Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
DOT/FAA/AM-23/30		

4. Title and Subtitle	5. Report Date
Risk Framework for Cabin Transmission of Infectious Diseases	September 2023 (Updated December 2023)
	6. Performing Organization Code

7. Author(s)	8. Performing Organization Report No.
Andy Anderegg, Nadya Huleatt, Gene Lin, Ilana Lisann, Rakhee Palekar Hamid Shirazi, Alex Wu	4-5.C.1-1

9. Performing Organization Name and Address	10. Work Unit No. (TRAIS)
The MITRE Corporation 7515 Colshire Dr. McLean, VA 22101	11. Contract or Grant No.

12. Sponsoring Agency Name and Address	13. Type of Report and Period Covered
Office of Aerospace Medicine Federal Aviation Administration 800 Independence Ave., S.W. Washington, DC 20591	Technical Presentation
	14. Sponsoring Agency Code

15. Supplementary Notes

Author ORCIDs:
Anderegg (0000-0003-0874-5165); Huleatt (0009-0004-1963-1993); Lin (0000-0002-8875-7782); Lisann (0000-0003-1836-1704); Palekar (0000-0001-5216-3117); Shirazi (0009-0005-0155-5520); Wu (0000-0002-5526-1318);
DOI: https://doi.org/10.21949/1529622

16. Abstract

The Federal Aviation Administration (FAA) has assumed leadership for developing a preparedness plan for communicable disease in air travel and identifying associated research needs. The FAA's approach to the planning effort is to use its existing Safety Risk Management (SRM) process, as documented in FAA Order 8040.4B. The FAA will then use the SRM outputs as inputs to the preparedness planning activity, thereby making the latter risk-based and data-driven. The FAA tasked the MITRE Corporation's Center for Advanced Aviation System Development to develop a risk matrix suitable for use in a safety risk assessment evaluating communicable disease transmission risk in commercial air travel, specifically focusing on the gate-to-gate travel segment. To accomplish this tasking, MITRE investigated SRM process activities as documented in FAA Order 8040.4B applicable to disease transmission; interviewed relevant stakeholders; identified categories of likelihood and severity applicable to disease transmission; and used the transmission of seasonal influenza among air travel passengers to establish historically accepted societal risk thresholds. Through this method, MITRE has provided the FAA with a decision pathway to integrate data driven SRM for communicable disease transmission and to initiate preparedness planning activities.

17. Key Word	18. Distribution Statement
Safety Management Systems, Aeromedical Certification, Aviation Safety Risk Management, Communicable Disease	Document is available to the public through the National Transportation Library: https://ntl.bts.gov/ntl

19. Security Classification (of this report)	20. Security Classification (of this page)	21. No. of Pages
Unclassified	Unclassified	14

Risk Framework for Cabin Transmission of Infectious Diseases

Risk Matrix Derived from Annual Seasonal Influenza Outbreaks

MITRE | Center for Advanced Aviation System Development

Risk acceptability rationale: seasonal influenza risks are de facto “acceptable.”

- Annual seasonal influenza outbreak is the baseline for acceptable levels of aviation disease transmission risk.
- Influenza outbreak is 32 weeks of the year with no unusual mitigation efforts other than those that have been practiced for years.

Past Seasons Estimated Influenza Disease Burden

These pages includes information about the estimated burden of influenza from past seasons, including tables of the estimated influenza disease burden (and 95% credible interval [Cr I]) by age group. Information on how these estimates are calculated can be found on CDC's web page How CDC Estimates the Burden of Seasonal Influenza in the U.S.

Table 1: Estimated Flu Disease Burden, by Season — United States, 2010-2011 through 2021-2022** Flu Seasons

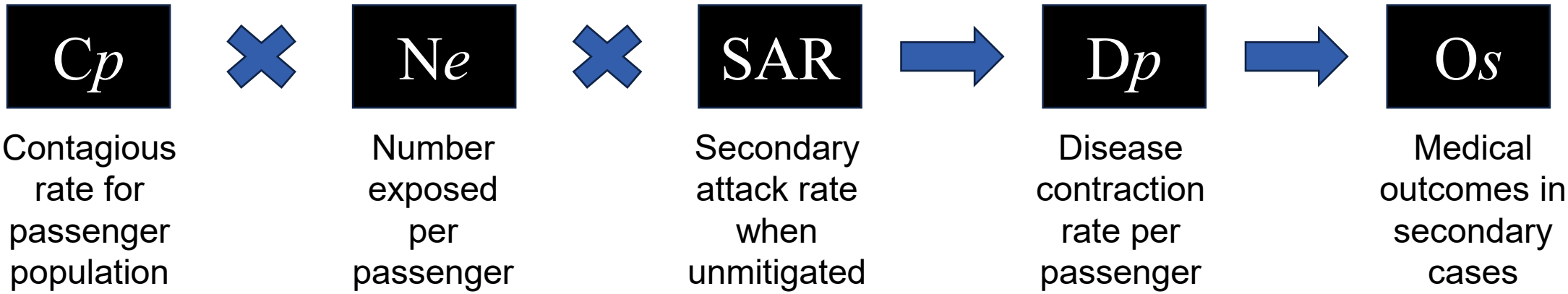
	Symptomatic Illnesses		Medical Visits		Hospitalizations		Deaths	
Season	Estimate	95% U I	Estimate	95% U I	Estimate	95% U I	Estimate	95% U I
2010-2011	21,000,000	(20,000,000 – 25,000,000)	10,000,000	(9,300,000 – 12,000,000)	290,000	(270,000 – 350,000)	37,000	(32,000 – 51,000)
2011-2012	9,300,000	(8,700,000 – 12,000,000)	4,300,000	(4,000,000 – 5,600,000)	140,000	(130,000 – 190,000)	12,000	(11,000 – 23,000)
2012-2013	34,000,000	(32,000,000 – 38,000,000)	16,000,000	(15,000,000 – 18,000,000)	570,000	(530,000 – 680,000)	43,000	(37,000 – 57,000)
2013-2014	30,000,000	(28,000,000 – 33,000,000)	13,000,000	(12,000,000 – 15,000,000)	350,000	(320,000 – 390,000)	38,000	(33,000 – 50,000)
2014-2015	30,000,000	(29,000,000 – 33,000,000)	14,000,000	(13,000,000 – 16,000,000)	590,000	(540,000 – 680,000)	51,000	(44,000 – 64,000)
2015-2016	24,000,000	(20,000,000 – 33,000,000)	11,000,000	(9,000,000 – 15,000,000)	280,000	(220,000 – 480,000)	23,000	(17,000 – 35,000)
2016-2017	29,000,000	(25,000,000 – 45,000,000)	14,000,000	(11,000,000 – 23,000,000)	500,000	(380,000 – 860,000)	38,000	(29,000 – 61,000)
2017-2018	41,000,000	(35,500,000 – 53,000,000)	21,000,000	(18,000,000 – 27,000,000)	710,000	(560,000 – 1,100,000)	52,000	(3,000 – 95,500)

[1] Source: Centers For Disease Control and Prevention (CDC), https://www.cdc.gov/flu/about/burden/past-seasons.html, accessed Sept. 13, 2023

MITRE

A simple model provides a conservative estimate of acceptable outcomes for in flight influenza transmission.

- The estimate is conservative by accounting only for passengers as a source and ignoring:
  - residual contagions from prior passengers, food, and surfaces;
  - crew members and boarding process interactions with other passengers; and
  - the jetway as a second location of encounters.
- This result provides a low precision lower bound as a trigger for the need for mitigation.



MITRE

Contagious passenger population on a flight (*Cp*): 0.2 percent ≈ one contagious flu case / 500 passengers.

- 41 million estimated seasonal influenza cases in 2017-2018 (a high-rate year)[1]
- 327 million U.S. population at the time
- Proportion of the general population contagious at any given time:

$$\frac{\#\ of\ cases}{population} = \times \frac{\#\ of\ days\ patient\ is\ contagious}{\#\ of\ days\ of\ the\ flu\ season} = 12.5\% \times \frac{8\ days}{32\ weeks \times 7\ days/wk} = 0.45\%$$

- Assumption: 50 percent of contagious individuals are well enough and willing to board[2]

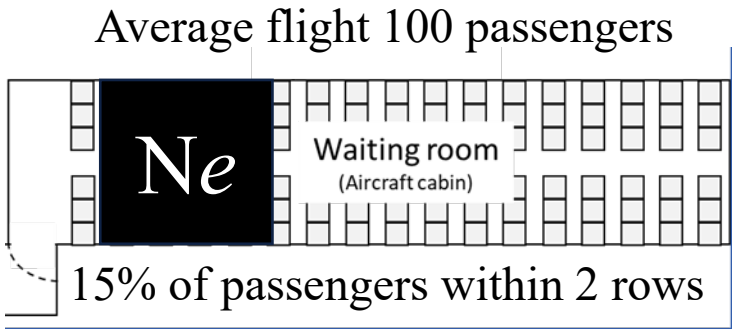
Cp 0.23% = 50% x 0.45% (~one contagious influenza case / 500 passengers)

[1] Centers For Disease Control and Prevention (CDC), https://www.cdc.gov/flu/about/burden/past-seasons.html accessed Sept. 13, 2023
[2] N. McCarthy, "The Majority Of Americans Still Go To Work While Sick [Infographic]," *Forbes*. https://www.forbes.com/sites/niallmccarthy/2016/11/10/the-majority-of-americans-still-go-to-work-while-sick-infographic/ accessed Sep. 15, 2023.

MITRE

Number exposed per passenger (Ne): A contagious passenger who boards exposes 15 other passengers, on average.

- The number of passengers exposed varies with the aircraft configuration.
- Every contagious passenger who boards exposes *Ne* passengers
  - Average aircraft carried 100 passengers, size varies
  - An average of 15% of passengers fall within 2 rows of any seat on narrow and wide body aircraft
  - These range from 25% in smaller planes to less than 10% in larger planes
  - A tighter square of 2 rows × 2 seats (~ 15 seats) around index case provided stronger contact tracing results[3]
    - 2 rows X 2 seats: 7.7% (95% confidence interval [CI] of 2.6% to 17.9%)
    - 2 rows, all seats: 1.4% (95% CI of 0.5% to 3.4%)



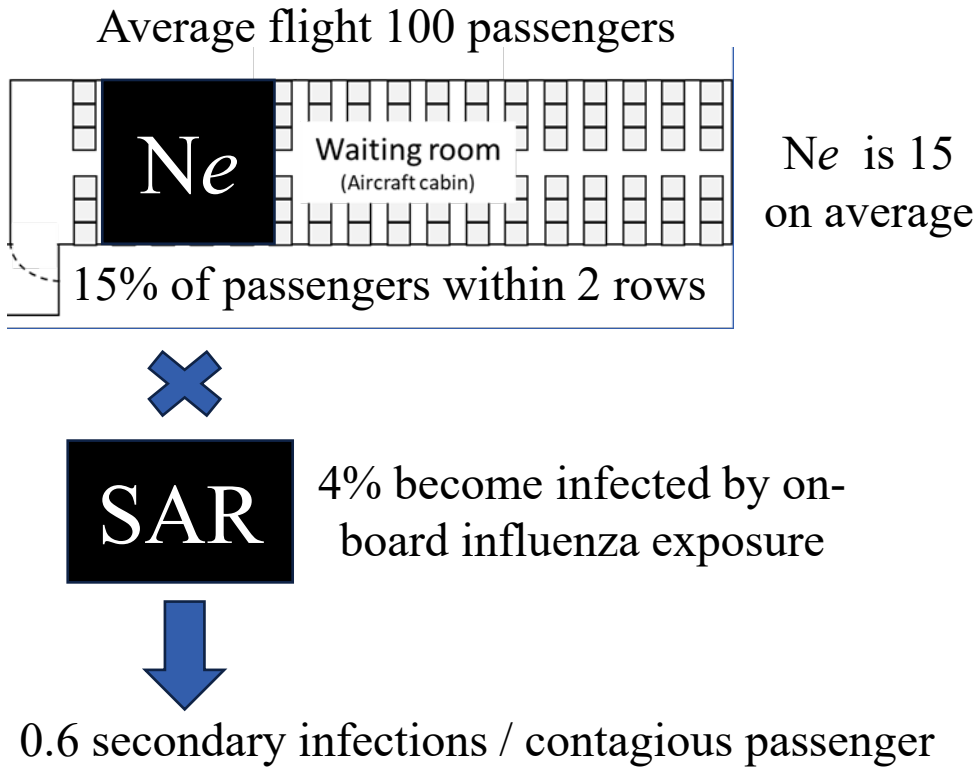
Ne is 15 on average

3 Foxwell A, Roberts L, Lokuge K, et al. Transmission of [H1N1] Influenza on International Flights, May 2009. Emerging Infectious Diseases. 2011;17(7):1188-1194. doi:10.3201/eid1707.101135.

MITRE

4 percent secondary attack rate (SAR) results in 0.6 secondary infections per contagious passenger.

- Empirical secondary attack rate for influenza by proximity is 4%[4]
  - Calculated by:
    - A 5% secondary attack rate to passengers seated within the 2-rows
    - The studies found a 3% risk to passengers beyond 2-rows from the infectious individual
  - These studies concluded based on the distribution that a second factor must be involved for infections beyond 2-rows and found these may be explained by contact in the ramp, boarding, or terminal areas[5]

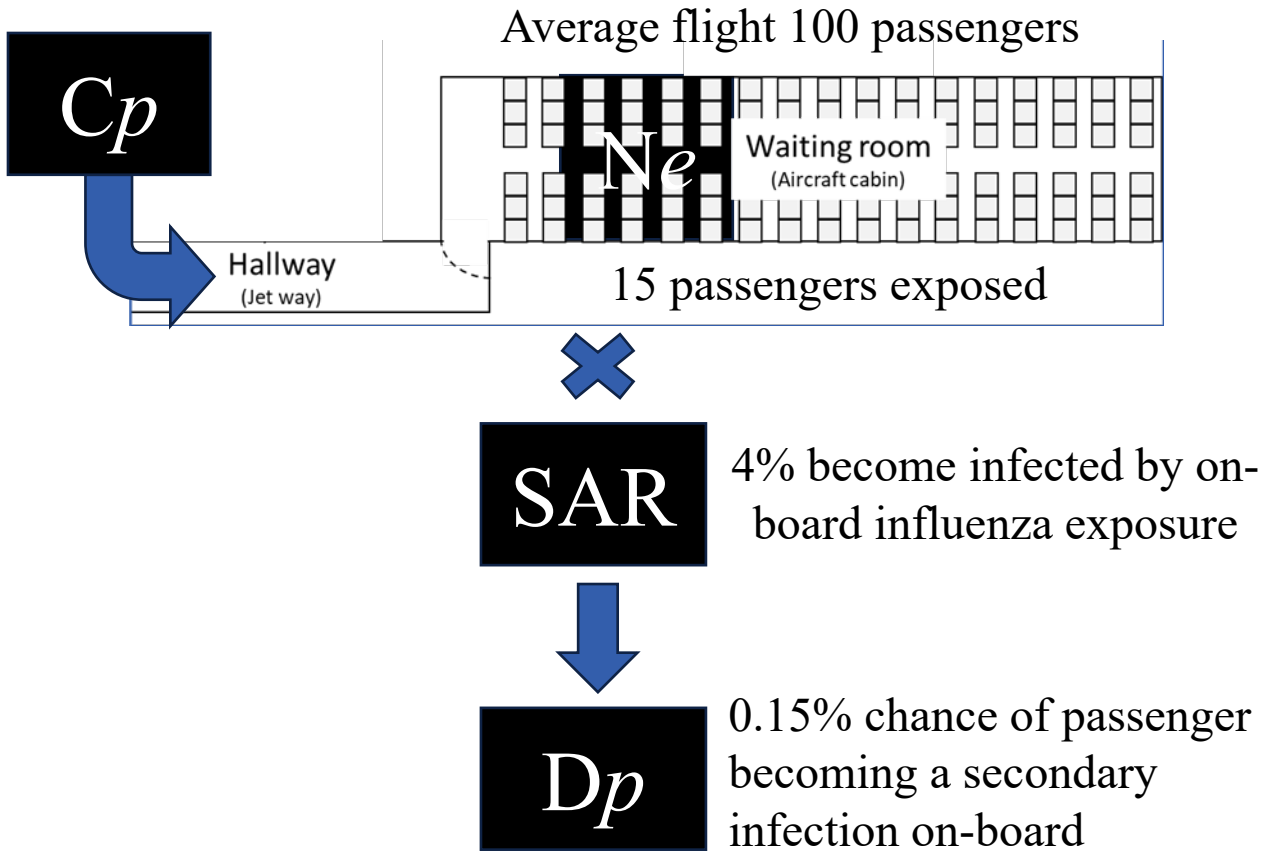


[4] V. Stover Hertzberg and H. Weiss, "On the 2-Row Rule for Infectious Disease Transmission on Aircraft", Annals of Global Health, vol. 82, no. 5, p. 819-823, 2016.DOI: https://doi.org/10.1016/j.aogh.2016.06.003.
[5] Anna C. Rafferty , Et. Al., "Does 2x2 airplane passenger contact tracing for infectious respiratory pathogens work? A systematic review of the evidence", Published: February 2, 2023, https://doi.org/10.1371/journal.pone.0264294.

MITRE

Disease contraction rate (D*p*): 1.38 x 10 ^{3} percent probability a passenger will contract influenza on a flight.

- 0.23% of passengers will board with a contagious case of influenza
- Average of 100 passengers[6]
- Only 15% of the passengers will sit within 2 rows of a specific seat
- 4% chance of contracting influenza
- 1.38 x 10^{-3} / flight (average is 2-hours)[6] = 6.90 x 10^{-4} / flight hour of becoming infected on a flight
  - 1.38 x 10^{-3} divided by 2



6 Bureau of Transportation Statistics, 2018 Traffic Data for U.S Airlines and Foreign Airlines U.S. Flights | Bureau of Transportation Statistics (bts.gov)

7 Leondaridis, Yanni. MITRE Transportation Data Platform analysis of commercial flight durations show average airborne time 102 min, σ = 64 min. ~2 hours boarding to deplaning, 2023

MITRE

Proposed severity and likelihood definitions for risk are consistent with FAA Order 8040.4C.

Minimal 5	Minor 4	Major 3	Hazardous 2	Catastrophic 1
Asymptomatic or self-treated illness	Illness resulting in medical visit	Illness resulting in hospitalization	Illness resulting in a fatal case	Public health system consequences are beyond aviation

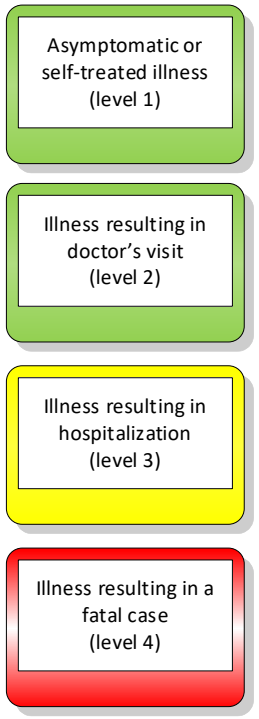
Category	Less than	Greater than or Equal to
Frequent – A	1	1×10^{-5} (1 per 100,000)
Infrequent – B	1×10^{-5} (1 per 100,000)	1×10^{-6} (1 per 1,000,000)
Extremely Infrequent – C	1×10^{-6} (1 per 1,000,000)	1×10^{-7} (1 per 10,000,000)
Remote – D	1×10^{-7} (1 per 10,000,000)	1×10^{-8} (1 per 100,000,000)
Extremely Remote – E	1×10^{-8} (1 per 100,000,000)	1×10^{-9} (1 per 1,000,000,000)
Improbable – F	1×10^{-9} (1 per 1,000,000,000)	1×10^{-10} (1 per 10,000,000,000)
Extremely Improbable – G	1×10^{-10} (1 per 10,000,000,000)	0

MITRE

Medical outcomes for the secondary infection vary with the severity of the outbreak.

Os

Severity and likelihood of medical outcomes determine the placement of risk[8]



Asymptomatic or self-care rate: 52.1%

Medical visit rate: 46%

Case Hospitalization Ratio (CHR): 1.8% - subset of medical visits

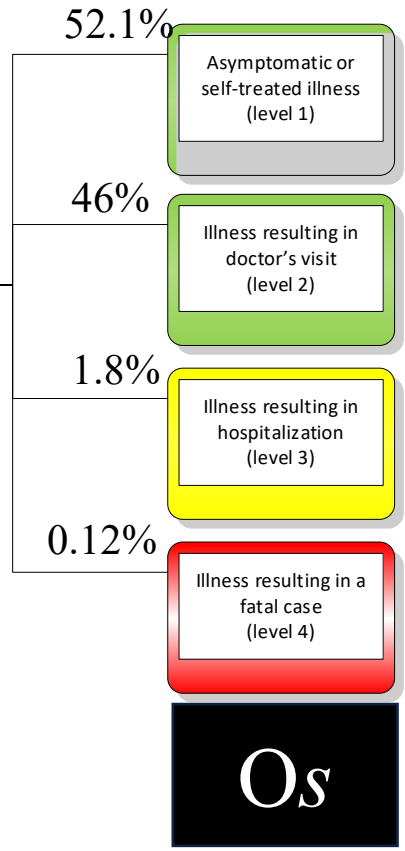
Case Fatality Ratio (CFR): 0.12% - subset of hospitalizations

8 Centers For Disease Control and Prevention (CDC), National Center for Immunization and Respiratory Diseases (NCIRD), "Estimated Flu-Related Illnesses, Medical Visits, Hospitalizations, and Deaths in the United States — 2017–2018 Flu Season," Centers for Disease Control and Prevention, https://archive.cdc.gov/#/details?url=https://www.cdc.gov/flu/about/burden/2017-2018.htm (accessed Dec. 7, 2023).

MITRE

Used together, these elements support a risk model of conservative estimates of the outcomes for on-board transmission of influenza.

1.38 x 10^{-3} / flight
6.90 x 10^{-4} /flight hour



Likelihood	Category	Severity
3.60×10^{-4}/ passenger flight hour	Frequent	Minimal
3.17 x 10^{-4}/ passenger flight hour	Frequent	Minor
1.19 x 10^{-5}/ passenger flight hour	Frequent / Infrequent	Major
8.97×10^{-7}/ passenger flight hour	Infrequent/ Extremely Infrequent	Hazardous

MITRE

The risk matrix captures acceptable disease transmission consequences and triggers for safety risk management.

This derived matrix combines the proposed definitions of severity and assumptions of influenza seasonal outbreak acceptability.

A low fidelity forecast for monitored contact trace disease's can be applied to the matrix to anticipate the need to actively control on-board transmission risk of future outbreaks.

Act

Monitor

Likelihood Category		Severity				
		Minimal 5	Minor 4	Major 3	Hazardous 2	Catastrophic 1
Frequent (A)	Greater than 10^{-4}	Asymptomatic or self-treated symptomatic flu	Flu-related medical visit			
	Greater than 10^{-5}			flu-related hospitalization		
Infrequent (B)	Greater than 10^{-6}					
Extremely Infrequent (C)	Greater than 10^{-7}				flu-related death	
Remote (D)	Greater than 10^{-8}					
Extremely Remote (E)	Greater than 10^{-9}					
Improbable (F)	Greater than 10^{-10}					
Extremely Improbable (G)	Greater than 0					

MITRE

Acronyms / Abbreviations

CDC	Centers for Disease Control and Prevention
CFR	Case fatality ratio
CHR	Case hospitalization ratio
FBO	Fixed-base operator
Pax	Passenger(s)
SAR	Secondary attack rate

Notices

Disclaimer

The views, opinions and/or findings contained in this report are those of The MITRE Corporation and should not be construed as an official government position, policy, or decision, unless designated by other documentation.

Distribution

This document was prepared for authorized distribution only. It has not been approved for public release.

Copyright Notice

Sponsor: Federal Aviation Administration
Department No.: P233
Project No.: 100976.10.102.1013
Outcome No.: 4
PBWP Reference: 4-5.C.1-1

MITRE | Center for Advanced Aviation System Development