DOT/FAA/AM-26/06

Aviation Safety

Office of Aerospace Medicine

Washington, D.C. 20591

Aviation Infectious Risk and Safety: A Collaborative Program for Modeling Infectious Disease Transmission in Air Travel

Jason Armstrong[1], Iain Koolhof[1], Ozge Ozcakir[1], Craig Pepper[1], Shelley Roberts[2], Paul Lebbin[2], James Bennett[3], Clive Brown[4], Sundari Mase[4], Shannon Gearhart[4], Steve Gwynne[5], Hilary Uyhelji[6], Anthony Tvaryanas[6]

[1]The Boeing Company, Arlington, Virginia, United States of America

[2]National Research Council Canada, Centre for Air Travel Research, Ottawa, Ontario, Canada

[3]National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention, Cincinnati, Ohio, United States of America

[4]National Center for Emerging and Zoonotic Infectious Diseases, Centers for Disease Control and Prevention, Atlanta, Georgia, United States of America

[5]Department of Mathematical Sciences, University of Greenwich, London, United Kingdom

[6]Federal Aviation Administration, Civil Aerospace Medical Institute, Oklahoma City, Oklahoma, United States of America

March 2026

NOTICE

This publication and all Office of Aerospace Medicine technical reports are available in full text from the Civil Aerospace Medical Institute's publications website and at the National Transportation Library's Repository & Open Science Access Portal.

Technical Report Documentation Page

1. Report No. DOT/FAA/AM-26/06	2. Title & Subtitle Aviation Infectious Risk and Safety: A Collaborative Program for Modeling Infectious Disease Transmission in Air Travel
3. Report Date March 2026	4. Performing Organization Code AAM-600
5. Author(s) Jason Armstrong[1], Iain Koolhof[1] (https://orcid.org/0000-0002-9923-7416), Ozge Ozcakir[1] (https://orcid.org/0000-0002-8672-344X), Craig Pepper[1], Shelley Roberts[2] (https://orcid.org/0000-0001-9269-350X), Paul Lebbin[2] (https://orcid.org/0000-0002-7750-9572), James Bennett[3] (https://orcid.org/0000-0002-5185-8678), Clive Brown[4] (https://orcid.org/0000-0002-3755-2824), Sundari Mase[4] (https://orcid.org/0000-0001-5363-0637), Shannon Gearhart[4] (https://orcid.org/0000-0001-9005-830X), Steve Gwynne[5] (https://orcid.org/0000-0002-2758-3897), Hilary Uyhelji[6] (https://orcid.org/0000-0002-3433-8320), Anthony Tvaryanas[6] (https://orcid.org/0000-0003-0180-2374)	6. Performing Org Report Number 202606
7. Performing Organization Name & Address [1]The Boeing Company, Washington, United States of America [2]National Research Council Canada, Centre for Air Travel Research, Ottawa, Canada [3]National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention, Cincinnati, Ohio, United States of America [4]National Center for Emerging and Zoonotic Infectious Diseases, Centers for Disease Control and Prevention, Atlanta, Georgia, United States of America	8. Contract or Grant Number NAT-I-8917 6973GH-23-H-00002 6973GH-23-N-00003 6973GH-23-H-00003 6973GH-25-H-00002 And an MOA between FAA, Boeing, GHD Inc., HHS, and DHS
9. Sponsoring Agency Name & Address Office of Aerospace Medicine Federal Aviation Administration 800 Independence Ave., S.W. Washington, DC 20591	10. Type of Report & Period Covered Technical Report
11. Supplementary Notes https://doi.org/10.21949/1529730	
12. Abstract The Aviation Infectious Risk and Safety (AIRS) program addresses the U.S. Government Accountability Office (GAO) recommendation for stronger federal leadership and coordination on communicable disease transmission in air travel. Led by the Federal Aviation Administration (FAA), AIRS integrated The Boeing Company, the Centers for Disease Control and Prevention, the National Institute for Occupational Safety and Health, National Research Council Canada, and other interdisciplinary partners to develop Travel Risk In Pandemics (TRIP-X), a modular, simulation-based tool estimating disease transmission risk in air travel. This commentary describes how TRIP-X filled GAO-identified gaps and highlights procedural enablers and challenges of multinational, intergovernmental, and industry collaboration: shared	

problem framing, iterative development, stakeholder engagement, and cross disciplinary trust building. TRIP-X offers a reproducible, operational decision support platform for evaluating mitigation strategies and informing policy. TRIP-X produces FAA-owned infection risk estimates intended to support Safety Risk Management, policy development, and aviation pandemic preparedness.		
13. Key Word Pandemics, Air Travel, Public Health Preparedness, Safety Risk Management, Risk Assessment		14. Distribution Statement Document is available to the public through the National Transportation Library at https://rosap.ntl.bts.gov
15. Security Classification (of this report) Unclassified	16. Security Classification (of this page) Unclassified	17. No. of Pages 22

Author Note

Funding	This work was funded by the Federal Aviation Administration, with additional support from contributing agencies and organizations through the contracts and agreements noted.
Data Availability	Not applicable.
Conflicts of Interest	The authors declare that they have no competing interests.
Author Contributions	Author contributions are formatted to the Contributor Roles Taxonomy (CRediT) system. Author 1: Methodology (equal); Investigation (equal); Writing - Original Draft (equal); Writing - Review & Editing (equal); Project administration (equal); Data Curation (equal). Author 2: Conceptualization (lead); Methodology (lead); Software (lead); Validation (equal); Formal analysis (equal); Investigation (equal); Writing - Original Draft (equal); Writing - Review & Editing (equal); Visualization (equal); Project administration (equal). Author 3: Conceptualization (lead); Methodology (lead); Software (lead); Validation (equal); Formal analysis (equal); Investigation (equal); Writing - Original Draft (equal); Writing - Review & Editing (equal); Visualization (equal); Project administration (equal). Author 4: Conceptualization (lead); Methodology (lead); Software (lead); Validation (equal); Formal analysis (equal); Investigation (equal); Writing - Original Draft (equal); Writing - Review & Editing (equal); Visualization (equal); Project administration (equal). Author 5: Methodology (equal); Investigation (equal); Validation (equal) Writing - Original Draft (equal); Writing - Review & Editing (equal); Visualization (equal) Project administration (equal); Data Curation (equal); Resources (equal). Author 6: Methodology (equal); Investigation (equal); Software (equal); Writing - Original Draft (equal); Writing - Review & Editing (equal); Project administration (equal); Resources (equal). Author 7: Methodology (equal); Investigation (equal); Writing - Review & Editing (equal); Project administration (equal); Resources (equal); Data Curation (equal). Author 8: Methodology (equal); Investigation (equal); Writing - Original Draft (equal); Writing - Review & Editing (equal); Project administration (equal); Resources (equal); Data Curation (equal).

	Author 9: Methodology (equal); Investigation (equal); Writing - Original Draft (equal); Writing - Review & Editing (equal); Project administration (equal); Resources (equal); Data Curation (equal). Author 10: Methodology (equal); Investigation (equal); Writing - Original Draft (equal); Writing - Review & Editing (equal); Project administration (equal); Resources (equal); Data Curation (equal). Author 11: Conceptualization (lead); Methodology (equal); Formal analysis (equal); Investigation (equal); Writing - Original Draft (equal); Writing - Review & Editing (equal); Project administration (equal); Supervision (lead). Author 12: Writing - Review & Editing (equal); Resources (equal); Project administration (equal). Author 13: Conceptualization (equal); Methodology (equal); Formal analysis (equal); Investigation (equal); Writing - Original Draft (equal); Writing - Review & Editing (equal); Resources (lead); Project administration (lead); Supervision (lead).

Table of Contents

List of Figures

List of Abbreviations

Acronym	Abbreviation Explained
ABM	Agent-Based Model
AIRS	Aviation Infectious Risk and Safety
CATR	Centre for Air Travel Research
CDC	Centers for Disease Control and Prevention
CFD	Computational Fluid Dynamics
CSV	Comma-Separated Values
FAA	Federal Aviation Administration
GAO	Government Accountability Office
HVAC	Heating Ventilation and Air Conditioning
GHD	Gutteridge Haskins & Davey
ICAO	International Civil Aviation Organization
JSON	JavaScript Object Notation
NIOSH	National Institute for Occupational Safety and Health
NRC	National Research Council
SMS	Safety Management System
SRM	Safety Risk Management
TRIP-X	Travel Risk In Pandemics

Introduction

The global aviation system plays a critical role in the rapid geographic spread of communicable diseases (Wardle et al., 2024). Although the risk of SARS-CoV-2 (COVID-19) infection related to air travel during the pandemic was thought to be low, questions remain about the risks of communicable disease transmission during air travel (Zhao et al., 2024). With billions of passengers traveling annually (IATA 2025), even a few infected individuals can cause cross-border transmission with significant public health, economic, and operational impacts. The COVID-19 pandemic highlighted the challenges of managing risks in the transportation sector, where inconsistent, assumptive strategies, reactive research, and fragmented coordination hampered outbreak containment efforts (Sun et al., 2022; GAO 2024; Sachs et al., 2022). Air travel environments, including airport gates, jet bridges, and aircraft cabins, likely pose risks due to limited space, high density, and shared breathing zones (Marcus 2020; Wang et al., 2022; Abouelhamd et al., 2024; Shao et al., 2021). Understanding and mitigating these risks requires coordinated action and technical tools that integrate behavioral science, ventilation engineering, epidemiology, and operational logistics.

In recognition of these challenges, the U.S. Government Accountability Office (GAO) issued three reports between 2015 and 2022 that identified specific gaps in national aviation pandemic preparedness. In its 2015 report, Air Travel and Communicable Diseases: Comprehensive Federal Plan Needed for U.S. Aviation System’s Preparedness (GAO-16-127) (GAO 2015), the GAO found that despite airport- and airline-level response plans, the nation lacked a coordinated federal aviation preparedness plan. In 2020, the GAO released Air Travel and Communicable Diseases: Status of Research Efforts and Action Still Needed to Develop Federal Preparedness Plan (GAO-20-655T) (GAO 2020) detailing how the lack of a federal preparedness plan resulted in a fragmented and inconsistent pandemic response in the aviation system during the early stages of the COVID-19 pandemic. The most recent report, Air Travel and Communicable Diseases: Federal Leadership Needed to Advance Research (GAO-22-104579) (GAO 2022), published in 2022, emphasized the need for stronger federal leadership and strategic direction to advance interdisciplinary research and develop evidence-based mitigation strategies tailored to air travel environments. Following the GAO findings and to better prepare for future outbreaks the Federal Aviation Administration (FAA) began incorporating communicable disease risk management into the Safety Management System (SMS) framework. Central to SMS is the Safety Risk Management (SRM) process, which evaluates baseline risks, identifies controls, and assesses residual risks for mitigation or acceptance. As part of the FAAs response, a multi-disciplinary and multi-agency collaboration was formed, and the Aviation Infectious Risk and Safety (AIRS) program was conceived to support FAA SRM decision-making through integrated, scenario-based infection risk estimation.

The AIRS program aimed to develop a quantitative modeling framework capable of estimating the risk of communicable disease transmission during air travel. The risk assessment tool developed was termed the Travel Risk In Pandemics (TRIP-X) model. Unlike traditional top-down efforts, TRIP-X was built through a highly collaborative, team-based approach involving multiple federal agencies—including the FAA, The Boeing Company, the Centers for Disease Control and Prevention (CDC) and the National Institute for Occupational Safety and Health

(NIOSH)—as well as international partners like the National Research Council (NRC) Canada and other industry and academic contributors. The goal was to build a scientifically credible, modular, and reproducible simulation tool capable of modeling transmission risks across realistic gate-to-gate travel scenarios, while also demonstrating the feasibility of complex interagency collaboration in a high-stakes, time-sensitive domain.

What sets TRIP-X apart is not only its ability to model airborne and contact-based disease transmission, but also its integration of diverse expertise—epidemiology, Heating Ventilation and Air Conditioning (HVAC) engineering, environmental control system engineering, computer science, public health, and human factors—within a unified operational scenario and modular software framework. This commentary examines how TRIP-X addressed the gaps identified by GAO, describes the structure and outputs of its team-based execution, and highlights key lessons learned from an applied research program that exemplifies how collaborative science can address real-world public health and transportation safety challenges.

Addressing GAO Findings through TRIP-X

TRIP-X aims to address the lack of a formal national aviation-preparedness plan by providing a structured modeling tool aligned with the International Civil Aviation Organization's (ICAO) SMS framework (ICAO 2018; ICAO 2016). SMS is a proactive, data-driven approach used across the aviation industry to identify hazards, assess and mitigate safety risks, and ensure continuous improvement in safety performance. TRIP-X was developed to support this framework by enabling systematic assessment of communicable pathogen transmission risks during all phases of commercial air travel—from the departure gate, through boarding and in-flight exposure, to deplaning at the arrival gate (a "gate-to-gate" exposure model). Instead of static estimates, TRIP-X simulates pathogen spread within a travelling population under varying conditions, including disease prevalence in the traveling population, environment and communicable disease parameters, passenger behavior, and mitigation strategies. This dynamic approach allows aviation planners and public health officials to conduct scenario-based evaluations of transmission risk and identify control strategies that align with safety policy and decision-making processes.

In response to stakeholder fragmentation observed during the COVID-19 pandemic, the AIRS program emphasized shared terms of reference and assumptions. During the pandemic, airports and airlines implemented disjointed measures with little coordination, which created passenger and industry confusion and operational inefficiencies. TRIP-X has begun to address this by developing and modeling a shared operational scenario—a two-hour flight on a narrow-body aircraft with consistent boarding practices and ventilation settings. This allowed all teams and partner agencies to work from the same assumptions, ensuring the comparability of results across simulation modules.

TRIP-X also filled longstanding gaps in disease transmission research. The program team collected field measurements of airflow within jet bridges and aircraft cabins to better understand environmental dispersion dynamics. Complementing this, extensive observational studies were conducted in simulated travel settings, where recruited participants enacted realistic airport and in-flight behaviors such as boarding, seating, speaking, and lavatory use.

This allowed for the quantification of human interactions and proximity patterns critical to modeling transmission events. In parallel, scientific experts synthesized current literature and consulted with subject matter specialists to develop parameter sets for respiratory and fomite-transmitted pathogens, including shedding rate, infectious dose, clinical profiles, aerosol particle distributions, and surface and airborne viability characteristics. These coordinated data collection and analysis activities allowed the program to produce a simulation model grounded in empirical evidence and calibrated for different pathogens.

Team-Based Execution Structure

The AIRS program, led and integrated by the FAA, was executed through a cross-functional team structure designed to support iterative model development, real-world data integration, and the production of FAA-owned infection risk estimate alignment with the ICAO SRM component of SMS—estimate baseline risks, model potential hazard pathway, and evaluate the effectiveness of various mitigation controls. Central to this structure were six core technical teams operating in parallel under centralized FAA oversight, each responsible for a distinct scientific or operational domain (see figure 1):

1. **Program Management and Oversight:** Led by the FAA, this team served as the program manager and primary integrator, coordinating the interdisciplinary teams, managing the overall schedule and deliverables, and stewarding funding and contractual relationships. The FAA established governance structures, maintained program-level risk, convened regular cross-team and external agency/industry meetings, and ensured alignment with aviation policy and ICAO's SMS. Acting as the central liaison to industry, research, and federal partners, the FAA organized stakeholder engagement, tracked program milestones, and facilitated access to operational expertise and data. In this role, the FAA serves as the institutional owner and consumer of TRIP-X infection risk estimates, ensuring outputs were traceable, interpretable, and suitable for aviation safety oversight and policy use.
2. **Human Behavior Data Acquisition:** Led by NRC Canada and GHD, Inc., this team collected empirical data on passenger and crew behaviors spanning the entire gate-to-gate journey. The team conducted both field observations and high-fidelity simulation trials at NRC's Centre for Air Travel Research (CATR) (National Research Council Canada 2023), the latter providing a surrogate environment that included an airport gate area, full-length jet bridge, and a cabin mockup of a single-aisle aircraft (see figure 2). More than 100 volunteers participated in simulated journeys, allowing researchers to collect over 50 behavioral variables related to disease transmission—such as interpersonal spacing, face orientation, speech volume, and lavatory contact patterns—using synchronized video, sensor networks, and computer vision tools. These data were then used to parameterize an agent-based behavior model.
3. **Ventilation Data Acquisition:** This team, led by NRC with support from NIOSH, captured airflow characteristics and thermal conditions in the airport gate, jet bridge, and aircraft cabin. They performed detailed field measurements in North American airports and onboard aircraft and constructed a 60-foot jet bridge mockup at the CATR facility for laboratory

testing. Thermal manikins and tracer gas experiments were used to replicate realistic airflow patterns, which informed boundary conditions for computational fluid dynamics (CFD), which models airflow and particle dispersion simulations. Their work addressed key data gaps in understanding aerosol dispersion in the gate-to-gate environment.

4. **Microbial Hazard Definition:** Comprising public health experts from CDC, this team contributed to establishing biological profiles for three pathogens, beginning with SARS-CoV-2 and H5N1. They provided detailed parameter estimates for shedding rates, infectious dose thresholds, aerosol size distributions, and inactivation kinetics in air and on surfaces. These values were integrated into the TRIP-X simulation framework, enabling dynamic modeling of infection risk based on realistic microbiological characteristics.
5. **Risk Controls:** Led by NIOSH, this team evaluated a broad range of mitigation strategies using the NIOSH Hierarchy of Controls and bowtie risk analysis. Control options such as masking, enhanced ventilation, queue management, and disinfection treatments were assessed for feasibility, effectiveness, and operational impact. Their findings were translated into simulation logic, enabling TRIP-X to estimate how various interventions influence transmission risk in complex travel scenarios. The team's work helped contextualize control efficacy within real-world aviation constraints and stakeholder concerns.
6. **Modeling and Simulation Software Development:** Boeing led this team in developing TRIP-X's modular, open-source simulation architecture (see figure 3). Core components included an agent-based model (ABM) for simulating passenger behavior and interactions, CFD airflow modeling, a pathogen dispersion and transmission model, an epidemiological model for exposure and infection, and visualization tools (see figure 4). The team ensured interoperability between modules via standard data formats (e.g., JSON, CSV), facilitating plug-and-play capability. Their architecture enabled independent module refinement and allowed rapid testing of new scenarios and communicable diseases, making TRIP-X adaptable for future use cases beyond the initial development scope.

Each team maintained defined integration points and participated in regular feedback cycles, enabling dynamic refinement of model components and shared assumptions.

Figure 1

FAA-led program management and system integration framework for TRIP-X. The TRIP-X collaboration was structured around six core technical teams, each focused on a critical domain of communicable disease risk modeling in air travel. Bidirectional interfaces and a shared operational scenario enabled integration across disciplines. This structure supported iterative development, modular design, and scientific coherence across the modeling framework.

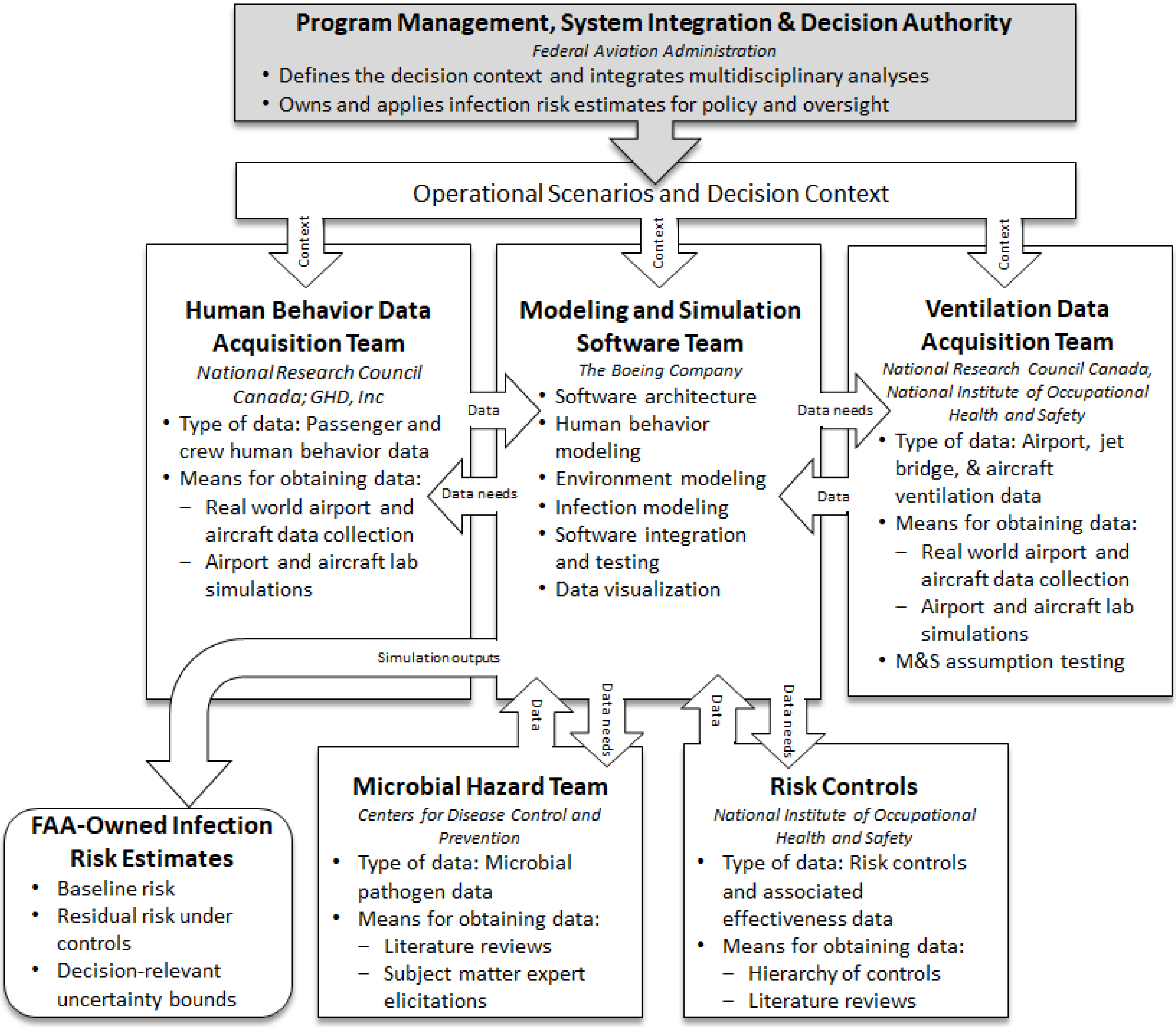


Figure 2

Simulated gate-to-gate travel environment at NRC's Centre for Air Travel Research (CATR) (NRCC 2023). CATR facility replicates a full-scale passenger journey through the airport terminal gate, jet bridge, and single-aisle aircraft cabin. This high-fidelity lab environment enabled controlled studies of passenger behavior and airflow dynamics under conditions matching the TRIP-X reference scenario, supporting the development of realistic disease transmission models for air travel.

Figure 3

Modular software architecture of the TRIP-X modeling framework. The TRIP-X system is composed of interoperable modules representing key components of disease transmission dynamics, including space geometry creation, agent-based simulation, CFD, pathogen dispersion, epidemiological progression, testing and screening, mitigation technologies, and visualization. Each module operates independently with standardized data interfaces, allowing iterative refinement and flexible integration of empirical inputs for various travel scenarios.

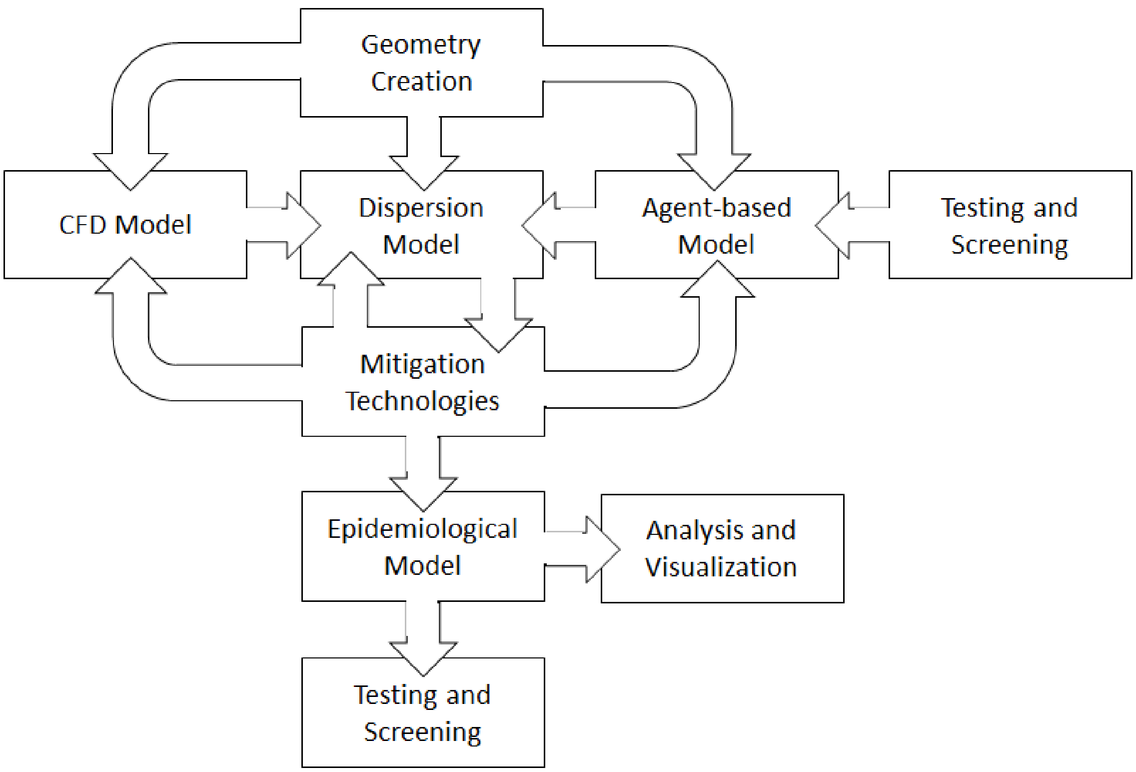


Figure 4

Visualization of a TRIP-X simulation scenario integrating behavior, airflow, and pathogen dispersion. This output visualizes simulated human agents in an airport gate and jet bridge, overlaid with airflow vectors and aerosol plumes. The visualization module allows dynamic assessment of transmission risk and mitigation strategies, enhancing stakeholder understanding and communication beyond statistics and data tables.

Lessons Learned

The AIRS program and the development of TRIP-X provided critical insights into the challenges and enablers of interdisciplinary applied research. Among the most important early lessons was the necessity of establishing a unified vision through early consensus on problem framing. With contributors from public health, engineering, behavioral science, aviation, and software development, the program required agreement on a guiding question: how can we assess the risk of communicable disease transmission across the full gate-to-gate air travel experience and evaluate the effectiveness of layered risk controls? This shared understanding laid the groundwork for the development of a reference operational scenario (see figure 5) that spanned key travel phases—from departure gate assembly and jet bridge queuing to in-flight exposure and deplaning. This scenario served as the foundation for aligning technical assumptions across all modeling teams.

Effective collaboration across disciplinary boundaries also depended on developing a shared working language. Each specialty brought its own terminology and modeling conventions: HVAC and environmental control system engineers spoke in terms of boundary conditions and flow regimes; microbiologists described particle viability and dose-response; behavioral scientists coded movements, touches, and speech. The creation of visual frameworks, such as the three-space model (which includes an airport gate area, boarding bridge, & aircraft cabin) and modular software architecture, helped reconcile these perspectives. These visual tools became critical to fostering clarity in communication, aligning expectations, and integrating parallel workstreams to produce a coherent simulation platform.

Methodological choices were also shaped by practical and ethical constraints. Direct data collection in active airports and onboard aircraft was limited by safety protocols, privacy concerns, and logistical challenges. As a result, the NRC's CATR emerged as a vital surrogate environment. Within this controlled high-fidelity facility, the team was able to collect behavioral and environmental data without interfering with commercial operations or violating passenger privacy. The ability to replicate realistic travel conditions—including gate areas, jet bridges, and cabin interiors—enabled the team to run structured behavioral trials that generated reproducible inputs for model parameterization.

The program's modular software architecture (see figure 3) proved to be a strategic asset. Each core module—covering the creation of the 3D environment, pre-departure and post-arrival screening, agent-based modeling, CFD, pathogen dispersion, epidemiological exposure and infection risk, the use of risk control assessment, and the implementation of mitigation technologies (that are within each these core modules)—was developed independently but connected via standardized interfaces. This allowed teams to iterate at different speeds and revise their components without disrupting the entire system. As new behavior data emerged or environmental measurements were refined, modules could be updated and tested within the existing architecture, maintaining program momentum and technical flexibility.

TRIP-X's relevance to real-world stakeholders was another essential ingredient for success. Gaining the cooperation of airlines, airports, and aircraft manufacturers required more than outreach—it required demonstrating that the model reflected operational realities. The TRIP-X model's design helped stakeholders see their environments and decisions represented in the simulation. This operational grounding not only enhanced the credibility of the model but also facilitated access to data, infrastructure, and expert feedback.

The program also benefited from a non-linear, iterative development process. As data were collected, simulation assumptions were updated. Field measurements led to refinements in airflow models; pilot studies informed behavioral timelines; and control strategies were recalibrated based on simulated outcomes. This feedback-rich environment allowed the model to evolve responsively, improving both its robustness and its credibility with decision-makers.

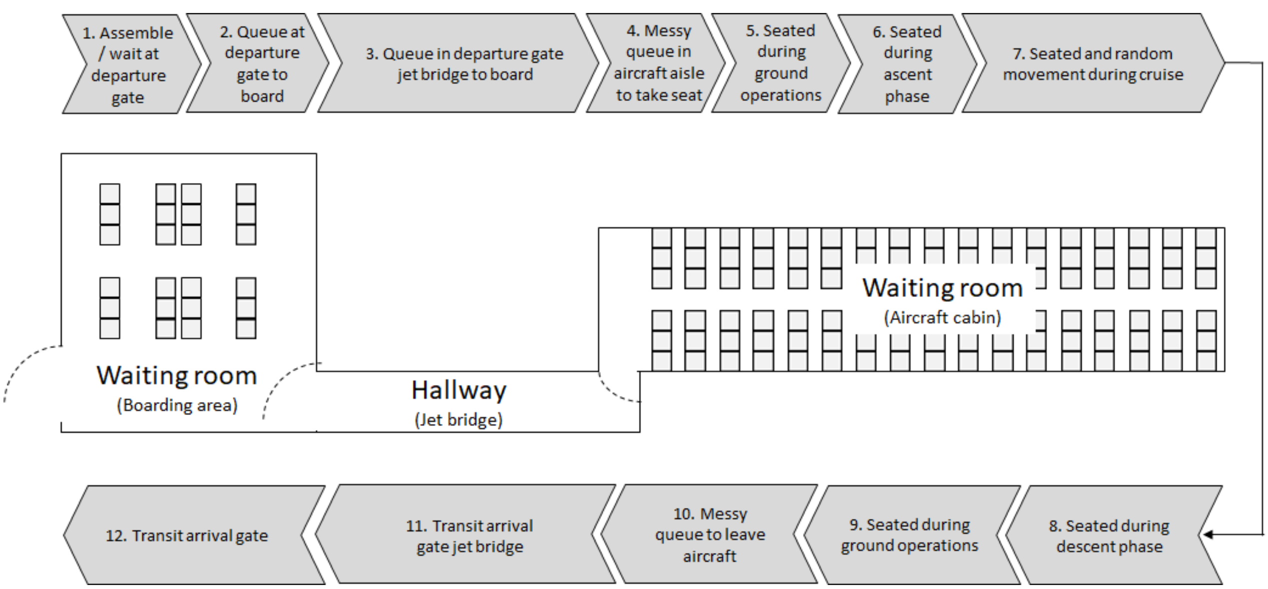
Balancing scientific rigor with computational and practical usability was another recurring theme. While the team aimed for accuracy, they quickly recognized the need for simplifying assumptions to ensure the model was computationally efficient and interpretable. For example, droplet and aerosol transmission were treated with a unified exposure model, and CFD grid resolution was optimized for efficiency. These tradeoffs were made consciously and transparently, keeping the model fit for its intended purpose as a decision-support tool within ICAO's SMS framework.

Perhaps most significantly, the AIRS program demonstrated that interdisciplinary trust is built not through uniform agreement but through transparency, flexibility, and a shared commitment to problem-solving. Disagreements inevitably arose—on topics ranging from data interpretation and control feasibility to model parameter selection. What kept the program on track was a culture of constructive dissent. Rather than force consensus, the team used comparative simulations to test alternative assumptions, leveraging independent CFD studies and the TRIP-X platform as a neutral ground for technical resolution. This process fostered mutual respect across disciplines and encouraged continued innovation even in the face of uncertainty.

These lessons—early consensus on scope, a shared conceptual framework, modular design, iterative development, stakeholder co-creation, and transparent negotiation of uncertainty—offer a replicable template for future modeling efforts where science, policy, and real-world operations must align.

Figure 5

Reference operational scenario for TRIP-X simulations. This diagram outlines the sequential phases of a representative gate-to-gate journey used to anchor all TRIP-X modeling activities. The scenario includes passenger assembly, queuing, boarding, in-flight phases, deplaning, and terminal transit, spanning from the departure gate through the jet bridge, cabin, and arrival gate. It served as a shared framework across teams to standardize assumptions for human behavior, environmental conditions, and disease transmission dynamics.



Conclusion

The AIRS program demonstrates that credible, operationally grounded tools for assessing communicable disease transmission risk in air travel can be developed through sustained interagency collaboration, clear federal leadership, rigorous technical integration, and early alignment with safety management frameworks. By directly addressing longstanding GAO concerns—such as fragmented stakeholder coordination, limited data access, and inadequate modeling infrastructure— the AIRS program not only delivered a functional simulation platform but also an FAA-centered model for integrating science into Safety Risk Management and policy-relevant decision making. As pandemic preparedness becomes central to global health security, TRIP-X offers both a usable decision-support tool and a foundation for continued innovation in public health and transportation safety modeling.

References

Wardle J, Bhatia S, Cori A, Nouvellet P. (2024). Temporal variations in international air travel: implications for modelling the spread of infectious diseases. *Journal of Travel Medicine,* 31(4), Article taae062. https://doi.org/10.1093/jtm/taae062

Zhao D, Cheng S, Tsui FR, et al. (2024). The risk of aircraft-acquired SARS-CoV-2 transmission during commercial flights: a systematic review. *International Journal of Environmental Research and Public Health,* 21(6), Article 654. https://www.mdpi.com/1660-4601/21/6/654

International Air Transport Association (IATA). (2025) *Industry statistics – fact sheet*. https://www.iata.org/en/iata-repository/pressroom/fact-sheets/industry-statistics

Sun X, Wandelt S, Zhang A. (2022). COVID-19 pandemic and air transportation: summary of recent research, policy consideration and future research directions. *Transportation Research Interdisciplinary Perspectives,* 16(100718). https://doi.org/10.1016/j.trip.2022.100718

U.S. Government Accountability Office (GAO). (2024) *Commercial aviation: key lessons from COVID-19 preparedness and emergency financial assistance to the industry.* https://www.gao.gov/products/gao-24-106754

Sachs, J. D., Karim, S. S. A., Aknin, L., Allen, J., Brosbøl, K., Colombo, F., ... & Michie, S. (2022). The Lancet Commission on lessons for the future from the COVID-19 pandemic. *The Lancet*, 400(10359), Article 1224. https://doi.org/10.1016/S0140-6736(22)01585-9

Marcus, L. J. (2020). Assessment of Risks of SARS-CoV-2 Transmission During Air Travel and Non-Pharmaceutical Interventions to Reduce Risk, Phase One Report: Gate-to-Gate Travel Onboard Aircraft. *Faculty and Scientists at the Harvard TH Chan School of Public Health*. https://npli.hsph.harvard.edu/wp-content/uploads/2023/08/Harvard-APHI-Phase1-FINAL3.pdf

Wang, F., You, R., Zhang, T., & Chen, Q. (2022). Recent progress on studies of airborne infectious disease transmission, air quality, and thermal comfort in the airliner cabin air environment. *Indoor Air*, *32*(4), e13032. https://doi.org/10.1111/ina.13032

Abouelhamd, I. M., Kuga, K., Yoo, S. J., & Ito, K. (2024). Effect of crowd density, wind direction, and air temperature on the formation of individual human breathing zones in a semi-outdoor environment. *Sustainable Cities and Society*, 103, 105274. https://doi.org/10.1016/j.scs.2024.105274

Shao, S., Zhou, D., He, R., Li, J., Zou, S., Mallery, K., ... & Hong, J. (2021). Risk assessment of airborne transmission of COVID-19 by asymptomatic individuals under different practical settings. *Journal of aerosol science*, *151*, 105661. https://doi.org/10.1016/j.jaerosci.2020.105661

U.S. Government Accountability Office (GAO). (2015). *Air travel and communicable diseases: comprehensive federal plan needed for U.S. aviation system's preparedness*. https://www.gao.gov/products/gao-16-127

U.S. Government Accountability Office (GAO). (2020) *Air travel and communicable diseases: status of research efforts and action still needed to develop federal preparedness plan.* https://www.gao.gov/products/gao-20-655t

U.S. Government Accountability Office (GAO). (2022) *Air travel and communicable diseases: federal leadership needed to advance research*. https://www.gao.gov/products/gao-22-104579

International Civil Aviation Organization (ICAO). *Safety Management Manual (SMM)*. 4th ed. Montréal (QC): ICAO; 2018. (Doc 9859)

International Civil Aviation Organization (ICAO). *Annex 19 to the Convention on International Civil Aviation: Safety Management*. 2nd ed. Montréal (QC): ICAO; 2016.

National Research Council Canada (NRCC). (2023) *Centre for Air Travel Research*. https://nrc.canada.ca/en/research-development/nrc-facilities/centre-air-travel-research