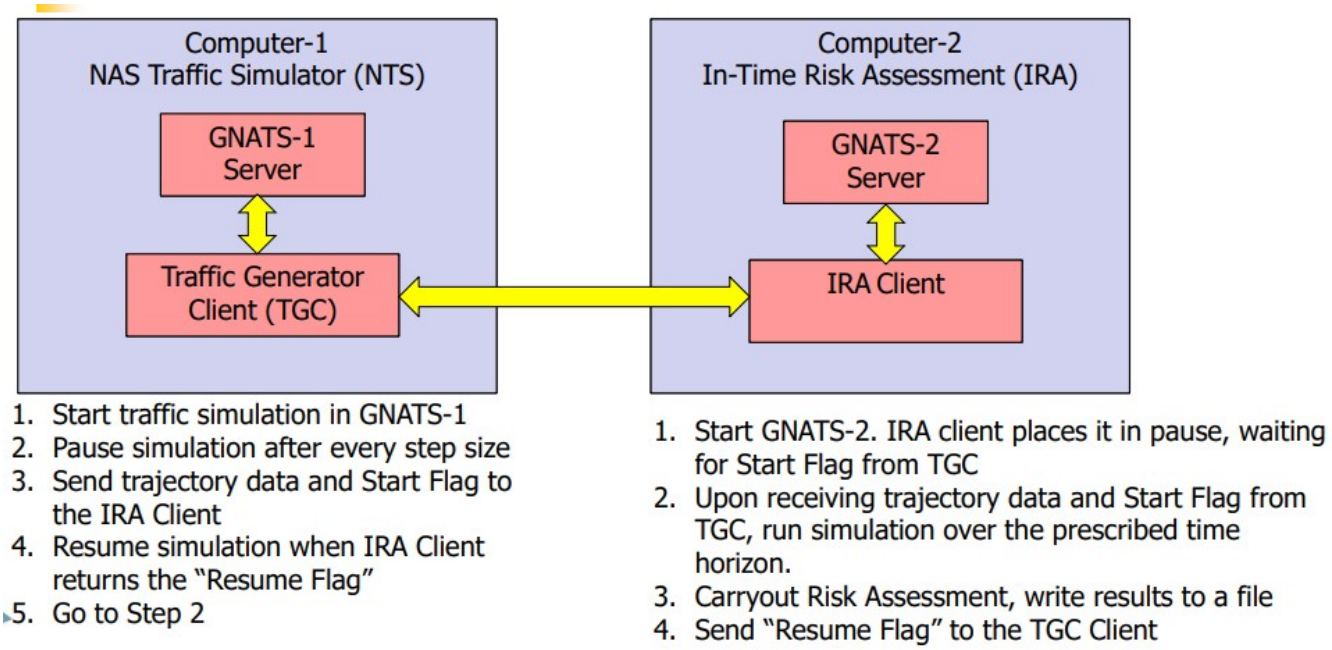
GNATS IRA-AOC Documentation

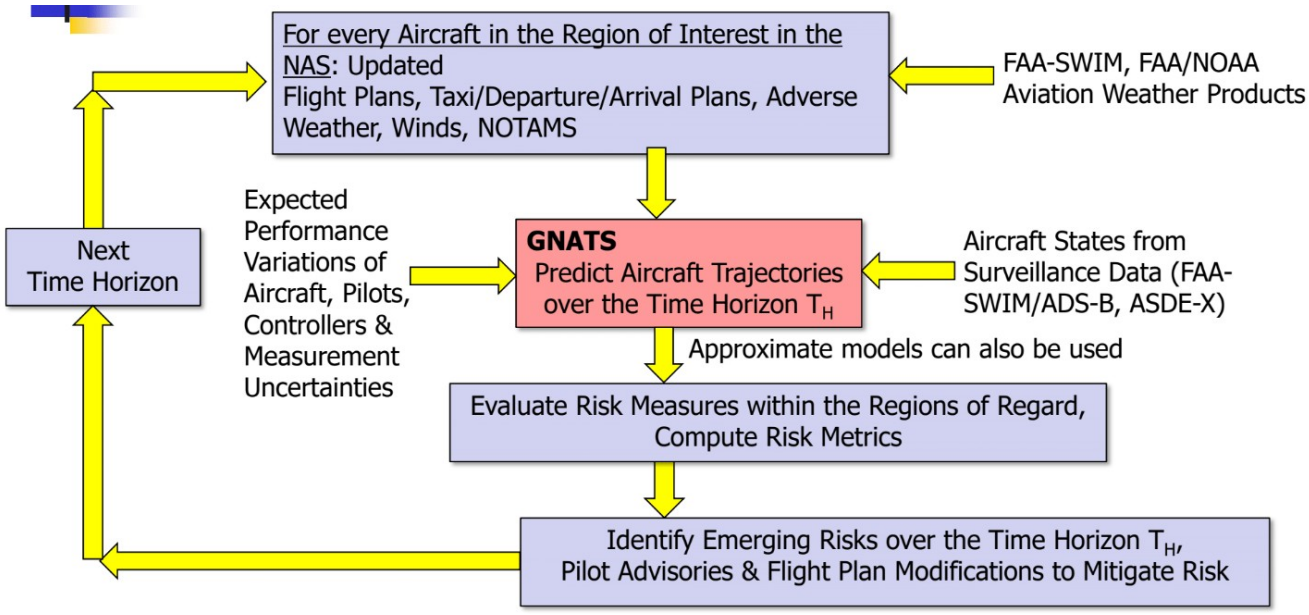
GNATS Production version 2.0 features IRA (In-Time Risk Assessment) simulation. It has been built for look-ahead simulation to detect and report potential accidents and flight failure.



Steps to run IRA:

1. Start GNATS Server on NAS Traffic Simulator.
2. Start GNATS Server on IRA Simulator.
3. Run GNATS_Client/sample/DEMO_TS.py on NAS Traffic Simulator.
4. On NAS Traffic Simulator, open GNATS_Client/sample/DEMO_TS.py, change the TRX file name to the desired one for simulation and Run GNATS_Client/sample/ DEMO_TS.py on NAS Traffic Simulator. Make sure the TRX is present in the share/ directory of both, IRA and NAS Traffic Simulator.
4. Run GNATS_Client/sample/DEMO_IRA.py on IRA Simulator.
5. The results from IRA simulation will be sent to NTS and the output will be displayed on the IRA GUI Agent.

The workflow of IRA is depicted by the following chart:



Region of Interest

Based on the use case, a select area of the airspace of ground can be set for analyzing air traffic. This is called the region of interest. This reduces the calculations required to determine safety and thereby makes simulation more time efficient. Here are the functions that can be used to set and get region of interest:

`int setRegionOfInterest(double[] regionBounds)`: This function can be used to set the region of interest with the input parameter as a double array of the latitude-longitude bounds of the region. The return data is a flag indicating success or failure.

`double[][] getRegionOfInterest()`: This function can be used to get the region of interest. The returned data is a nested double array of the latitude-longitude bounds of the region.

Region of Regard

For each aircraft, based on the flight phase it is in, there is a region within which other aircraft or objects pose a potential risk. This is called the region of regard.

GNATS has preset regions of regard for aircraft based on the flight phase, and it is as follows:

Flight Phase	Dimensions of the Region of Regard centered on the aircraft (Down Range, Cross Range, Altitude)
Gate/ramp	1000′×1000′
Taxiway	2000′×2000′
Runway	2 Nautical Miles (nm) ×1000′
Between 0 and 18,000 feet	6 nm ×6 nm ×1000′
Between18,000 feet and cruise altitude	10 nm ×10 nm ×5000′
Cruise altitude	20 nm ×20 nm ×5000′
Initial descent	10 nm ×10 nm ×5000′
Final descent	6 nm ×6 nm ×1000′

However, the user has the ability to change these bounds based on the situation requirements. These functions have been built into GNATS to provide this feature:

`int setRegionOfRegard(String aircraft, String flightPhase, double[] regionBounds)`: This function can be used to set the region of regard with the input parameter as a double array of the latitude-longitude bounds of the region. The return data is a flag indicating success or failure.

`double[][] getRegionOfRegard(String aircraft, String flightPhase)`: This function can be used to get the region of regard. The returned data is a nested double array of the latitude-longitude bounds of the region.

To get flights that are contained within the preset or user defined region of regard, following function can be used:

`String[] getAircraftInRegionOfRegard(String aircraft)`: This function returns a string array of the callsigns of all the aircraft within the region of regard for the aircraft provided as the input parameter.

Accident Occurence Categories (AOC)

GNATS has equipped with 13 AOC categories that all denote the potential risks that aircraft, ground vehicles might face during operations and flight. They are as follows:

Ground Collision (GCOL): A collision between aircraft or ground vehicles during taxi phase.

Taxiway Excursion (TE): Lateral or longitudinal excursion of an aircraft or ground vehicle during taxi phase.

Taxiway Incursion (TI): Lateral incursion of aircraft or ground vehicle during taxi or Longitudinal incursion of an aircraft while landing.

Runway Excursion (RE): Lateral excursion of aircraft or ground vehicle during takeoff/drive.

Runway Incursion (RI): Collision between aircraft taking off and an aircraft/ground vehicle crossing the runway.

Wake Turbulence (WAKE): A trailing smaller aircraft flying into the wake vortex caused by a leading heavier aircraft.

Collision with Obstacles during Takeoff (CTOL): Aircraft not being able to clear an obstacle (Airport compound wall or building up to 35 ft) during take off.

Runway Undershoot (US): Aircraft landing before the start of the runway due to steeper than needed glide slope.

Runway Overshoot (OS): Aircraft not able to stop after landing or take off before runway ends.

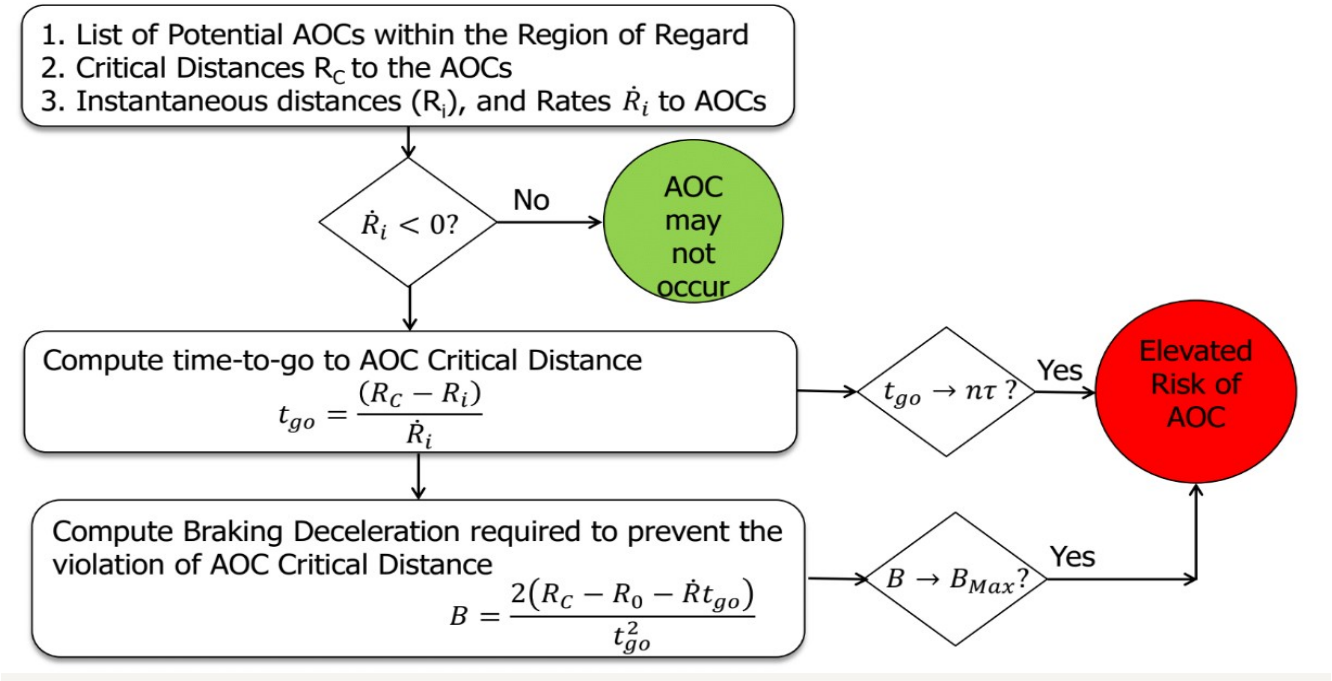
Mid Air Collision (MAC): Two aircraft colliding mid air.

Misaligned Landing (ML): When the aircraft landing is not aligned per runway center line and is drifting away.

Controlled Flight into or towards terrain (CFIT): An aircraft's line of sight is headed towards collision into terrain.

Wind shear or thunderstorm (WSTRW): An aircraft approaching a convective weather event.

The general algorithmic principle of calculating proximity and approach of vehicles towards each other to detect and analyze risk is as follows:

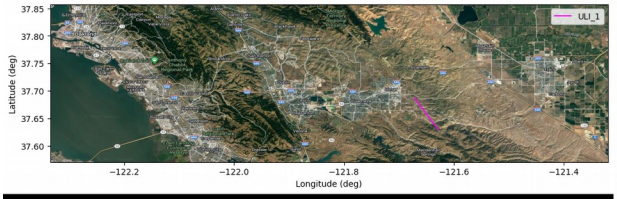


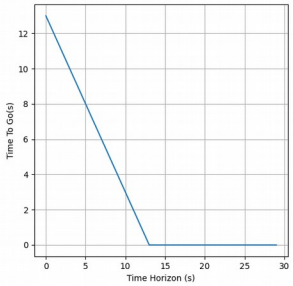
IRA and NAS Traffic Simulator (NTS) are together used to have this look ahead simulation that runs for the aircraft within the region of interest and based on the individual aircraft's region of regard. The AOCs are reported using the IRA GUI Client as follows:

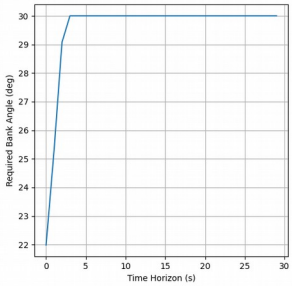
GNATS: IRA AOC Status

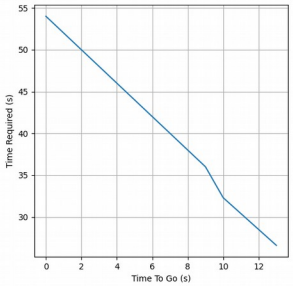
	Time-to-Go (s)	Likelihood of Occurence (%)		AOC	Flight Phase	Location	Primary Aircraft	Secondary Aircraft
1	10	89.25		TE	Taxi	Txy_D_001, KOAK	SWA1803	
2	18	82.18		US	Taxi	Rwy_02_001, KOAK	SWA1804	
3	34	70.94		TE	Taxi	Txy_W_004, KOAK	UAL1807	
4	37	69.17		OS	Taxi	Rwy_02_007, KOAK	BAW1800	
5	42	66.4		GCOL	Taxi	Txy_W_008, KOAK	UAL170	AAL920
6	38	68.6		TE	Taxi	Txy_J_004, KOAK	AAL123	

CFIT

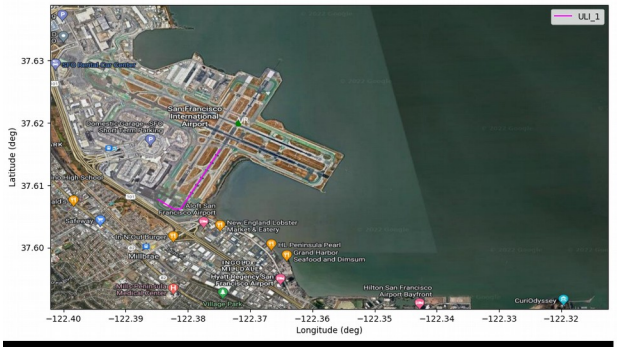

ULI_1
Latitude (deg)
Longitude (deg)

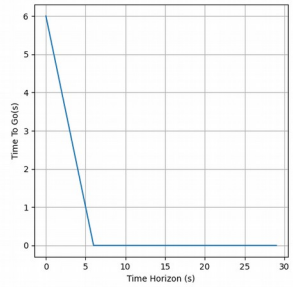

Time To Go(s)
Time Horizon (s)

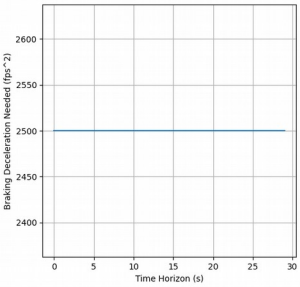

Required Bank Angle (deg)
Time Horizon (s)

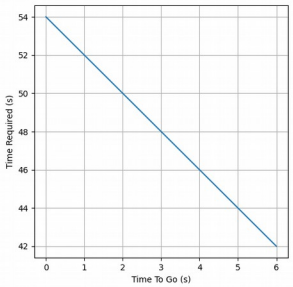

Time Required (s)
Time To Go (s)

CTOL

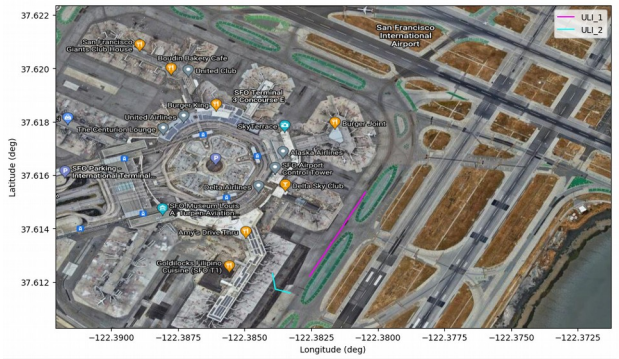

ULI_1
Latitude (deg)
Longitude (deg)
San Francisco International Airport

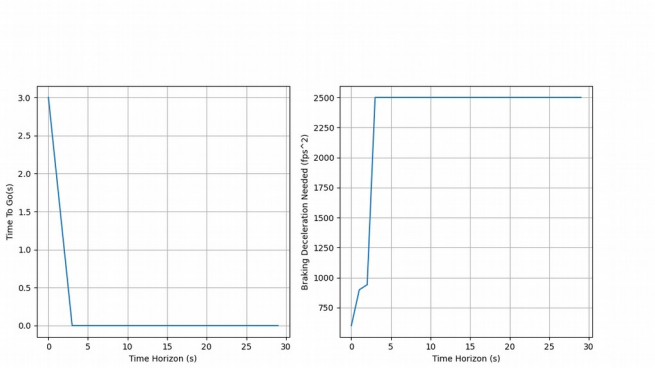

Time To Go(s)
Time Horizon (s)

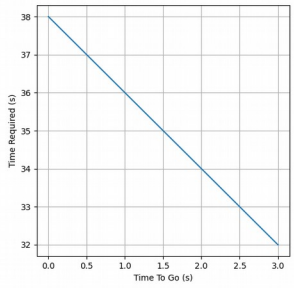

Braking Deceleration Needed (fps^2)
Time Horizon (s)


Time Required (s)
Time To Go (s)

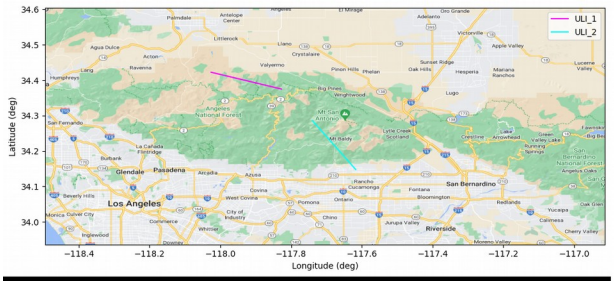
GCOL

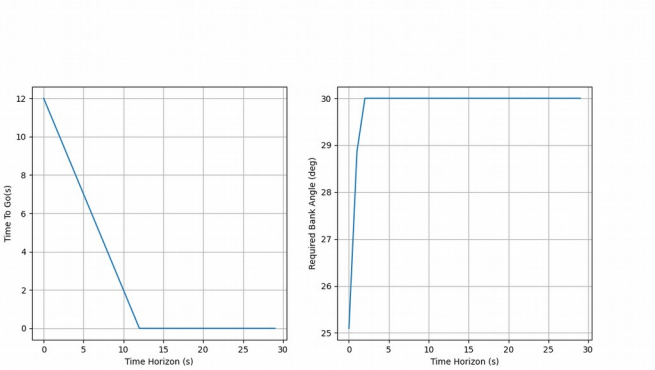

ULI_1
ULI_2
San Francisco International Airport
Latitude (deg)
Longitude (deg)

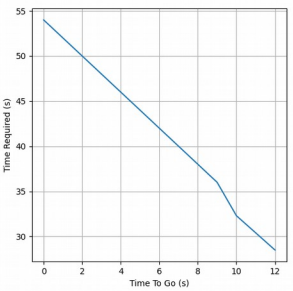

Time To Go(s)
Time Horizon (s)
Braking Deceleration Needed (fps^2)
Time Horizon (s)


Time Required (s)
Time To Go (s)

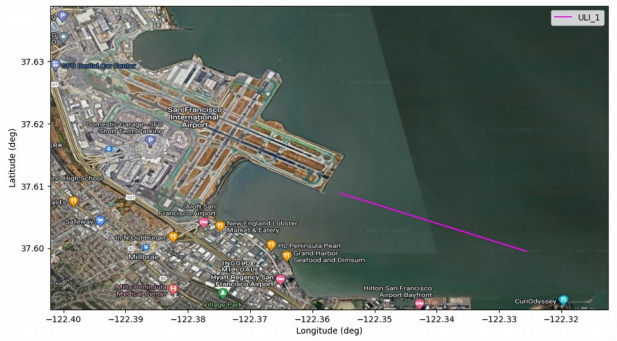
MAC

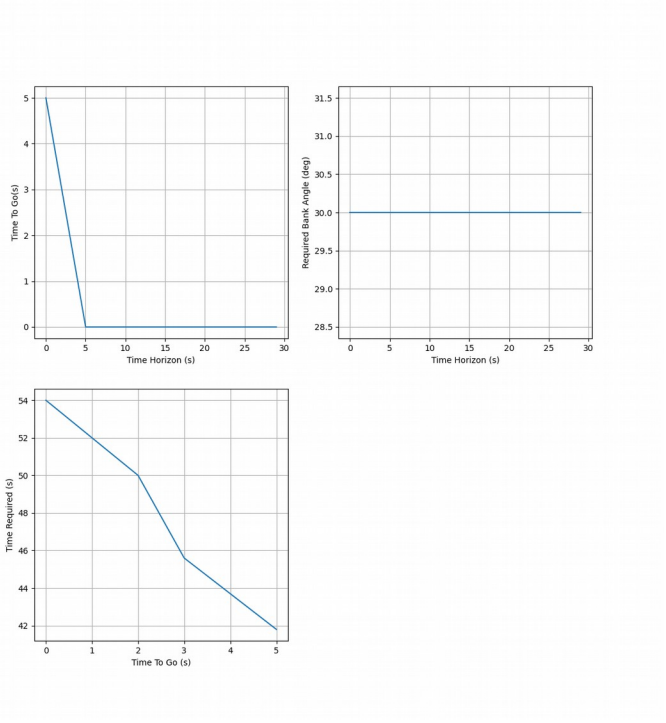

ULI_1
ULI_2
Los Angeles
Riverside
San Bernardino
Latitude (deg)
Longitude (deg)


Time To Go(s)
Time Horizon (s)
Required Bank Angle (deg)
Time Horizon (s)

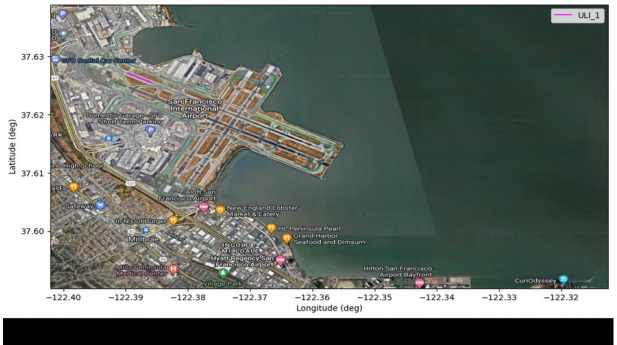

Time Required (s)
Time To Go (s)

ML


ULI_1
Latitude (deg)
Longitude (deg)
37.63
37.62
37.61
37.60
−122.40
−122.39
−122.38
−122.37
−122.36
−122.35
−122.34
−122.33
−122.32
San Francisco International Airport
Hilton San Francisco Airport Bayfront
CuriOdyssey


Time To Go(s)
Time Horizon (s)
Required Bank Angle (deg)
Time Horizon (s)
Time Required (s)
Time To Go (s)

OS


ULI_1
Latitude (deg)
Longitude (deg)
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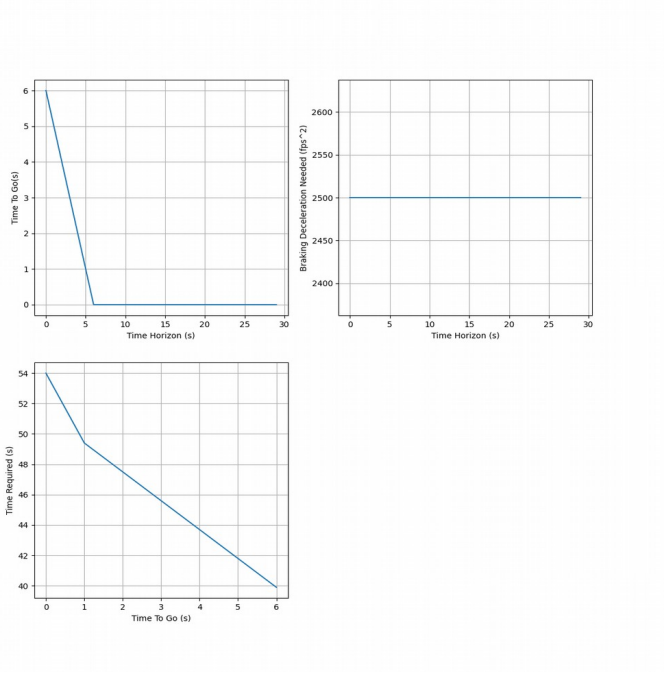
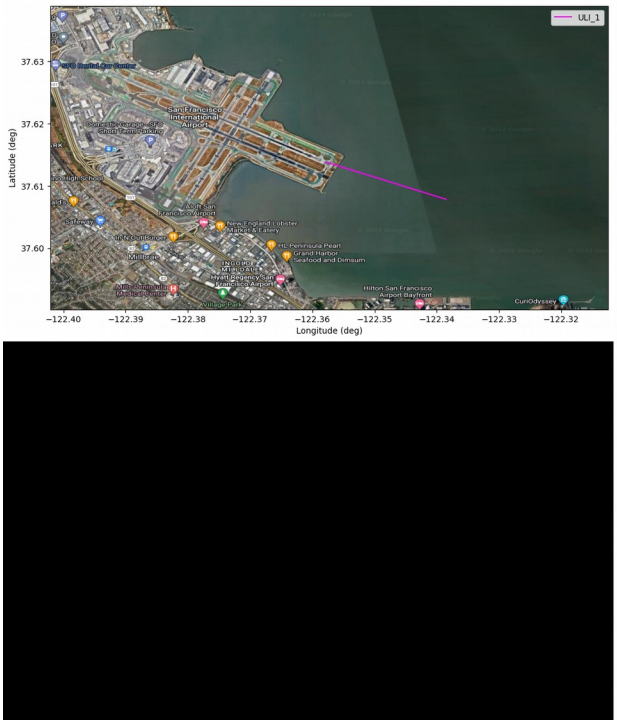
37.62
37.61
37.60
−122.40
−122.39
−122.38
−122.37
−122.36
−122.35
−122.34
−122.33
−122.32
San Francisco International Airport
Hilton San Francisco Airport Bayfront
CuriOdyssey


Time To Go(s)
Time Horizon (s)
Braking Deceleration Needed (fps^2)
Time Horizon (s)
Time Required (s)
Time To Go (s)

RE


ULI_1
Latitude (deg)
Longitude (deg)
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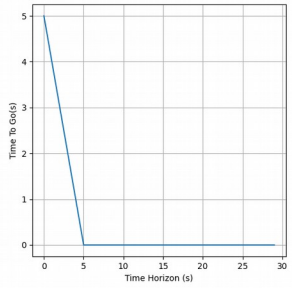
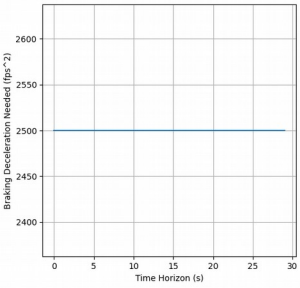
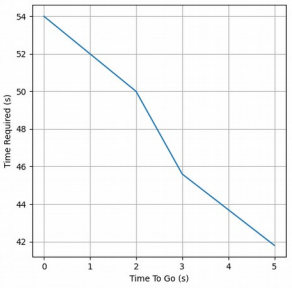
37.62
37.61
37.60
−122.40
−122.39
−122.38
−122.37
−122.36
−122.35
−122.34
−122.33
−122.32
San Francisco International Airport
Hilton San Francisco Airport Bayfront
CuriOdyssey


Time To Go(s)
Time Horizon (s)


Braking Deceleration Needed (fps^2)
Time Horizon (s)


Time Required (s)
Time To Go (s)

RI


ULI_1
ULI_2
Latitude (deg)
Longitude (deg)
37.63
37.62
37.61
37.60
−122.40
−122.39
−122.38
−122.37
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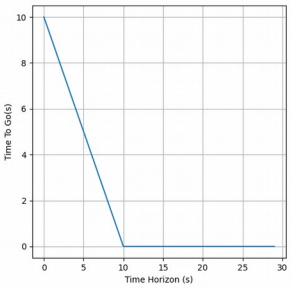
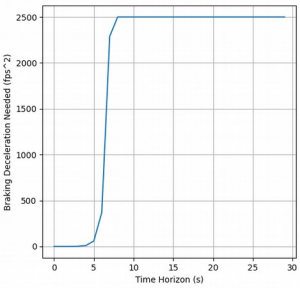
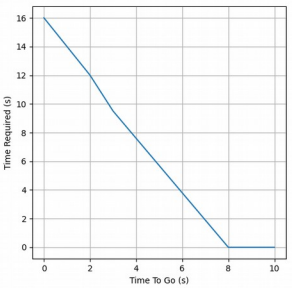
−122.34
−122.33
−122.32
San Francisco International Airport
Hilton San Francisco Airport Bayfront
CuriOdyssey

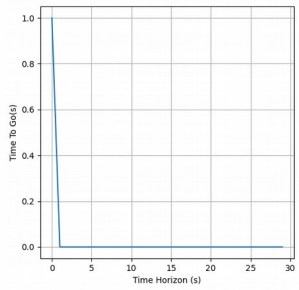

Time To Go(s)
Time Horizon (s)

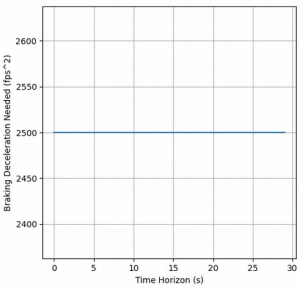

Braking Deceleration Needed (fps^2)
Time Horizon (s)

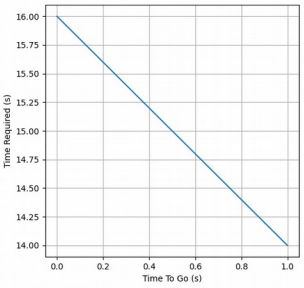

Time Required (s)
Time To Go (s)

TE


ULI_1
Latitude (deg)
Longitude (deg)
San Francisco International Airport
Hilton San Francisco Airport Bayfront
CuriOdyssey

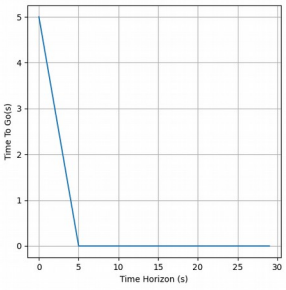

Time To Go(s)
Time Horizon (s)

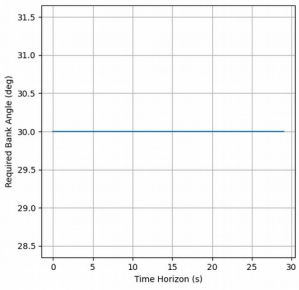

Braking Deceleration Needed (fps^2)
Time Horizon (s)

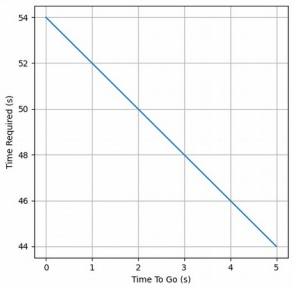

Time Required (s)
Time To Go (s)

TI

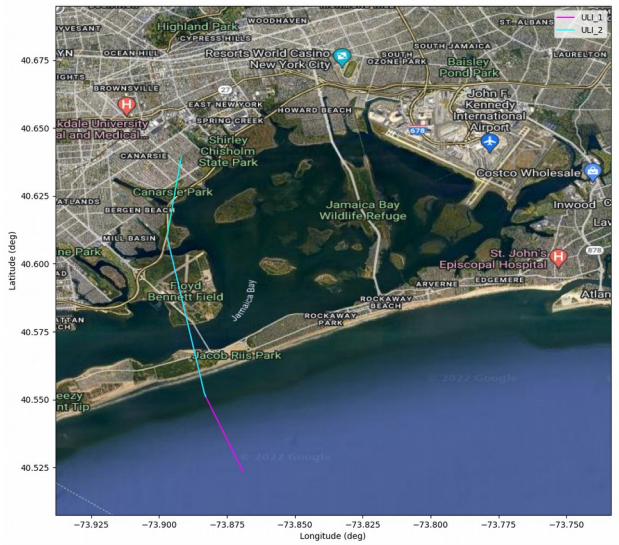

ULI_1
Latitude (deg)
Longitude (deg)
San Francisco International Airport
Hilton San Francisco Airport Bayfront
CuriOdyssey

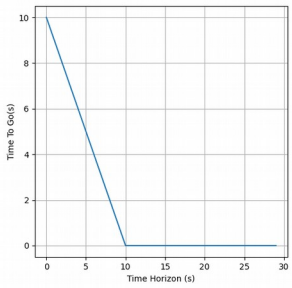

Time To Go(s)
Time Horizon (s)

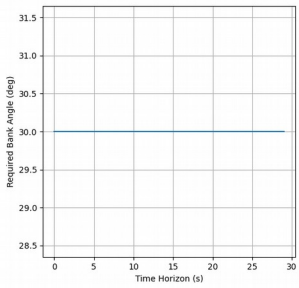

Required Bank Angle (deg)
Time Horizon (s)

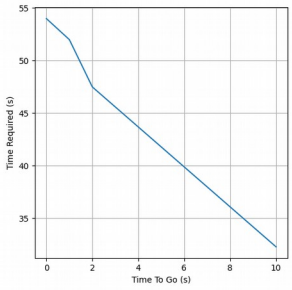

Time Required (s)
Time To Go (s)

WAKE

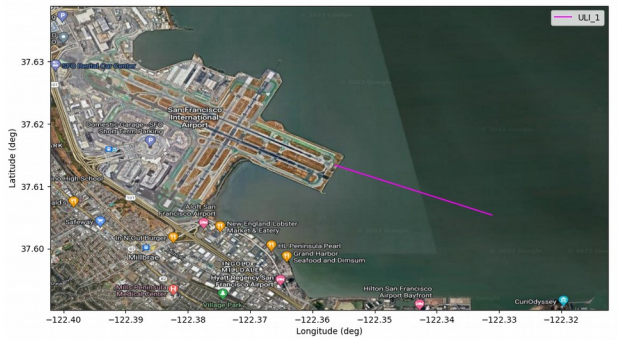

ULI_1
ULI_2
Highland Park
Resorts World Casino New York City
Baisley Pond Park
John F. Kennedy International Airport
Shirley Chisholm State Park
Costco Wholesale
Canarsie Park
Jamaica Bay Wildlife Refuge
St. John's Episcopal Hospital
Floyd Bennett Field
Jacob Riis Park
Jamaica Bay
Latitude (deg)
Longitude (deg)

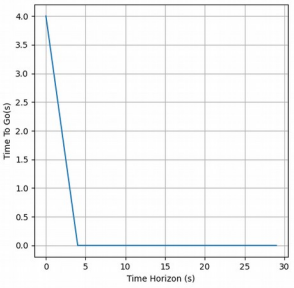

Time To Go(s)
Time Horizon (s)

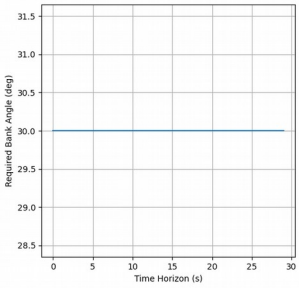

Required Bank Angle (deg)
Time Horizon (s)

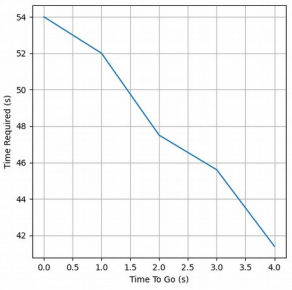

Time Required (s)
Time To Go (s)

US

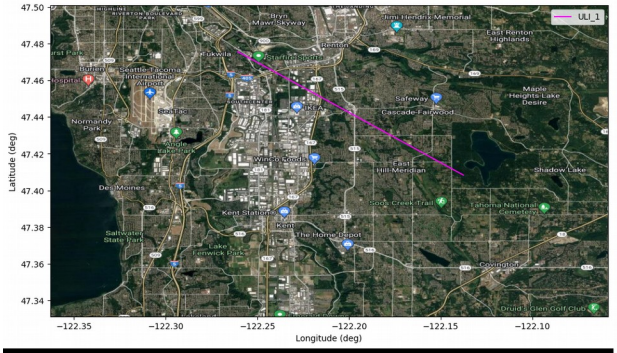

ULI_1
San Francisco International Airport
Latitude (deg)
Longitude (deg)

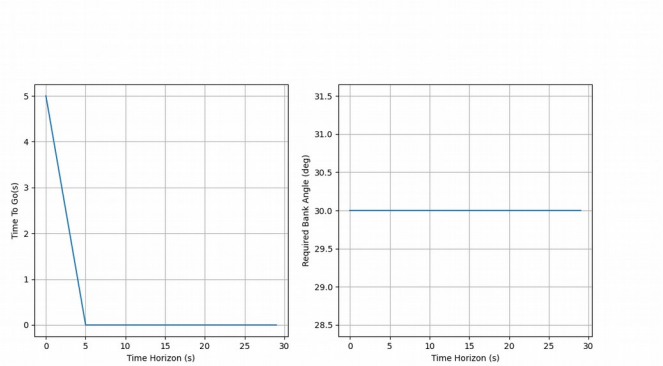

Time To Go(s)
Time Horizon (s)


Required Bank Angle (deg)
Time Horizon (s)

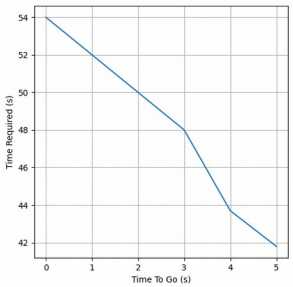

Time Required (s)
Time To Go (s)

WSTRW


ULI_1
Latitude (deg)
Longitude (deg)
47.50
47.48
47.46
47.44
47.42
47.40
47.38
47.36
47.34
−122.35
−122.30
−122.25
−122.20
−122.15
−122.10
Jimi Hendrix Memorial
East Renton Highlands
Renton
Seattle Tacoma Int'l Airport
Seattle
Normandy Park
Safeway
Cascade-Fairwood
Maple Heights-Lake Desire
Shadow Lake
East Hill-Meridian
Des Moines
Kent Station
Kent
Soos Creek Trail
Tahoma National Cemetery
Saltwater State Park
Lake Fenwick Park
The Home Depot
Covington
Druid Glen Golf Club


Time To Go(s)
Time Horizon (s)
0
1
2
3
4
5
0
5
10
15
20
25
30

Required Bank Angle (deg)
Time Horizon (s)
28.5
29.0
29.5
30.0
30.5
31.0
31.5
0
5
10
15
20
25
30


Time Required (s)
Time To Go (s)
42
44
46
48
50
52
54
0
1
2
3
4
5