NOTICE

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12. Abstract In response to the U.S. Government Accountability Office report GAO-22-104579, the Federal Aviation Administration has initiated leadership of the Aviation Infectious Risk and Safety program. This consortium is comprised of industry, academic, governmental, and international partners to develop computationally efficient modeling techniques to simulate disease transmission in air travel, and assess the relative efficacy of risk mitigation strategies. A key component of the endeavor involves acquiring datasets for realistic model parameterization and validation research. This report provides a detailed human behavior dataset collected in both commercial air travel and simulated laboratory settings representing the gate area, jet bridge, and aircraft cabin. Data presented include passenger movement, speech, surface touches, and ambient conditions such as temperature and dew point.	
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Aerospace - Flight Research Centre

Communicable Disease Transmission in Air Travel: Human Behaviour

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Outline

Introduction

Refer to https://doi.org/10.21949/1529730 for an overview of the program titled "Aviation Infectious Risk and Safety: A Collaborative Program for Modeling Infectious Disease Transmission in Air Travel"

Project Background

To better prepare for future pandemic/disease outbreaks, the Federal Aviation Administration (FAA) is 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 (https://www.faa.gov/regulations_policies/orders_notices/index.cfm/go/document.information/documentID/1042164). Applying SRM to disease transmission necessitates tools that quantitatively analyze risks for passengers and aviation workers. To meet these goals, an international, cross-disciplinary collaboration was established to study real-world scenarios and human behavior and ventilation data in airports and aboard aircraft. Refer to https://doi.org/10.48321/D10D9E1D06 for the 'Communicable Disease Transmission in Air Travel' executive summary.

Method

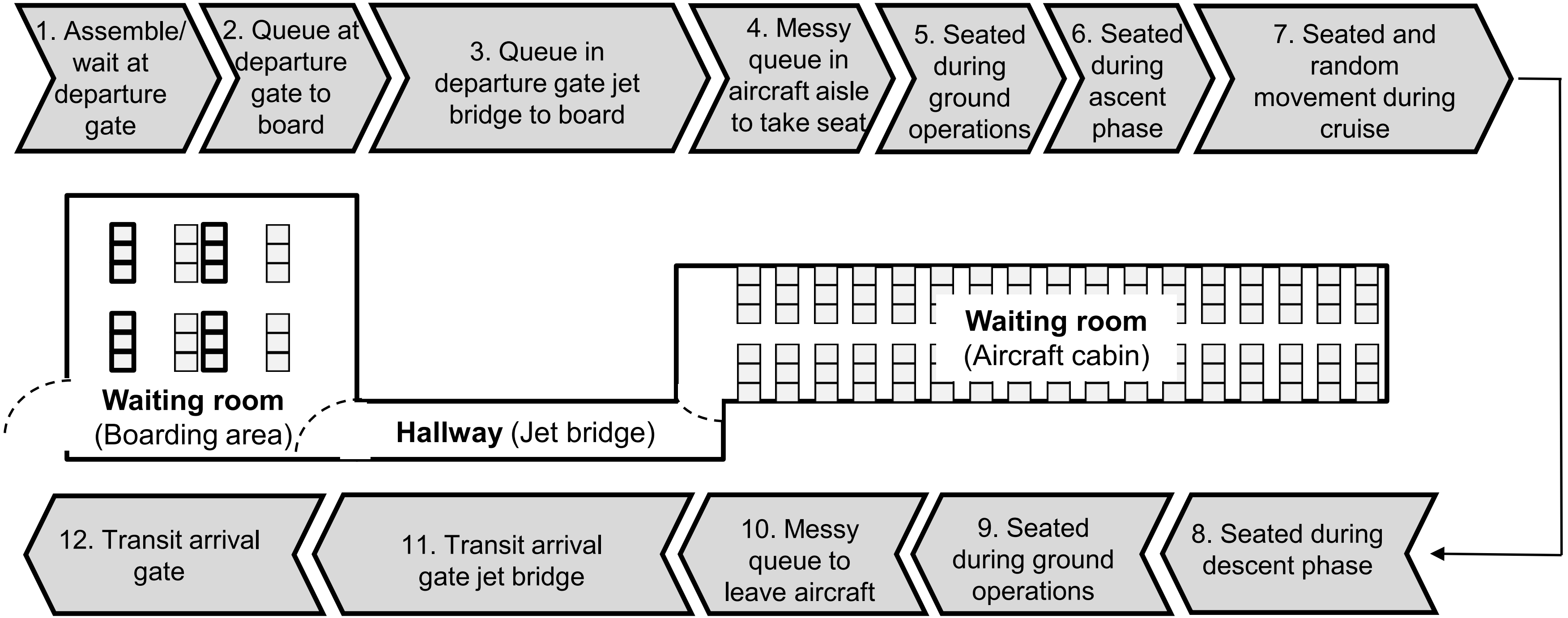
Refer to https://doi.org/10.21949/1528567 for further details on the protocol and methods used to capture this dataset titled “Communicable Disease Transmission in Air Travel: Human Behavior – Phase 1 Report”

Scenario

A gate-to-gate travel scenario, represented as a 3-space (referred to as dyads) building framework, guided the project (function flow depicted on next slide) and included:

- A single aisle narrowbody airliner,
- A 30-inch seat pitch in economy class seating with front-to-back boarding by zones,
- A two-hour flight with passengers wearing winter clothing, receiving food service,
- One unknown infectious individual, no transmission controls other than normal operations, e.g. passengers/crew optionally wearing masks and
- Recirculation fans active only during boarding and deplaning.

Scenario – Function Flow

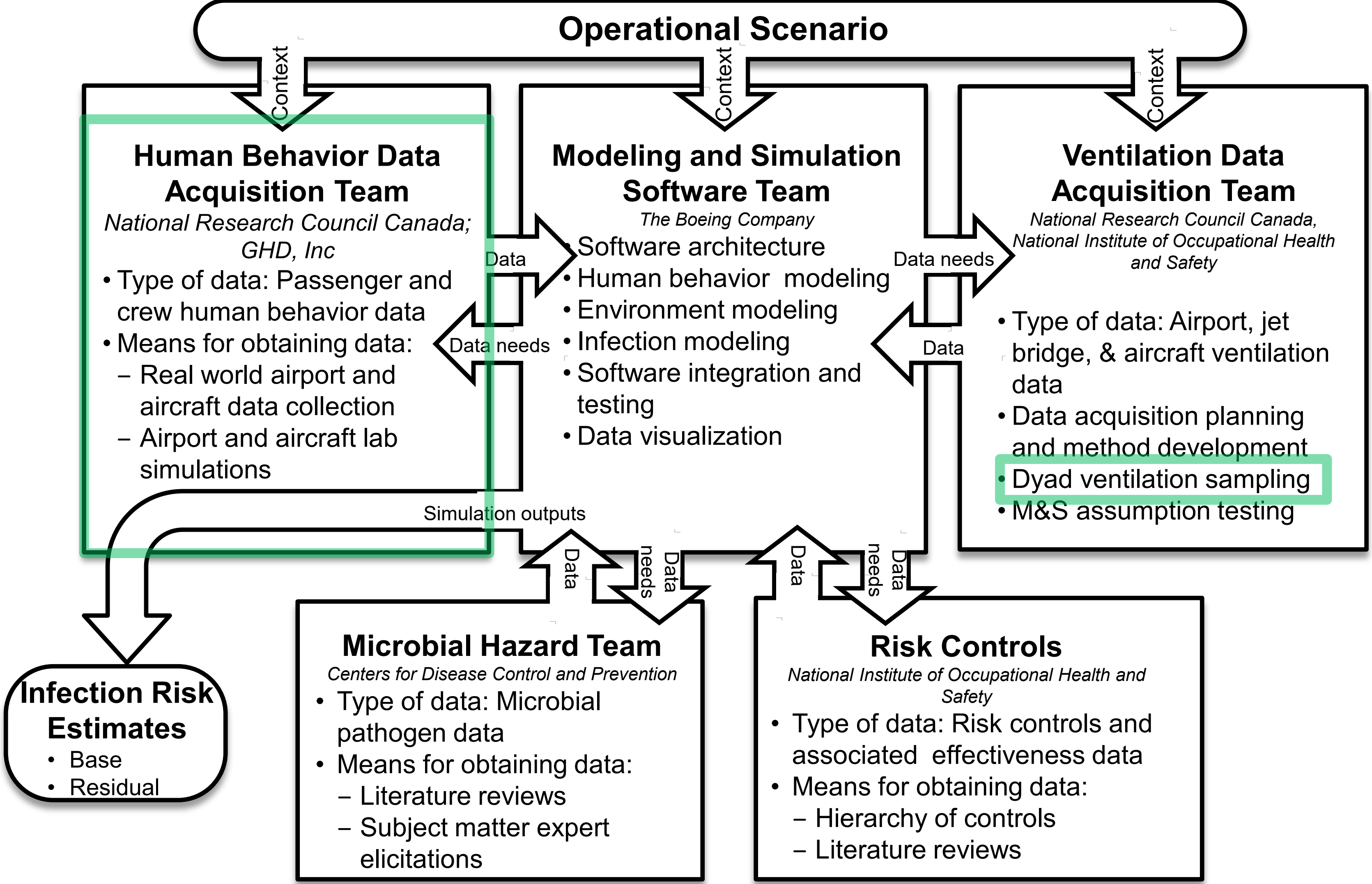


The gate-to-gate air travel scenario represented both as (1) a function flow of environment-person behavior dyads, and (2) a generic 3-space building. From https://doi.org/10.21949/1529730

Team Based Execution Framework

On the next slide the graphic depicts the team based execution framework with feedback loops between data collected and data needed for model used to develop the M&S solution for estimating infection risk.

In the graphic the Green box represents the Human Behaviour and Ventilation Data captured and reported in this dataset.



Operational Scenario
Context
Context
Context
Human Behavior Data Acquisition Team
National Research Council Canada; GHD, Inc
• Type of data: Passenger and crew human behavior data
• Means for obtaining data:
– Real world airport and aircraft data collection
– Airport and aircraft lab simulations
Data
Data needs
Modeling and Simulation Software Team
The Boeing Company
• Software architecture
• Human behavior modeling
• Environment modeling
• Infection modeling
• Software integration and testing
• Data visualization
Data needs
Data
Ventilation Data Acquisition Team
National Research Council Canada, National Institute of Occupational Health and Safety
• Type of data: Airport, jet bridge, & aircraft ventilation data
• Data acquisition planning and method development
• Dyad ventilation sampling
• M&S assumption testing
Simulation outputs
Data
Data needs
Data
Data needs
Infection Risk Estimates
• Base
• Residual
Microbial Hazard Team
Centers for Disease Control and Prevention
• Type of data: Microbial pathogen data
• Means for obtaining data:
– Literature reviews
– Subject matter expert elicitations
Risk Controls
National Institute of Occupational Health and Safety
• Type of data: Risk controls and associated effectiveness data
• Means for obtaining data:
– Hierarchy of controls
– Literature reviews

Method Explained

- The data collection method was built from a systematic review of existing approaches, in-field observations, and the lessons learned from 2 pilot studies.
- Data was collected from a combination of field data (5 flights) and simulation trials using a gate-to-gate simulation lab (Centre for Air Travel Research).

- The lab was configured such that the conditions matched the reference scenario simulating a terminal gate, jet bridge, and a single-aisle narrowbody air cabin.
- The environment is of medium-high fidelity, and includes multiple media (e.g. real flight audio and simulated video) and crew members to facilitate the participants' experience.

Data Collection Method

1. **Parameter Selection** — The broader team identified 50+ behavioural and ventilation parameters based on their relevance to disease transmission dynamics and the feasibility of data collection.

2. **Pilot Studies** — Methodology was informed and refined via pilot studies in the field and lab. Data was collected through a combination of video recordings, manual observations, and sensor instrumentation tailored to the specific context (Research Ethics Approval #2023-141)

3. **Technology Development** — NRC developed bespoke software to facilitate manual behaviour annotation, and advanced machine learning techniques were employed to automate complex tagging tasks such as facial orientation and passenger flow. Dedicated protocols were developed for field and lab trials to ensure that the parameters were populated using the various tools employed.

4. **Data Collection** — Data collection included a combination of: 3 trials (N=113) in the lab, 4 field flights and 5 flights captured via video at an airport gate and jet bridge.

5. **Data Annotation and Processing** — Manual and sensor-derived data were analyzed through behavior counts, while video data required annotation using either manual methods or computer vision algorithms. Bespoke software was relied on to facilitate manual annotation, and advanced machine learning techniques were employed to automate complex tagging tasks such as facial orientation and passenger flow.

6. **Assessment of Data Reliability** — Where possible, all parameters underwent an inter-rater reliability process and is described in this report. High inter-rater reliability indicates that the assessment tool or method produces stable and consistent results across different observers.

Clarifying Definitions

What is the manual method?

What is the machine learning method?

What is the assisted method?

What is derived data?

What is field data?

What is laboratory data?

What is in-person observation data?

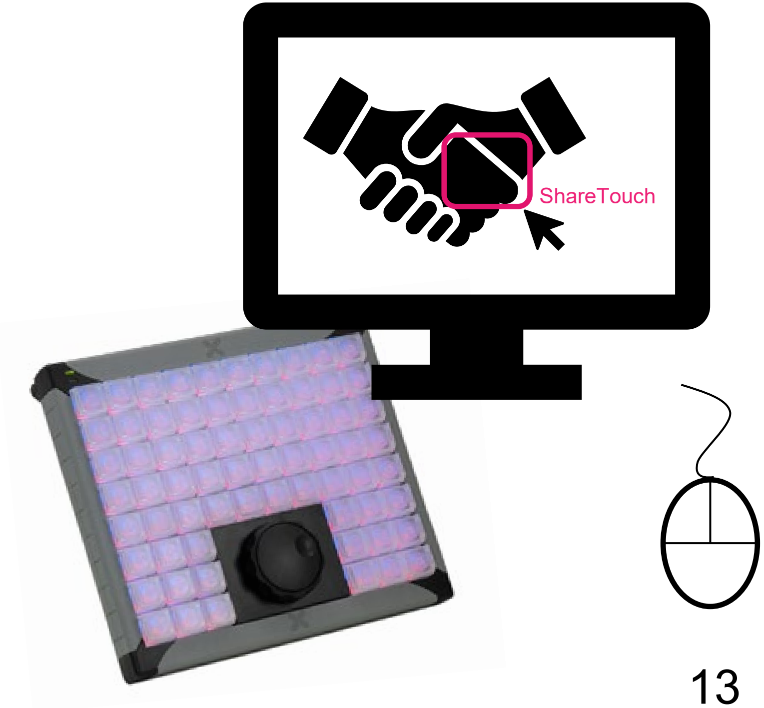
What is ventilation data?

What is the Manual Method?

Researchers use a video annotation tool to tag behaviors observed in video recordings from the Laboratory and Field (gate/jet bridge).

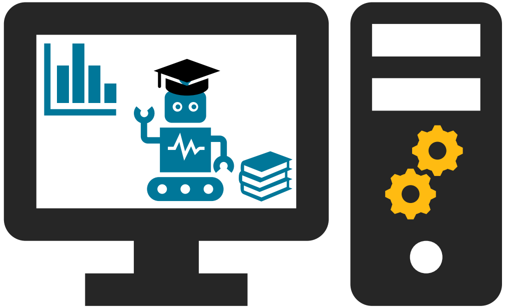
Camera views are selected to observe. A mouse and pre-programed keyboard was used to tag each behaviour.

The annotation tool can collect count and duration data.



What is the Machine Learning Method?

The source video is analyzed using selected computer vision and pattern recognition algorithms to detect specific object, object positions or events of interest. Method and algorithms/models used vary significantly by parameter.



The video is pre-processed, video images are classified/localized/segmented to locate objects of interest to the parameter such as people, specific body segments, luggage, seats, etc. The output is then post-processed, filtered and sorted to calculate the specific metric of interest.

For Example: Video from CATR/Field gate cameras is run through an algorithm that determines the locations of the people in the video. Using the known positions of all cameras, the positions of the people in the room can be calculated to create a location map. The data can then be used to calculate the relative density of individuals or their physical spacing.

What is the Assisted Method?

The assisted method refers to parameters that are collected using multiple methods. Some parameters are too challenging to collect for both **manual** and **machine learning** separately thus a hybrid method is used.

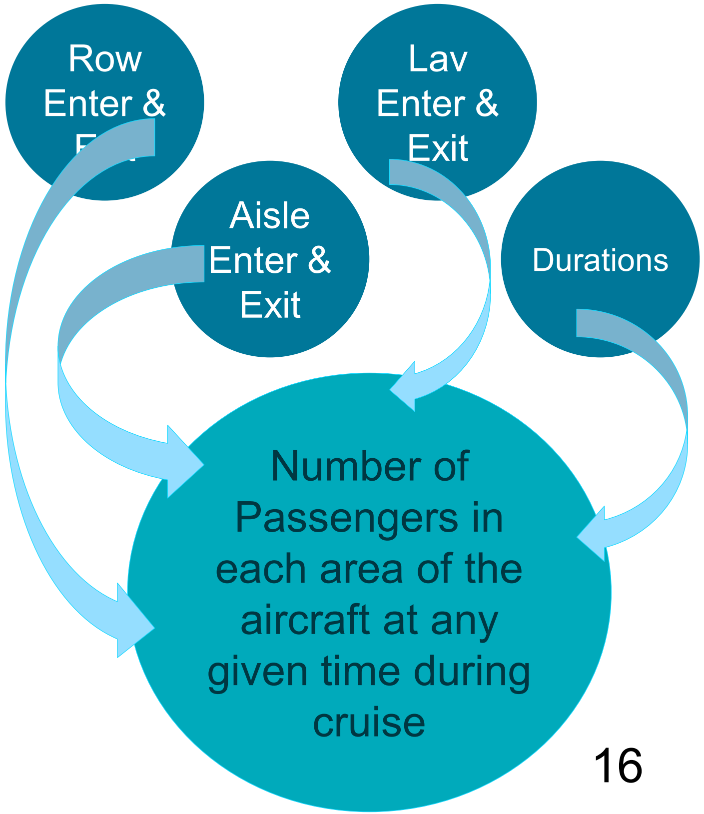
For example: Seatback touches is collected by using machine learning to detect video frames where a change has been detected above the top of the seat. A researcher then reviews these frames and identifies instances of an actual hand making contact with the top of the seat, drastically reducing time to view behaviours.

Top of Seat Touch

What is Derived Data?

Derived data is multiple annotated data parameters that are combined and organized to create the parameter of interest.

For example: Tracking passenger movements in the cabin was derived from Cabin enter/exit, Lavatory (LAV) enter/exit, Aisle enter/exit, and Row enter/exit.



What is Field Data?

Field data is data collected from an airport and commercial aircraft. Field data is ecologically superior to laboratory data but has limitations:

Gate and Jet Bridge

- Video data collection: lack control of the camera location, quality and angles.
- In-person collection: lack control of the scenario (power outages, medical emergencies, timings etc.).

Cabin

- Video collection: no access to video cameras in the air cabin.
- In-person collection: smaller sample size with no validation, limited visual views to observe, and researcher fatigue.

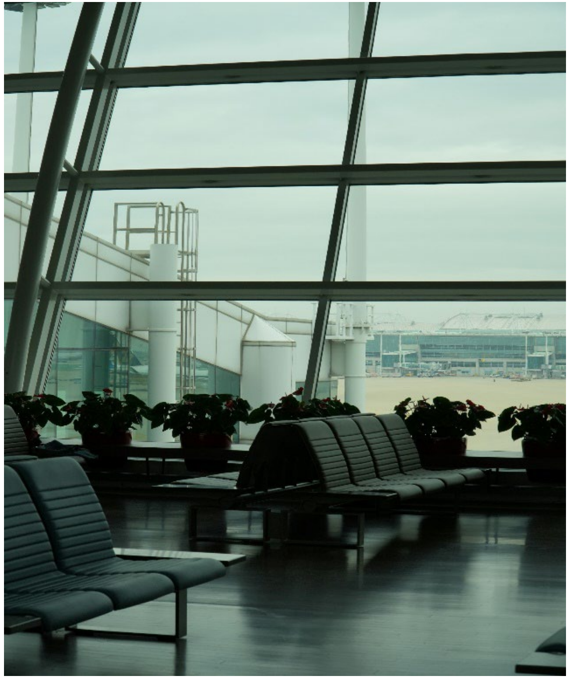


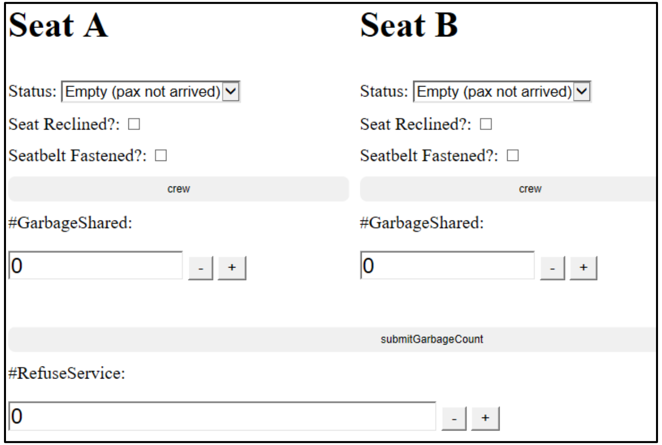
Photo by Eun Jun Kim https://unsplash.com

What is Laboratory Data?

Laboratory data was collected at NRC's Center for Air Travel Research Lab (CATR) which is an equipped gate to flight simulator with cameras, audio recording devices, sensors, and ventilation data collection tools.

What is In-person Observation Data?

In-person observation was used in the field where video cameras were not permitted: i.e. the air cabin. An electronic application was designed by NRC to collect data. Researchers took flights to observe the behaviours of passengers. The data was collected using a webform on a tablet that saves .CSV files.



What is Ventilation Data?

Ventilation is used to recreate the gate, jet-bridge, and cabin environments to be representative of that found in the field with the exception that hypobaric conditions were not replicated. The data include basic objective measures like dry-bulb temperature, dewpoint temperature, air flow rate, barometric pressure, and carbon dioxide concentrations. The ventilation data was captured in the CATR (simulator) and data associated with the field trials when applicable.

Inter-rater Reliability

Reliability of Human Behaviour

Inter-Rater Reliability (IRR) Definition:
Refers to the degree of agreement or consistency between 2 or more raters or observers assessing the same phenomenon. High inter-rater reliability indicates that the assessment tool or method produces stable and consistent results across different observers, enhancing the credibility and validity of the findings. *Anastasi, A., & Urbina, S. (1997). Psychological testing (7th ed.) Upper Saddle River, NJ: Prentice Hall.*

Where possible, all parameters underwent an inter-rater reliability process and is described next.

Reliability of In-person Data Collection

In-person field observation

This method did not have two observers monitoring the same behaviours at the same time of the same individuals. Thus, there are no reliability measures to report within these observations.

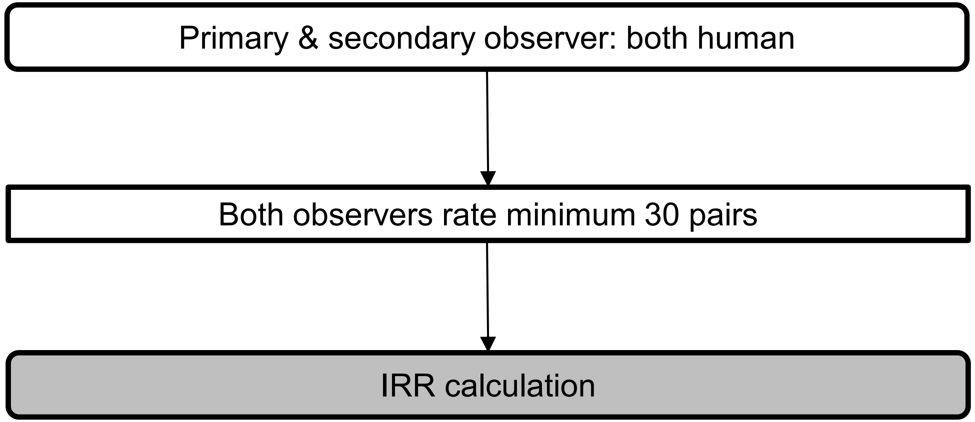
Reliability of Video Data Collection

Video data collection

This method of data collection allowed for two observers, either human or machine learning algorithm, to detect and categorize events from video data.

Reliability Procedure by Observer Type: Case 1

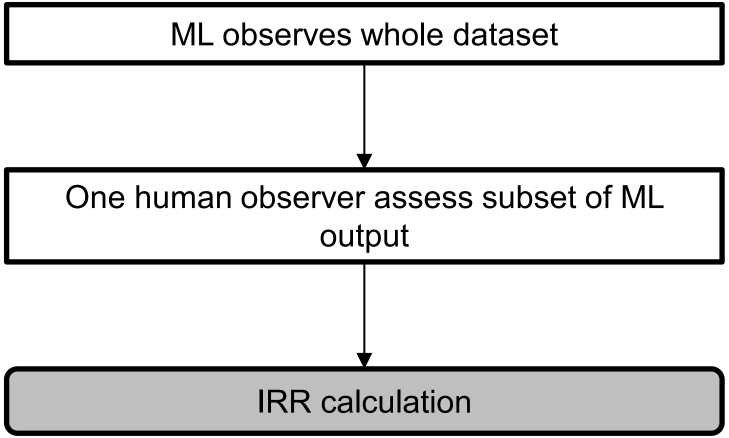
Case 1: Two human observers



Reliability Procedure by Observer Type: Case 2

Case 2: Assessing performance of machine learning (ML) algorithm

Machine learning results were evaluated by human observers. A human observer assesses the sample outputs of the machine learning algorithm.



Inter-Rater Reliability

It is important to note that some parameters did not go through the IRR process because:

1. The parameter was so exceptionally straightforward that there was no concern for disagreement.

or,

2. There were other parameters that were very similar that did go through IRR and therefore IRR assumption was made.

Inter-Rater Reliability Assumed (1/2)

The following parameters were seen as exceptionally straightforward (i.e. binary, clear) and therefore IRR was not necessary.

- Window Shade Movements (up/down)
- Seat Reclined (Reclined or upright)
- Participant time seated at the gate (Standing/seated)

Inter-Rater Reliability Assumed (2/2)

The following parameters were so similar or the same as other parameters that IRR was assumed.

- Barrier Touches was deemed similar to fuselage and overhead bin touch (> 80%)
- Face Direction at the queue (Gate) was deemed similar to Face Direction standing in the Cabin (98%)
- Desk Processing in the field video was deemed similar to Desk processing in the Laboratory (100%)
- All time tracking parameters (timelines and durations) were expected to have high IRR results because the pilot study had a duration agreement of $r = 0.99$.

Please see file "Data Dictionary Column IRR_% and If_Assumed" for all IRR details and descriptions for each parameter

Inter-Rater Reliability Method

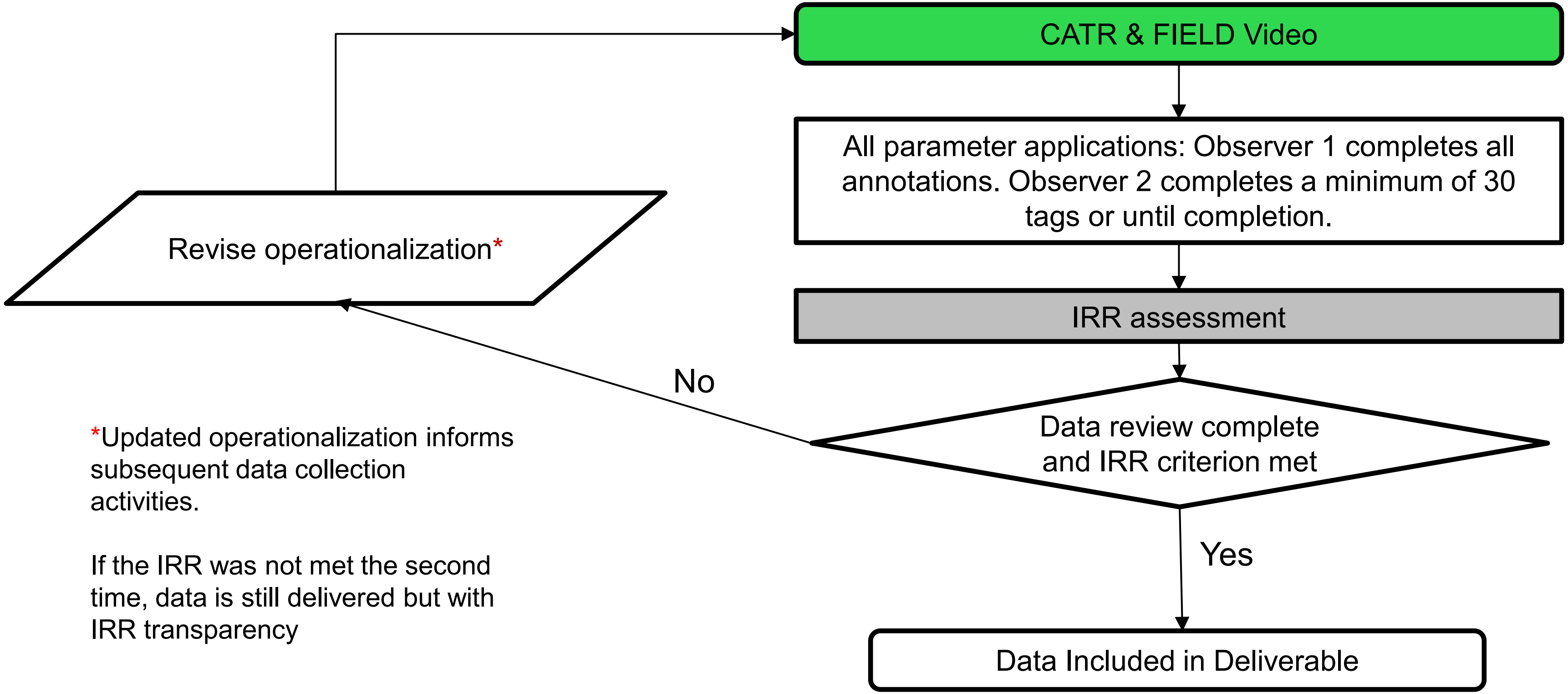
Frequency/Count Data:

Second observer required a minimum sample of 30 tags unless the total parameter was less than 30 tags. If this was the case, observer two would tag the behaviour from start to finish. The acceptance criterion suggested is 80% based on conventions in Kappa agreement.

Duration Data:

Pearson correlations was used to detect a correlation coefficient of .7 or higher (.8 is our suggested criterion). The first IRR test for an entire flight scenario reared an almost perfect agreement, thus future duration annotations were only done by one observer.

Overall Inter-Rater Reliability Assessment Flow Chart

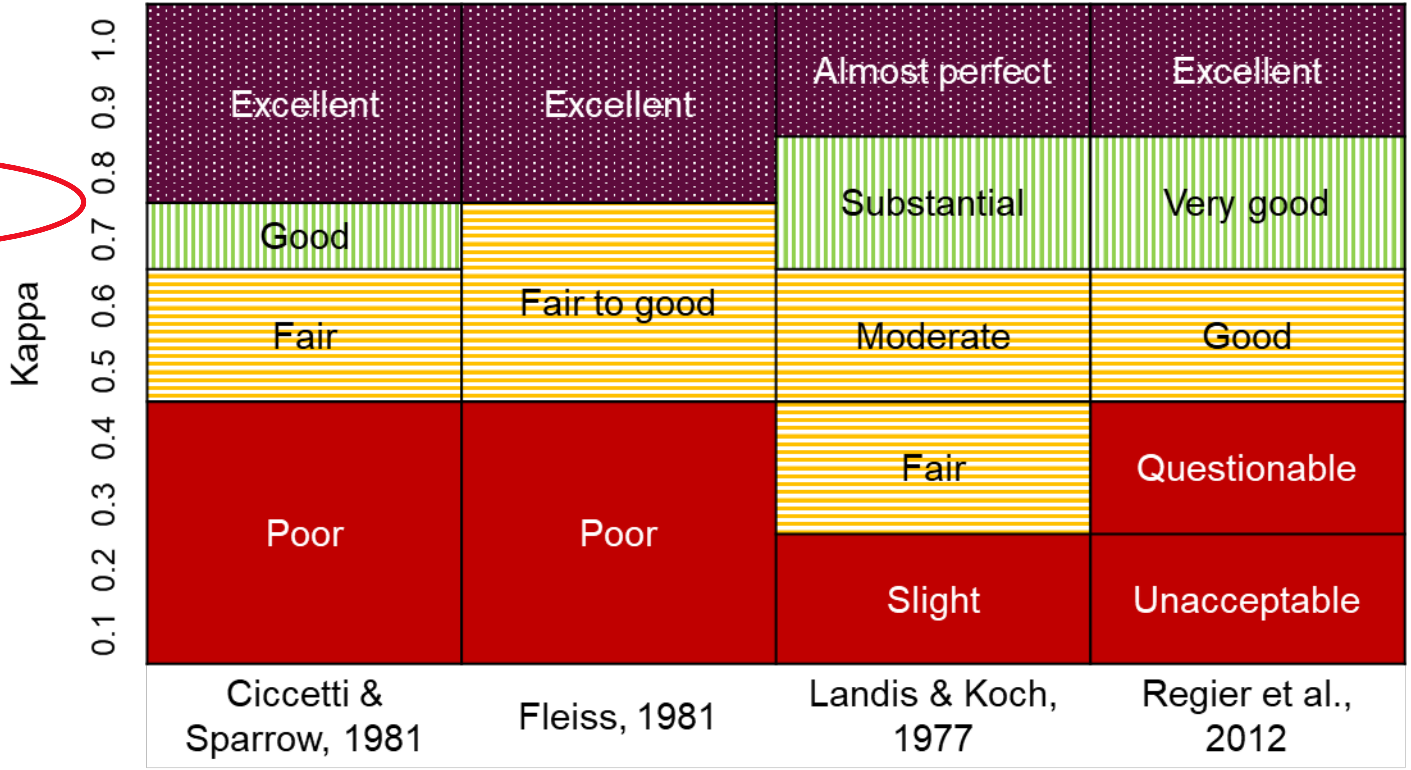


*Updated operationalization informs subsequent data collection activities.

If the IRR was not met the second time, data is still delivered but with IRR transparency

Kappa conventions

Suggested cut off



Reproduced from https://encord.com/blog/inter-rater-reliability/

Example IRR: Shared Touches in Air cabin

The IRR **Frequency/count data** for shared touch points was calculated between 2 observers.

Percent agreement = (Total number of hits/total number of events)*100

The percent agreement is above acceptance criterion.

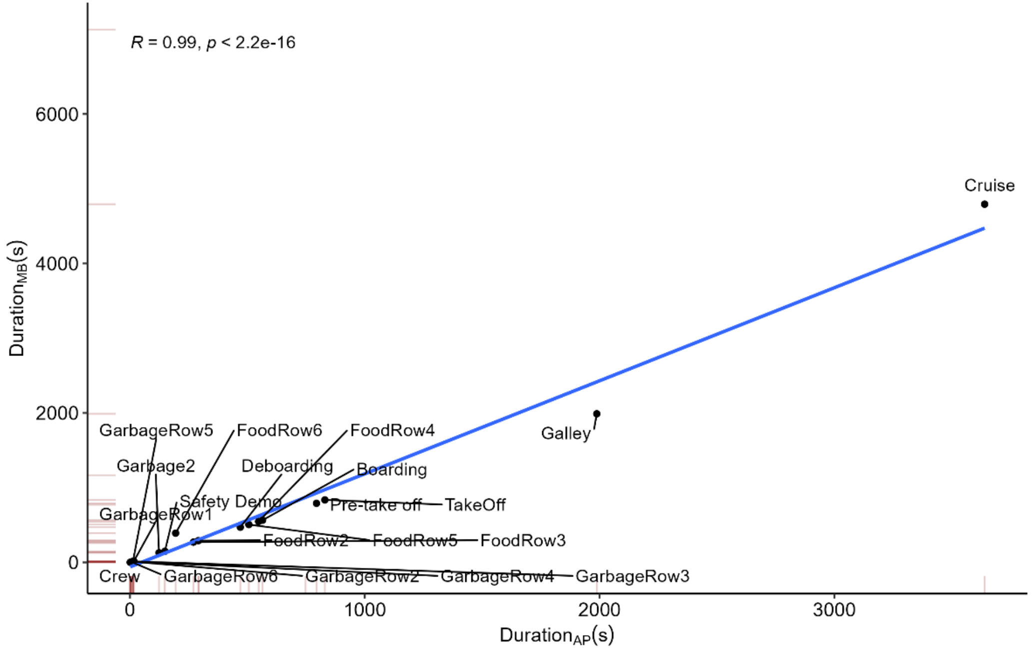
Observation Type	Count
Total Number of Hits Tags matching between Observers 1 and 2	**101**
Observer 1 Misses Tags that did not match with Observer 2	**7**
Observer 2 Misses Tags that did not match with Observer 1	**13**
Total number of events Total number of tags: hits and misses	**121**
Total number of misses	**20**
Percent agreement	**83%**

Example: Durations

IRR calculated between two observers for a range of durations.

Overall, very high alignment ($r_{Pearson}$ = *.99).*

Alignment decreases with increased overall durations.



Inter-Rater Reliability Failures

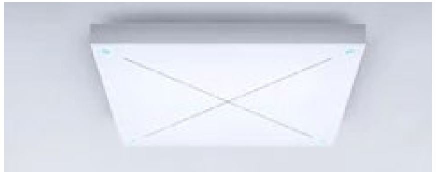
All Parameters tested met or exceeded the IRR criterion except for:

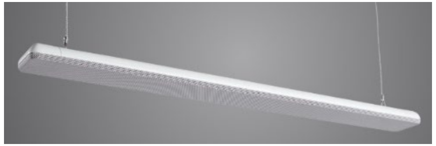
- Armrest Touch (64%)
- Seat Pouch Pocket Touch (74%)

Both behaviours were challenging to observe due to camera placement and occlusions. Additionally, observer perceptions of when a hand was lifted off or on the object of interest varied slightly which varied the number of touches across observers. To elaborate, often it was agreed that touches were made but there were disagreements regarding the exact number of touches.

Speech Detection – Analysis and Reliability (1/2)

A combination of 3 microphone types were used to capture data: Shure MXA710 microphone array, ATL: Sennheiser TeamConnect SL Ceiling 2 Microphone Array and Audio Technica PRO44 Unidirectional condenser boundary microphone. Audio files recorded during the three lab trials were analyzed using an in-house developed speech diarization Artificial Intelligence (AI) algorithm.





The speech detection output data was synchronized with the video data, and each event identified by the AI algorithm was manually confirmed through the visualization of the corresponding video recording. This process not only validated the timestamps of speech segment start and end times but also highlighted the limitations of voice signature identification due to the complex acoustic environment.

Speech Detection – Analysis and Reliability (2/2)

The timestamps of speech segments identified by the AI algorithm were found to be very accurate.

The speech diarization results revealed the limitations of the current AI algorithm, indicating a need for further development and enhancements to achieve higher accuracy. Additionally, manual visual verification of the results underscored the necessity for thorough validation to confirm the speaker ID for each speech segment identified by the algorithm and to eliminate any errors.

Ventilation Data – Analysis and Reliability

Ventilation data was cross checked against other sources where possible. For example, the lab barometric pressure was verified against the airport weather station for accuracy.

The cabin ventilation measurements collected via UPAS devices closely agreed with the lab ventilation system with one exception. The UPAS device reported higher temperatures due to picking up heat from other electrical components in a tight space.

The cabin carbon dioxide level was about 1,000 ppm lower than measured in the field due to the occupancy load being lower than a typical commercial flight. This will have some effect on passenger behavior.

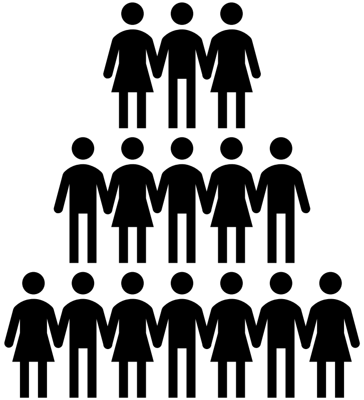
For more information on UPAS devices and how they were used to measure ventilation parameters in the field and in the lab please refer to https://doi.org/10.21949/ac4p-zd78

Demographics

Laboratory Trial Demographics

Demographics data were collected in the laboratory trials, however could not be collected in the field. This section includes participant demographic data collected across the three lab trials and includes:

- Age
- Gender/Sex
- Race/Ethnicity
- Body Mass Index
- Frequency of Air Travel



Age

Trial Number	Mean Age (years)	Standard Deviation	Range
Trial One	46.3	20.02	20 - 78
Trial Two	39	18.20	06 - 76
Trial Three	40.2	15.96	13 - 67

Sex/Gender

Trial Number	Female	Male	Other
Trial One	41.7%	58.3%	0%
Trial Two	57.0%	43.0%	0%
Trial Three	58.3%	41.7%	0%

Race/Ethnicity

Trial	Asian	Black /African	Hispanic	Indigenous	Other	White
Trial One	17.4%	4.3%	1.6%	5%	1.9%	69.8%
Trial Two	40%	8.6%	2.9%	0%	5.7%	42.8%
Trial Three	13.9%	0%	0%	0%	8.3%	77.8%

For those who answered other, they identified as either South Asian, North African, or Middle Eastern

Body Mass Index (BMI)

Trial Number	Mean BMI	Standard Deviation	Range
Trial One	25.29[1]	4.90	18.12 to 37.02
Trial Two	25.9[1]	6.04	13.12 to 43.36
Trial Three	25.76[1]	4.70	19.24 to 41.00

1. *According to World Health Organization (2014) Average population BMI = 27.2*

Frequency of Air Travel

Trial Number	Travel Frequently/Moderately	Travel Rarely	Prefer not to say
Trial One	53%	42%	5%
Trial Two	54.3%	42.9%	2.8%
Trial Three	52.8%	47.2	0%

Data

Important Notes (1/2)

1. The data provided is a basic set of raw data without further processing to preserve detail for modelling use. A future report will provide a higher-level of data processing (e.g. descriptives) for each parameter.

2. Each parameter was operationalized in order for the data to be reliably reproduced by others. These can be found in the file labeled “data dictionary”.

3. Each dataset should be treated as temporally independent from each other. The timings provided in the datasheets are specific to each individual parameter, even within the same trial. **The timings associated with the data should not be considered a common time scale and cannot be used to align events from different parameter datasets.**

Important Notes (2/2)

4. There are multiple datasets available for certain parameters, resulting from different methods of data collection, data sources and/or multiple laboratory trials. These methods include laboratory trials, field flights, and video recordings at airport gates and jet bridges. To enhance efficiency for end-users, the team has provided one specific dataset when multiple options were available, referred to as the ‘Primary’ Dataset. The recommendations are based on various factors, such as sample size. For instance, the dataset recommended may have a larger sample size, or be collected via video which is verifiable.

5. Data from the lab trials are the primary resource provided, with field observations also included (primarily in the Cabin dyad), to fill in gaps in the data captured from the lab trials.

Data Sources & Scenario Timelines

Source	Dyads included	Number of Flights/Trials	Timeline & Duration Data
Laboratory Video	All	3 trials	All 3 flight scenarios have full and complete timelines and durations
Field Video	Gate & Jet bridge	5 flights	1 of the flight scenarios has timeline and durations
Field In-person	All	4 flights	All 4 flight scenarios have partial and/or approximate timings and durations

Gate Parameters (20)

No.	Parameter Name	No.	Parameter Name
GT01	Face Direction Queuing at the Desk	GT11	Barometric Pressure
GT02	Time Seated at Gate	GT12	Supply Dry-Bulb Temperature
GT03	Queue Positions at Gate	GT13	Supply DewPoint Temperature
GT04	Passenger and Crew Shared Touches	GT14	Space Dry-Bulb Temperature
GT05	Face Direction Seated at Gate	GT15	Space DewPoint Temperature
GT06	Passenger Luggage	GT16	Space Carbon Dioxide Concentration
GT07	Desk processing Duration at Gate	GT17	Ventilation Rate
GT08	Passenger Duration in Desk Queue	GT18	Supply Dry-Bulb Temperature
GT09	Speech Gate	GT19	Space Dry-Bulb Temperature
GT10	Queue Length at Gate	GT20	Space Dewpoint Temperature

Jet Bridge Parameters (15)

No.	Parameter Name	No.	Parameter Name
JB01	Queue Density Boarding	JB09	Supply Dry-Bulb Temperature at Gate Doors
JB02	Jet Bridge Enter and Exit	JB10	Supply Dry-Bulb Temperature at Gate Doors
JB03	Face Direction Standing in Jet bridge	JB11	Barometric Pressure
JB04	Passenger and Crew Shared Touches	JB12	Outdoor Dry-Bulb Temperature
JB05	Speech Jet bridge	JB13	Outdoor Dewpoint Temperature
JB06	Total Queue Length	JB14	Solar Radiation
JB07	Duration of Delay between Passengers at Entrance of Cabin	JB15	Wind Measurements
JB08	Fuselage Touches		

Air Cabin Parameters (37) (Slide 1 of 3)

No.	Parameter Name	No.	Parameter Name
CB01	Frequency of Lavatory Use and Queue	CB09	Call Button
CB02	Sink Faucet On Button	CB10	Overhead Bin touch
CB03	Toilet Cover	CB11	Window Shade Movements
CB04	Toilet Seat	CB12	Window Touches
CB05	Toilet Flush Button	CB13	Seat Reclined
CB06	Internal Lavatory Door Lock	CB14	Barrier Touches
CB07	Gaspers	CB15	Tray Table Movements
CB08	Light Button	CB16	Tray Table Touches

Air Cabin Parameters (37) (Slide 2 of 3)

No.	Parameter Name	No.	Parameter Name
CB17	Armrest Touches	CB24	Seat Belt On and Off
CB18	Top of Seat Touches	CB25	Passenger Duration Seated in Cabin
CB19	Passenger and Crew Shared Touches	CB26	Cabin Movements Boarding
CB20	Shared Touches by Service Row Duration	CB27	Cabin Movements Cruise
CB21	Seat Pouch Touch	CB28	Cabin Movements Deboarding
CB22	Face Direction Seated in Cabin	CB29	Seated Face Touches
CB23	Face Direction Standing in Cabin	CB30	Speech Cabin

Air Cabin Parameters (37) (Slide 3 of 3)

No.	Parameter Name	No.	Parameter Name
CB31	Space Carbon Dioxide Concentration	CB35	Supply DewPoint Temperature
CB32	Barometric Pressure	CB36	Space Dry-Bulb Temperature
CB33	Ventilation Rate	CB37	Space DewPoint Temperature
CB34	Supply Dry-Bulb Temperature		

Data Template – Explained (1/2)

Each parameter is associated with one slide in this section.

Metadata associated with each parameter is provided in these tables with links to the raw data.

**Parameter Name**

Dyad (Cabin/Jetbridge/Gate)

Source:	Where the data is sourced from: Laboratory, Airport video, Airport Manual etc.
Method:	Method of data extraction: Manual, Machine learning
Brief Description:	The frequency of passengers facing forward or not while standing in line at the gate
Sample Size:	Number of people observed
Primary Data:	Primary dataset name

Data Template – Explained (2/2)

“Parameter Name” and the “Dyad” (gate, jet bridge or cabin) associated with the parameter.

“Source” provides information about where the data was collected and how.

Sample size varies and is dependent on the source of the data.

“Primary Data” will provide the reader with a direct link to the recommended raw data source associated with each parameter slide.

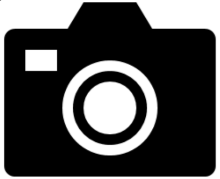
Parameter Name

Dyad (Cabin/Jetbridge/Gate)

Source:	Where the data is sourced from: Laboratory, Airport video, Airport Manual etc.
Method:	Method of data extraction: Manual, Machine learning
Brief Description:	The frequency of passengers facing forward or not while standing in line at the gate
Sample Size:	Number of people observed
Primary Data:	Primary dataset name

“Method” provides information about how the data was annotated and processed

“Brief Description” provides a high level description of the parameter.



A picture to provide the reader with a visual depiction of data capture

Data Dictionary - Metadata described (1/2)

Important Metadata in Data Dictionary File Described

Column	Metatdata Name	Description
A	Dyad	Location the data was collected from either **Gate**, **Jet Bridge**, or **Air Cabin**.
B	ParamNumber	Individually assigned identification numbers for each parameter.
C	Parameter_Name	Name of the behaviour/parameter.
D	Brief_Description	High level description of the parameter.
E	Parameter_Source	Reference to where the data was collected from: airport or laboratory.
F	Data_Sheet_Name	Reference to the raw data sheet name.
G	Category	The categorization of the parameter: touch, movement, individual characteristic, or speech

Data Dictionary - Metadata described (2/2)

Important Metadata Described

Column	Metatdata Name	Description
H	Passenger_Population_Size	Total number of passengers from a given source.
I	Passenger_Sample_Size	Number of passengers whose data was collected for any given parameter.
J	Crew_Population_Size	Total number of air cabin service crew members in the air cabin
K	Collection_Method	The data collection method used to collect the data.
L	Operationalizations	Rules and descriptions researchers followed to annotate behaviours.
M	Service_type	The type and number of food/drink services offered onboard the flight.
N	Airframe	The type of body/structure excluding the engine and other systems of the aircraft.
O	Notes-important considerations	Additional notes that may be relevant to the modelers

GT01 Face Direction Queuing at the Desk Gate

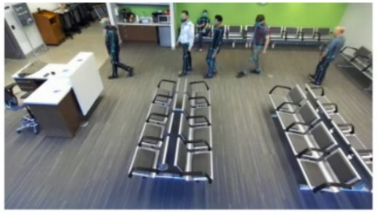
Variable	Value
Source:	Trial 1 Laboratory Video
Method:	Annotation Tool Manual
Brief Description:	The frequency of passengers facing forward or not while standing in line at the gate
Sample Size:	36
Primary Data:	Gate_QueueFaceDir_T1

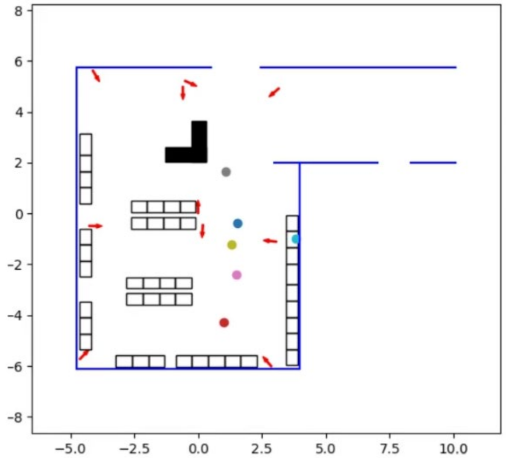
GT02 Time Seated at Gate
Gate

Variable	Value
Source:	Field Video 1
Method:	Annotation Tool Manual, Derived
Brief Description:	The proportion of time passengers spend seated at the gate
Sample Size:	28 Seats Observed
Primary Data:	Gate_SeatedDuration_FV1

GT03 Queue Positions at Gate Gate

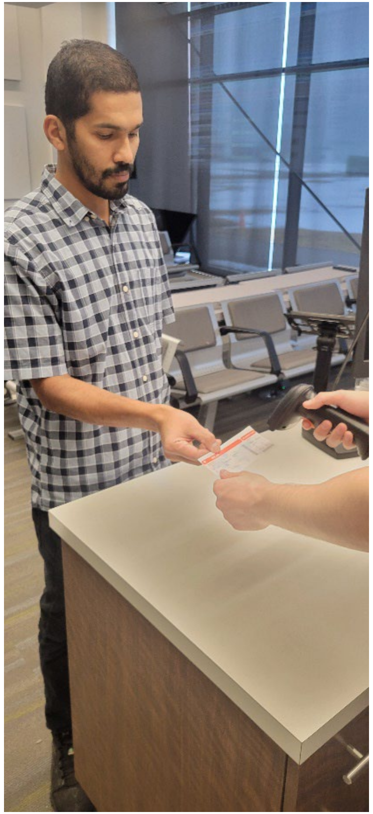
Variable	Value
Source:	Field Video 1
Method:	Machine Learning, Assisted
Brief Description:	The relative position of passengers in queue at the gate (waiting for boarding pass/ID verification)
Sample Size:	151
Primary Data:	Gate_BoardQueuePositions_FV1





GT04 Passenger and Crew Shared Touches Gate

Variable	Value
Source:	Field Video 5
Method:	Annotation Tool Manual
Brief Description:	The count of passengers and crew directly touching hands or passing an object to each other
Sample Size:	171
Primary Data:	Gate_ShareTouch_FV5

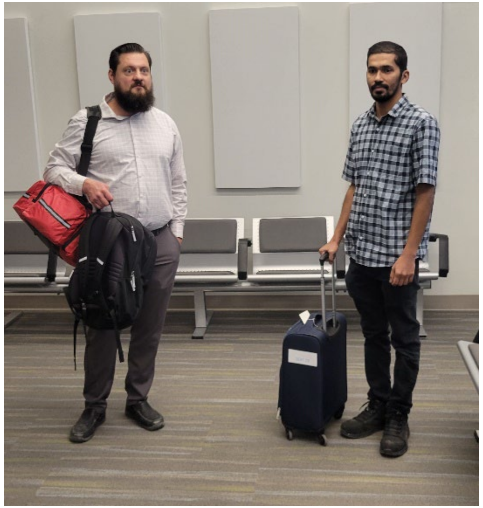


GT05 Face Direction Seated at Gate Gate

Variable	Value
Source:	Field Video 1
Method:	Annotation Tool Manual
Brief Description:	The frequency of passengers facing forward or not while seated at the gate
Sample Size:	28 Seats Observed
Primary Data:	Gate_SeatFaceDir_FV1

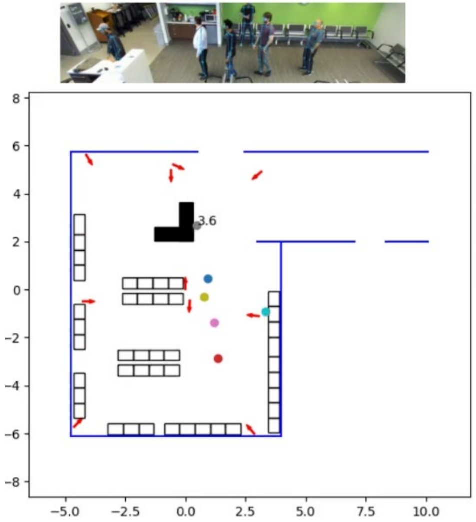
GT06 Passenger Luggage Gate

Variable	Value
Source:	Field Video 1
Method:	Annotation Tool Manual
Brief Description:	The type and count of luggage passengers bring on a flight
Sample Size:	151
Primary Data:	Gate_Luggage_FV1



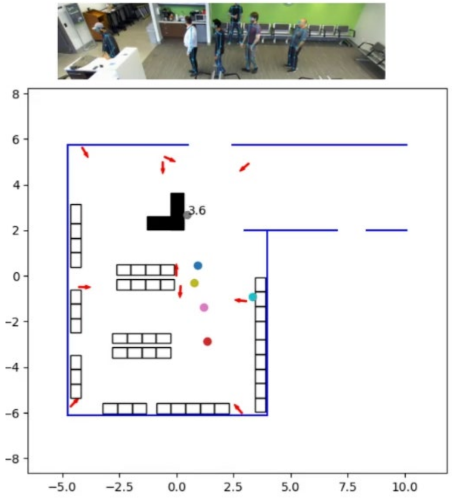
GT07 Desk processing Duration at Gate Gate

Variable	Value
Source:	Field Video 5
Method:	Annotation Tool Manual, Derived
Brief Description:	The duration of each passenger to approach and depart the gate desk
Sample Size:	171
Primary Data:	Gate_DeskProcessing_FV5



GT08 Passenger Duration in Desk Queue Gate

Variable	Value
Source:	Field Video 1
Method:	Annotation Tool Manual, Derived
Brief Description:	The duration each passenger is in the desk queue
Sample Size:	73
Primary Data:	Gate_PaxDurationDeskQueue_FV1



GT09 Speech Gate Gate

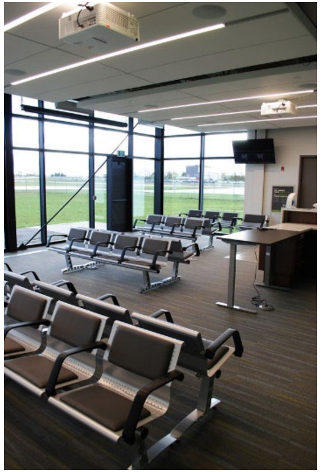
Variable	Value
Source:	Trial 3 Laboratory Video
Method:	Audio Recording
Brief Description:	The overall sound pressure level (OASPL) of individual passengers and crew by time at the gate/terminal
Sample Size:	36
Primary Data:	Gate_Speech_T3

GT10 Queue Length at Gate Gate

Variable	Value
Source:	Field Video 1
Method:	Annotation Tool Manual
Brief Description:	Every 10 seconds, the number of passengers waiting in gate queue
Sample Size:	151
Primary Data:	Gate_DeskQueueLength_FV1

GT11 Barometric Pressure Gate

Variable	Value
Source:	Trial 1 Laboratory Sensors
Method:	Sensor
Brief Description:	Barometric pressure of the air (hPa; hectopascals)
Sample Size:	N/A
Primary Data:	Gate_Pressure_Inst_T1



P

GT12 Supply Dry-Bulb Temperature (GT12) Gate

Variable	Value
Source:	Trial 1 Laboratory Sensors
Method:	Sensor
Brief Description:	Dry-bulb temperature of the air entering the space
Sample Size:	N/A
Primary Data:	Gate_DryBulb_Inst_T1

GT13 Supply DewPoint Temperature Gate

Variable	Value
Source:	Trial 1 Laboratory Sensors
Method:	Sensor
Brief Description:	Dewpoint temperature of the air entering the space
Sample Size:	N/A
Primary Data:	Gate_DewPoint_Inst_T1

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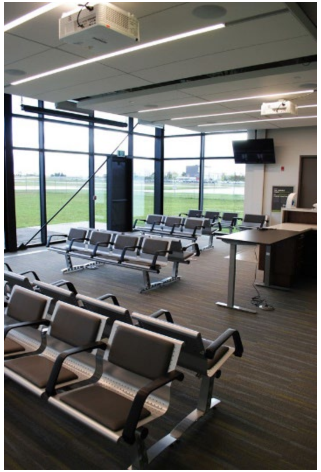
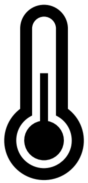
GT14 Space Dry-Bulb Temperature Gate

Variable	Value
Source:	Trial 1 Laboratory Sensors
Method:	Sensor
Brief Description:	Dry-bulb temperature of the air leaving the space
Sample Size:	N/A
Primary Data:	Gate_DryBulb_Inst_T1

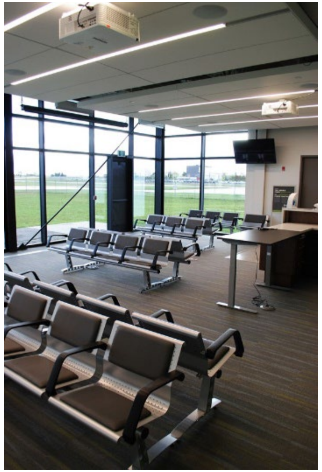


T_{db}



GT15 Space DewPoint Temperature Gate

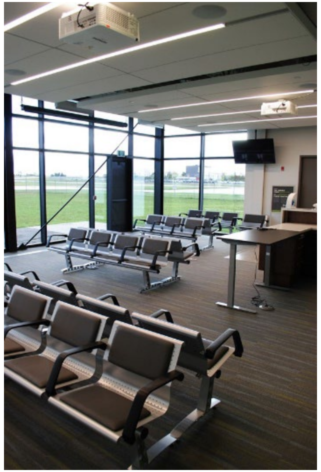
Variable	Value
Source:	Trial 1 Laboratory Sensors
Method:	Sensor
Brief Description:	Dewpoint temperature of the air leaving the space
Sample Size:	N/A
Primary Data:	Gate_DewPoint_Inst_T1

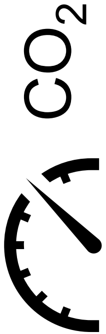


Dewpoint

GT16 Space Carbon Dioxide Concentration Gate

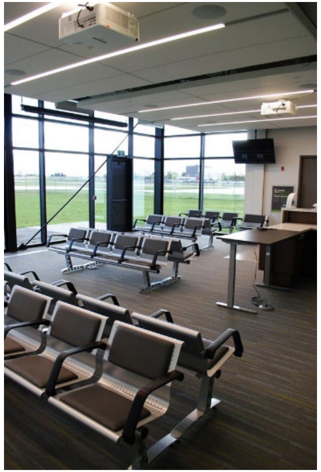
Variable	Value
Source:	Trial 1 Laboratory Sensors
Method:	Sensor
Brief Description:	Carbon dioxide concentration in air (ppm: parts per million)
Sample Size:	N/A
Primary Data:	Gate_SpaceCO2_Inst_T1

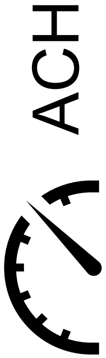




GT17 Ventilation Rate Gate

Variable	Value
Source:	Trial 1 Laboratory Sensors
Method:	Sensor
Brief Description:	Ventilation rates for mass flow (kg/s) and air exchange rate (1/hr)
Sample Size:	N/A
Primary Data:	Gate_Flow_Inst_T1



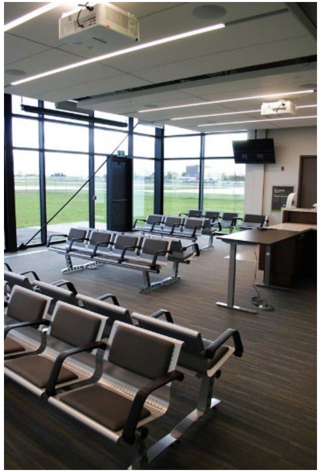


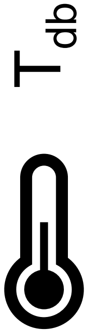
GT18 Supply Dry-Bulb Temperature (GT18) Gate

Variable	Value
Source:	Field HVAC Sensors 1
Method:	Sensor
Brief Description:	Dry-bulb temperature of the air entering the space
Sample Size:	N/A
Primary Data:	Gate_Ventilation_Inst_FV1

GT19 Space Dry-Bulb Temperature (GT19) Gate

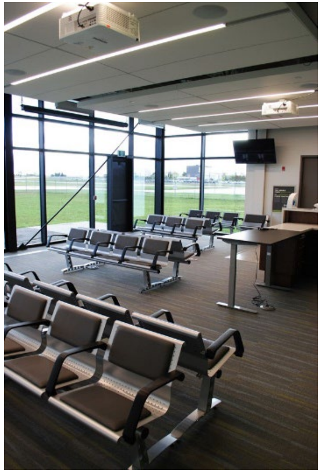
Variable	Value
Source:	Field HVAC Sensors 1
Method:	Sensor
Brief Description:	Dry-bulb temperature of the air leaving the space
Sample Size:	N/A
Primary Data:	Gate_Ventilation_Inst_FV1





GT20 Space Dewpoint Temperature (GT20) Gate

Variable	Value
Source:	Field HVAC Sensors 1
Method:	Sensor
Brief Description:	Dewpoint temperature of the air leaving the space as measured at the air handler
Sample Size:	N/A
Primary Data:	Gate_Ventilation_Inst_FV1



Dewpoint

JB01 Queue Density Boarding Jetbridge

Variable	Value
Source:	Field Video 1
Method:	Machine Learning
Brief Description:	The queue density of passengers in the Jet Bridge, in a defined area visible to camera at front of jet bridge (by air cabin door), roughly to first telescoping joint
Sample Size:	151
Primary Data:	Jetbridge_BoardQueueDensity_FV1

JB02 Jet Bridge Enter and Exit Jetbridge

Variable	Value
Source:	Field Video 1
Method:	Annotation Tool Manual
Brief Description:	The time between entering and exiting the jet bridge per passenger
Sample Size:	151
Primary Data:	Jetbridge_EnterExit_FV1

JB03 Face Direction Standing in Jet bridge Jetbridge

Variable	Value
Source:	Trial 3 Laboratory Video
Method:	Annotation Tool Manual
Brief Description:	The frequency of passengers facing forward or not while standing in the Jet bridge
Sample Size:	36
Primary Data:	Jetbridge_StandFaceDir_T3

JB04 Passenger and Crew Shared Touches (JB04) Jetbridge

Variable	Value
Source:	Field Video 1
Method:	Annotation Tool Manual
Brief Description:	The count of passengers and crew directly touching hands or passing an object to each other
Sample Size:	151
Primary Data:	Jetbridge_ShareTouch_FV1

JB05 Speech Jet bridge Jetbridge

Variable	Value
Source:	Trial 3 Laboratory Video
Method:	Audio Recording
Brief Description:	The overall sound pressure level (OASPL) of individual passengers and crew by time in the jet bridge
Sample Size:	36
Primary Data:	Jetbridge_Speech_T3

JB06 Total Queue Length Jetbridge

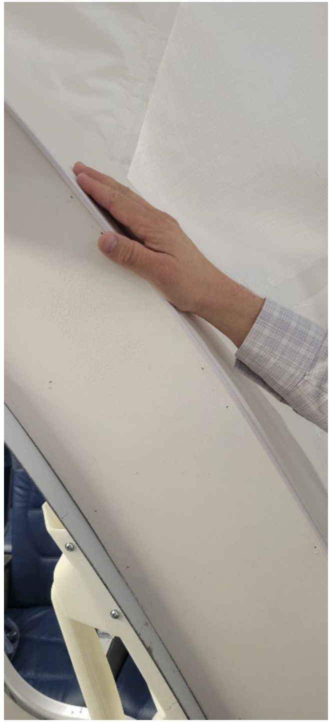
Variable	Value
Source:	Trial 3 Laboratory Video
Method:	Machine Learning, Derived
Brief Description:	The total number of passengers in the jet bridge at any given time
Sample Size:	36
Primary Data:	Jetbridge_QueueLength_T3

JB07 Jetbridge Duration of Delay between Passengers at Entrance of Cabin

Variable	Value
Source:	Trial 3 Laboratory Video
Method:	Machine Learning
Brief Description:	The duration each passenger spent in the vestibule of the CATR jet bridge
Sample Size:	36
Primary Data:	Jetbridge_DelayEntrance_T3

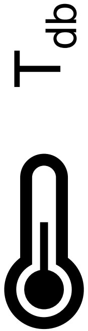
JB08 Fuselage Touches Jetbridge

Variable	Value
Source:	Field Video 1
Method:	Annotation Tool Manual
Brief Description:	The count of passengers touching the exterior of the aircraft prior to entering the cabin
Sample Size:	151
Primary Data:	Jetbridge_FuselageTouch_FV1



JB09 Supply Dry-Bulb Temperature at Gate Doors Jetbridge

Variable	Value
Source:	Field HVAC Sensors 1
Method:	Sensor
Brief Description:	Dry-bulb temperature of the air entering the space at gate doors
Sample Size:	N/A
Primary Data:	Jetbridge_Ventilation_Inst_FV1



JB10 Space Dry-Bulb Temperature at Aircraft Jetbridge

Variable	Value
Source:	Field HVAC Sensors 1
Method:	Sensor
Brief Description:	Dry-bulb temperature of the air leaving the space at aircraft
Sample Size:	N/A
Primary Data:	Jetbridge_Ventilation_Inst_FV1

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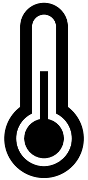
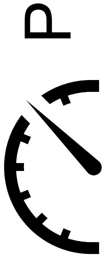


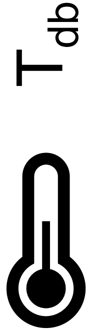
JB11 Barometric Pressure (JB11) Jetbridge

Variable	Value
Source:	Field HVAC Sensors 1
Method:	Sensor
Brief Description:	Barometric pressure (hPa; hectopascals) of the air as reported by the airport weather station
Sample Size:	N/A
Primary Data:	Jetbridge_Ventilation_Inst_FV1



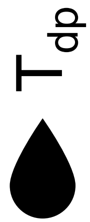
JB12 Outdoor Dry-Bulb Temperature Jetbridge

Variable	Value
Source:	Field HVAC Sensors 1
Method:	Sensor
Brief Description:	Outdoor Dry-Bulb Air Temperature (°C)
Sample Size:	N/A
Primary Data:	Jetbridge_Ventilation_Inst_FV1



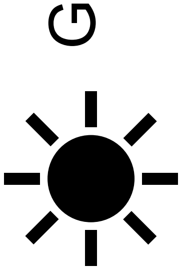
JB13 Outdoor Dewpoint Temperature Jetbridge

Variable	Value
Source:	Field HVAC Sensors 1
Method:	Sensor
Brief Description:	Outdoor Dewpoint Temperature (°C)
Sample Size:	N/A
Primary Data:	Jetbridge_Ventilation_Inst_FV1



JB14 Solar Radiation Jetbridge

Variable	Value
Source:	Field HVAC Sensors 1
Method:	Sensor
Brief Description:	Solar load as measured by the airport weather station
Sample Size:	N/A
Primary Data:	Jetbridge_Ventilation_Inst_FV1



JB15 Wind Measurements Jetbridge

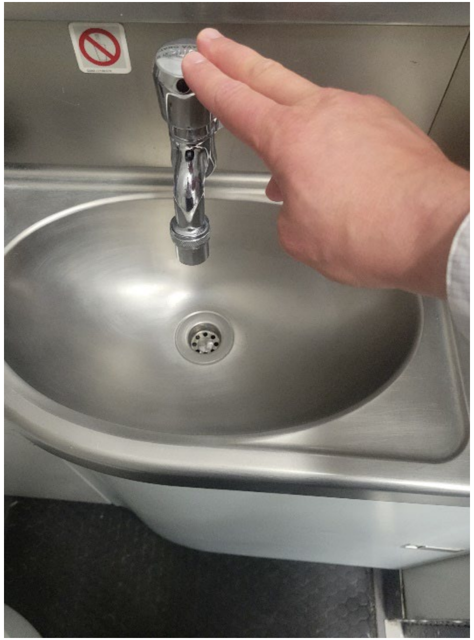
Variable	Value
Source:	Field HVAC Sensors 1
Method:	Sensor
Brief Description:	The wind speed, direction, and speed of gust of wind if present
Sample Size:	N/A
Primary Data:	Jetbridge_Ventilation_Inst_FV1

CB01 Frequency of Lavatory Use and Queue Cabin

Variable	Value
Source:	Field In-person Observation
Method:	Manual App Observation
Brief Description:	The count and duration of the passengers and crew lavatory use and duration in lavatory queue
Sample Size:	Flight 2: 170, Flight 3: 175, Flight 4: 172
Primary Data:	Cabin_LavUse_inperson

CB02 Sink Faucet On Button Cabin

Variable	Value
Source:	Trial 1 Laboratory Sensors
Method:	Sensor
Brief Description:	The count of passengers and crew activating the sink faucet in the lavatory
Sample Size:	36
Primary Data:	Cabin_LavSensor_Inst_T1



CB03 Toilet Cover
Cabin

Variable	Value
Source:	Trial 1 Laboratory Sensors
Method:	Sensor
Brief Description:	The count of passengers and crew moving the toilet cover in the lavatory
Sample Size:	36
Primary Data:	Cabin_LavSensor_Inst_T1

CB04 Toilet Seat
Cabin

Variable	Value
Source:	Trial 1 Laboratory Sensors
Method:	Sensor
Brief Description:	The count of passengers and crew moving the toilet seat in the lavatory
Sample Size:	36
Primary Data:	Cabin_LavSensor_Inst_T1

CB05 Toilet Flush Button
Cabin

Variable	Value
Source:	Trial 1 Laboratory Sensors
Method:	Sensor
Brief Description:	The count of passengers and crew activating the toilet flush button in the lavatory
Sample Size:	36
Primary Data:	Cabin_LavSensor_Inst_T1

CB06 Internal Lavatory Door Lock Cabin

Variable	Value
Source:	Trial 1 Laboratory Sensors
Method:	Sensor
Brief Description:	The count of passengers and crew activating the door lock button in the lavatory
Sample Size:	36
Primary Data:	Cabin_LavSensor_Inst_T1

CB07 Gaspers Cabin

Variable	Value
Source:	Trial 1 Laboratory Sensors
Method:	Sensor
Brief Description:	The count of passengers activating the air vent
Sample Size:	36
Primary Data:	Cabin_PSUTouch_Inst_T1

CB08 Light Button Cabin

Variable	Value
Source:	Trial 1 Laboratory Sensors
Method:	Sensor
Brief Description:	The count of passengers activating the reader light
Sample Size:	36
Primary Data:	Cabin_PSUTouch_Inst_T1

CB09 Call Button
Cabin

Variable	Value
Source:	Trial 1 Laboratory Sensors
Method:	Sensor
Brief Description:	The count of passengers activating the call button
Sample Size:	36
Primary Data:	Cabin_PSUTouch_Inst_T1

CB10 Overhead Bin touch
Cabin

Variable	Value
Source:	Trial 1 Laboratory Video
Method:	Annotation Tool Manual
Brief Description:	The count of passengers and crew touching the overhead bins doors
Sample Size:	36
Primary Data:	Cabin_OverheadBinTouch_T1

CB11 Window Shade Movements Cabin

Variable	Value
Source:	Trial 1 Laboratory Video
Method:	Annotation Tool Manual
Brief Description:	The count of passengers opening and closing the cabin window shade
Sample Size:	36
Primary Data:	Cabin_WindowMove_T1

CB12 Window Touches
Cabin

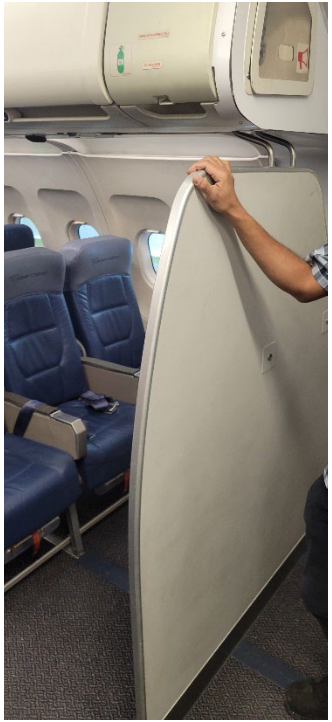
Variable	Value
Source:	Field In-person Observation
Method:	Manual App Observation
Brief Description:	The count of passengers touching the window and window shade
Sample Size:	Flight 2: 16, Flight 3: 20
Primary Data:	Cabin_WindowTouch_inperson

CB13 Seat Reclined
Cabin

Variable	Value
Source:	Trial 1 Laboratory Video
Method:	Annotation Tool Manual, Sensor assisted
Brief Description:	The count and duration of passengers with their seats in the reclined position
Sample Size:	36
Primary Data:	Cabin_SeatRecline_T1

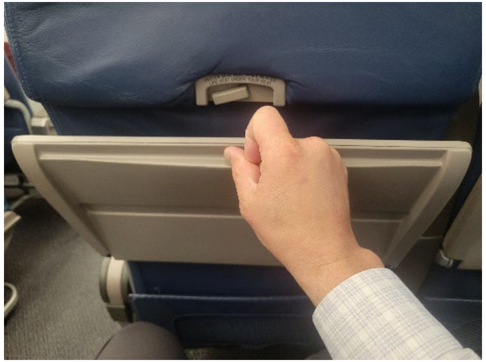
CB14 Barrier Touches Cabin

Variable	Value
Source:	Trial 1 Laboratory Video
Method:	Annotation Tool Manual
Brief Description:	The count of passengers and crew touching the barriers in the galley
Sample Size:	36
Primary Data:	Cabin_BarrierTouch_T1



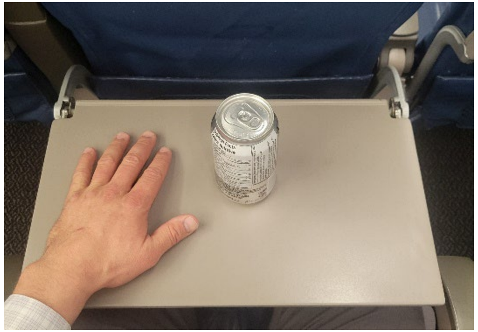
CB15 Tray Table Movements
Cabin

Variable	Value
Source:	Trial 3 Laboratory Video
Method:	Annotation Tool Manual
Brief Description:	The count and duration of tray tables down
Sample Size:	36
Primary Data:	Cabin_TrayTableMove_T3



CB16 Tray Table Touches Cabin

Variable	Value
Source:	Field In-person Observation
Method:	Manual App Observation
Brief Description:	The count of passengers touching a tray table
Sample Size:	Flight 2: 16, Flight 3: 20
Primary Data:	Cabin_TTableTouch_inperson



CB17 Armrest Touches Cabin

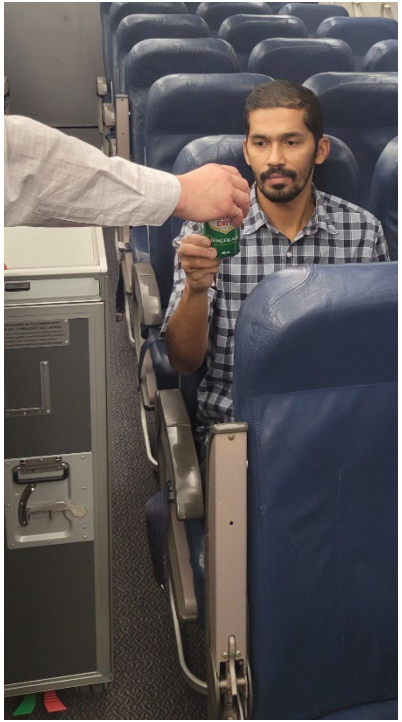
Variable	Value
Source:	Trial 1 Laboratory Video
Method:	Annotation Tool Manual
Brief Description:	The count of passengers and/or crew touching an armrest within a monument (4 armrests per monument)
Sample Size:	6 (2 monuments)
Primary Data:	Cabin_ArmrestTouch_T1

CB18 Top of Seat Touches Cabin

Variable	Value
Source:	Trial 1 Laboratory Video
Method:	Machine Learning, Assisted
Brief Description:	The count of passengers and crew touching the top of seat
Sample Size:	36
Primary Data:	Cabin_SeatTopTouch_T1

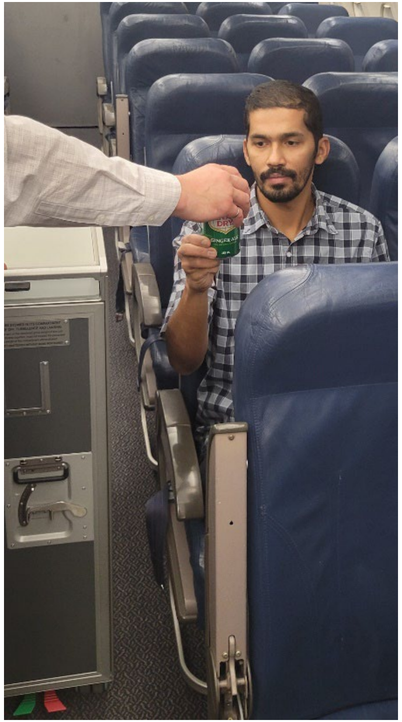
CB19 Passenger and Crew Shared Touches (CB19) Cabin

Variable	Value
Source:	Trial 1 Laboratory Video
Method:	Annotation Tool Manual
Brief Description:	The count of passengers and crew directly touching hands or passing an object to each other throughout the flight (including service and garbage pick-up)
Sample Size:	36
Primary Data:	Cabin_ShareTouch_T1



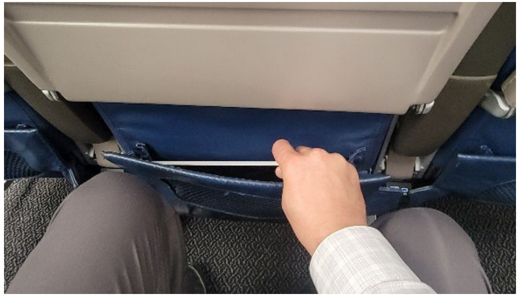
CB20 Shared Touches by Service Row Duration Cabin

Variable	Value
Source:	Trial 1 Laboratory Video
Method:	Annotation Tool Manual, Derived
Brief Description:	The count of passengers and crew directly touching hands or passing an object to each other by row during service
Sample Size:	36
Primary Data:	Cabin_ShareTouchCabinRow_T1



CB21 Seat Pouch Touch
Cabin

Variable	Value
Source:	Trial 3 Laboratory Video
Method:	Annotation Tool Manual
Brief Description:	The count of passengers touching or using the seat pouch/pocket
Sample Size:	9 (3 monuments)
Primary Data:	Cabin_PouchTouch_T3

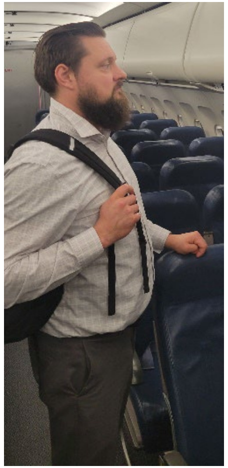


CB22 Face Direction Seated in Cabin Cabin

Variable	Value
Source:	Trial 1 Laboratory Video
Method:	Machine Learning
Brief Description:	The overall duration spent looking forward, right or left as well as the duration of two passengers facing each other, per passenger
Sample Size:	36
Primary Data:	Cabin_SeatFaceDir_T1

CB23 Face Direction Standing in Cabin Cabin

Variable	Value
Source:	Trial 1 Laboratory Video
Method:	Annotation Tool Manual
Brief Description:	The frequency of passengers facing forward or not while standing in the cabin
Sample Size:	36
Primary Data:	Cabin_StandFaceDir_T1

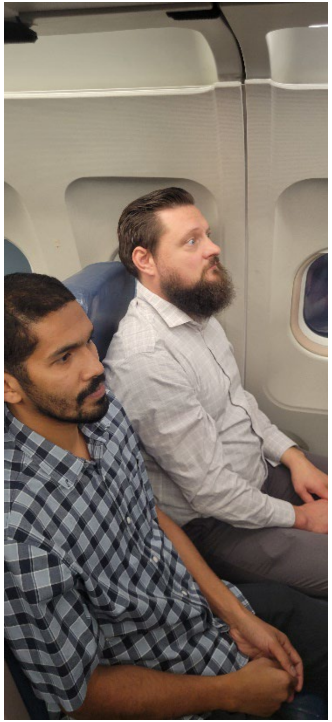


CB24 Seat Belt On and Off
Cabin

Variable	Value
Source:	Trial 3 Laboratory Video
Method:	Annotation Tool Manual
Brief Description:	The count of passengers fastening/unfastening their seat belts
Sample Size:	9 (3 monuments)
Primary Data:	Cabin_SeatBelt_T3

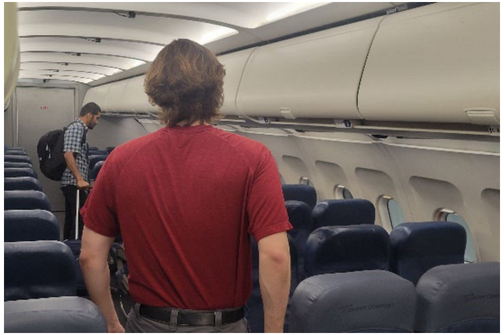
CB25 Passenger Duration Seated in Cabin Cabin

Variable	Value
Source:	Trial 1 Laboratory Video
Method:	Annotation Tool Manual, Derived
Brief Description:	The proportion of time passengers spend in their assigned seat during cruise
Sample Size:	36
Primary Data:	Cabin_SeatedDur_T1



CB26 Cabin Movements Boarding Cabin

Variable	Value
Source:	Trial 1 Laboratory Video
Method:	Annotation Tool Manual, Derived
Brief Description:	The time that a passenger enters each cabin area (Galley, LAV, Aisle, Row) and the total number of passengers within each cabin area at any given time during boarding
Sample Size:	36
Primary Data:	Cabin_BoardMove_T1

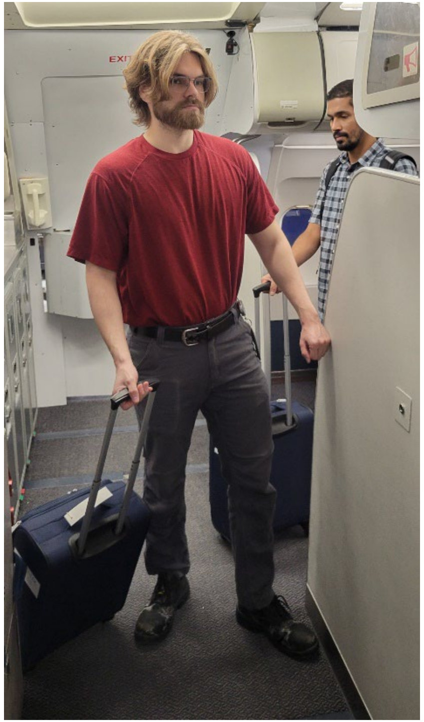


CB27 Cabin Movements Cruise Cabin

Variable	Value
Source:	Trial 1 Laboratory Video
Method:	Annotation Tool Manual, Derived
Brief Description:	The time that a passenger enters each cabin area (Galley, LAV, Aisle, Row) and the total number of passengers within each cabin area at any given time during cruise
Sample Size:	36
Primary Data:	Cabin_CruiseMove_T1

CB28 Cabin Movements Deboarding Cabin

Variable	Value
Source:	Trial 1 Laboratory Video
Method:	Annotation Tool Manual, Derived
Brief Description:	The time that a passenger enters each cabin area (Galley, LAV, Aisle, Row) and the total number of passengers within each cabin area at any given time during deboarding
Sample Size:	36
Primary Data:	Cabin_DeboardMove_T1



CB29 Seated Face Touches Cabin

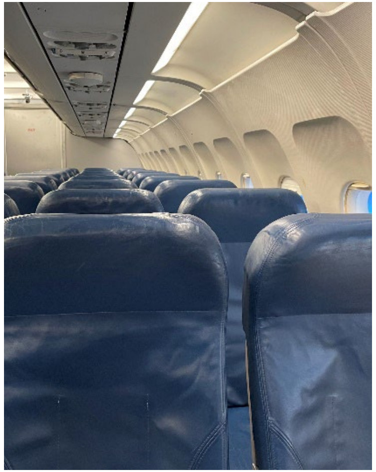
Variable	Value
Source:	Trial 1 Laboratory Video
Method:	Machine Learning
Brief Description:	The count and average duration of face touches per passenger while seated in the cabin
Sample Size:	36
Primary Data:	Cabin_SeatFaceTouch_T1

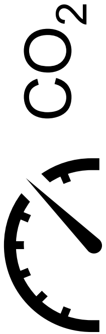
CB30 Speech Cabin Cabin

Variable	Value
Source:	Trial 3 Laboratory Video
Method:	Audio Recording
Brief Description:	The overall sound pressure level (OASPL) of individual passengers and crew by time in the air cabin
Sample Size:	36
Primary Data:	Cabin_Speech_T3

CB31 Space Carbon Dioxide Concentration (CB31) Cabin

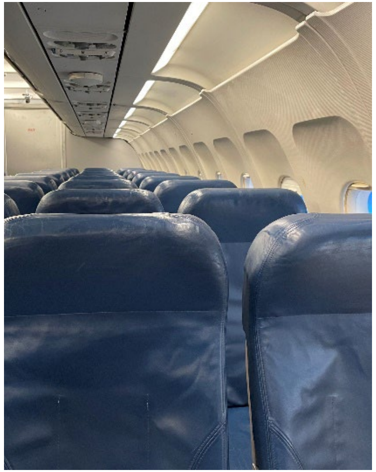
Variable	**Value**
Source:	Trial 1 Laboratory Sensors
Method:	Sensor
Brief Description:	Carbon dioxide concentration in air (ppm: parts per million)
Sample Size:	N/A
Primary Data:	Cabin_SpaceCO2_Inst_T1

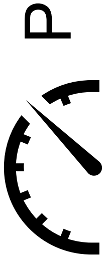




CB32 Barometric Pressure (CB32) Cabin

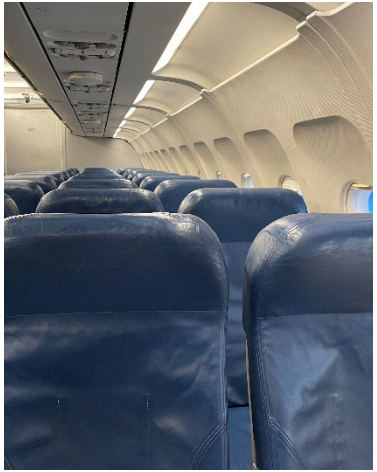
Variable	Value
Source:	Trial 1 Laboratory Sensors
Method:	Sensor
Brief Description:	Barometric pressure of the air (hPa; hectopascals)
Sample Size:	N/A
Primary Data:	Cabin_Pressure_Inst_T1

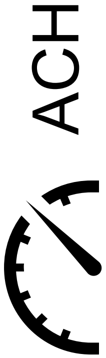




CB33 Ventilation Rate (CB33) Cabin

Variable	Value
Source:	Trial 1 Laboratory Sensors
Method:	Sensor
Brief Description:	Ventilation rates for mass flow (kg/s), air exchange rate (1/hr), and OA:RA ratio
Sample Size:	N/A
Primary Data:	Cabin_Flow_Inst_T1





CB34 Supply Dry-Bulb Temperature Cabin

Variable	Value
Source:	Trial 1 Laboratory Sensors
Method:	Sensor
Brief Description:	Dry-bulb temperature of the air entering the cabin
Sample Size:	N/A
Primary Data:	Cabin_DryBulb_Inst_T1

T_{db}

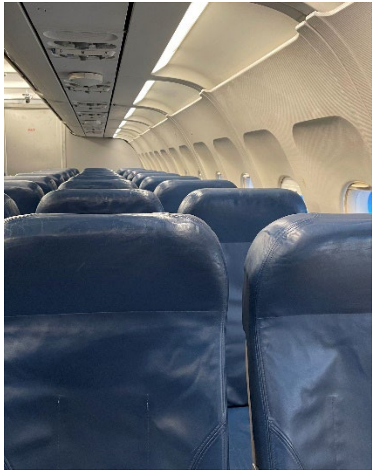
CB35 Supply DewPoint Temperature (CB35) Cabin

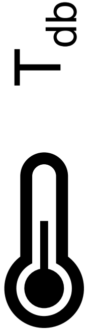
Variable	Value
Source:	Trial 1 Laboratory Sensors
Method:	Sensor
Brief Description:	Dewpoint temperature of the air entering the cabin
Sample Size:	N/A
Primary Data:	Cabin_DewPoint_Inst_T1

T_{dp}

CB36 Space Dry-Bulb Temperature (CB36) Cabin

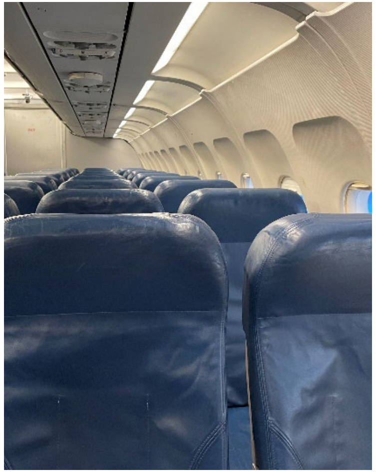
Variable	Value
Source:	Trial 1 Laboratory Sensors
Method:	Sensor
Brief Description:	Dry-bulb temperature of the cabin air
Sample Size:	N/A
Primary Data:	Cabin_DryBulb_Inst_T1





CB37 Space DewPoint Temperature (CB37) Cabin

Variable	Value
Source:	Trial 1 Laboratory Sensors
Method:	Sensor
Brief Description:	Dewpoint temperature of the cabin air
Sample Size:	N/A
Primary Data:	Cabin_DewPoint_Inst_T1



T_{dp}

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