The 2019 Winter Simulation Conference 2019

Data-driven Spatiotemporal Simulation Of Ground Movements Of Aircraft For Preventive Airport Safety

Dr. Pingbo Tang; Yanyu Wang; Zhe Sun and Dr. Yongming Liu

IRA A. FULTON SCHOOLS OF engineering
ARIZONA STATE UNIVERSITY

WINTER SIMULATION CONFERENCE
WSC'19
NATIONAL HARBOR, MD

Outline

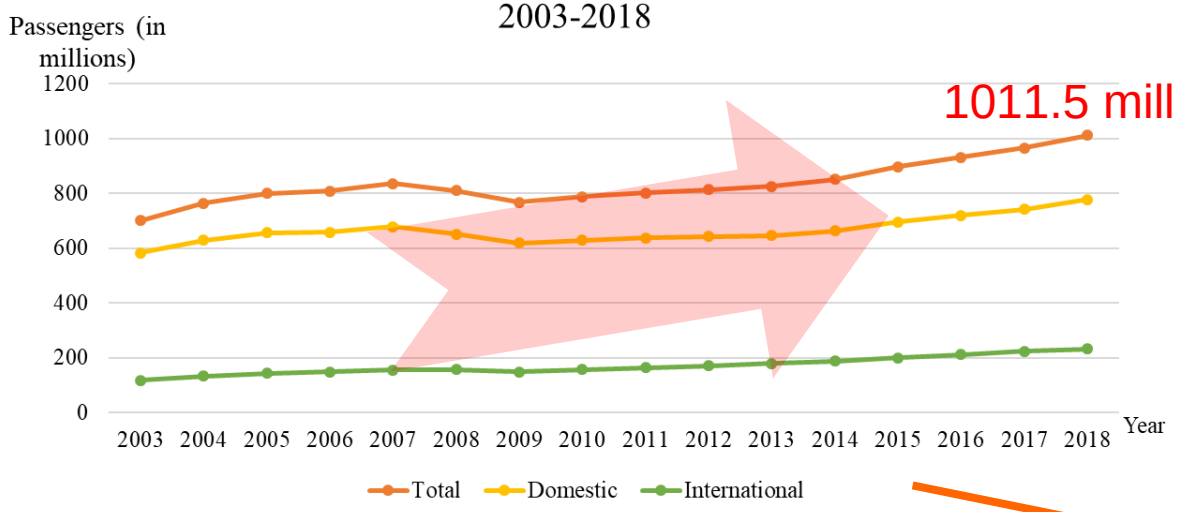
1. Introduction
2. Methodology
3. Preliminary Results
4. Conclusion & Future Work

Motivation

United States Department of Transportation

Bureau of Transportation Statistics

Annual Passengers on All U.S. Scheduled Airline Flights (Domestic & International) and Foreign Airline Flights to and from the United States, 2003-2018



Capacity Pressure

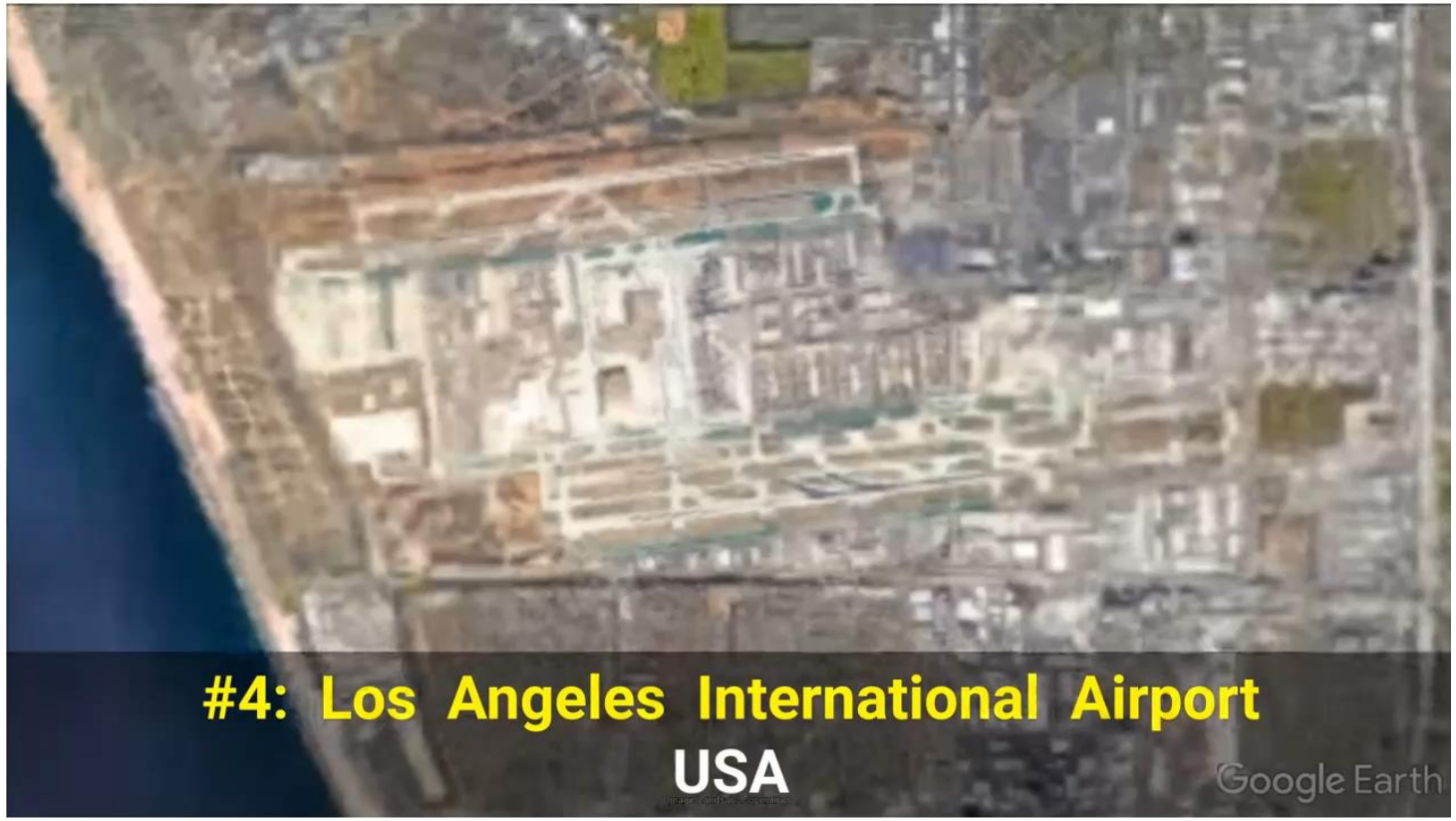
1011.5 millions

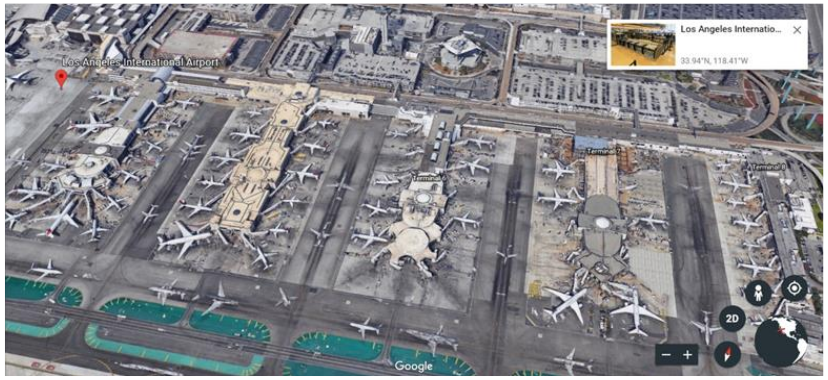
Capacity Pressure

IRA A. FULTON SCHOOLS OF engineering
ARIZONA STATE UNIVERSITY

WINTER SIMULATION CONFERENCE WSC'19 NATIONAL HARBOR, MD

Introduction





The Ground Area of Los Angeles International Airport (LAX) from the Google Earth

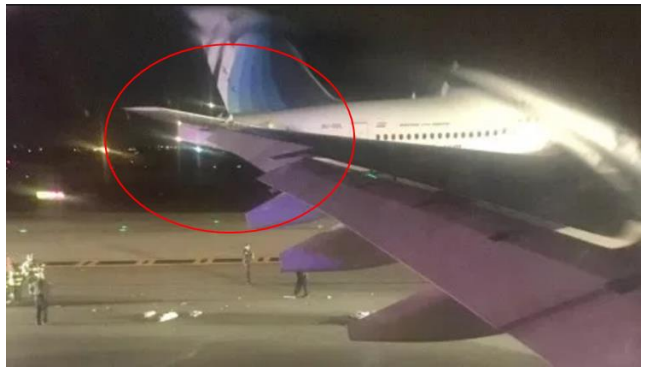
Introduction

National Transportation Safety Board
Aviation Accident Data Summary

Location:	Los Angeles, CA	**Accident Number:**	DCA17CA195A
Date & Time:	09/12/2017, 1310 PDT	**Registration:**	N69813
Aircraft:	BOEING 737-924ER	**Injuries:**	140 None
Flight Conducted Under:	Part 121: Air Carrier - Scheduled		

Introduction

Introduction

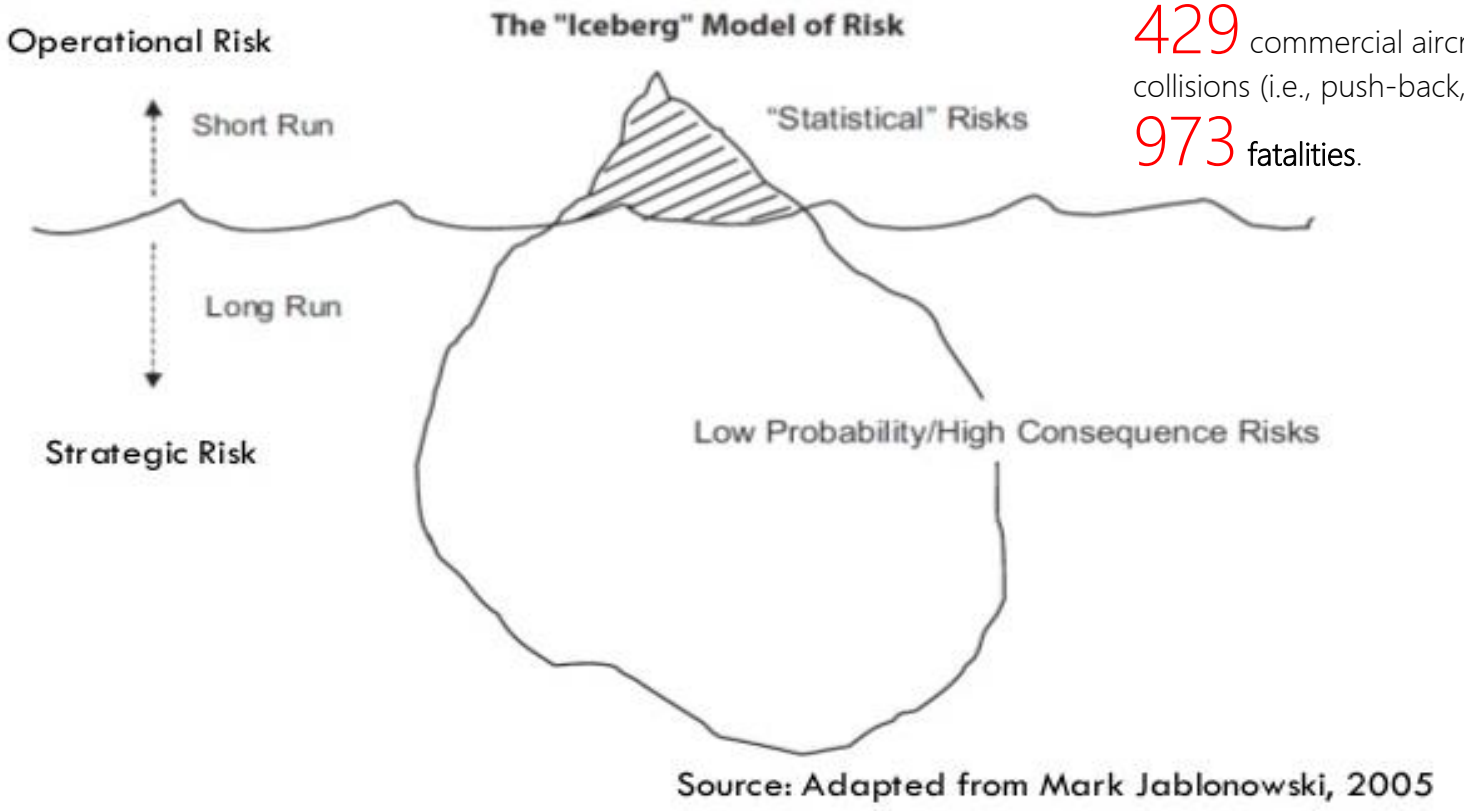


429 commercial aircraft were involved in ground collisions (i.e., push-back, taxi, and so on), resulting in 973 fatalities.

ASU IRA engineering
ARIZONA STATE UNIVERSITY

WINTER SIMULATION CONFERENCE
WSC'19
NATIONAL HARBOR, MD

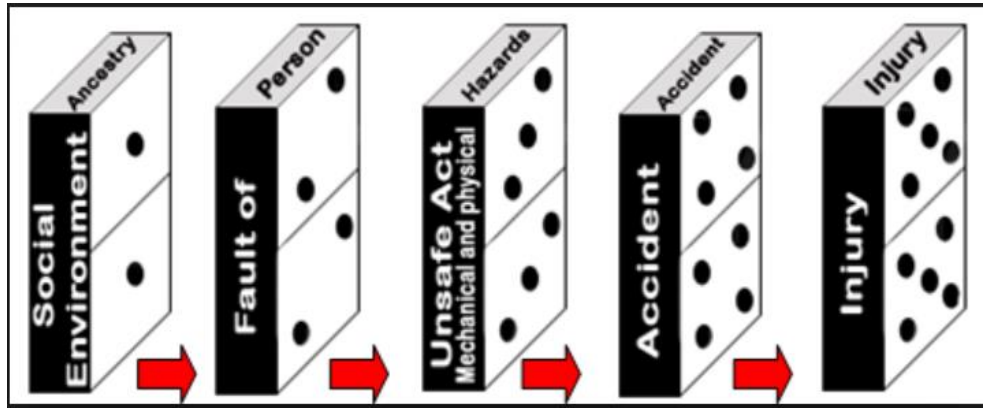
Introduction



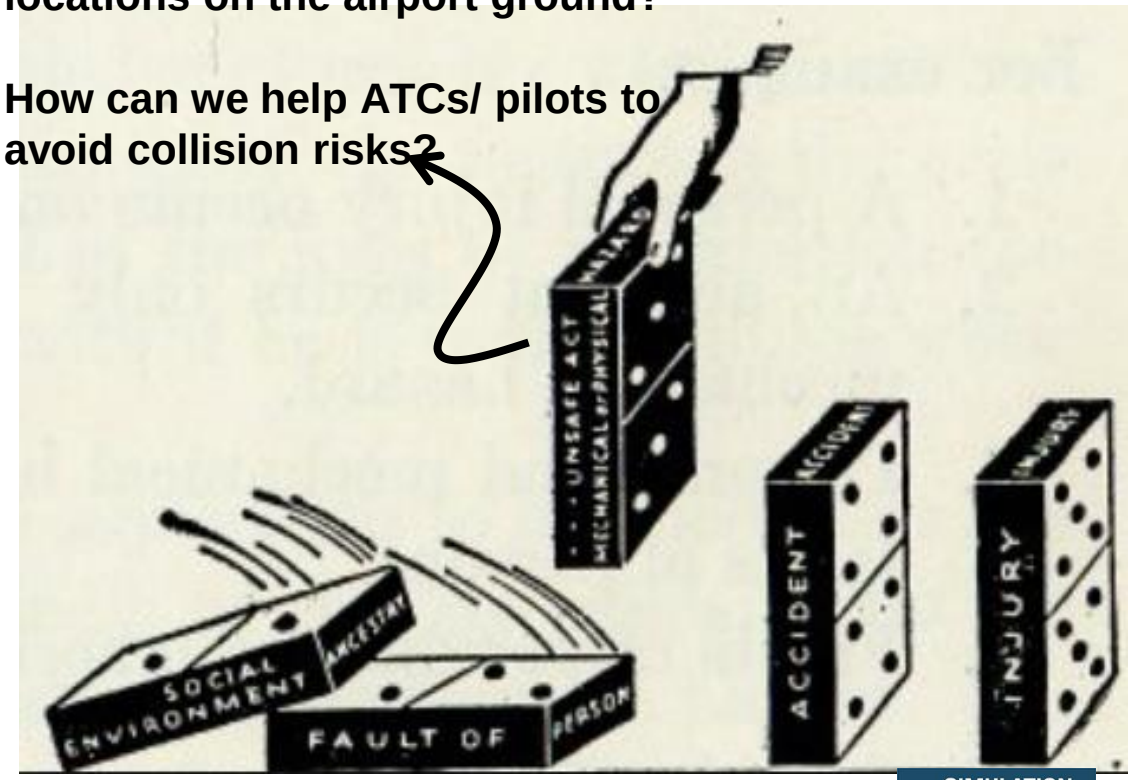
Source: Adapted from Mark Jablonowski, 2005

429 commercial aircraft were involved in ground collisions (i.e., push-back, taxi, and so on), resulting in 973 fatalities.

Introduction



- **Where are the high collision risk locations on the airport ground?**
- **How can we help ATCs/ pilots to avoid collision risks?**

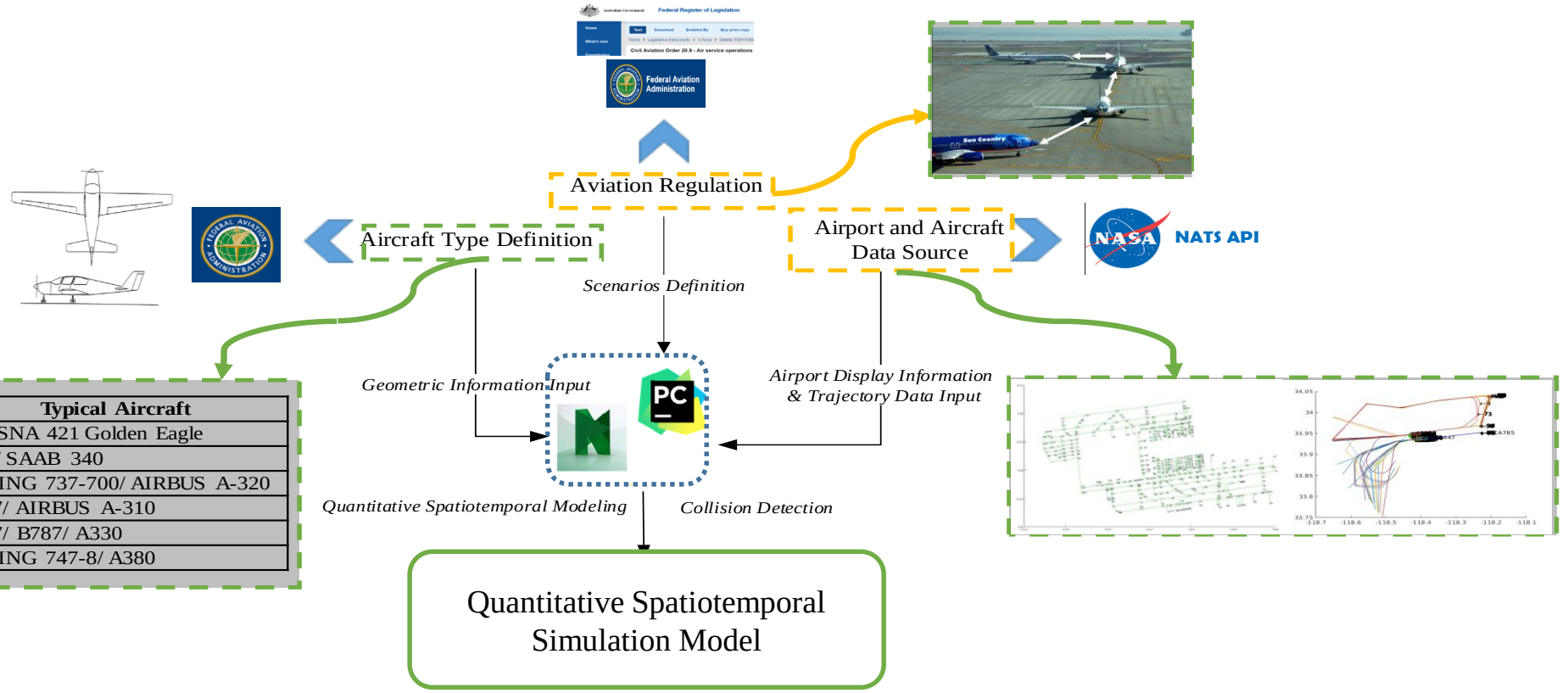


Salmon, P. M., Read, G. J., Stanton, N. A., & Lenné, M. G. (2013). The crash at Kerang: Investigating systemic and psychological factors leading to unintentional non-compliance at rail level crossings. Accident Analysis & Prevention, 50, 1278-1288.

Outline

1. Introduction
2. Methodology
3. Preliminary Results
4. Conclusion & Future Work

Methodology of Establishing Quantitative Spatiotemporal Simulation • Framework



Group	Typical Aircraft
I	CESSNA 421 Golden Eagle
II	CRJ/ SAAB 340
III	BOEING 737-700/ AIRBUS A-320
IV	B767/ AIRBUS A-310
V	B777/ B787/ A330
VI	BOEING 747-8/ A380

Methodology of Establishing Quantitative Spatiotemporal Simulation • Airport Regulation

NOTICES TO AIRMEN PUBLICATION
DOMESTIC/INTERNATIONAL
EFFECTIVE JANUARY 4, 2018 - JANUARY 31, 2018

General Information | Part 1. FDC NOTAMs | Part 2. Part 95 Revisions | Part 3. International NOTAMS | Part 4. Graphic Notices

< PREVIOUS | BOTTOM | NEXT >

Standardized Taxi routes for Los Angeles International Airport (KLAX)

The following Standardized Taxi routes may be issued to all taxiing aircraft.

North Route

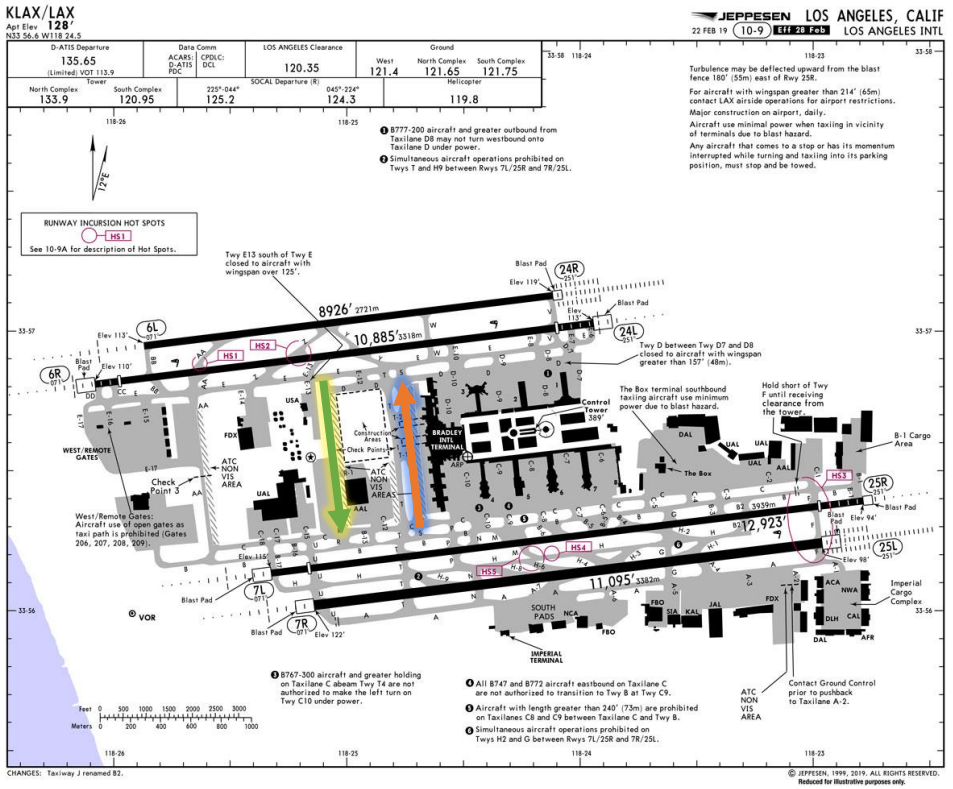
Taxi towards taxilane Sierra (S) taxi northbound on taxilane Sierra (S), and at Check-point-1 contact Ground Control on frequency 121.65, hold short of taxiway Delta (D).

Taxilane Sierra (S) is not visible from the ATCT

South Route

Taxi towards taxiway Romeo (R) taxi southbound on taxiway Romeo (R), and at Check-point-2 contact Ground Control on frequency 121.4, hold short of taxiway Charlie (C).

Taxiway Romeo (R) is not visible from the ATCT



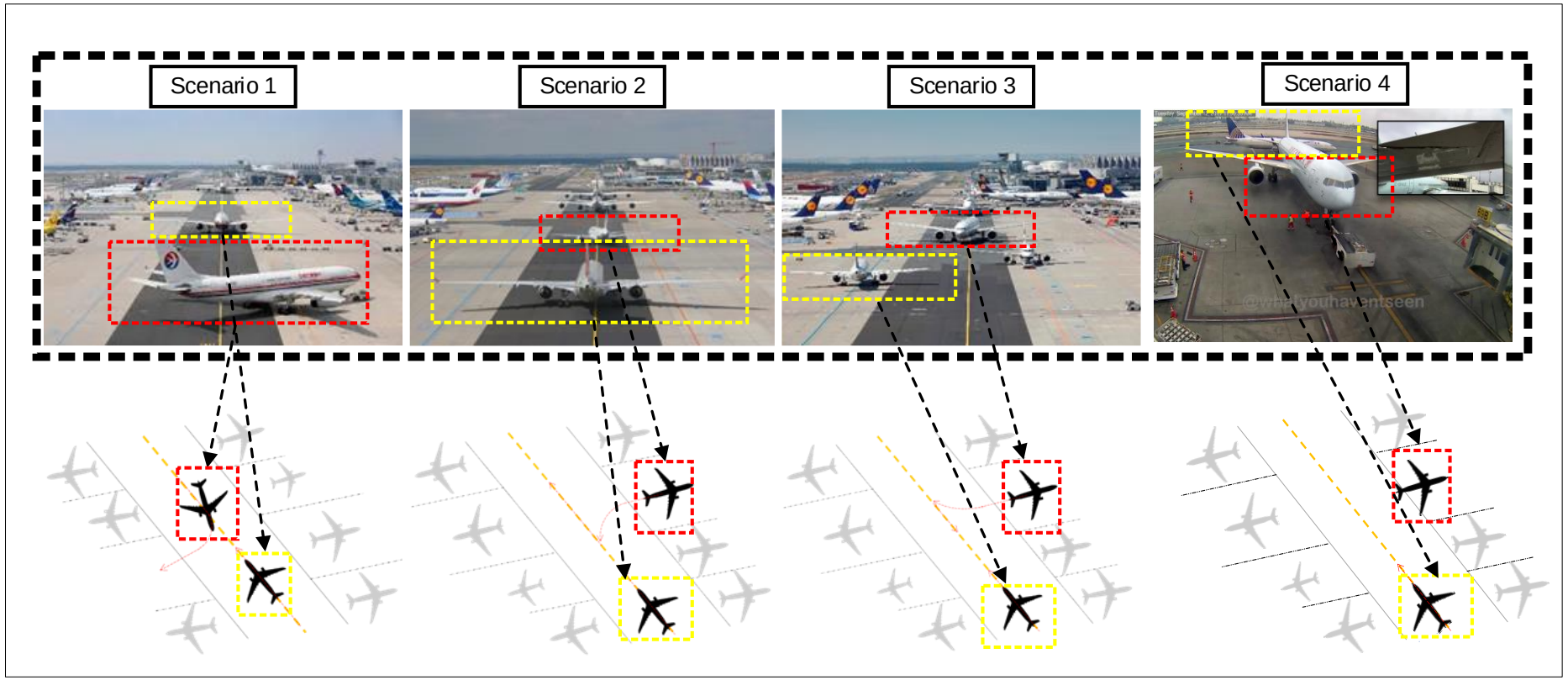
Methodology of Establishing Quantitative Spatiotemporal Simulation • Data Source

Airport Surface Detection Equipment, Model X (ASDE-X)

ASDE-X is a surveillance system using radar, multilateration and satellite technology that allows air traffic controllers to track surface movement of aircraft and vehicles.

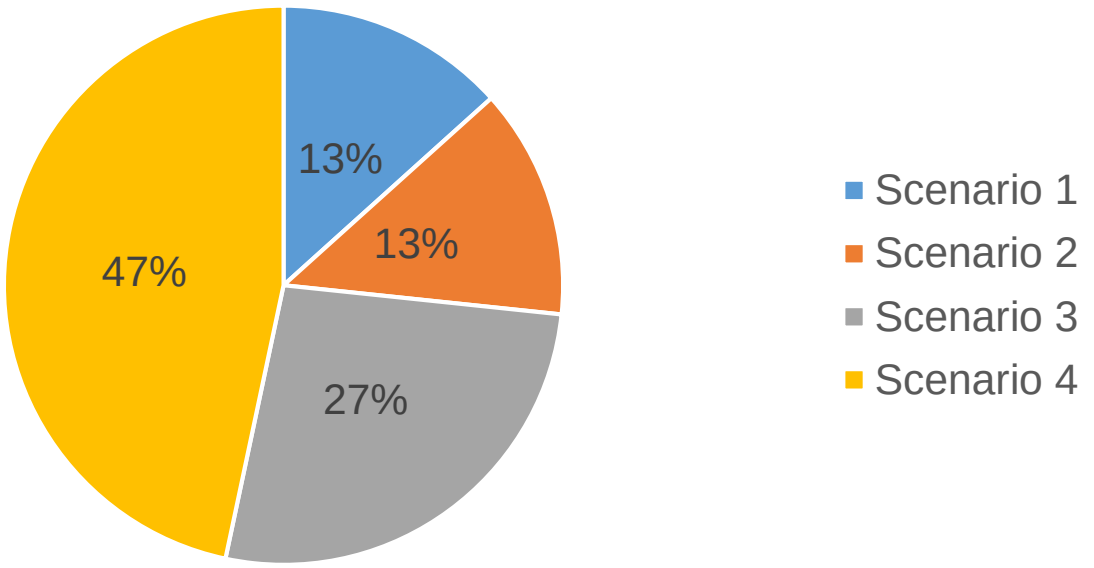
Call Sign	Latitude	Longitude	Time Stamp
EVA015	33.93979	-118.40815	1505202239
EVA015	33.93978	-118.40814	1505202240
EVA015	…	…	…

Methodology of Establishing Quantitative Spatiotemporal Simulation • Collision Scenarios



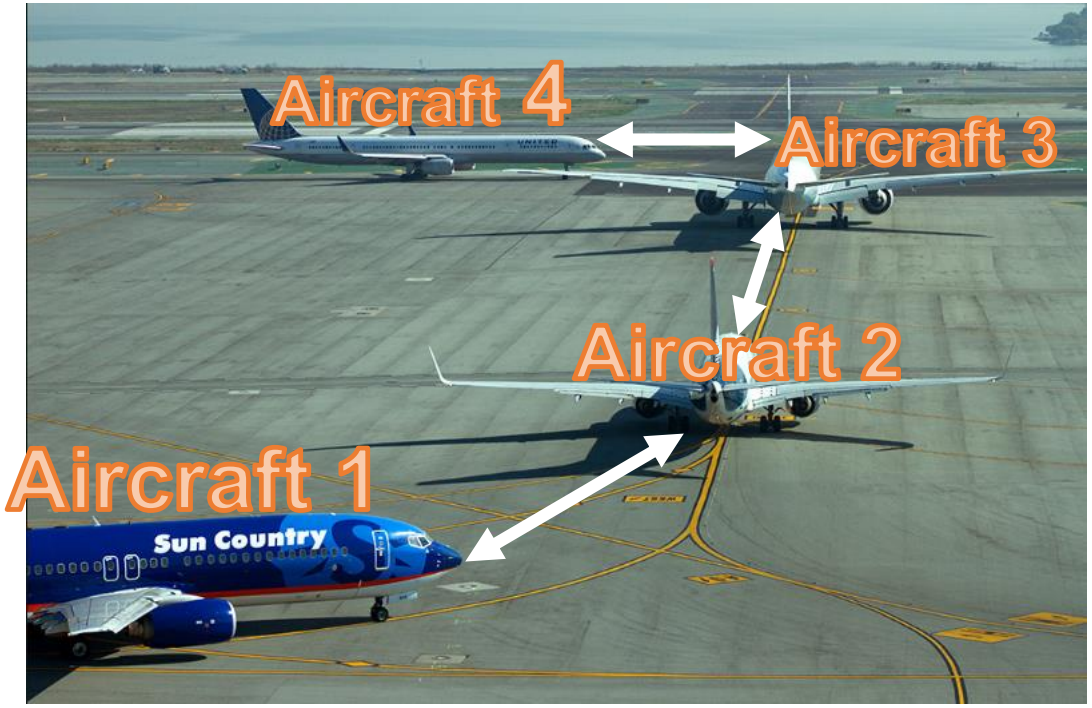
Four different scenarios of aircraft in conflicts

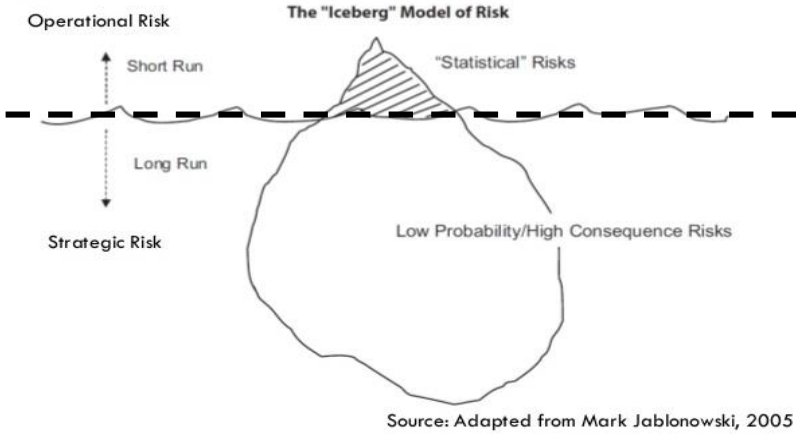
Methodology of Establishing Quantitative Spatiotemporal Simulation • Collision Scenarios



Four different type of scenarios of potential collisions in the stand area.

Methodology of Establishing Quantitative Spatiotemporal Simulation • Algorithm

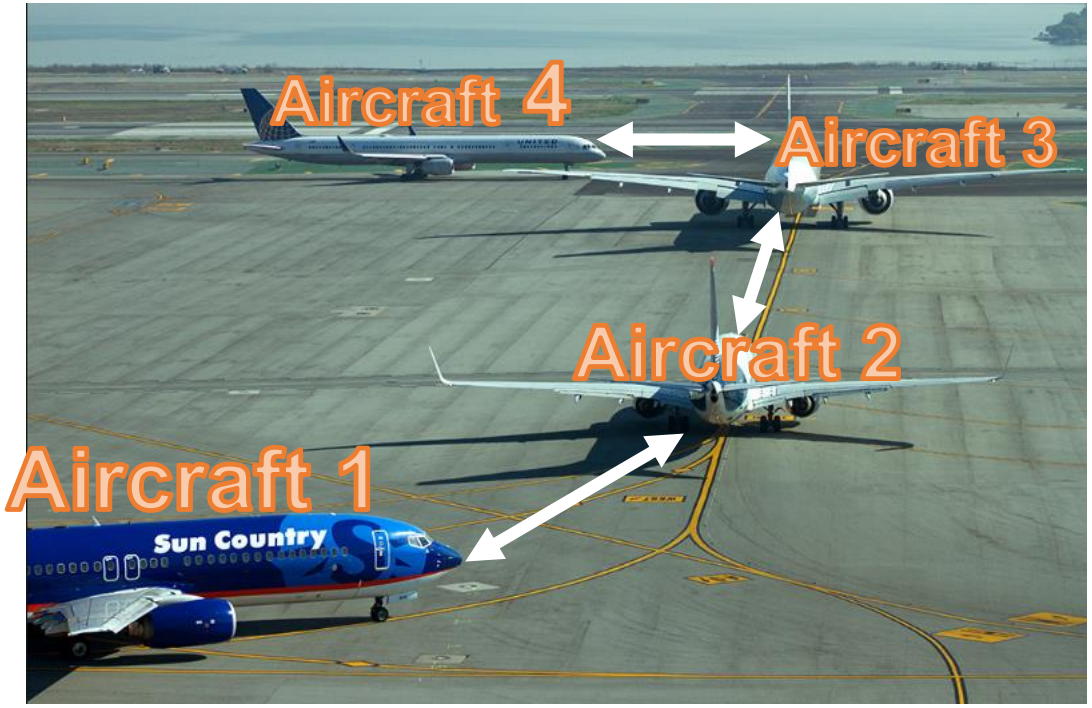




Proximity Case:

Distance < 50 meters

Methodology of Establishing Quantitative Spatiotemporal Simulation • Algorithm



Aircraft 1

Call Sign	Latitude	Longitude	Time
EVA015	33.93979	-118.40815	1505202239
EVA015	33.93978	-118.40814	1505202240
EVA015	...	...	...

Aircraft 2

Call Sign	Latitude	Longitude	Time
CAL159	33.94382	-118.43075	1505199060
CAL159	33.94383	-118.43074	1505199061
CAL159	...	...	...

Aircraft 3

Call Sign	Latitude	Longitude	Time
AAL1071	33.9392	-118.405	1505202606
AAL1071	33.93912	-118.405	1505202607
AAL1071	...	...	...

.
.
.

Aircraft n

For i = 1 to n-1:

read in the all trajectory and time data of Aircraft i

For j = i+1 to n:

read in the trajectory and time data of Aircraft j

If the time of Aircraft i and j have overlap:

Find the overlap duration [t1,t2]

For the time= t1 to t2:

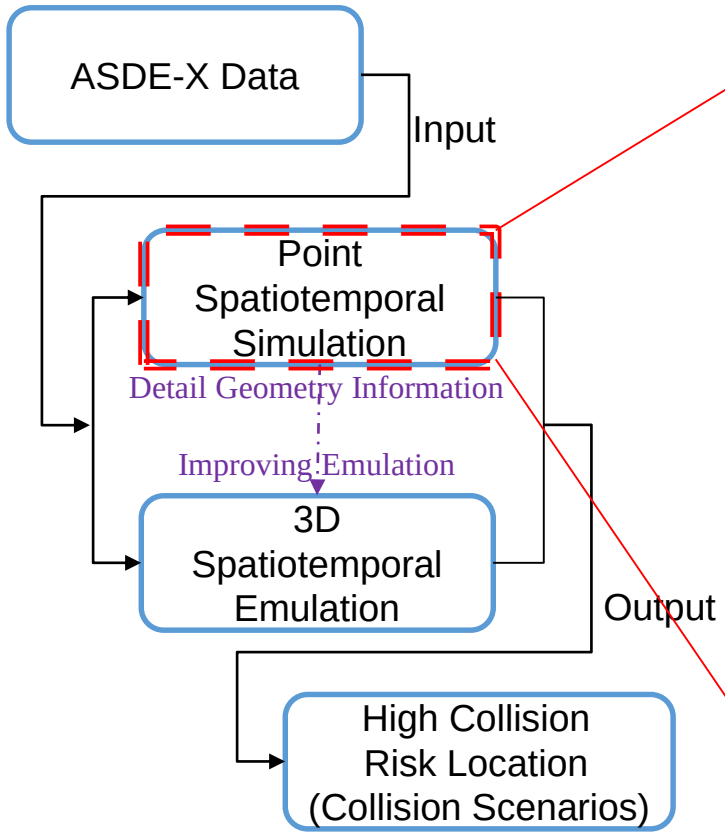
Calculate the distance between Aircraft i and j

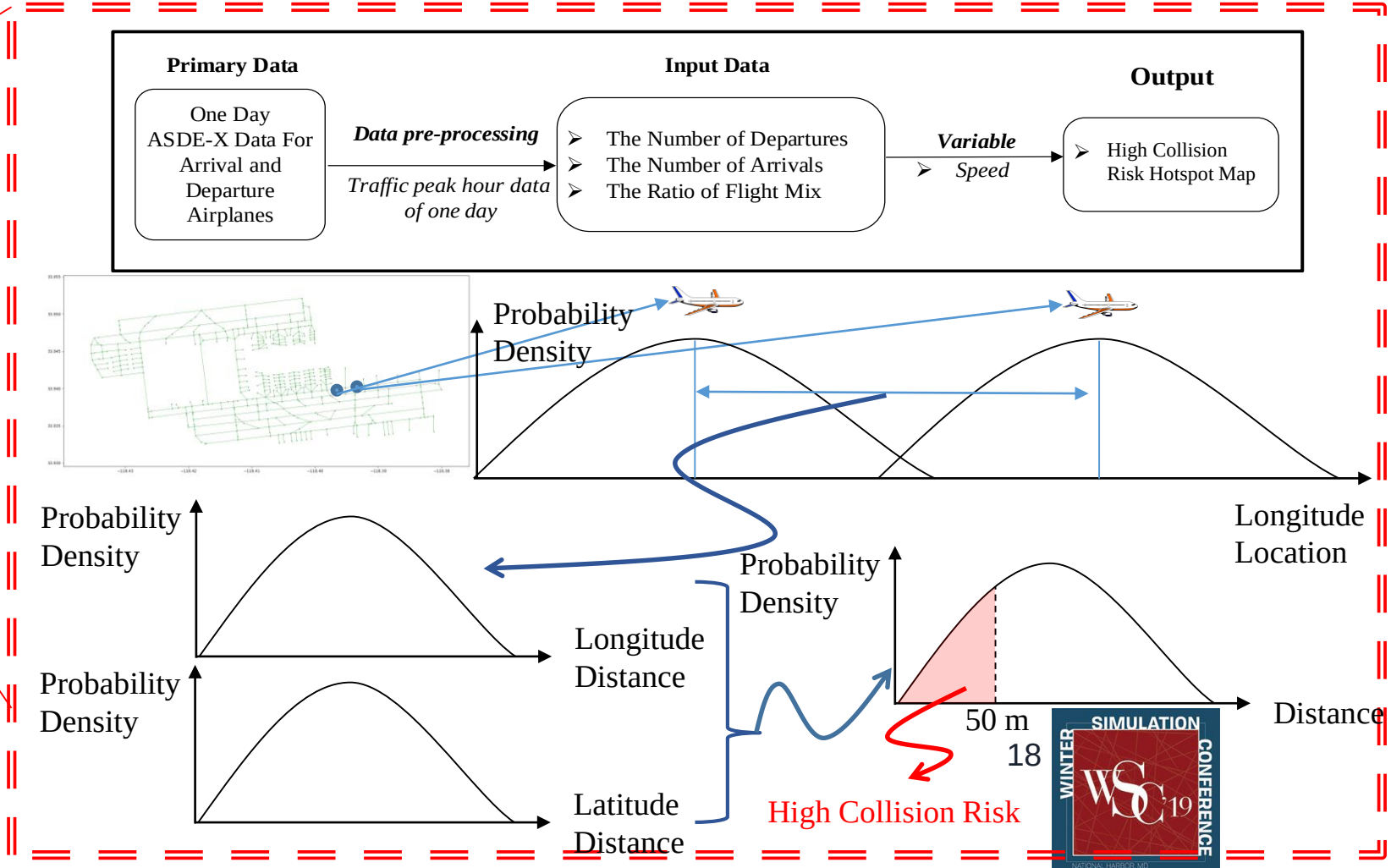
If the distance < regulation requirement

Find the nearest airport map nodes of Aircraft i and j

Record the find time of each airport map node

Methodology of Establishing Quantitative Spatiotemporal Simulation • Model





IRA A. FULTON SCHOOLS OF engineering
ARIZONA STATE UNIVERSITY

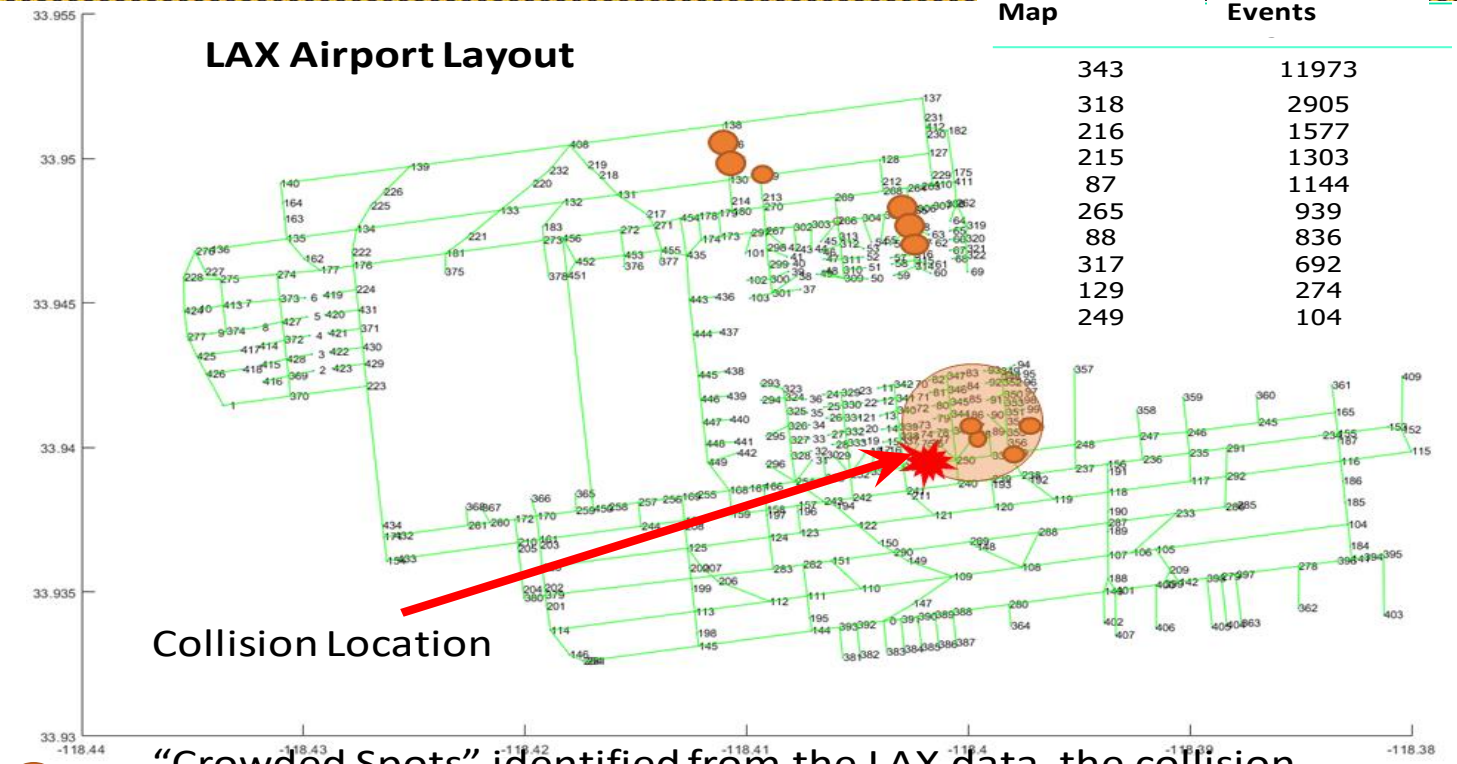
Outline

1. Introduction
2. Methodology
3. Preliminary Results
4. Conclusion & Future Work

Preliminary Results

09/12/2017

11:20:00AM-
12:20:00PM

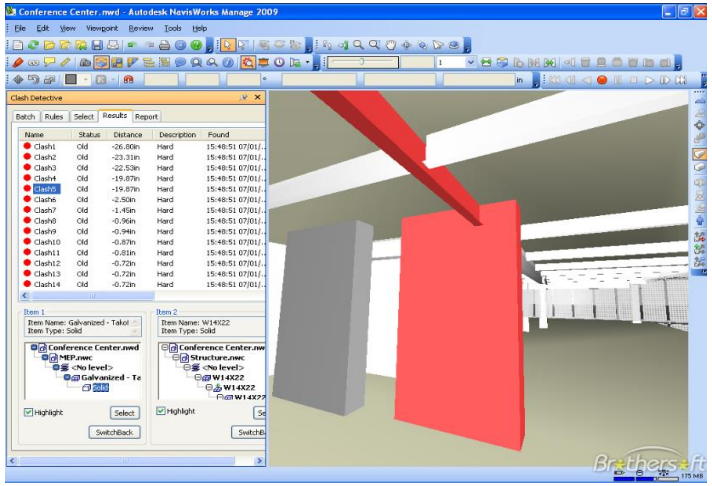


Node Number on the Airport Map	Number of Proximity Events
343	11973
318	2905
216	1577
215	1303
87	1144
265	939
88	836
317	692
129	274
249	104

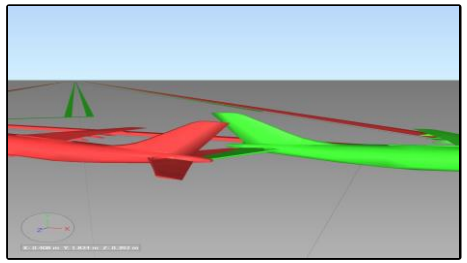
"Crowded Spots" identified from the LAX data, the collision location is close to one of the spot with many proximity events

Spatial distribution of proximity cases based on the ASDE-X data analysis to identify the crowded area in LAX airport

Preliminary Results



Preliminary Results



```
Clashes
------------------
Report Batch
  Clash detection
tolerance:      0.001m          type:    cleareance

Task Link start:0:0:0        end:       0:0:19  Animator
scene:clash detection
  name: clash 1      distance : -0.057m          status:new
clash point:    2.162m, 0.000000197m, 7.358m
Item 1 GUID:    5aa25055-4a83-4b85-b025-1ade2d6021be
Item 2 GUID:    5aa2502e-4a83-4b85-b025-1ade2d6021be
```

The 3D Coordinate Position of the Collision

Aircraft Model Identificaiton

One Time Simulation Collision Report.

Outline

1. Introduction
2. Methodology
3. Preliminary Results
4. Conclusion & Future Work

Conclusion:

- The spatiotemporal distribution of the proximity situations derived from ASDE-X data can be a good historical indicator for predicting the likelihood of collisions at certain times and around certain areas of airports.
- The proximity cases mostly occurred between standing aircraft and takeoff aircraft in taxiing and most proximity cases occurred in the terminal areas.
- With the detailed geometry simulation model, the authors can help pilots to detect collision risks.

Future Work

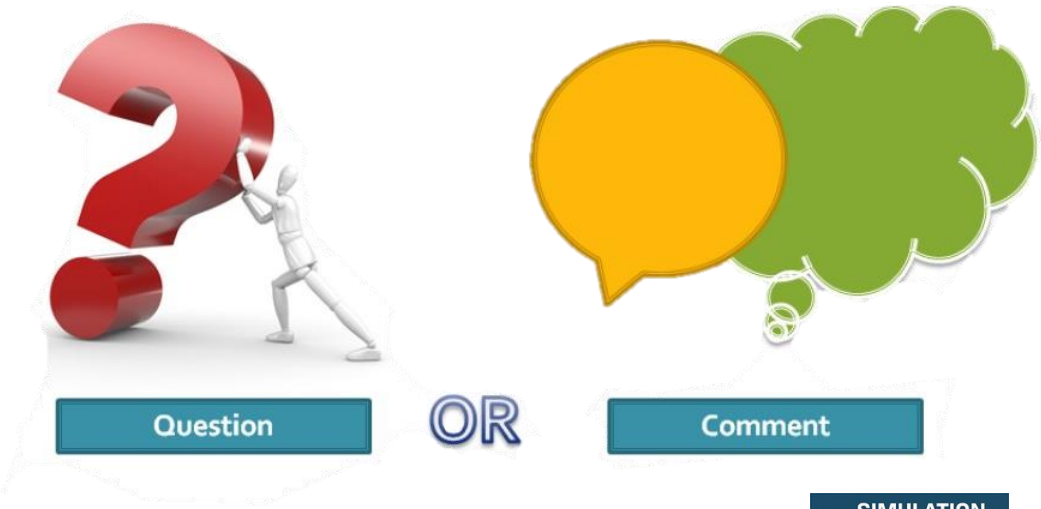
- 1) Complete more simulation for all four scenarios defined in this paper;
- 2) Conduct more statistical analysis about the spatiotemporal distributions of proximity events and use those statistical analysis results to define random parameters related to spatiotemporal conflicts between aircraft movements on the ground;
- 3) Examine more detailed geometric representations of aircraft for understanding how detailed geometric information influence the reliability of collision prediction produced by the simulation.

Reference

- https://www.youtube.com/watch?v=QtNR_r1SPuc
- https://www.youtube.com/watch?v=thfHfQc59Qk
- https://www.bts.dot.gov/newsroom/2018-traffic-data-us-airlines-and-foreign-airlines-us-flights
- https://www.youtube.com/watch?v=MWn7amCUQfg
- https://www.ntsb.gov/_layouts/ntsb.aviation/index.aspx
- https://www.youtube.com/watch?reload=9&v=waqT1m4SWQw
- https://www.youtube.com/watch?reload=9&v=waqT1m4SWQw
- https://thepointsguy.com/2017/11/egyptair-777-strikes-virgin-atlantic-a330/
- http://www.jacdec.de/2015/07/07/2015-07-06-emirates-boeing-777-200-collides-with-hak-air-737-at-lagos/
- https://abcnews.go.com/US/planes-clip-wings-yorks-laguardia-airport/story?id=27791267
- https://www.slideshare.net/ShivSTripathi/enterprise-risk-risk-management-i
- https://risk-engineering.org/concept/Heinrich-dominos
- https://www.flickr.com/photos/45000502@N04/15742967051
- http://www.brothersoft.com/autodesk-navisworks-175054.html
- https://www.modlar.com/profile/1380/pauly-j/airbus-a-380-for-revit/
- https://www.pngfly.com/png-9qmnbl/download.html

Thank you!

Dr. Pingbo Tang; Yanyu Wang; Zhe Sun and Dr. Yongming Liu



IRA A. FULTON SCHOOLS OF engineering
ARIZONA STATE UNIVERSITY

WINTER SIMULATION CONFERENCE
WSC'19
NATIONAL HARBOR, MD