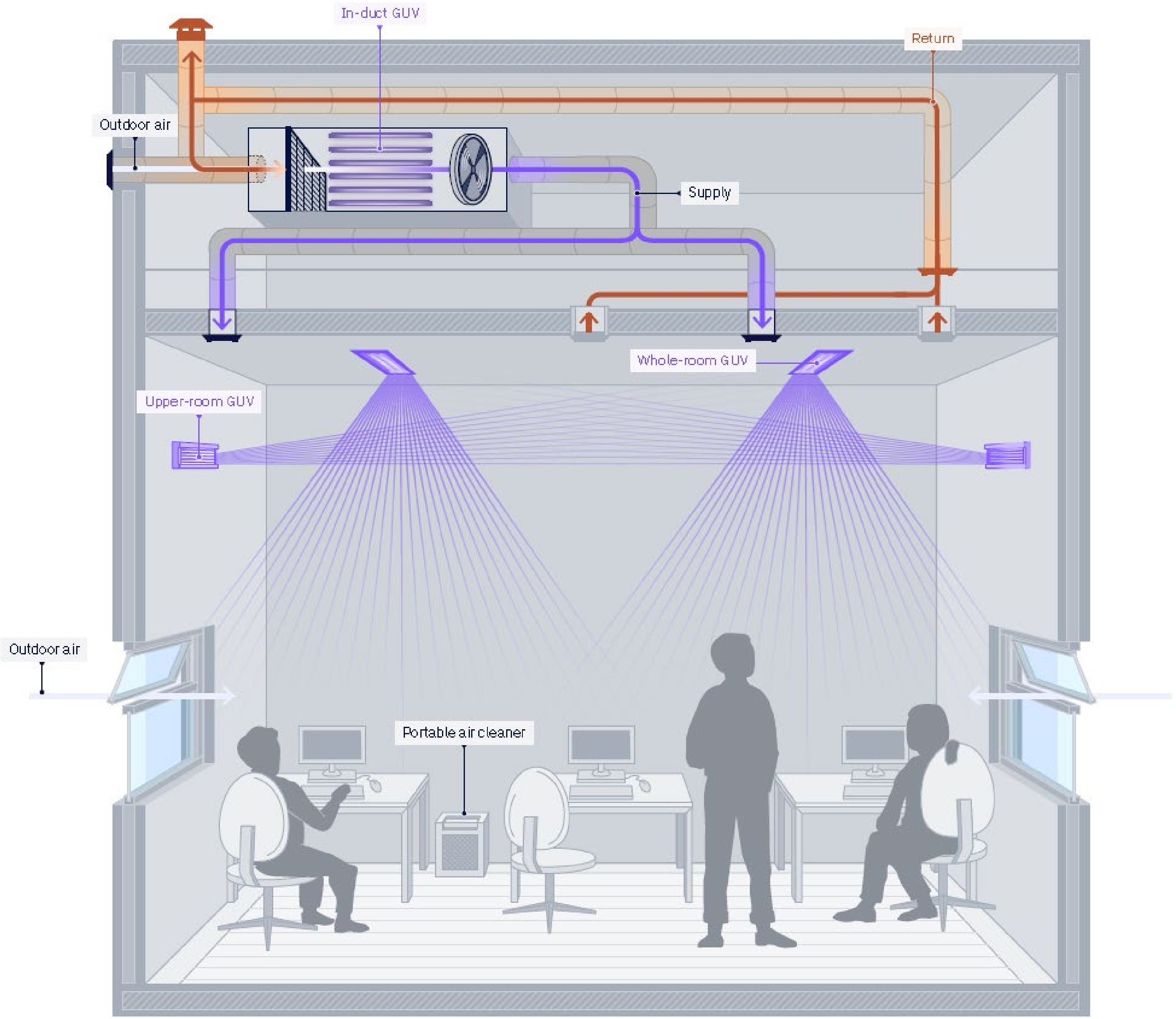
VI: ssRNA-RT viruses (positive- strand or 'sense') RNA with DNA intermediate in life-cycle
(**Retroviruses** such as HIV & HTLV)
Retroviruses have a single-stranded RNA genome but, in general, are NOT considered RNA viruses because they use DNA intermediates to replicate. **Reverse transcriptase**, a viral enzyme that comes from the virus itself after it is uncoated, converts the viral RNA into a complementary strand of DNA, which is copied to produce a double-stranded molecule of viral DNA. After this DNA is integrated into the host genome using the viral enzyme **Integrase**, expression of the encoded genes may lead to the formation of new virions.

VII: dsDNA-RT viruses DNA with RNA intermediate in life-cycle
(e.g. Hepadnaviruses)

'Common-Cold': Rhinoviruses (~70%), Coronaviruses (~15%), Adenoviruses (~5%), Pneumoviruses (~5%), Influenza viruses, ...

FIGURE 1.5. Picture from the Wells' study using GUV in the upper room portion of school classrooms[35]. The metallic chandelier holds UV lamps. These lamps point upwards, irradiating the unoccupied upper section of the room, relying on air circulation to move pathogens up and clean air down.

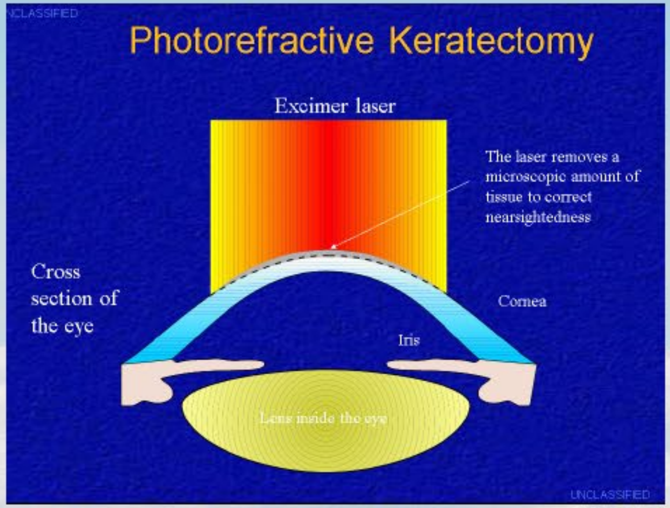
Germicidal UV applications

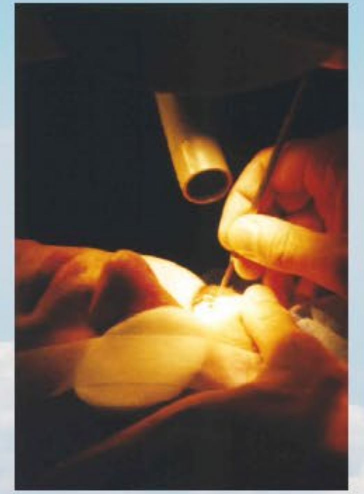


US FAA Challenge: AMA or AsMA Review and Support of UV-C

USN Laser Eye Surgery Retention Study

- UV-C Similar Level of Acceptance
- Contact Under "G"
- VISX Excimer Laser
  - Non Ionizing Radiation
  - Does Not Detach Electrons from Atoms / Molecules
- More Energy vs. UV-C





Recent Aerospace Medicine & Human Performance UV-C Publications

Safety and Effectiveness Assessment of Ultraviolet-C Disinfection in Aircraft Cabins

Kris Belland; Diego Garcia; Charles DeJohn; Gary R. Allen; William D. Mills; Stephen P. Glaudel

INTRODUCTION: Aircraft cabins, susceptible to disease transmission, require effective strategies to minimize the spread of airborne diseases. This paper reviews the James Reason Swiss Cheese Theory in mitigating these risks, as implemented by the International Civil Aviation Organization during the COVID-19 pandemic. It also evaluates the use of airborne ultraviolet-C (UV-C) light as an additional protective measure.

METHODS: Our approach involved a thorough literature review by experts and a detailed risk-vs.-benefit analysis. The review covered existing research to understand the scientific foundation, while the analysis used established techniques to assess the impact of influenza and COVID-19 in terms of infections, deaths, and economic costs.

RESULTS: Integrating UV-C light in aircraft cabins, when applied with appropriate scientific understanding and engineering safeguards, has the potential to reduce in-flight disease transmission. This additional mitigation strategy can work synergistically with existing measures.

DISCUSSION: The research and risk-vs.-benefit analysis present strong evidence for the safety and effectiveness of continuous UV-C disinfection in aircraft cabins. It suggests that UV-C light, maintained below exposure limits, can be a valuable addition to existing measures against disease transmission during flights.

KEYWORDS: UV-C disinfection, ultraviolet-C, UV-C, aircraft, sanitization, airborne pathogen, disease disinfection, disease transmission, disease translocation, risk mitigation strategy.

Belland K, Garcia D, DeJohn C, Allen GR, Mills WD, Glaudel SP. ***Safety and effectiveness assessment of ultraviolet-C disinfection in aircraft cabins.*** **Aerosp Med Hum Perform. 2024; 95(3):147–157.**

The use of ultraviolet (UV) light to decrease in-flight disease transmission has received attention as a potential measure to reduce the spread of infectious diseases, particularly during the COVID-19 pandemic. This paper is prepared in support of adding UV-C light-emitting diode (LED) lighting aboard aircraft to reduce the transmission and translocation of airborne diseases. Infectious diseases claim millions of lives globally each year.[12,57,58] The World Health Organization (WHO) addresses this situation as a major global health challenge, especially for low- and middle-income countries.[57] Many respiratory pathogens, including severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2), influenza, respiratory syncytial virus, common colds, tuberculosis (TB), etc., are transmitted via three principal mechanisms: 1) inhaling infectious airborne droplets (from unshielded coughs or sneezes) before they fall to the floor (within 1–2 m);[40,42,53] 2) touching contaminated surfaces (fomites) before the pathogen decays; and 3) exposure to infected persons even by simple breathing or talking, which can produce aerosols that linger for minutes to hours and travel much farther than the 1–2 m traveled by droplets.[8,9,53] Early in COVID-19 pandemic, it was recognized that aerosols are a significant route of infection in indoor environments.[31] All pathogens that possess either DNA or RNA—viruses, bacteria, fungi, protozoa—are susceptible to UV disinfection.[1] This by no means suggests that UV-C airborne use is the only risk-mitigation strategy, but that it supplements other multiple layers including high efficiency particulate air (HEPA) filters, air flow, outside air ventilation, masks, vaccines,

From AeroClenz Inc., Bonita Springs, FL, United States.

This manuscript was received for review in August 2023. It was accepted for publication in December 2023.

Address correspondence to: Dr. Kris Belland, D.O., M.P.H., 1804 Kinsale Dr, Keller, TX 76262, United States; kris.belland@gmail.com.

DOI: https://doi.org/10.3357/AMHP.6350.2024

Recent Aerospace Medicine & Human Performance UV-C Publications

Methods of Aircraft Disinfection to Reduce Airborne Infectious Disease Transmission

Charles DeJohn; Kris Belland; Diego Garcia

INTRODUCTION: This review aims to assess the safety and efficacy of the use of ultraviolet-C technology for disinfecting aircraft and compare it with other methods currently used in the aviation industry.

METHODS: The authors conducted a comprehensive, systematic review of the literature on disinfection of aircraft. Independent double reviews were conducted and consultations with a third reviewer were performed in the event of disagreements.

DISCUSSION: Although infectious disease transmission in aircraft cabins has been shown to be low, a recent study has described reports of passengers on commercial aircraft infecting other passengers. Incorporating ultraviolet-C technology into aircraft disinfection protocols holds the potential to add a significant level of risk mitigation to effectively reduce disease transmission and enhance safety.

KEYWORDS: pathogen, transmission, disinfection, risk mitigation, ultraviolet-C, UV-C.

DeJohn C, Belland K, Garcia D. *Methods of aircraft disinfection to reduce airborne infectious disease transmission.* Aerosp Med Hum Perform. 2024; 95(12):930–936.

Previous studies have documented the occurrence of various respiratory illnesses, including influenza and severe acute respiratory syndrome (SARS) on aircraft.[1,2] While the transmission of infectious diseases within aircraft cabins is generally low, instances of passengers infecting fellow travelers on commercial flights have been documented, and a 2023 study found strong evidence of in-flight transmission.[3]

One promising approach is the incorporation of ultraviolet-C (UV-C) technology into aircraft disinfection protocols. UV-C is ultraviolet (UV) radiation with wavelengths between 100–280 nm. This technology has the potential to significantly mitigate the risk of disease transmission when proper optical engineering controls are in place. The optical engineering system should be designed with multiple redundancies to provide reliable emitter processing integrity, employing the use of multiple redundant sensor-types, such as ultrasound and infrared ranging. The application of UV-C light can potentially deactivate pathogens that might be introduced if an infected passenger boards the aircraft following episodic disinfection between flights. While further research is needed to fully endorse continuous UV-C utilization on aircraft, this review suggests that combining UV-C disinfection with proper optical engineering controls, together with other methods, could contribute to maintaining a safer aircraft cabin environment.

The objective of this study is to conduct a comprehensive literature review to compare the safety and effectiveness of different methods currently used for disinfecting aircraft and explore the potential benefits and limitations of using UV-C technology as an adjunct to current methods of aircraft disinfection.

METHODS

A systematic search was conducted to identify relevant studies on the efficacy and safety of different methods of aircraft disinfection, with an emphasis on UV disinfection. Multiple electronic databases, including Google Scholar, PubMed, Medline,

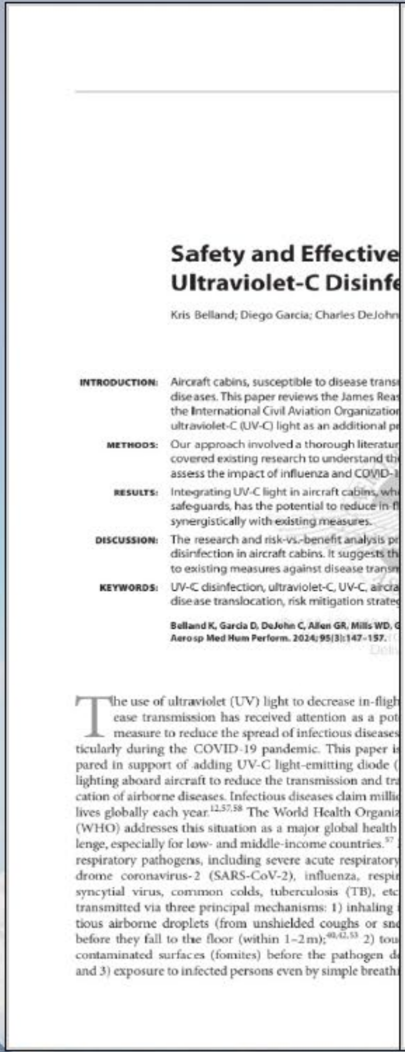
From DeJohn AeroMed Research, LLC, Oklahoma City, OK; Aerospace Medicine Strategic Consultation, PLLC, Keller, TX; and Embry Riddle University, Daytona Beach, FL, United States.

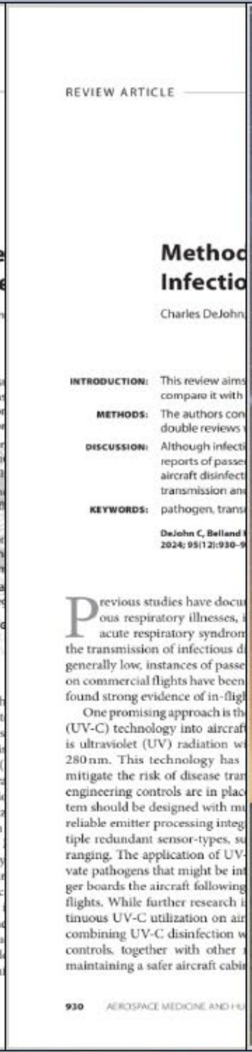
This manuscript was received for review in July 2023. It was accepted for publication in August 2024.

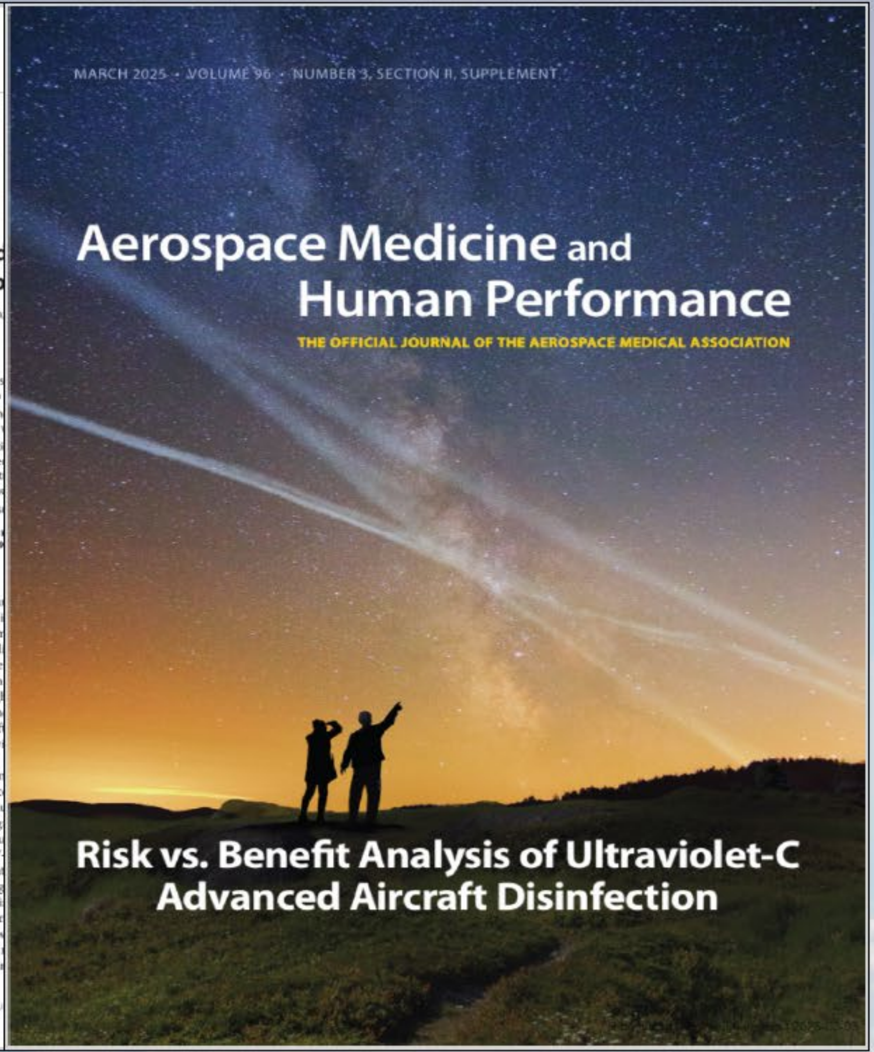
Address correspondence to: Dr. Charles DeJohn, DeJohn Aeromed Research, Oklahoma City, OK, United States; chuck@dejohnaeromed.com.

DOI: https://doi.org/10.3357/AMHP.6348.2024

Recent Aerospace Medicine & Human Performance UV-C Publications







Inactivation of Pathogens in Air Using Ultraviolet Direct Irradiation Below Exposure Limits

- Risk analysis Combined Flu / COVID-19 inflight infections
  - Over 3 million cases, 10 thousand deaths and 200 billion dollars
- One estimate of the COVID-19 Pandemic Cost $16 trillion
  - Includes the economic cost of premature deaths at 4.4 trillion
  - Long-term complications at 2.6 trillion
  - Mental health impairment in the general population at 1.6 trillion
  - Lost productivity at 7.6 trillion
- UV-C Addition Increasing ComAir Equivalent Air exchange rate (from 30 to 120)
- Reducing residual airborne pathogen concentration by up to:
  - 96% on the ground (equivalent to an increase of 5 air exchanges per hour)
  - 89% during cruise (equivalent to 15 air exchanges per hour)
  - **Potential to reduce Transmissions / Infections / Deaths by over 80%**


Distribution Statement A: Approved for public release; distribution is unlimited
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Breaking Through Intelligence Silos for Domestic Emergency Management
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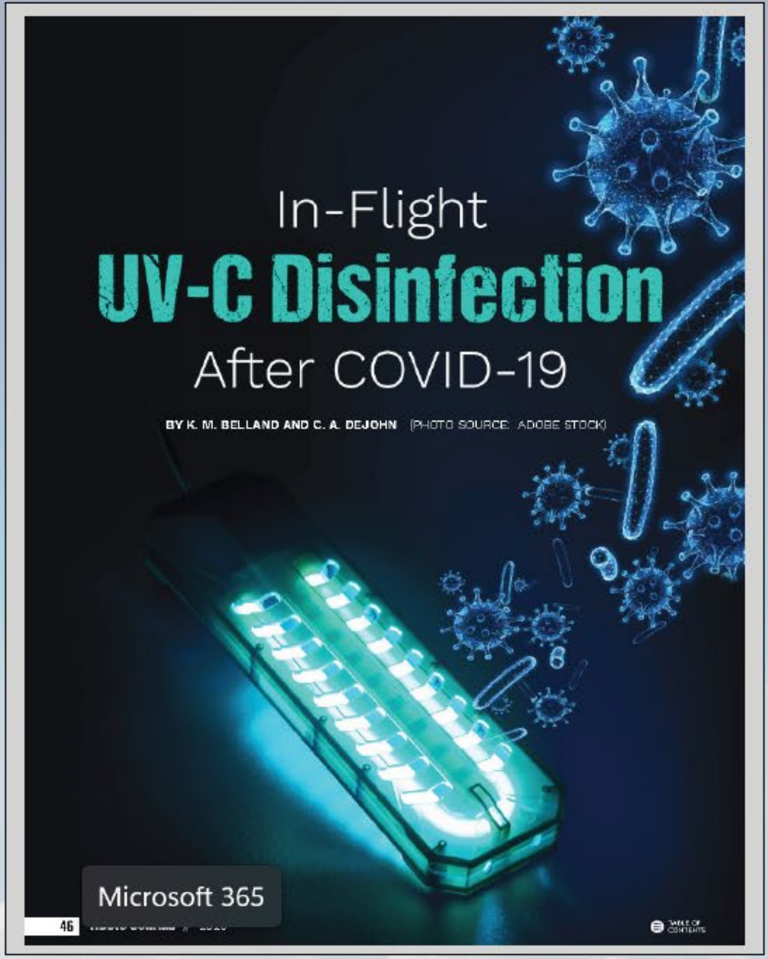
EMP Hardening of Critical Infrastructure
PAGE 37
In-Flight UV-C Disinfection After COVID-19
PAGE 46
PAGE 26
Integrated Sensing and Communications for Small UAV Applications in
CELLULAR NETWORKS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UV-C Disinfection
After COVID-19
BY K. M. BELLAND AND C. A. DEJOHN (PHOTO SOURCE: ADOBE STOCK)
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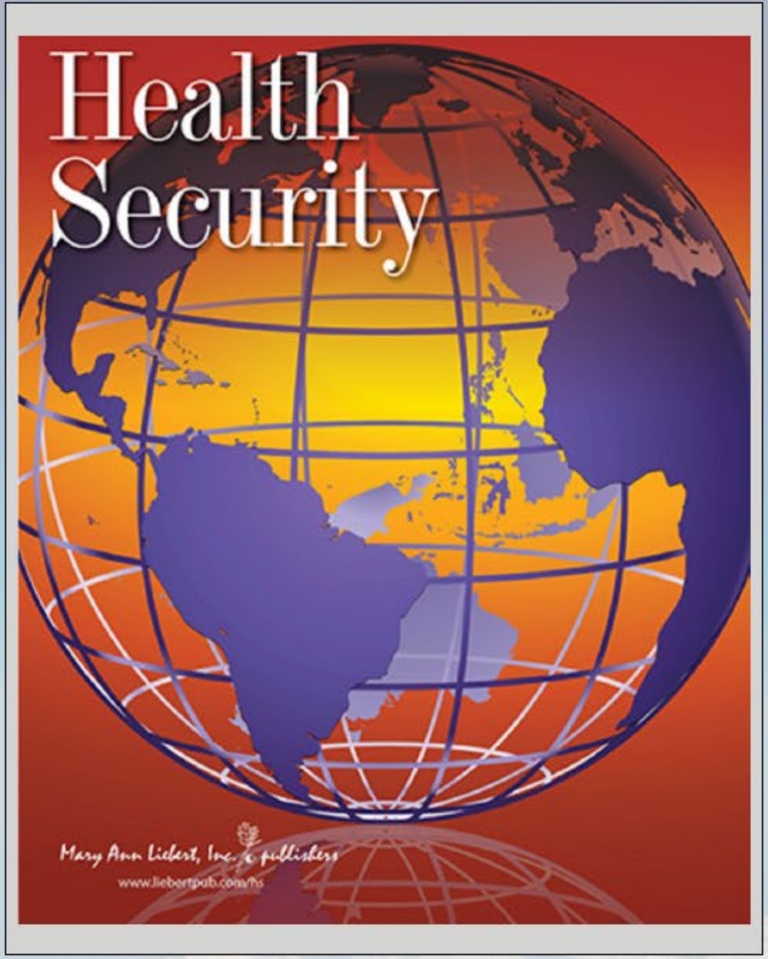
Health Security
Mary Ann Liebert, Inc. publishers
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Johns Hopkins Health Security Comprehensive Review: Ultraviolet-C (UV-C) Disinfection in Aircraft Cabins

Abstract: Ultraviolet-C (UV-C) disinfection has gained considerable attention as a continuous, real-time method to mitigate the transmission of airborne pathogens within aircraft cabins [1,2]. Recent investigations have demonstrated its potential to inactivate viruses such as SARS-CoV-2, influenza, and other emerging infectious agents in situ, thereby reducing both immediate infection risks and broader public health burdens [3,6,16]. This paper evaluates how continuous UV-C disinfection—applied in tandem with established preventive measures—may effectively curtail disease transmission, reassure passengers, and inform the future direction of in-flight health and safety standards.

ACCEPTED FOR PUBLICATION

AsMA Resolution 2023-01 - THEREFORE BE IT RESOLVED:

Aerospace Medical Association

President
Joseph P. Dervay, MD, MPH, FAsMA
League City, Texas

Executive Director
Jeffrey C. Sventek, MS, CAsP, FAsMA
Association Headquarters Office

320 South Henry Street
Alexandria, VA 22314-3579
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www.asma.org

December 11, 2023

Susan Northrup, MD, MPH
US Federal Air Surgeon (AAM-01)
Federal Aviation Administration
800 Independence Avenue, SW
Washington, DC 20591

SUBJECT: Ultra Violet "C" (UV-C) Light Emitting Diode (LED) Technology as an additional component of the multi-layered risk mitigation strategy for aircraft disinfection

Dear Dr. Northrup,

On 21 November 2023, the membership of the Aerospace Medical Association (AsMA) passed a resolution on the use of ultraviolet "C" (UV-C) Light Emitting Diode (LED) technology as an additional component of the multi-layered risk mitigation strategy for aircraft disinfection.

This resolution advocates for the use of continuous inflight Ultraviolet "C" (UV-C) Light Emitting Diode (LED) technology in occupied aircraft cabins as an integral part of the multi-layered risk mitigation strategy for aircraft disinfection, with a special emphasis on the safety and well-being of aircrew members.

The AsMA resolution specifically states: **"The continuous use of UV-C aboard aircraft, below exposure limits, and with appropriate engineering safeguards, can be an additional synergistic, safe, and effective risk-mitigation layer to reduce disease transmission and translocation."**

The impetus for this resolution comes from the global health challenge posed by infectious diseases, as identified by the World Health Organization and Centers for Disease Control and Prevention. Despite advancements in aircraft cabin engineering and environmental control systems, the risk of transmission and spread of infectious diseases, including COVID-19, influenza, Respiratory Syncytial Virus (RSV), measles, tuberculosis, and the common cold, remains a significant concern. These diseases, transmitted through aerosols and surface contamination, necessitate robust air and surface disinfection measures.

-FAA Risk vs. Benefit Analysis and Peer Review Articles (Five) and AMA or AsMA Support:
"The continuous use of UV-C aboard aircraft, below exposure limits and with appropriate engineering safeguards, can be an additional synergistic, safe, and effective risk-mitigation layer to reduce disease transmission and translocation"
-FAA Certificate of Approval

FAA 08AUG24

- this letter is to inform you that the Federal Aviation Administration East Certification Branch has no objections for the installation of DIBEL LED UV-C germ cleansing lights in unoccupied areas of the aircraft when a physical barrier exists between occupants and the UV-C light emitted by the AeroClenz device such as an unoccupied lavatory.

U.S. Department of Transportation
Federal Aviation Administration

Aircraft Certification Service
Compliance & Airworthiness Division

East Certification Branch
1701 Columbia Ave.
College Park, Georgia 30337

August 8, 2024

In Reply, Reference FAA Correspondence #: 750-24-00293

Mr. Matt Saberton
Founder/CEO
AeroClenz
P.O. Box 367263
Bonita Springs, FL 34136

Dear Mr. Saberton:

As a follow-up to our recent discussions, this letter is to inform you that the Federal Aviation Administration East Certification Branch has no objections for the installation of DIBEL LED UV-C germ cleansing lights in unoccupied areas of the aircraft when a physical barrier exists between occupants and the UV-C light emitted by the AeroClenz device such as an unoccupied lavatory.

Please submit at your earliest convenience an STC application along with the certification plan and cover letter for unoccupied lavatory installation with proper automated detection that turn off the UV-C lights when the lavatory is occupied.

If you have any further questions, you may contact Alan Silva at 404-474-5574 or via email at alan.silva@faa.gov.

Sincerely,

JAMES LEE Digitally signed by JAMES LEE Date: 2024.08.08 10:16:52 -04'00'

FAA November 20, 2024 Ref #: 750-24-00780
Conservative Aviation Safety Approach

- **FAA Direct UV-C Exposure to Aircraft Occupants DIBEL Concerns**
  - **Informed Consent**
    - **Disclosure Public Service Announcement or Turn Off for Pax Aircrew**
    - **Current Approved Systems Shuts Off Automatically**
  - **Repeated Aircrew Exposures**
    - **Well Under Published Exposure Limits (TLV) 8hr X 5 Days x 40 years or OFF**
    - **8 hr under UV-C is Roughly Equivalent to <5min Direct Sunlight (Energy, Wavelength, Duration, Distance)**
  - **Potential Photokeratitis / Eye Damage / Sensitive Passengers**
    - **More Risk Transiting to Airport / Aircraft**
- **Health Benefits Outweigh Risk**
  - **Published Risk vs Benefit Research**
- **Need More Reliable Studies – (787 MAX Caution) - Cutting Edge Tech**
  - **NAMRL / NAMRU-D / BOLB / LHRC**
  - **Similar Trajector as PRK in DoD / ASM**

Naval Medical Research Unit DAYTON (NAMRU-D)
Naval Aerospace Medical Research Laboratory (NAMRL)
Environmental Health Effects Laboratory (EHEL)

DoD Operational and MTF UV-C Applications in Disease Transmission Translocation Mitigation

27 June 2025

DEPARTMENT OF THE NAVY
NAVAL MEDICAL RESEARCH UNIT DAYTON
2624 Q STREET, BLDG 851, AREA B
WRIGHT-PATTERSON AIR FORCE BASE, OHIO 45433-7955

From: Director, Naval Aerospace Medical Research Laboratory, Naval Medical Research Unit Dayton

Subj: LETTER OF INTENT IN SUPPORT OF PROMISING DOD AEROSPACE MEDICAL ULTRAVIOLET (UV-C) RESEARCH

1. Naval Aerospace Medical Research Laboratory (NAMRL) is pleased to advocate for continued investment in UV-C disinfection technology as an integral component of aerospace medicine to defend our forces from infectious agents protects our operational readiness.

2. UV-C technology for half a century has demonstrated significant capability for reducing the transmission and translocation of airborne/surface biologic and viral pathogens, a critical concern for maintaining operational readiness and safeguarding the health of military personnel. UV-C will add another layer to the already-in-place multi-layered risk mitigation protocols that have traditionally been used.

3. As a leader in the research and development of advanced aerospace medical solutions, NAMRL recognizes the immense value of agile and adaptive UV-C disinfection systems. These technologies offer a high-value proposition by addressing one of the most pressing challenges in aerospace medicine: mitigating airborne pathogen exposure in confined environments such as aircraft, ships, and operational command centers. The rapid and effective reduction of microbial contamination using UV-C systems can sustain force health protection in dynamic and demanding environments. Additionally, research and development in this area has the potential to significantly mitigate the potential threat of natural and manmade diseases (bio-weapons / threat).

4. Supporting UV-C research not only reflects NAMRL's commitment to advancing the science of aerospace medicine but also underscores our pivotal role in ensuring that our armed forces remain resilient against all biological threats whether traditional, emerging or manmade. The integration of UV-C disinfection systems within DoD operations has significant potential to enhance operational efficiency and reduce disease outbreaks, ultimately preserving mission-critical capabilities.

5. As an indicator of our belief in the tremendous potential of this technology to Naval Aviation and beyond, in FY 2025 we started an annual investment of $300K in UV-C research from our discretionary research budget, which amounts to nearly half of our entire discretionary budget. This decision and the associated flexibility of research foci ensure that solutions can be tailored to meet the unique needs of different operational contexts, from troop transport to medical evacuation, reinforcing the technology's strategic importance to the DoD.

Subj: APPOINTMENTS OF THE INSTITUTIONAL REVIEW BOARD

6. We are confident that these efforts will yield transformative advancements, reinforcing the DoD's ability to protect the health of its service members and achieve mission success. For more information I can be reached at richard.arnold.10@us.af.mil, or (937) 938-3877.

R.D. ARNOLD, PhD
Director, Naval Aerospace Medical Research Laboratory
By direction of the Commanding Officer

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The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

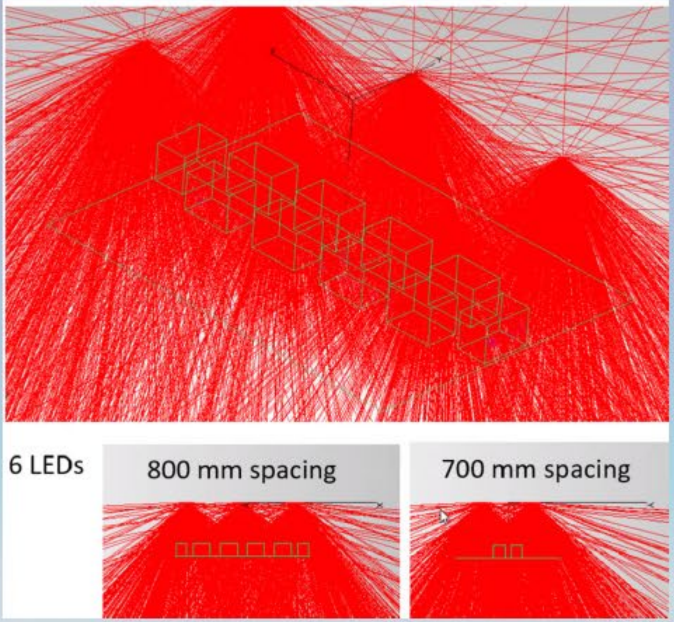
An Outbreak of Covid-19 on an Aircraft Carrier

Matthew R. Kasper, Ph.D., Jesse R. Geibe, M.D., Christine L. Sears, M.D., Asha J. Riegodedios, M.S.P.H., Tina Luse, M.P.H., Annette M. Von Thun, M.D., Michael B. McGinnis, M.D., Niels Olson, M.D., Daniel Houskamp, M.D., Robert Fenequito, M.D., Timothy H. Burgess, M.D., Adam W. Armstrong, M.D., Gerald DeLong, Ph.D., Robert J. Hawkins, Ph.D., and Bruce L. Gillingham, M.D.

ABSTRACT

Naval Medical Research Unit DAYTON (NAMRU-D)
Naval Aerospace Medical Research Laboratory (NAMRL)
Environmental Health Effects Laboratory (EHEL)

- Study #1 – Exposure Modeling in Osprey
- Study #2 – Ocular Exposure Evaluation
- Study #3 – Real-World Exposure Characterization (normal)
- Study #4 – Real-World Exposure Characterization (worst-case)
- Study #5 – Dermal Evaluation
- Study #6 – Operational Environment Characterization



DEPARTMENT OF THE NAVY
NAVAL MEDICAL RESEARCH UNIT DAYTON

From: Director, Naval Aerospace Medical Research Laboratory, Naval Medical Research Unit Dayton

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3. As a leader in the research and development of advanced aerospace medical solutions, NAMRL recognizes the immense value of agile and adaptive UV-C disinfection systems. These technologies offer a high-value proposition by addressing one of the most pressing challenges in aerospace medicine: mitigating airborne pathogen exposure in confined environments such as aircraft, ships, and operational command centers. The rapid and effective reduction of microbial contamination using UV-C systems can sustain force health protection in dynamic and demanding environments. Additionally, research and development in this area has the potential to significantly mitigate the potential threat of natural and manmade diseases (bio-weapons / threat).

4. Supporting UV-C research not only reflects NAMRL's commitment to advancing the science of aerospace medicine but also underscores our pivotal role in ensuring that our armed forces remain resilient against all biological threats whether traditional, emerging or manmade. The integration of UV-C disinfection systems within DoD operations has significant potential to enhance operational efficiency and reduce disease outbreaks, ultimately preserving mission-critical capabilities.

5. As an indicator of our belief in the tremendous potential of this technology to Naval Aviation and beyond, in FY 2025 we started an annual investment of $300K in UV-C research from our discretionary research budget, which amounts to nearly half of our entire discretionary budget. This decision and the associated flexibility of research foci ensure that solutions can be tailored to meet the unique needs of different operational contexts, from troop transport to medical evacuation, reinforcing the technology's strategic importance to the DoD.

Subj: APPOINTMENTS OF THE INSTITUTIONAL REVIEW BOARD

6. We are confident that these efforts will yield transformative advancements, reinforcing the DoD's ability to protect the health of its service members and achieve mission success. For more information I can be reached at richard.arnold.10@us.af.mil, or (937) 938-3877.

R.D. ARNOLD, PhD
Director, Naval Aerospace Medical Research Laboratory
By direction of the Commanding Officer

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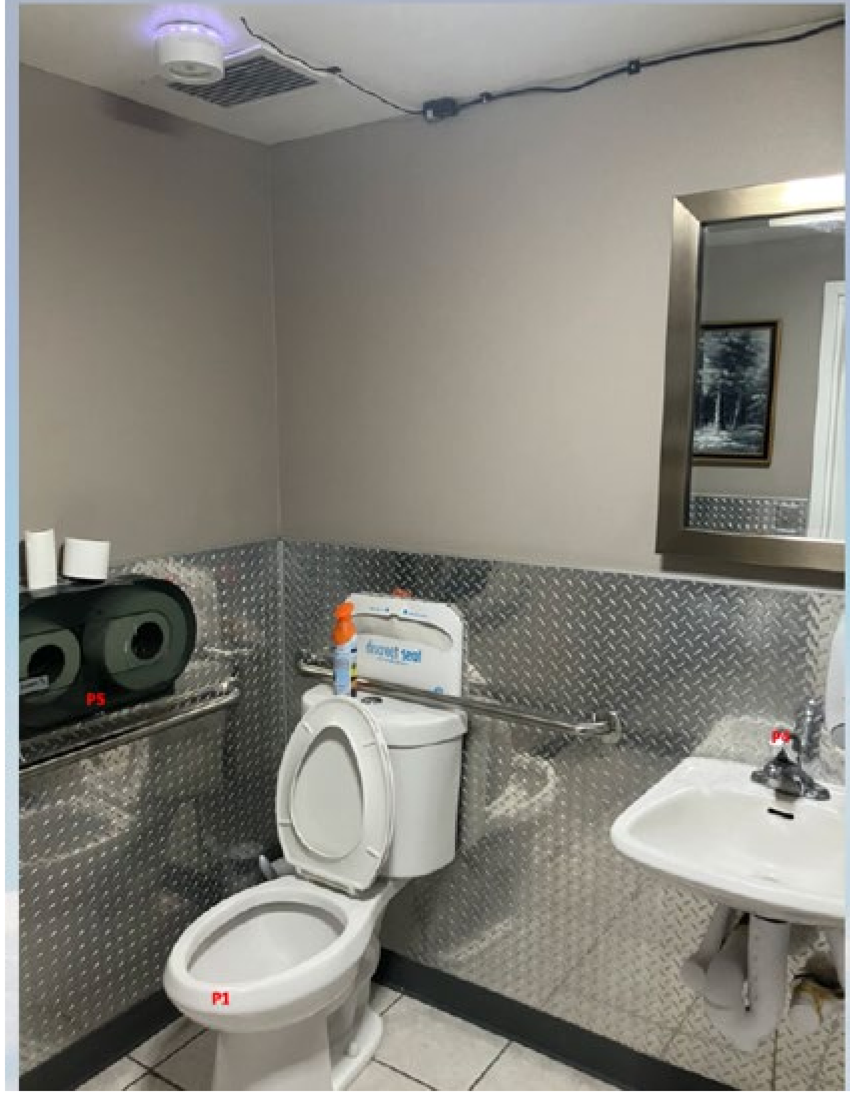
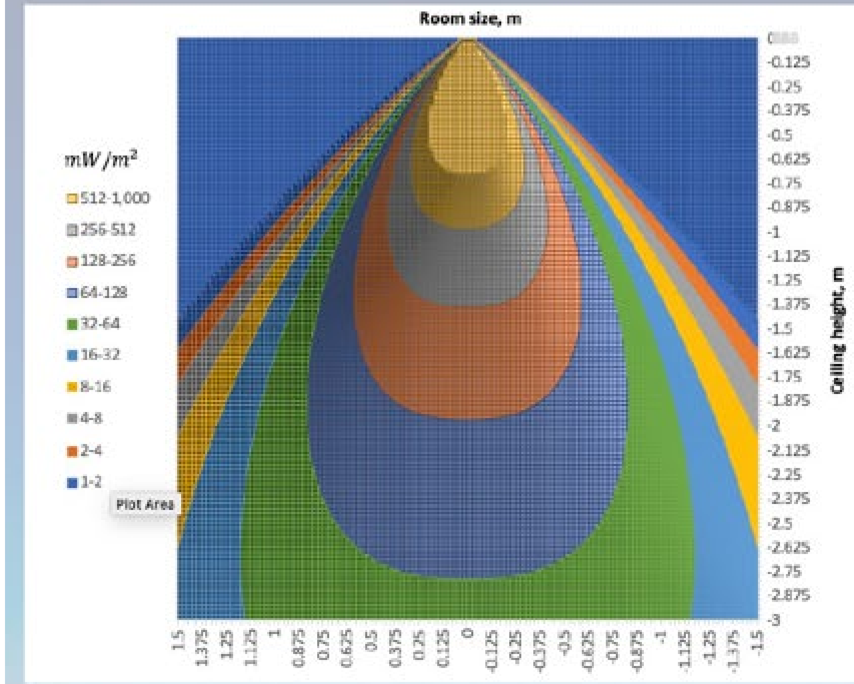
BOLB Study





Perforamance Examples

Table 2 – SARS-COVID-2 air disinfection example

% Deactivation	Dosage [1], mJ/cm2	Room Height, ft	Room Width, ft	Room Length, ft	Room Volume, ft^3	Calculated Kill Time, minutes[2]
99.3	0.6	7	10	10	700	10

Table [illegible] – E.Coli surface disinfection example at a 3 ft counter height level

% Deactivation	Dosage [3], mJ/cm2	Room Height, ft	Area Width, ft	Area Length, ft	Surface, Area ft^2	Calculated Kill Time, minutes[4]
90	2.4	8	6	6	36	3.1

Table [illegible] – Spores surface disinfection example at a 0 .9 m counter height level

% Deactivation	Dosage [3], mJ/cm2	Room Height, ft	Area Width, ft	Area Length, ft	Surface, Area ft^2	Calculated Kill Time, minutes[4]
90	50	8	6	6	36	64

Product Third-party Aerosol Disinfection Test Reports

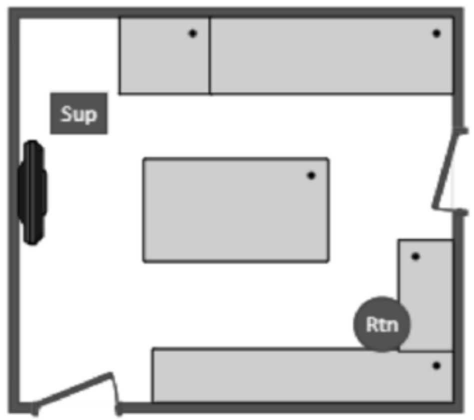
99.9% Fungus, Bacterium (E-Coli, Staph, A Niger), Virus, Mold

Conference Room

Test Results & Commentary

Scenario	UV Off eACH	UV On eACH MS2-scaled	UV On eACH TB-scaled*	UV Off Occupancy ASHRAE 241	UV On Occupancy** ASHRAE 241
UV On, HVAC Off, Mixing Fan Off, Door Closed	1.99	5.33	30.55	2	6
UV On, HVAC Off, Mixing Fan On, Door Closed	2.17	6.43	38.55	2	7
UV On, HVAC On, Mixing Fan Off, Door Closed	6.09	10.44	43.22	6	11

*TB scaling is based on Kowalski Ultraviolet Germicidal Irradiation Handbook 2009
**UV On occupancy results calculated per ASHRAE 241 (MS2 scaled)

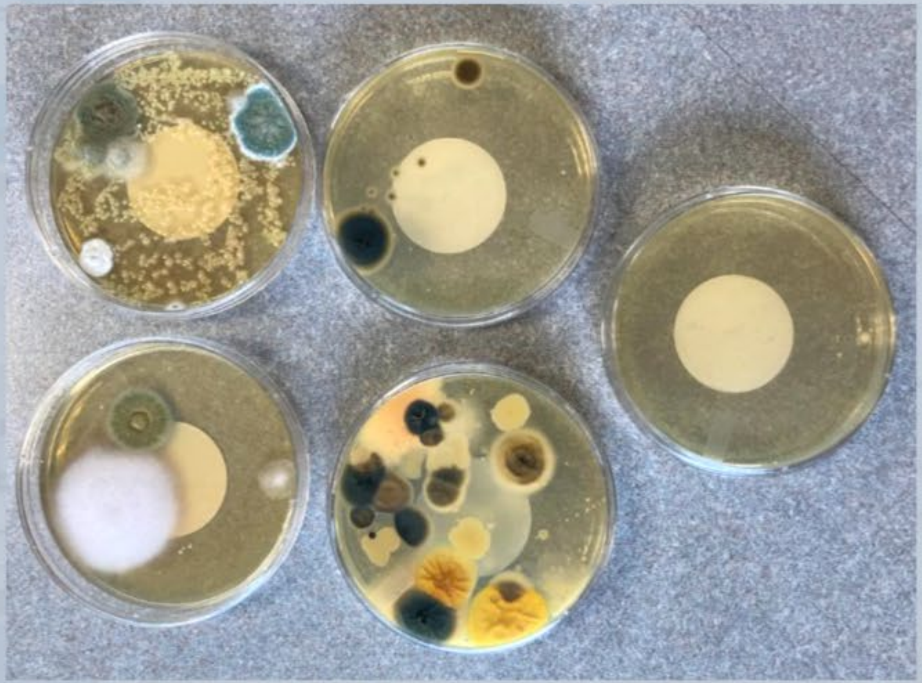


Upper Air System: eACH Equivalent Air Exchanges
SafeAirTraces: MS-2 DNA Tag (Human Safe)
Sensitive UV-C and Natural Decay as Background
Used for ASHRE Standard Evaluation
Radiometer used to show Safe Levels of UV-C in Office Space

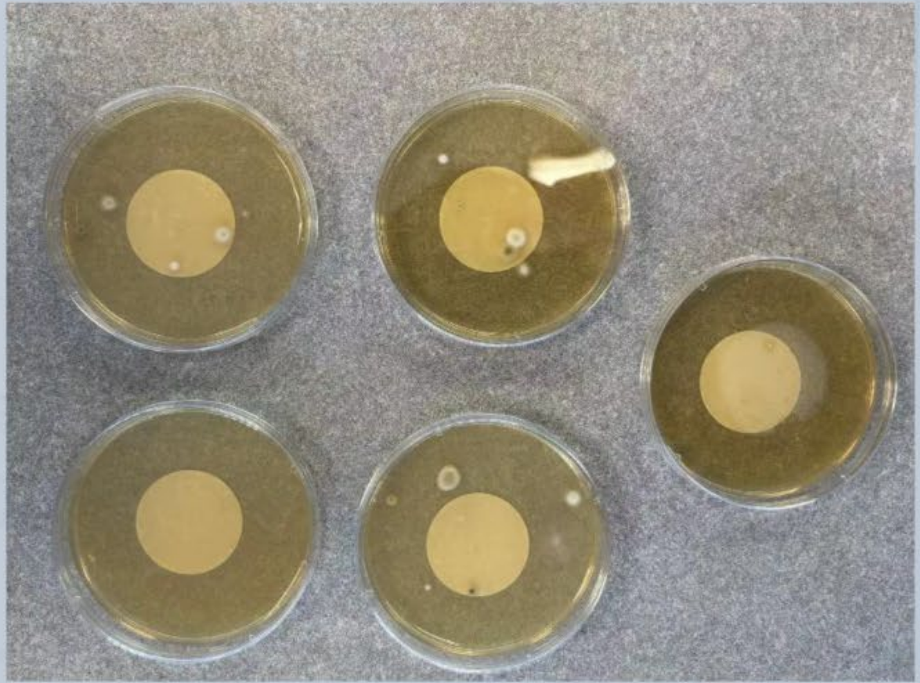
safetraces®

Proven Results

Without UV-C



With UV-C



UV-C Technology Makes a Measurable Difference!

Florida Compound Pharmacy: System delivered hospital-level microbial reductions — approaching sterilization efficacy — while remaining safe for occupied spaces.

Location / System	Before	After	Reduction	Interpretation
Clean Room Sink – Bacteria (Upper + Intermittent)	~17 CFU (mixed flora: *Staphylococcus epidermidis*, *Corynebacter*, *Bacillus*)	<1 CFU (no growth)	≥ 1.2 log	Already clean, now sterile
Clean Room Sink – Fungi (Upper + Intermittent)	*Aspergillus fumigatus* ≈ 5 CFU	*Mycelia sterilia* 1 CFU	≈ 0.7 log	Only background spore detected — excellent air quality
Bathroom Sink – Bacteria (Intermittent only)	>10^7 CFU (confluent; *S. epidermidis*, *Streptococcus viridans*, *Micrococcus*, *S. aureus*)	24 CFU (*Bacillus* sp.)	≥ 5.6 log	Enormous improvement — essentially sterile
Bathroom Sink – Fungi (Intermittent only)	11 CFU (*A. fumigatus*)	2 CFU (*A. niger*)	≈ 0.7 log	Trace environmental spores only — well controlled
Handicap Rail – Bacteria (Intermittent only)	>10^7 CFU (*Micrococcus*, *S. epidermidis*, *Bacillus*)	2.95×10^2 CFU	≥ 4.5 log	Strong kill on a high-touch metal surface, validating dose delivery
Toilet Seat (Left) (Intermittent only)	>10^7 CFU (*S. epidermidis*, *Micrococcus*, *Corynebacter*, *Bacillus*, *A. baumannii*)	1.12×10^2 CFU (*Micrococcus*, *S. epidermidis*)	≥ 5 log	Outstanding — practically decontaminated
Toilet Seat (Right) (Intermittent only)	>10^7 CFU (*S. epidermidis*, *Micrococcus*, *Bacillus*, *S. aureus*)	1.65×10^2 CFU (*S. epidermidis*, *Chryseomonas luteola*)	≈ 4.8 log	Major reduction — microbial risk virtually eliminated

Counts reflect HPC CFU per swab (USP 61/62). All data verified by Micrim Labs via Sporelytics chain-of-custody forms.

LT. General Dr. PK Carlton (Ret)
USAF 17th Surgeon General)

Vice Admiral Michael McCabe (Ret)
Prior THIRD Fleet commander.

Endorsed by Medical Professionals

"I was impressed by your presentation, your commitment to best available science, the team you have put together, and am excited about your well thought out and detailed pathway to getting UV-C in commercial aviation and then in other applications."

- Lt. Gen. (ret) Dr. PK Carlton, Jr., 17th Surgeon General of the US Air Force

Endorsed by Medical Professionals

"The numbers speak for themselves"

- Dr. Bill Mills, M.D., Ph.D. (Epidemiology) MPH (Occupational & Environmental Health), MS Physics

Endorsed by Medical Professionals

"The ongoing implementation of UV-C below exposure limits on aircraft serves as an additional, synergistic, safe, and effective measure to mitigate the risks associated with disease transmission and translocation.

- Dr. Charles DeJohn

Closing: UV-C Concern Area Risk Communication

UV-C damages DNA / RNA Pathogen by Disruption Pyrimidine Bonds, Blocking Replication & Death

Copious Use Data for Decades Peer Reviewed by CDC / NIOSH – backed use cases: TB, COVID-19

Current Eng, Tech and Manufacturing Will Not Allow Threshold Levels to be Exceeded

- **Triple Fail Safe to Off Mode: Shielding Interlocks & Dosimetry maintain exposure Mitigates Unintended Exposures <TLV**
- **Complete Fail: Ex: 5 min of Sunlight Delivers Vastly More Light Energy than 8 hours UV-C – Well Under TLV Exposure Levels**
- **No Evidence of Mutagenesis in Humans Below TLV**

Skin and Eye Safety: UV-C penetration (Wavelength, Energy, Duration, Eng/Tech/Manufacturing)

- **Anyone with True Skin Sensitivity Far More Exposure Walking Into Terminal and Transiting to Aircraft**
- **Tear Film Layer and Stratum Corneum (Outer Skin Layer) Contrast LASIK / PRK / SMILE - Both Are Now Sufficiently Controlled**
- **Safety Standards Generous Margins: ASHRAE - TLV / ANSI**
- **Not Considered FDA Medical Device – EPA Registration Requires Accurate labeling and scientific substantiation**
- **Recognized by CDC, OSHA and ASHRAE guidance as supplementary method for infection prevention. Not Directly Regulated**

Regulatory – No Human Medical Use, No FDA Approval Required – Not a Med Device

FAA No Objections for Inflight use – Unoccupied Spaces (Like Lavatory) with wall between Passengers

Continue to Press the Envelope / DIBEL With Ongoing Laboratory Studies – Similar Regulatory Pathway as PRK

Metagenomics and Its Role in Aerospace Medicine

- Laboratory cultures (still used due to abundance and low cost)
- Polymerase Chain Reaction (PCR), DNA / RNA amplification was created

- Instead of looking at one organism at a time. It is a cutting-edge, mainstream research tool that’s transforming microbiology. It uses DNA / RNA sequencing of all fragments. Reconstruct partial or full microbial genomes (metagenome-assembled genomes, or MAGs). Practical for public health surveillance and complex diagnostics, but not yet routine in everyday clinical care or small labs because of cost, speed, and interpretive complexity.
- Study of genetic material from environmental samples, Captures all microbial DNA/RNA (Live or Dead)
- Reveals full microbial ecosystems without culturing
- How it works: Sample Collection, Nucleic Acid Extraction, Sequencing, Bioinformatics Analysis, Interpretation
- Good for: Microbial Monitoring / load analysis, Epidemiological Surveillance
- Can Not Differentiale Living versus Dead Organisms

Conclusions

Wonderful work done by ICAO, CAPSCA members, WHO: Dodged a Bullet, Got Lucky:

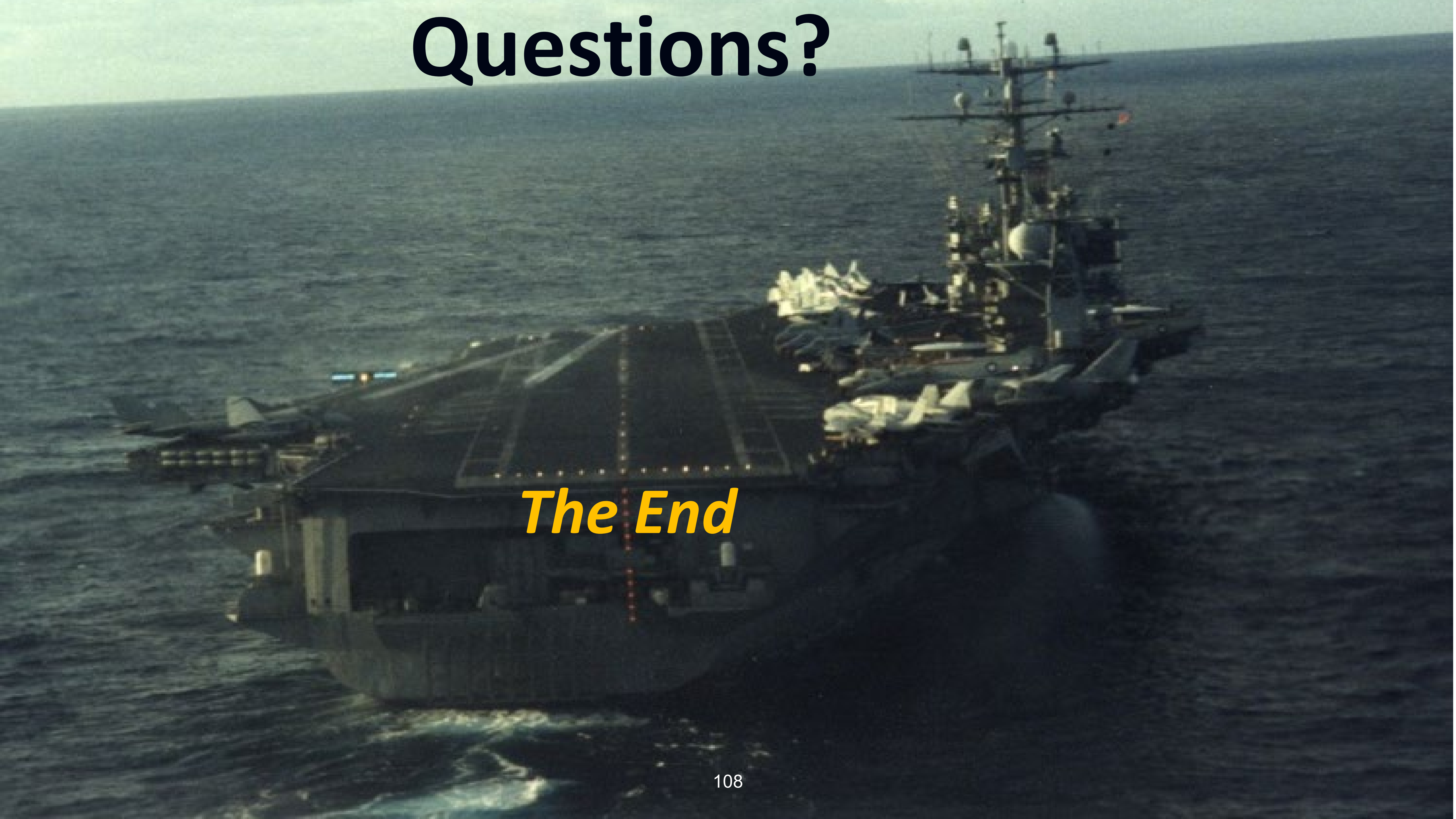
- Hockey Analogy, ASM SME-Skating to where hockey puck will be, Not Where it is at!
- Prepare for next Pandemic - Capture Readily available Lessons Learned (Break Glass)
  - Testing and Cross-border Risk Management Measures Man (3rf Ed)-2021 ICAO Doc 10152
  - **Presentations and Education:** Corporate Knowledge, Ready Room Knowledge Transfer
- RESOURCES, Personnel, Training, Equipment – Ask for it now - Do not let a Crisis go to Waste!
- Synergism between WHO, ICAO with Credible ASM specialists
- Misinformation - Infodemic

Risk Mitigation Measures (Swiss Cheese Theory) Synergistically Reduces Risk

- There is No Way to Totally Eliminate All Risk
- Layered Defense – Reason Swiss Cheese Theory, good risk communication tool!
  - WORKS FOR ALL INFECTIOUS DISEASES, and Bio-Engineered Diseases
- WHO - Balance Economics of Travel and the Health and Well Being - Challenge of our Times
- UV-C Offers Another Viable and Synergistic Risk Mitigation Layer

Relationships Matter Most - Collegial Cordial Communication and Coordination – Why We Are Here!

Questions?



The End





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