

The 2019 AIAA AVIATION Forum

Predicting Collisions between Aircraft through Spatiotemporal Data-Driven Simulation of Airport Ground Operations

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

Motivation



https://www.youtube.com/watch?v=QtNR_r1SPuc



<https://www.youtube.com/watch?v=thfHfQc59Qk>

Outline

1. Introduction
2. Methodology
3. Model
4. Results

Introduction

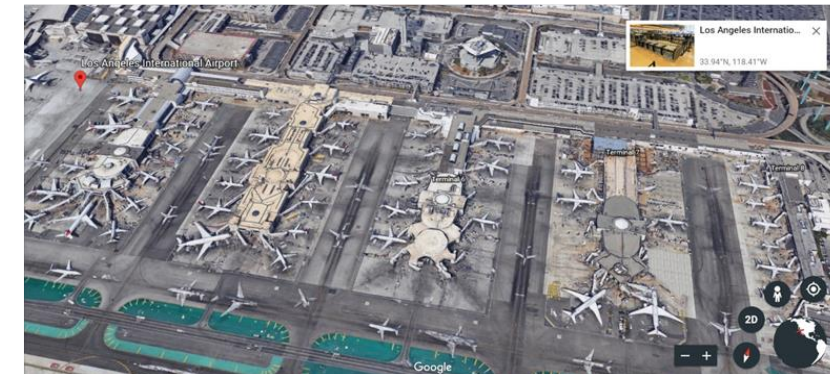
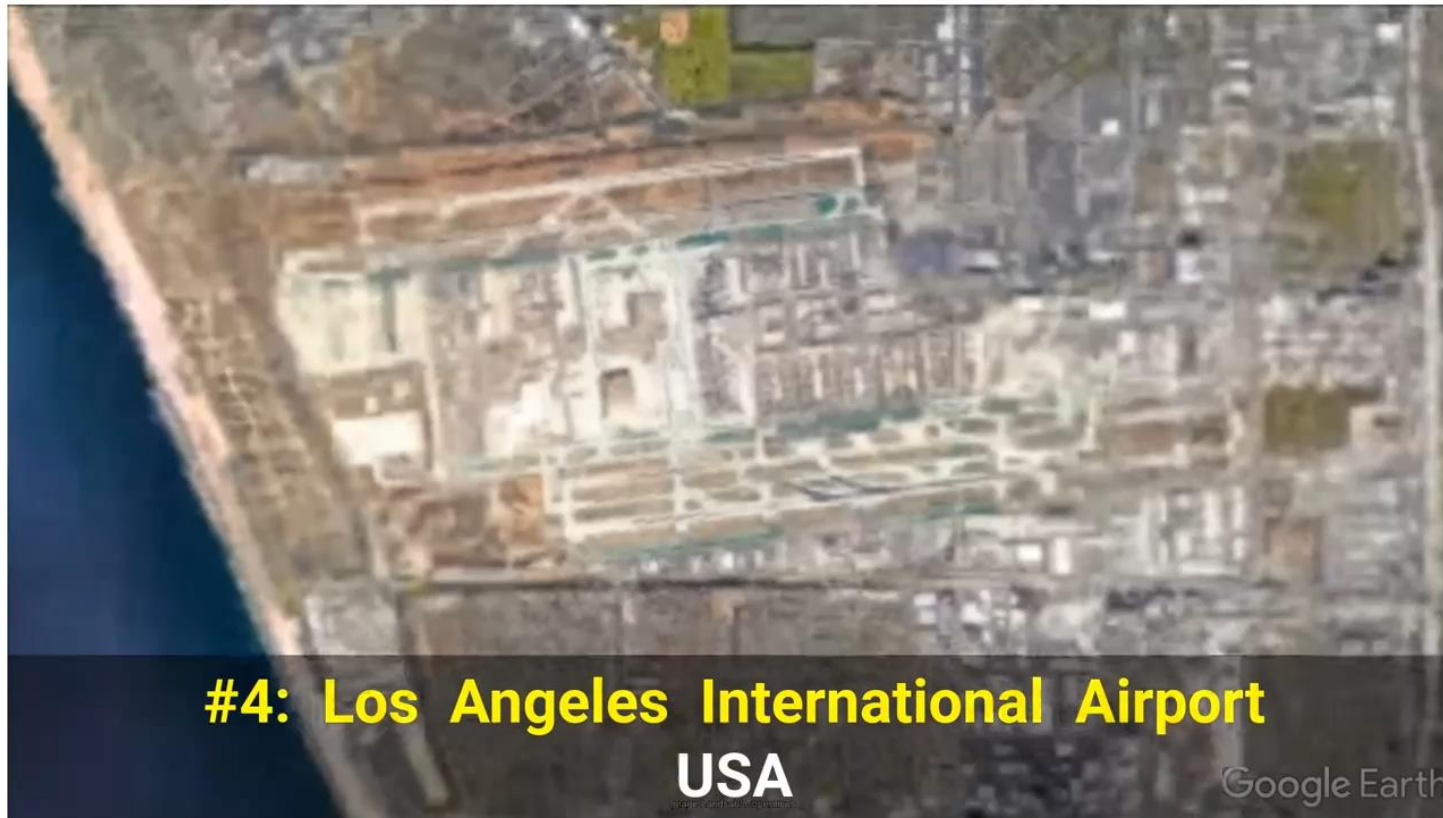


Fig. 1 The Ramp Area of Los Angeles International Airport from the Google Earth

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		

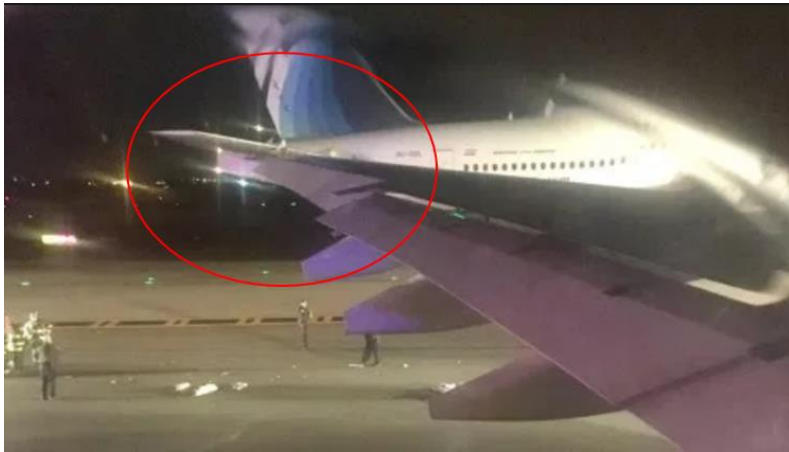
<https://www.nts.gov/layouts/nts.aviation/index.aspx>



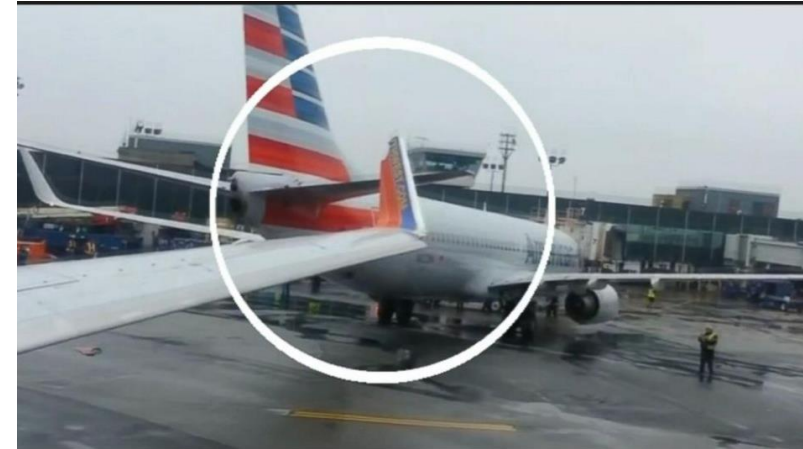
Introduction



Introduction



<https://thepointsguy.com/2017/11/egyptair-777-strikes-virgin-atlantic-a330/>

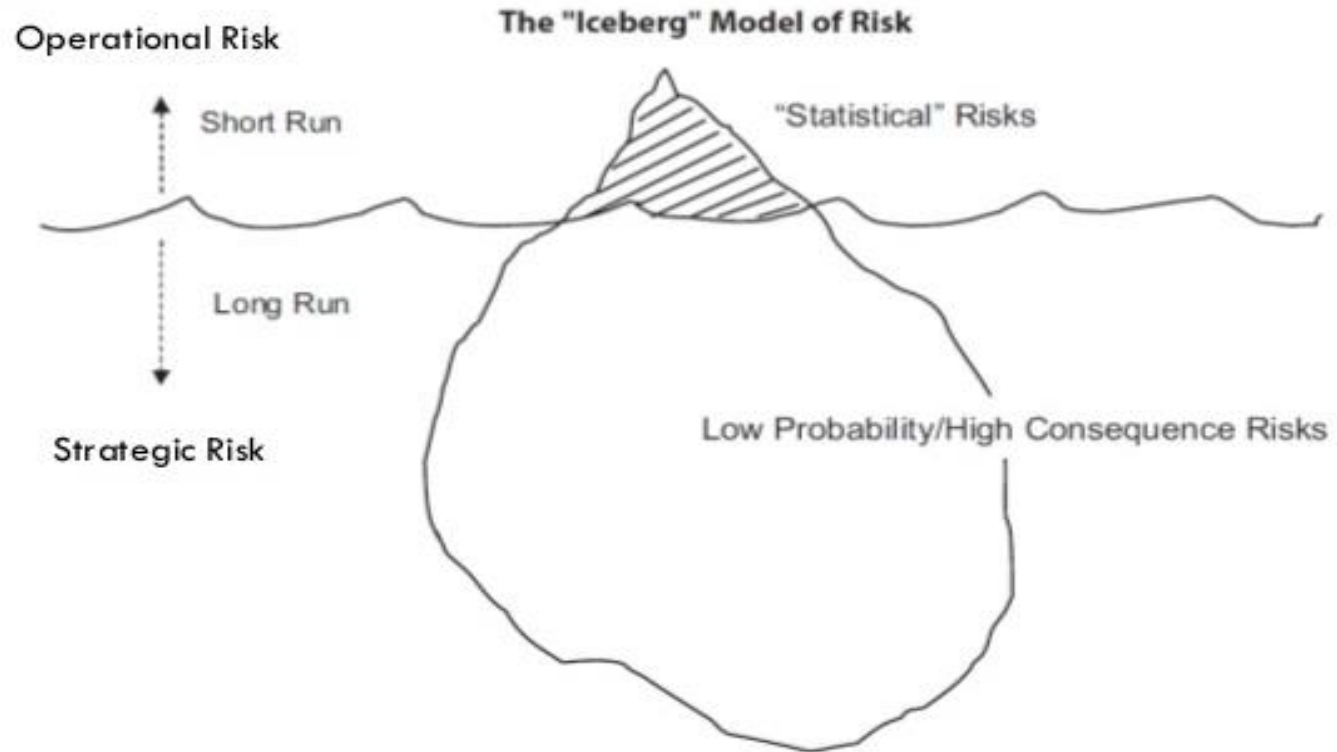


<https://abcnews.go.com/US/planes-clip-wings-yorks-laguardia-airport/story?id=27791267>



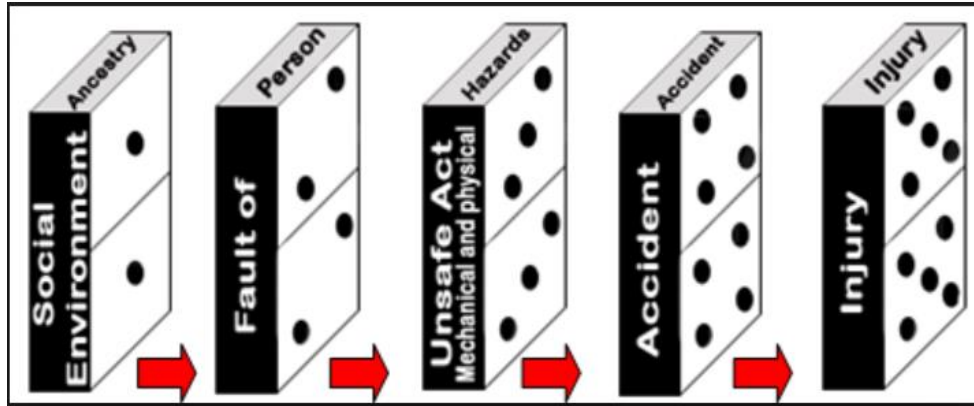
<http://www.jacdec.de/2015/07/07/2015-07-06-emirates-boeing-777-200-collides-with-hak-air-737-at-lagos/>

Introduction

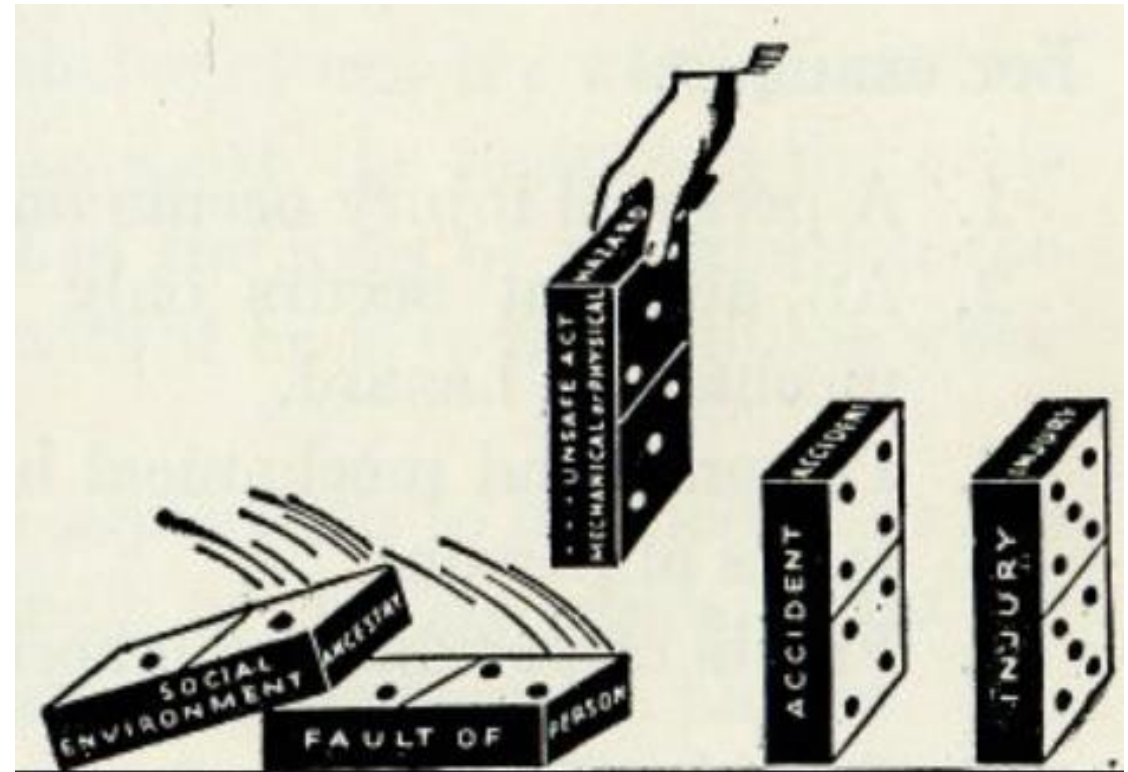


Source: Adapted from Mark Jablonowski, 2005

Introduction



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.



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Methodology

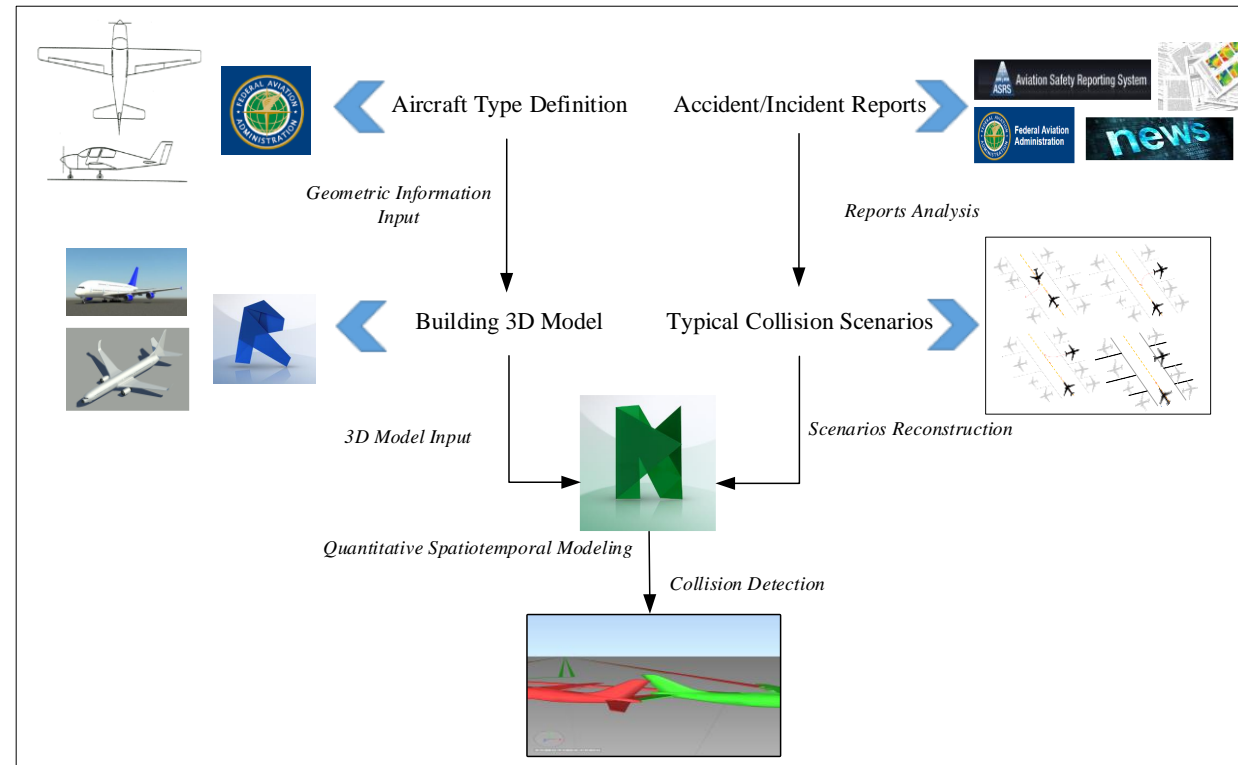


Fig.2 Methodology of Establishing Quantitative Spatiotemporal Model.

Methodology

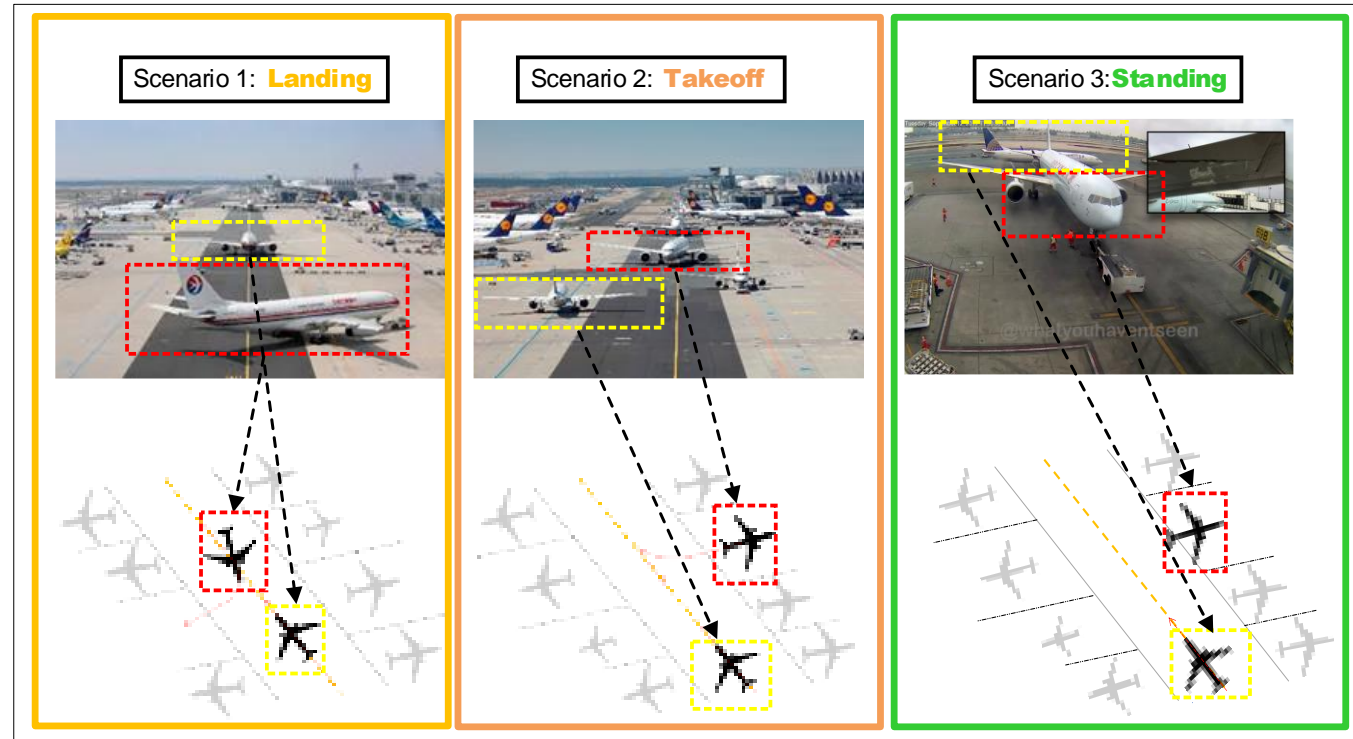
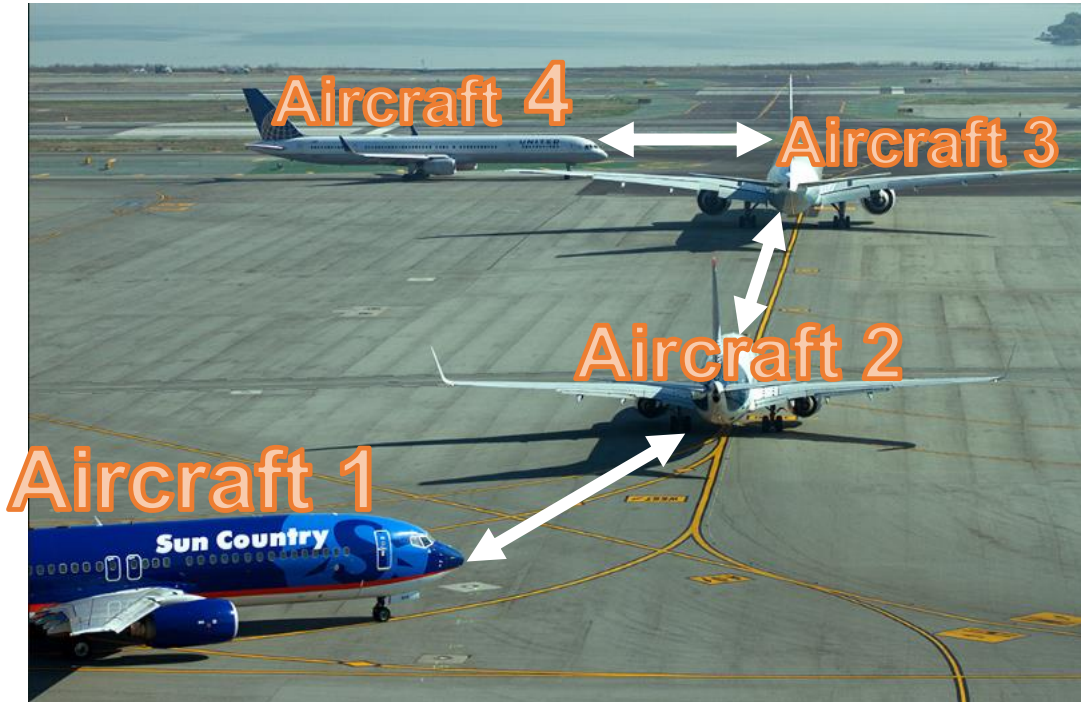


Fig. 3 Three different scenarios of aircraft in conflicts

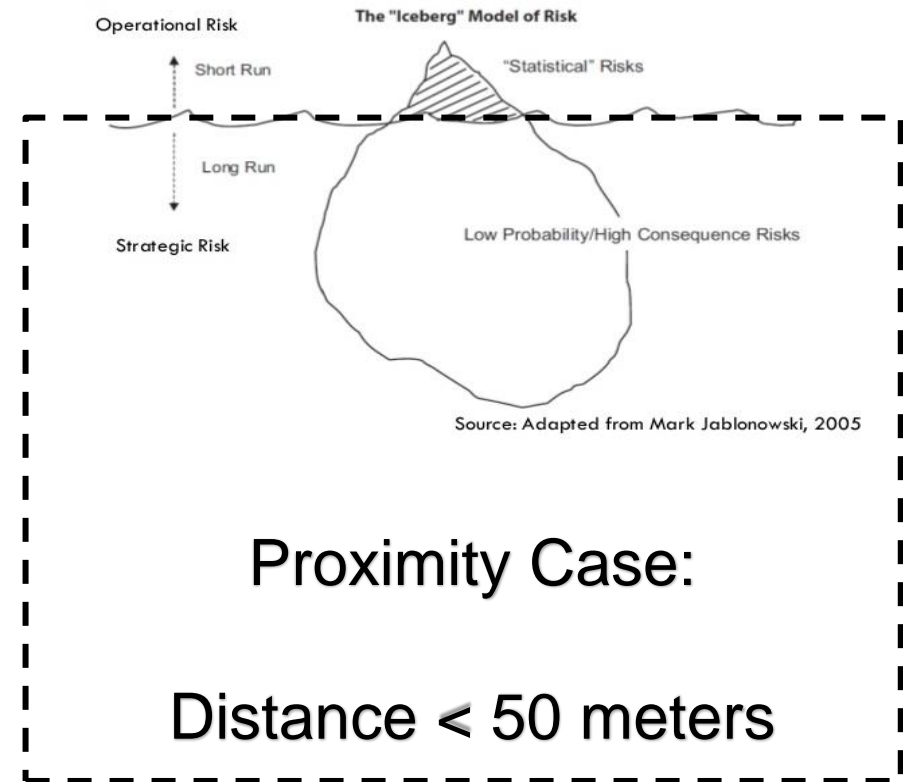
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Model



<https://www.flickr.com/photos/45000502@N04/15742967051>



Model

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	...	...	...

Model

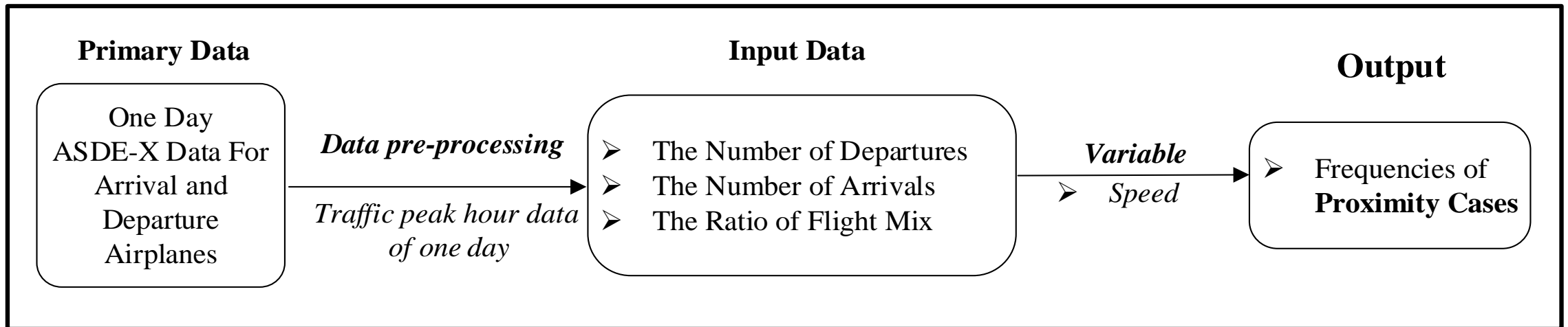
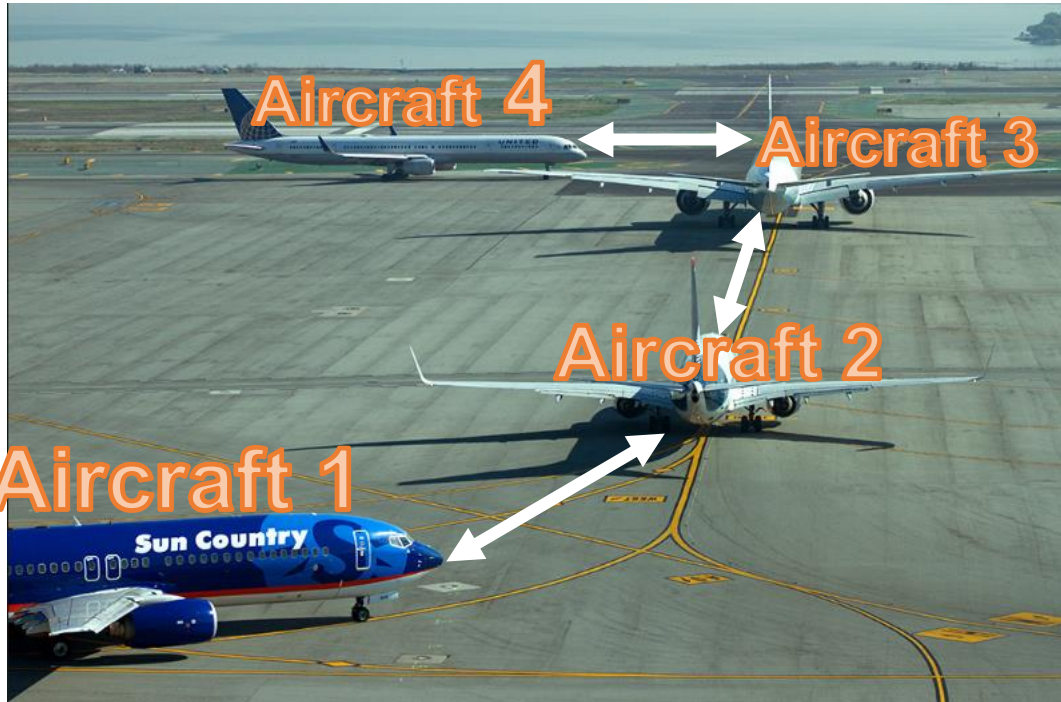


Fig. 4 Workflow of Quantitative Spatiotemporal Model.

Model



<https://www.flickr.com/photos/45000502@N04/15742967051>

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 $[t_1, t_2]$

For the time = t_1 to t_2 :

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

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Results

09/12/2017

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

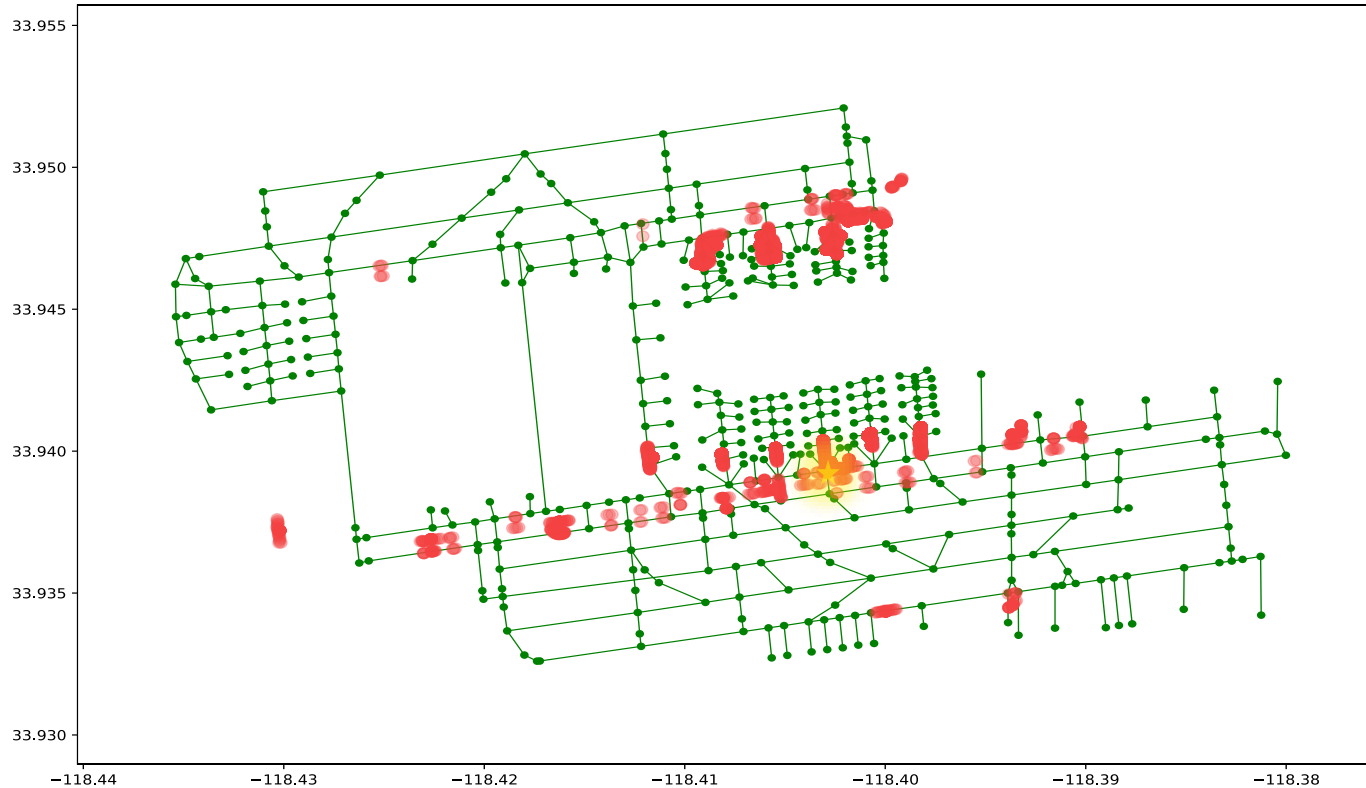


Fig. 5 Spatial distribution of proximity cases based on the ASDE-X data analysis to identify the crowded area in LAX airport

Results

	Time Stamp	Aircraft α	Scenario of Aircraft α	Aircraft β	Scenario of Aircraft β	Distance between Aircraft 1 and Aircraft 2 (m)	
Session 1	1505240802	Aircraft 1	Takeoff	Aircraft 2	Standing	49.78240374	Data Point 1
	1505240803	Aircraft 1	Takeoff	Aircraft 2	Standing	49.23255618	Data Point 2
	...	...	...	...	...	...	Data Point 3
Session 2	1505240818	Aircraft 1	Takeoff	Aircraft 2	Standing	49.67144682	
	1505240817	Aircraft 1	Takeoff	Aircraft 3	Takeoff	48.27414134	
	
Session 206	1505240823	Aircraft 1	Takeoff	Aircraft 3	Takeoff	46.61703881	
	...	...	...	...	...	...	Data Point 7,709

Results

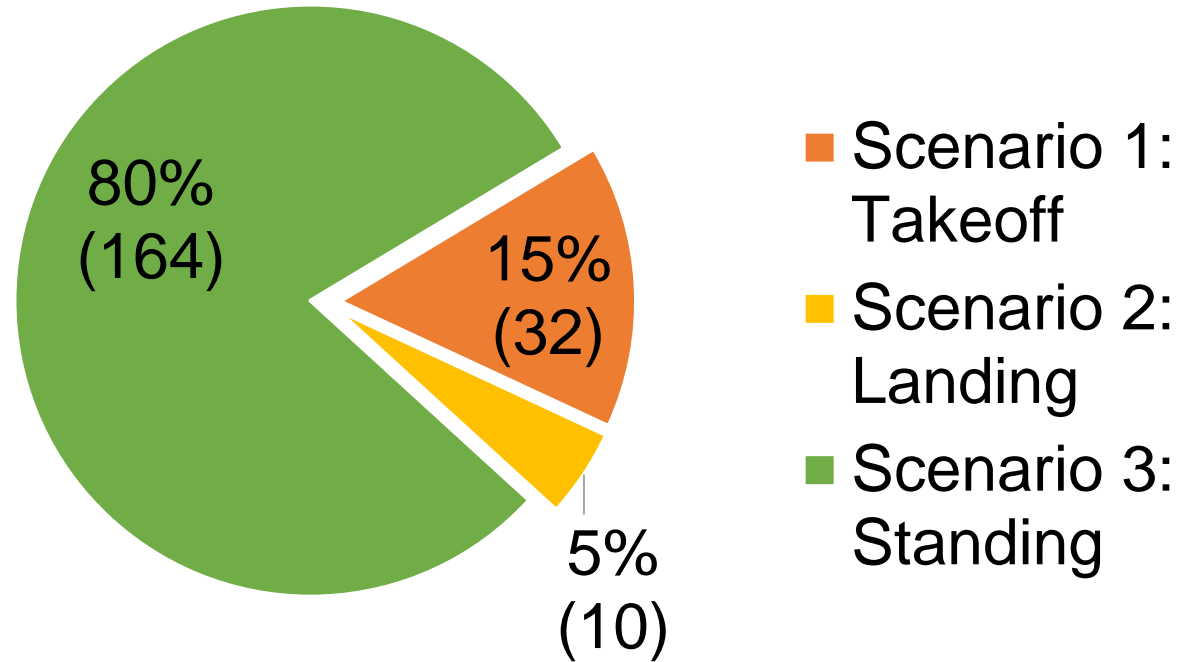
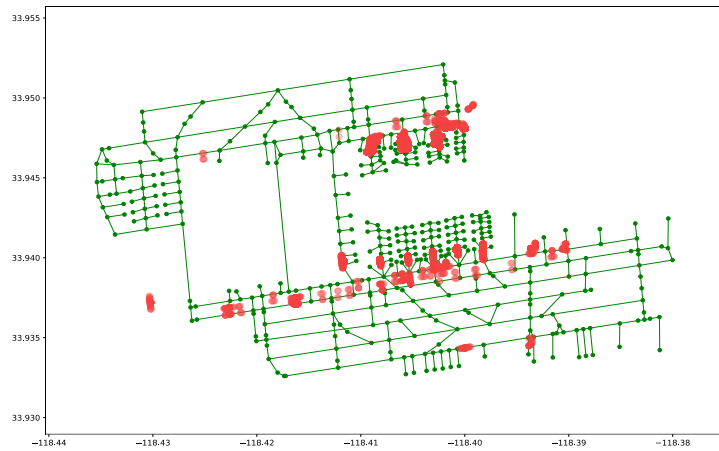


Fig. 6 Pie-charts showing the composition of the different proximity scenarios in simulation 21

Results

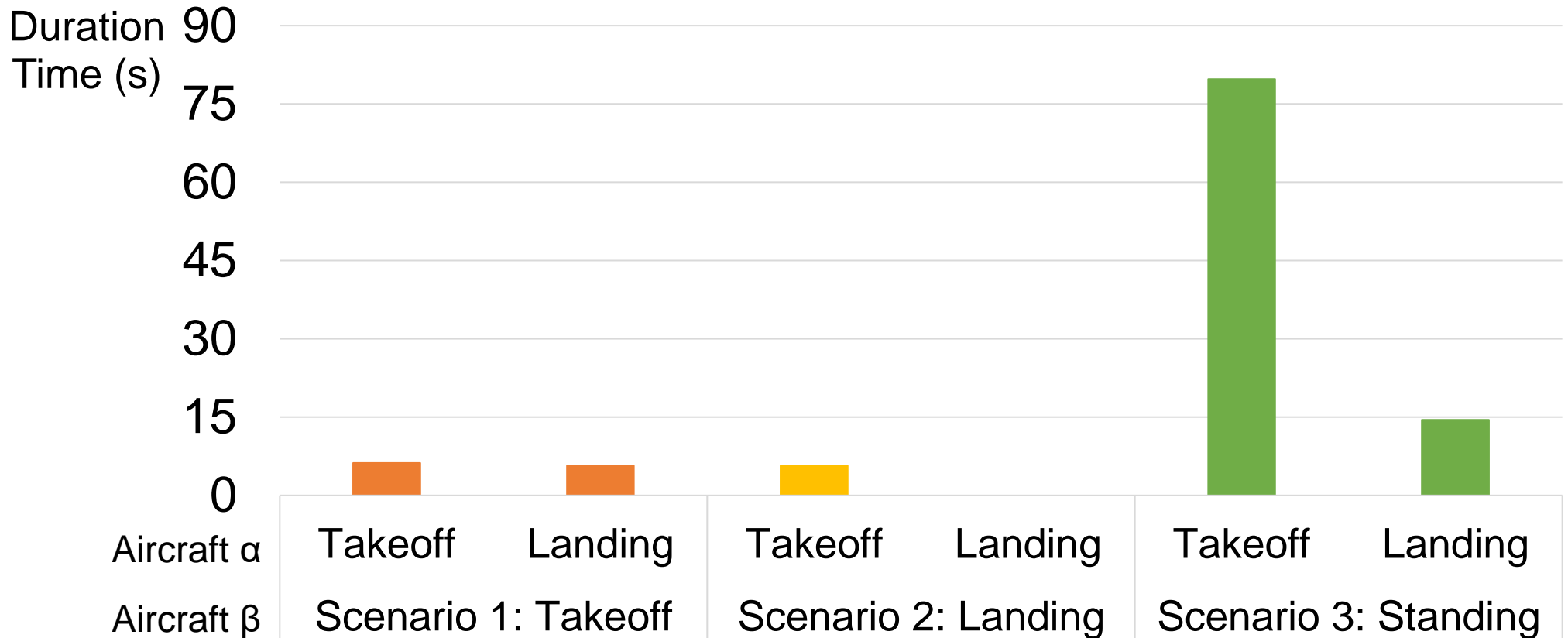


Fig. 7 The frequency distribution of proximity situations in different scenarios from the simulation

Results

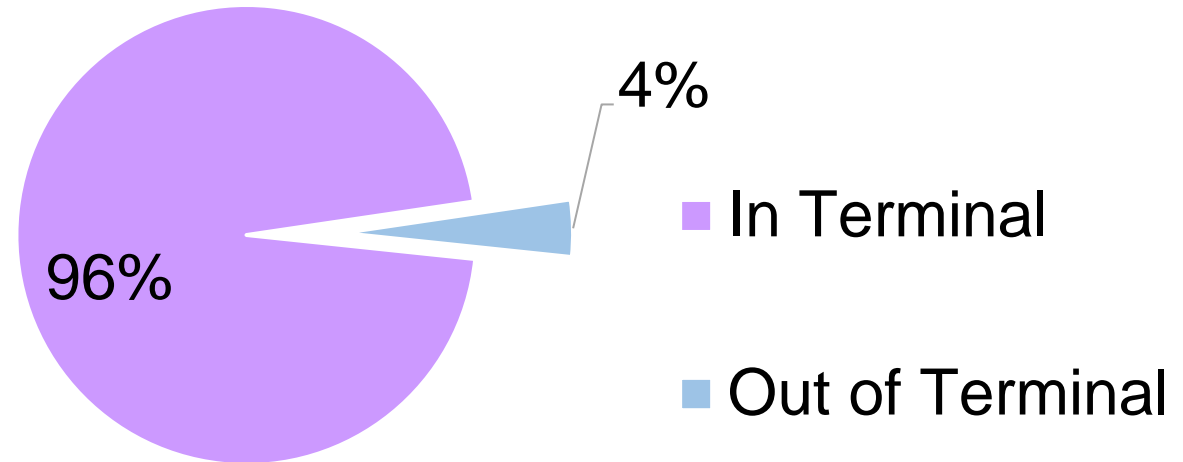
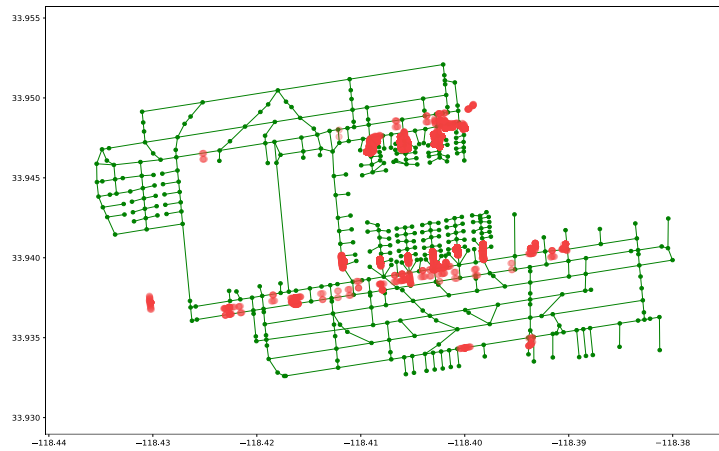
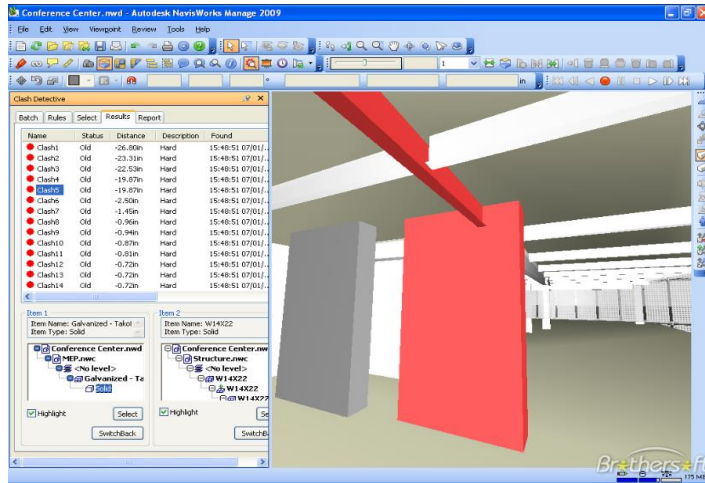


Fig. 8 Pie-charts showing the composition of the spatial distribution in proximity situation in or out of the terminal

Results



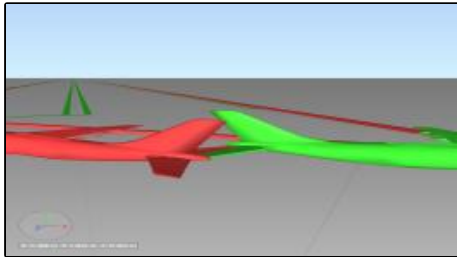
<http://www.brothersoft.com/autodesk-navisworks-175054.html>



<https://www.modlar.com/profile/1380/pauly-j/airbus-a-380-for-revit/>



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

Fig. 9 One Time Simulation Collision Report.

Results

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.

Results

Future Work

- Do more simulations to extract more spatiotemporal regulation of collision between aircraft
- Come up with a method to make the simulate model can predict the collision in real-time.

Thank you!

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

