



AIRLINE SERVICES

Proposed by <https://www.appsintellect.org/>

24th June 2023

Version 2.7

GOALS

Using one unique web based / database tool, accessible from any browser, Airlines are able to

- Configure their fleet, aircraft types, hourly operational costs, crew costs, turn times
- Plan graphically their routes using a 3 Dimensions map,
- Exploit main results from a 4 Dimensions trajectory such as trip duration, distance flown, fuel consumptions, etc.
- For each flight leg, choose the best aircraft
 - to minimize Costs,
 - to minimize Costs per Available Seat Miles,
 - to maximize Seat Miles
- Support flight leg planning through fuel estimation
- ...

Benefits of a full-fledged interactive 3D Globe with street maps hence runways

TOOL MAIN CONFIGURATION

3 different airlines have been configured with different parameters

Airline Configuration data is stored in a SQL database

AmericanWings



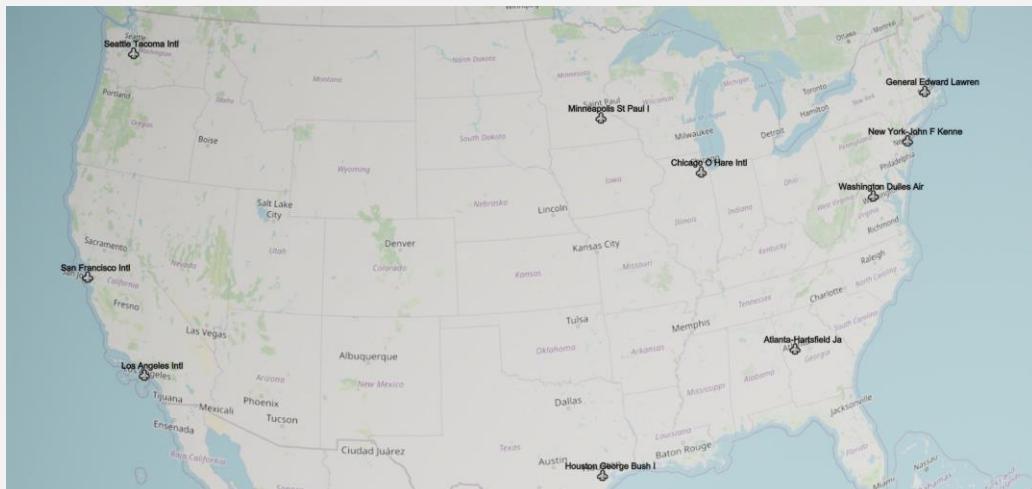
AmericanWings

EuropeanWings

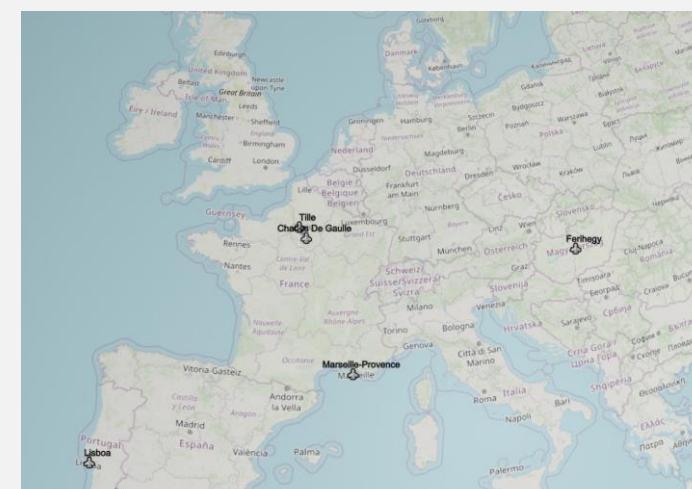
IndianWings

Each airline has its own viewport (initial map limits)

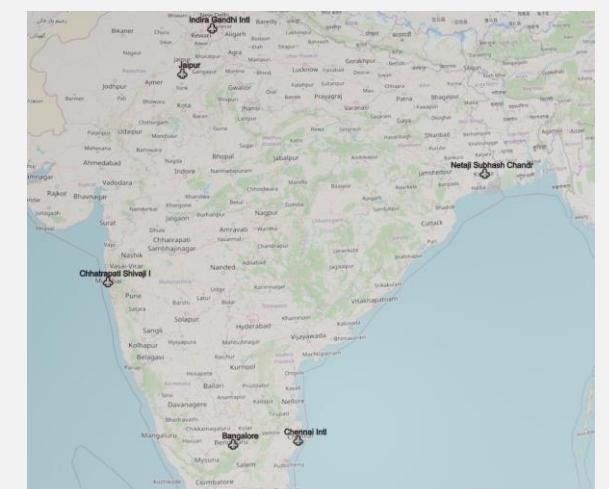
AmericanWings



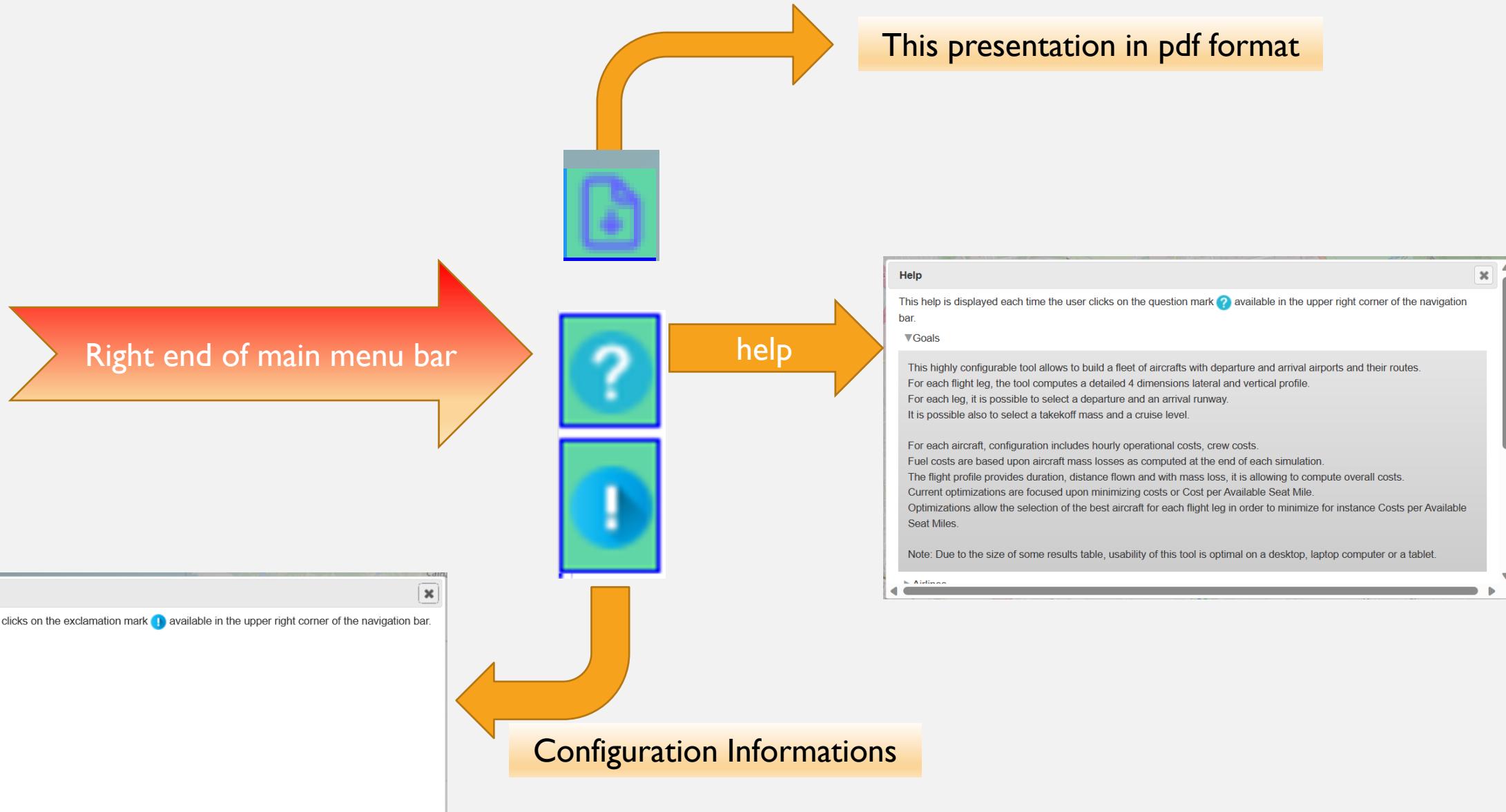
EuropeanWings



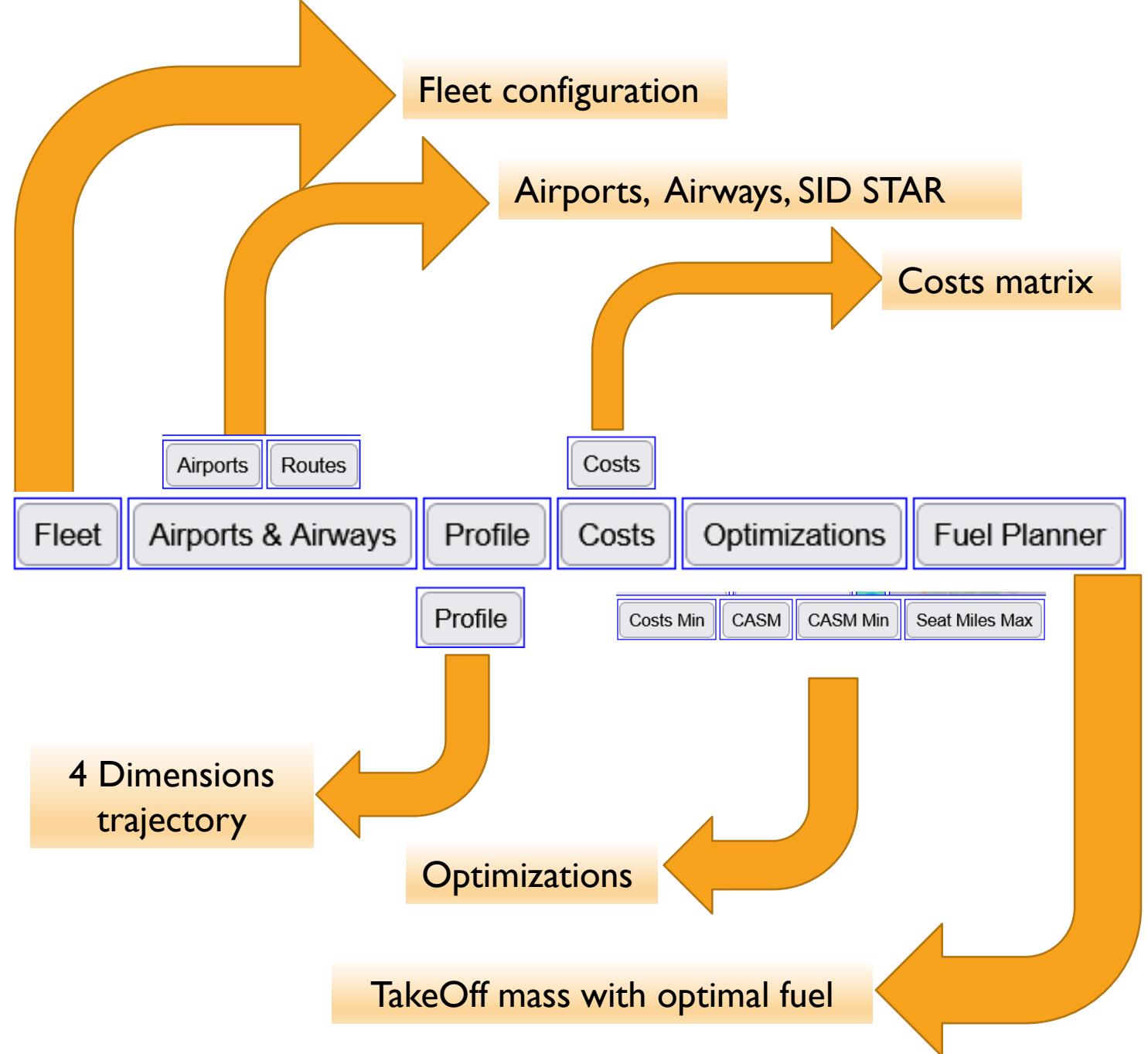
IndianWings



(ONLINE) HELP & CONFIGURATION



MAIN MENU BAR



FLEET CONFIGURATION

Values are specific to each airline

Values are loaded into a database

Click here to move -> Airline Fleet Configuration											Click to hide
Airline	Aircraft ICAO Code	Aircraft Full Name	Number of Aircrafts	Number of Seats	Flying Costs per Hour (US\$)	Crew Costs per Hour (US\$)	Minimum Take Off Mass (kg)	Reference Mass (kg)	Maximum Take Off Mass (kg)	Aircraft Turn Around Time (min)	
AmericanWings	A320	Airbus A320	2	157	2840	1657	39000	64000	77000	25	
AmericanWings	A332	Airbus A330-200	3	234	3300	1857	120600	190000	230000	35	
AmericanWings	B738	Boeing 737-800	4	160	3010	1557	41150	65300	78300	25	

Used to compute CASM

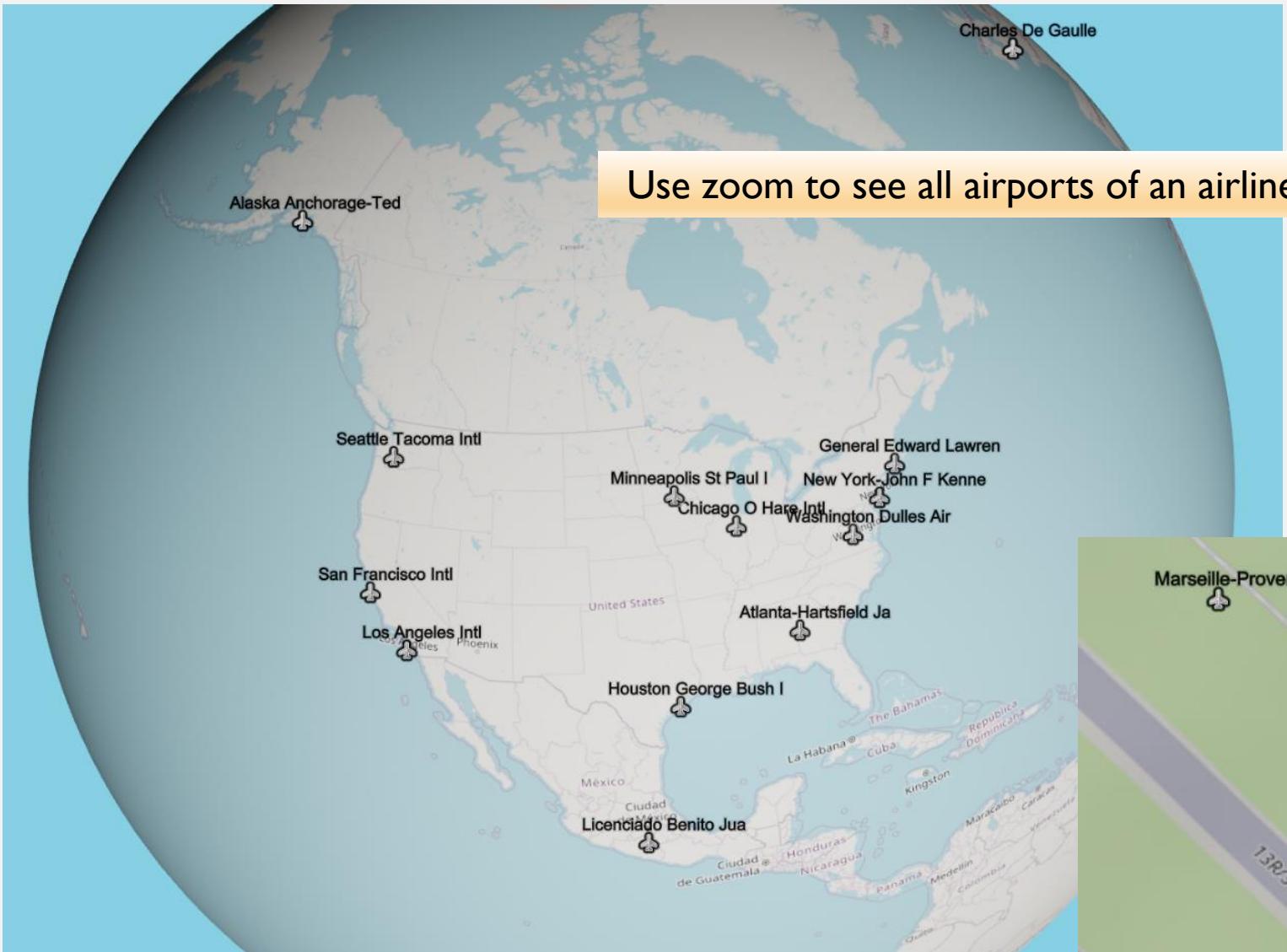
CASM : Cost per Available Seat Miles

Used to compute costs

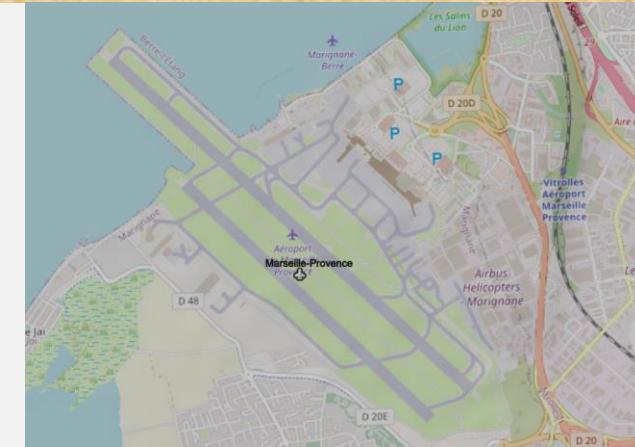
Used to compute profiles

Used to compute airport turn around times -> compute Seat Miles

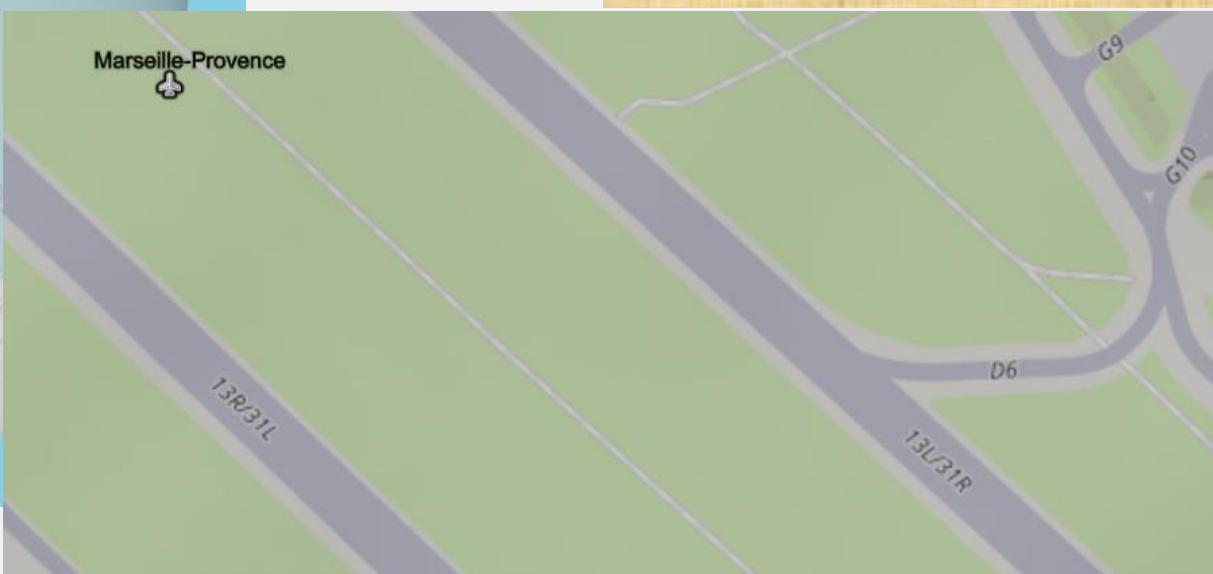
AIRPORTS



Street map appears only when « sufficient » zoom is set – tile must be available

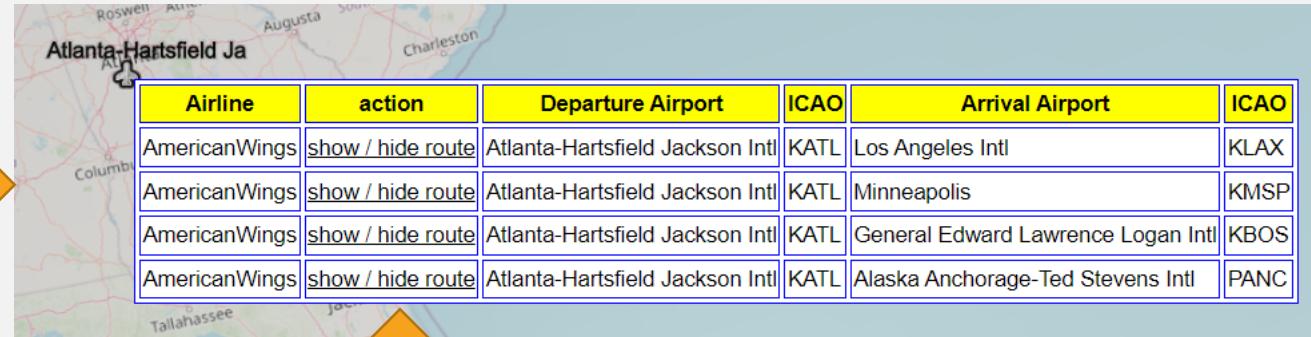


-> Runways are visible



ROUTES - AIRWAYS

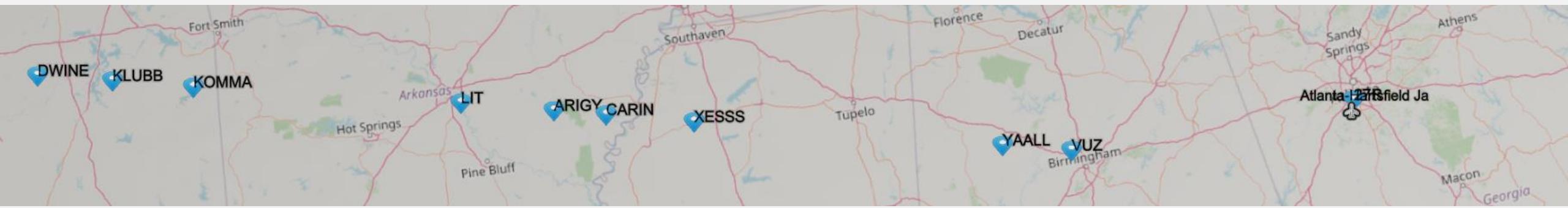
Right click on an airport
to see routes starting from this airport



Airline	action	Departure Airport	ICAO	Arrival Airport	ICAO
AmericanWings	show / hide route	Atlanta-Hartsfield Jackson Intl	KATL	Los Angeles Intl	KLAX
AmericanWings	show / hide route	Atlanta-Hartsfield Jackson Intl	KATL	Minneapolis	KMSP
AmericanWings	show / hide route	Atlanta-Hartsfield Jackson Intl	KATL	General Edward Lawrence Logan Intl	KBOS
AmericanWings	show / hide route	Atlanta-Hartsfield Jackson Intl	KATL	Alaska Anchorage-Ted Stevens Intl	PANC



Click on the link to see / hide the waypoints of the route on the map



ROUTES

Click here to move Airline Routes Configuration

Airline	Departure Airport	Adep	Best RunWay	Destination Airport	Ades	Best RunWay	Action
AmericanWings	Atlanta-Hartsfield Jackson Intl	KATL	27R	Los Angeles Intl	KLAX	07L	Hide

Click to hide

Click to show / hide the way points on the map

Best runway also displayed on the map

Best runway computation based upon distance from runway end to first / last waypoint of the route

EXCEL configuration file

order	wayPoint	latitude	longitude
1	VUZ	N33°40'12.47"	W086°53'59.41"
2	YAALL	N33°47'36.30"	W087°28'51.23"
3	XESSS	N34°18'50.62"	W090°07'02.78"
4	CARIN	N34°27'14.98"	W090°53'13.05"
5	ARIGY	N34°32'07.71"	W091°20'49.90"
6	LIT	N34°40'39.62"	W092°10'49.90"

SQL Database table view

	WayPointName [PK] character varying	Type character varying	Latitude double precision	Longitude double precision	Continent character varying
343	VLN	WayPoint	50.66/005555555555	-104.889/1111111111	North America
344	VORIN	WayPoint	41.548002777777775	-89.336375	North America
345	VUZ	WayPoint	33.67013055555555	-86.89983611111111	North America



AIRPORTS DATA

Example of database content for Airports

	AirportICAOcode [PK] character varying	AirportName character varying	Latitude double precision	Longitude double precision	FieldElevationAboveSeaLevelMeters double precision	Continent character varying
1	KATL	Atlanta-Hartsfield Jackson Atlanta Intl	33.636719	-84.428067	312.7248	United States
2	KBOS	General Edward Lawrence Logan Intl	42.364347	-71.005181	5.7912	United States
3	KIAD	Washington Dulles Airport Intl	38.944533	-77.455811	95.4024	United States
4	KIAH	Houston George Bush Intl	29.984433	-95.341442	29.5656	United States
5	KJFK	New York-John F Kennedy Intl	40.639751	-73.778925	3.9624	United States
6	KLAX	Los Angeles Intl	33.942536	-118.408075	38.4048	United States
7	KMSP	Minneapolis St Paul Intl	44.881956	-93.221767	256.33680000000004	United States
8	KORD	Chicago O'Hare Intl	41.978603	-87.904842	203.6064	United States
9	KSEA	Seattle Tacoma Intl	47.449	-122.309306	131.9784	United States
10	KSFO	San Francisco Intl	37.618972	-122.374889	3.9624	United States



Each airport is defined by its unique ICAO code

RUNWAYS DATA

Example of database content for runways of KATL - Atlanta

	id [PK] integer	Name character varying	LengthFeet double precision	TrueHeadingDegrees double precision	LatitudeDegrees double precision	LongitudeDegrees double precision	Airport_id character varying
1	1	08L	9000	90	33.64950180053711	-84.43900299072266	KATL
2	2	26R	9000	270	33.64950180053711	-84.40950012207031	KATL
3	3	08R	10000	90	33.64680099487305	-84.43840026855469	KATL
4	4	26L	10000	270	33.64680099487305	-84.40550231933594	KATL
5	5	09L	11890	90	33.634700775146484	-84.447998046875	KATL
6	6	27R	11890	270	33.634700775146484	-84.40889739990234	KATL
7	7	09R	9001	90	33.63180160522461	-84.447998046875	KATL
8	8	27L	9001	270	33.63180160522461	-84.41840362548828	KATL
9	9	10	9000	90	33.62030029296875	-84.4478988647461	KATL
10	10	28	9000	270	33.62030029296875	-84.41829681396484	KATL



Number of Runways contribute to the airport turn around time specific part

WAYPOINTS DATA

Example of database content for waypoints (one database for all airlines)

	WayPointName [PK] character varying	Type character varying	Latitude double precision	Longitude double precision	Continent character varying
1	47N050W	WayPoint	47.5	-50	Europe
2	49N040W	WayPoint	49.5	-40	Europe
3	51N030W	WayPoint	51.5	-30	Europe
4	52N020W	WayPoint	52.5	-20	Europe
5	ABQ	WayPoint	35.04379444444444	-106.8163111111112	North America
6	ABR	WayPoint	45.41735277777778	-98.36871944444444	North America
7	ADUKE	WayPoint	31.882430555555555	-94.21646666666666	North America
8	AGROM	WayPoint	22.529163888888885	84.83333055555555	India
9	AHEIM	WayPoint	33.82031388888889	-117.91197222222222	North America
10	ALBED	WayPoint	18.11721944444444	78.6566638888889	India
11	ALEPO	WayPoint	42.343608333333336	-1.963333333333334	Europe
12	AMDID	WayPoint	48.09721944444445	12.396944444444443	Europe
13	ANDAV	WayPoint	17.471666666666664	78.81361111111111	India

Warning: waypoint name (as a key) must be unique for all routes / all flight legs

SID STAR -> CLICK ON ROUTES

Click here to move Airline Routes Configuration Click to hide

Airline	Departure Airport	Adep	SID	Best RunWay	Destination Airport	Ades	STAR	Best RunWay	Action
EuropeanWings	Charles-De-Gaulle-France	LFPG	LFPG/26L/ERIXU		Lisbonne-Lisboa-Portugal	LPPT			Show

SID

Click to see the SID on the map

Click here to move Airline Routes Configuration Click to hide

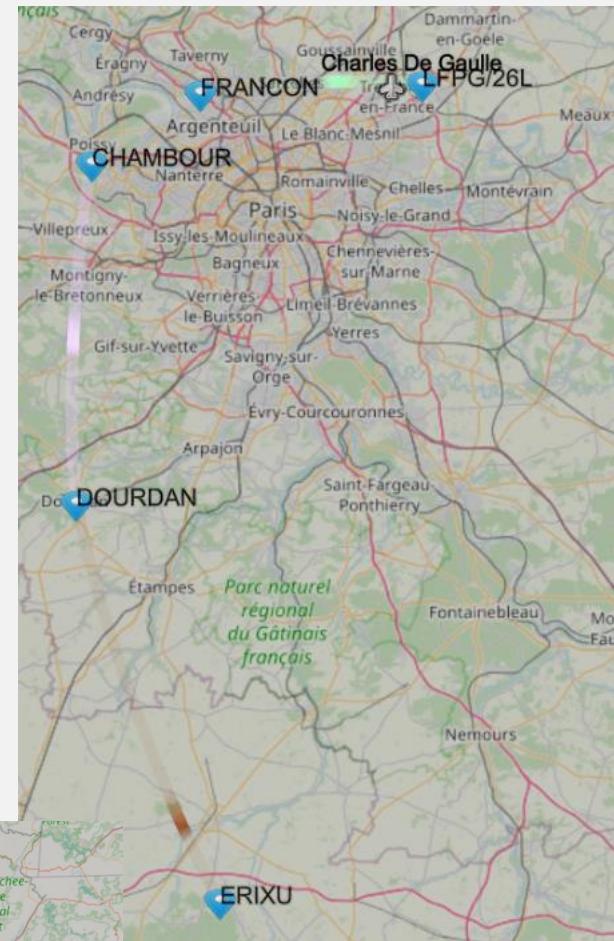
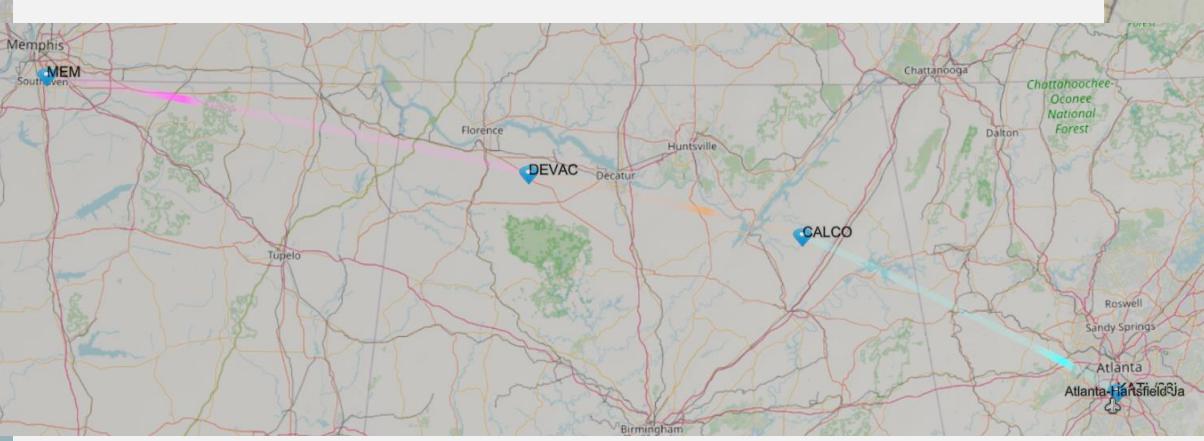
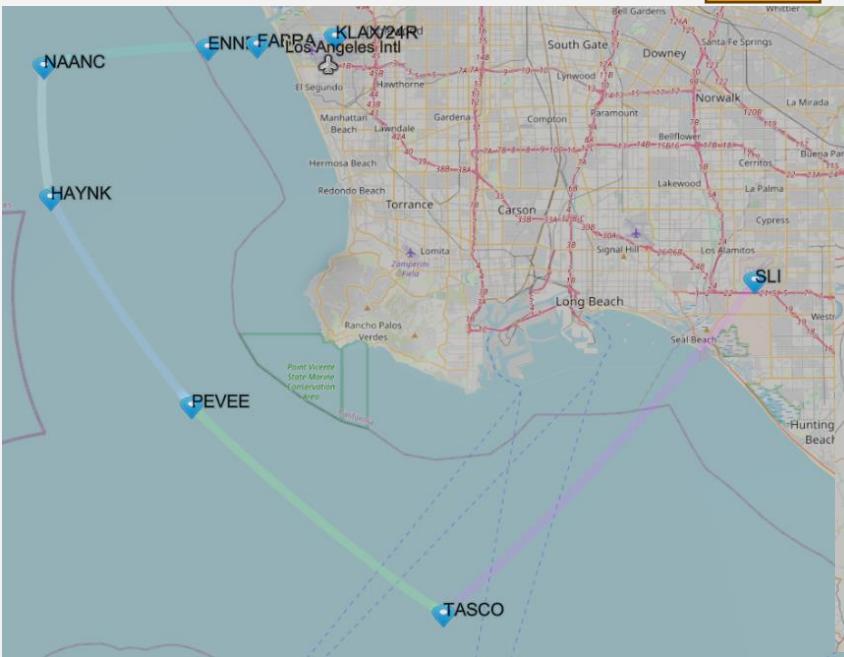
Airline	Departure Airport	Adep	SID	Best RunWay	Destination Airport	Ades	STAR	Best RunWay	Action
AmericanWings	Los Angeles Intl	KLAX	KLAX/24R/SLI		Atlanta-Hartsfield Jackson Intl	KATL	KATL/26L/MEM		Show

SID

Click to see the SID on the map

STAR

Click to see the STAR on the map



4 DIMENSIONS TRAJECTORY (CORE FEATURE)

Click here to move > Flight Profile Computation Click to hide

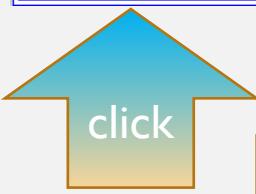
Aircraft -> Airbus A320 TakeOff Weight (kg) -> 77000 Flight Level (feet) -> 39000

Route -> Los Angeles Intl -> Atlanta-Hartsfield Jackson Intl

Departure RunWay -> 24R -> 263 degrees True Heading

Arrival RunWay -> 26L -> 270 degrees True Heading

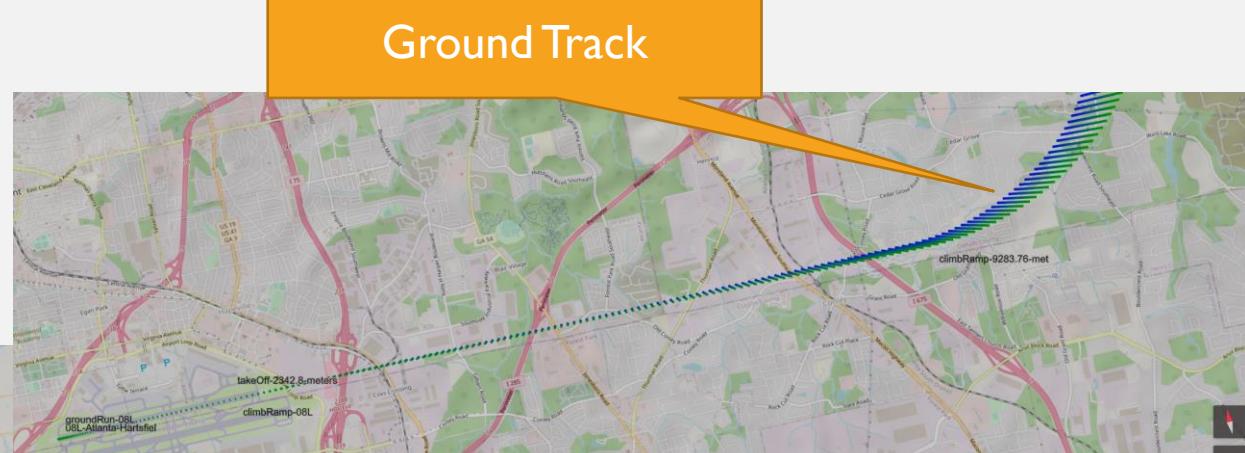
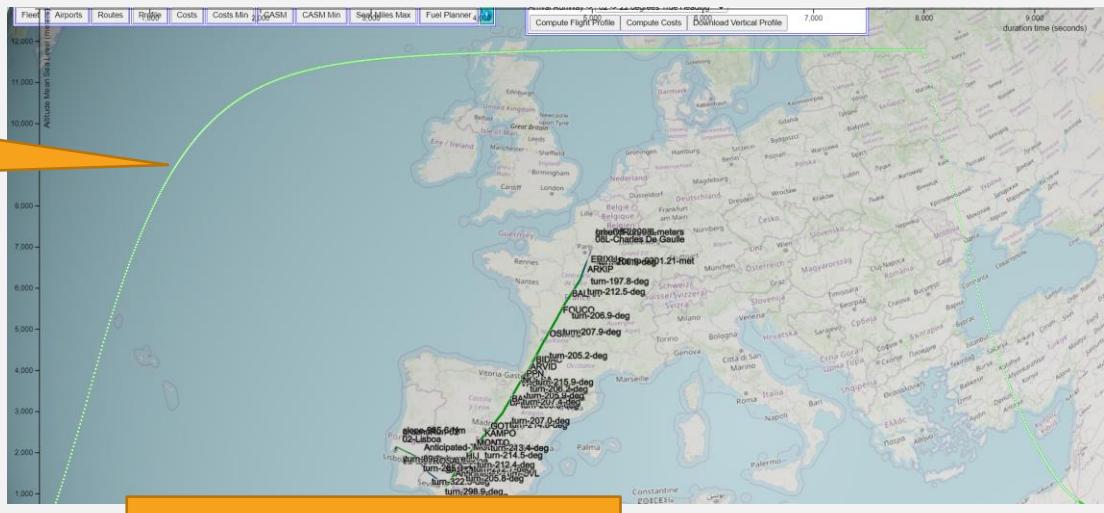
Compute Flight Profile Compute Costs Download Vertical Profile Download KML



Time Reference

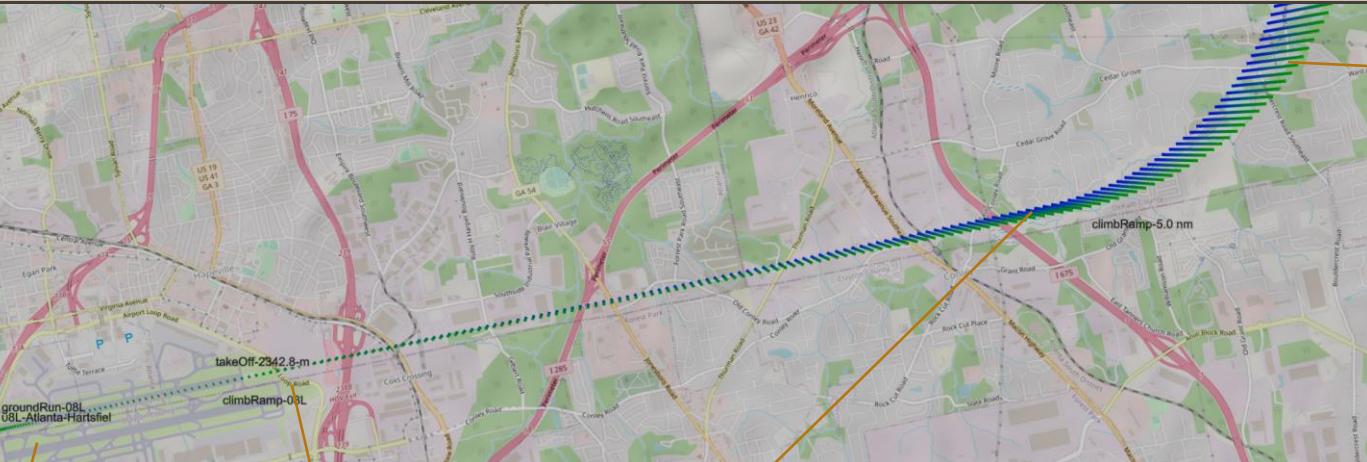
elapsed-time-seconds	altitude-MSL-meters	altitude-MSL-feet	t
57	125,9735776	413,2991396	
58	132,4804677	434,6472044	
59	139,0022023	456,0439714	
60	145,5387129	477,4892162	
61	152,0899309	498,9827137	
62	158,6557876	520,5242384	
63	165,2362141	542,1135641	
64	171,8311411	563,7504639	
65	178,2942447	584,954872	
66	184,7753603	606,2183745	
67	191,2744371	627,540805	
68	197,791424	648,9219957	
69	204,3262696	670,3617778	

Vertical
Profile



Lateral Route

4 DIMENSIONS TRAJECTORY (CORE FEATURE)

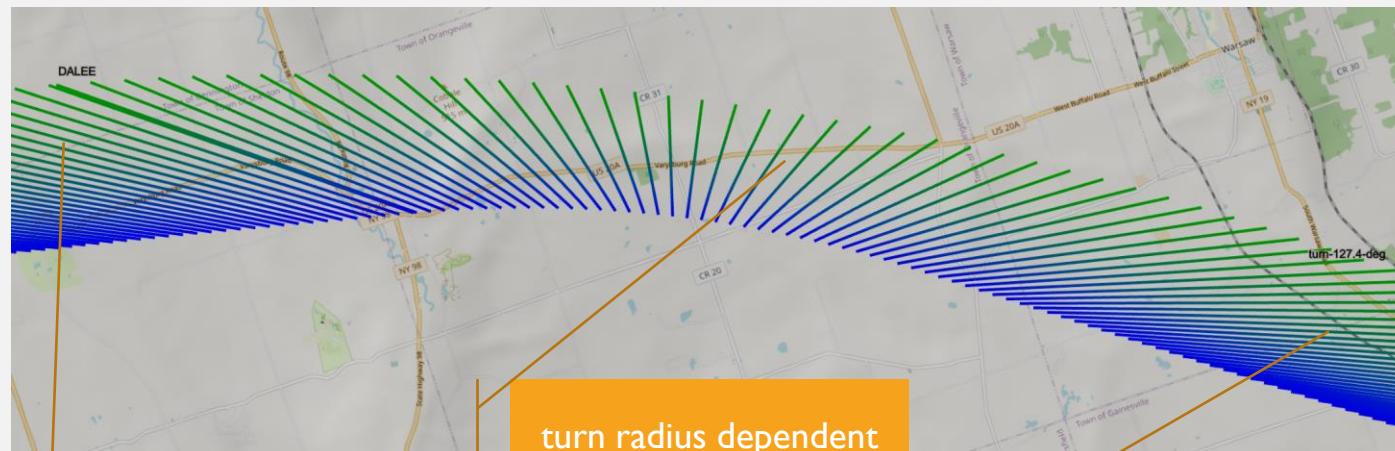


Ground run

Takeoff

8 degrees Climb
Ramp \rightarrow 5 nautics

First turn – radius
dependent of speed



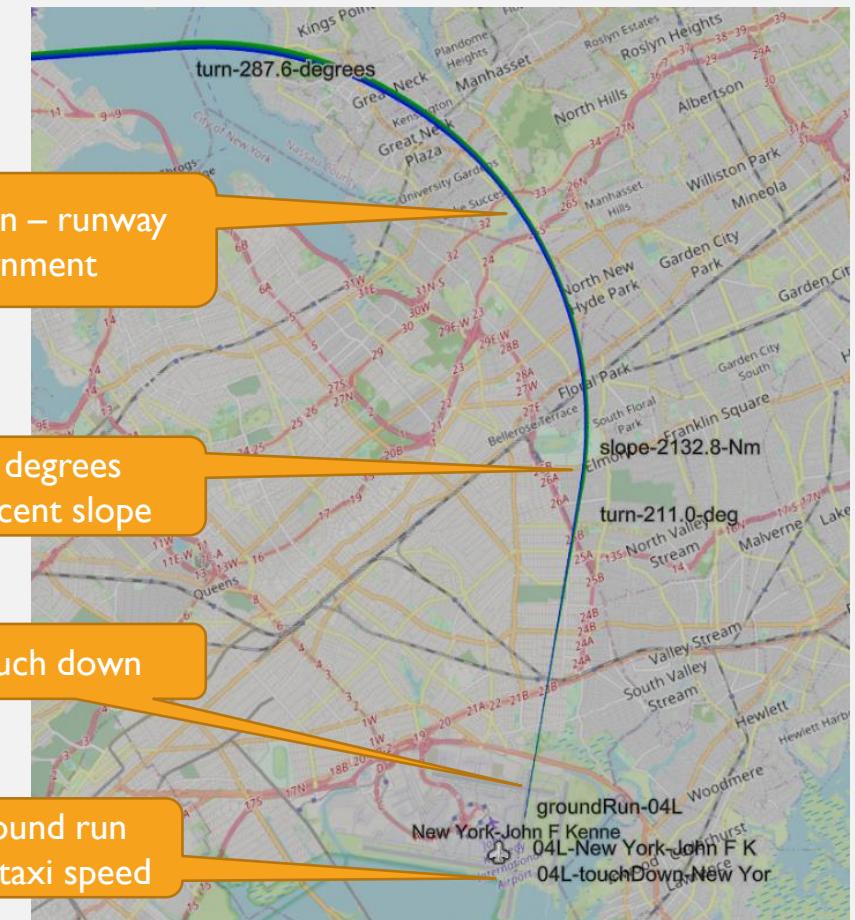
Great circle

turn radius dependent
of speed

Great circle

Ground run
until taxi speed

Last turn – runway
alignment



3 degrees
descent slope

Touch down

4 DIMENSIONS TRAJECTORY (GROUND RUN)



Airbus A330-200 - TakeOff Mass = 190 tons

Mexico – Mean Sea Level = 2230 meters

Ground Run = 2661,8 meters

TakeOff Speed CAS = 117 knots

TakeOff True Air Speed = 81.21 m/s

Explanation: Air density is lower at Mexico airport MSL = 2230 meters -> true speed must be higher before the take-off

NB :Temperature not yet used

Airbus A330-200 - TakeOff Mass = 190 tons

JF Kennedy – Mean Sea Level = 4 meters

Ground Run = 1779,3 meters

TakeOff Speed CAS = 117 knots

TakeOff True Air Speed = 72,67 m/s



SID & STAR

SID waypoints are inserted in the fix list as soon as following matches occur

- 1) Departure airport is matching SID airport
- 2) Departure runway is matching SID runway
- 3) First fix of the route is matching last waypoint of the SID

STAR waypoints are inserted in the fix list as soon as following matches occur

- 1) Arrival airport is matching STAR airport
- 2) Arrival runway is matching STAR runway
- 3) Last fix of the route is matching first waypoint of the STAR

Airline Fix list from KLAX to KATL

SLI-AHEIM-OLLIE-POXKU-EBITE-PDZ-CIVET-RUSTT-PIONE-TNP-CADEZ-HIPPI-DRK-PYRIT-ZUN-ABQ-TCC-PNH-CRUSR-IRW-DWINE-KLUBB-KOMMA-LIT-GEEYY-MEM****

SID from
KLAX/24R
to SLI

STAR from
MEM to
KATL/26L

KLAX/24R

departure

arrival

KATL/26L

SID STAR DATA

SID & STAR are not related to any airline route

SID & STAR waypoints are inserted automatically in the fix list when an adequate runway is selected

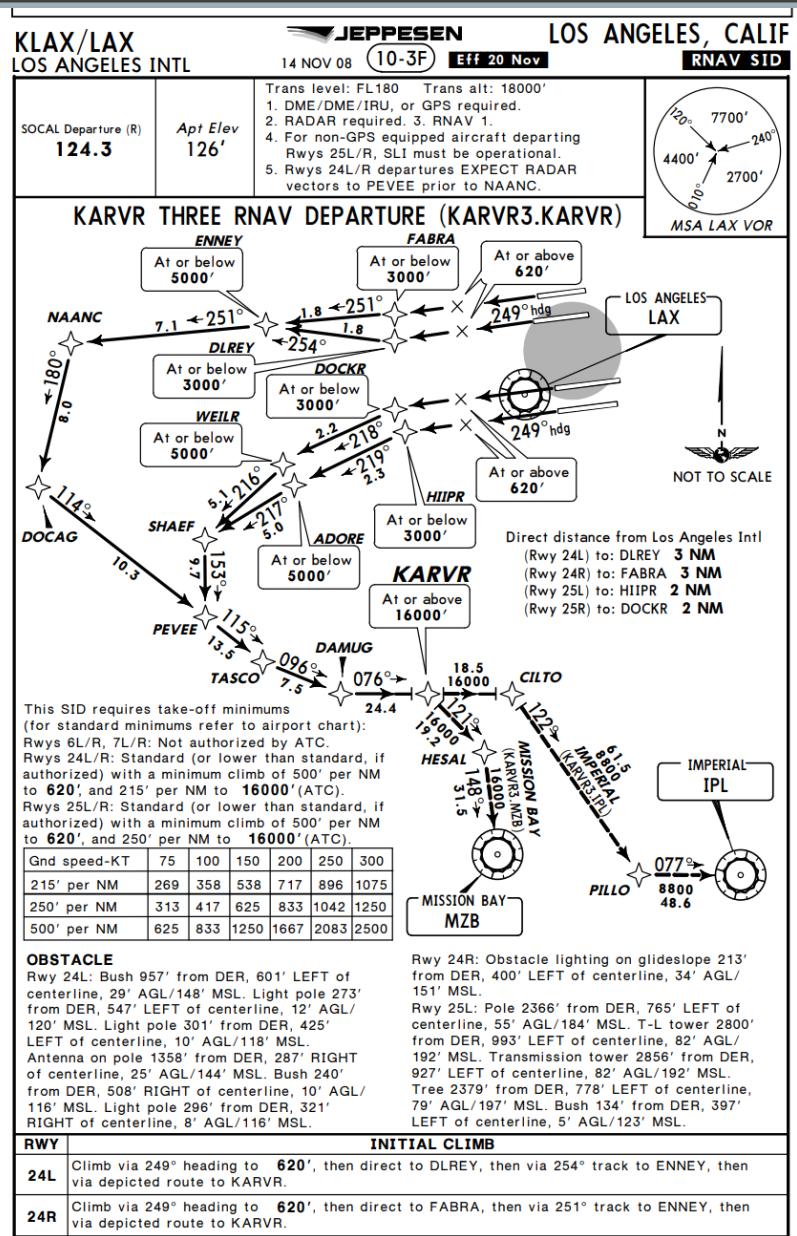
	id [PK] integer	isSID boolean	DepartureArrivalAirport_id character varying	DepartureArrivalRunWay_id integer	FirstLastRouteWayPoint_id character varying
1	19	true	KLAX	1168	SLI
2	20	false	KATL	1122	MEM



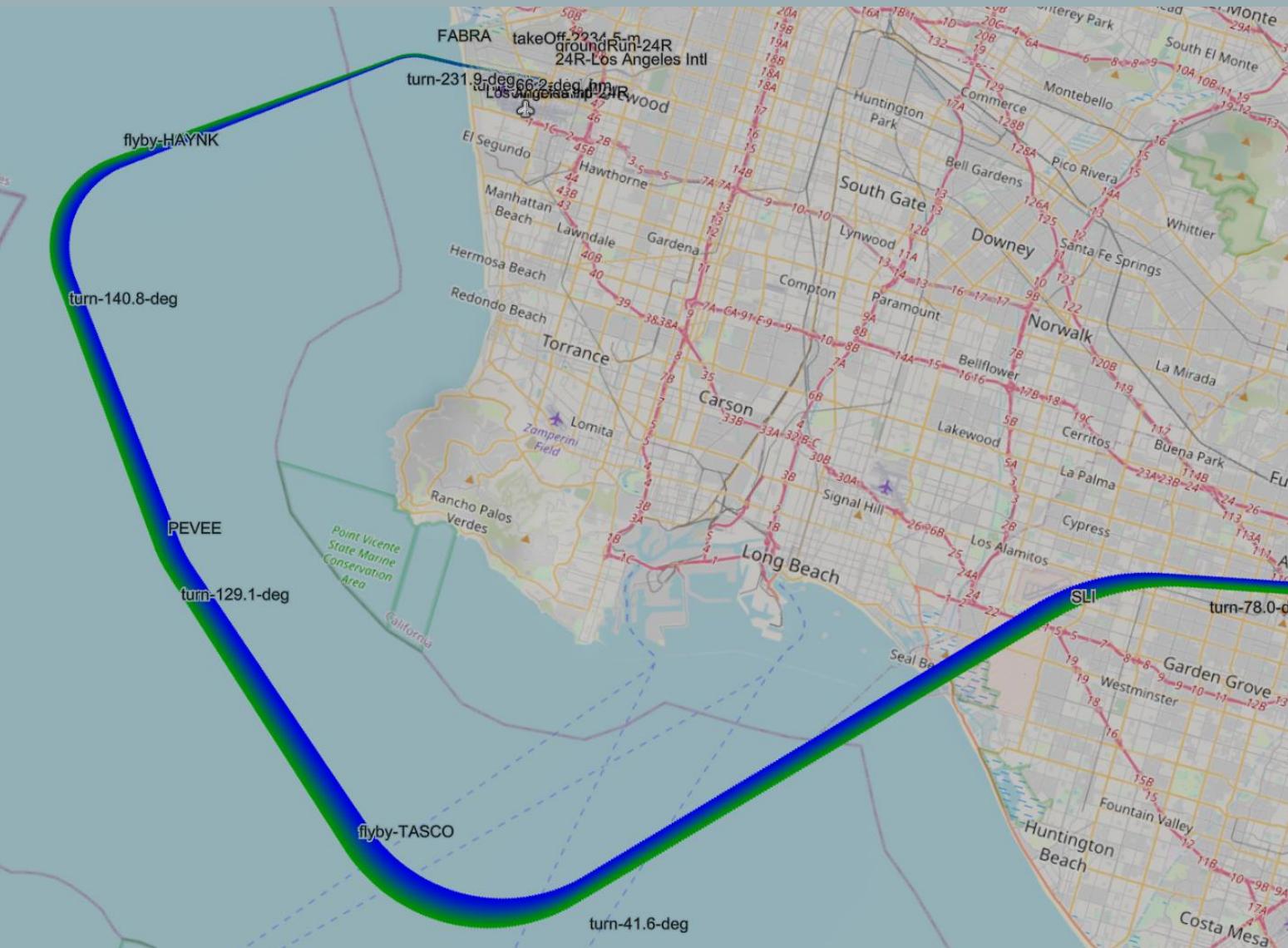
Id(s) are allowing to establish Database relationships

	id [PK] integer	Order integer	WayPointName character varying	LatitudeDegrees double precision	LongitudeDegrees double precision	Route_id integer
1	25	0	KLAX/24R	33.95209884643555	-118.4020004272461	19
2	26	1	FABRA	33.94638888888888	-118.46708333333333	19
3	27	2	ENNEY	33.94461111111111	-118.5078888888889	19
4	28	3	NAANC	33.93166666666665	-118.6438888888889	19
5	29	4	HAYNK	33.84075000000001	-118.63791666666668	19
6	30	5	PEVEE	33.69722222222216	-118.52083333333333	19
7	31	6	TASCO	33.55361111111111	-118.31277777777777	19
8	32	7	SLI	33.78329722222224	-118.05475555555556	19
9	33	1	MEM	35.01511666666664	-89.98320833333332	20
10	34	2	DEVAC	34.61830555555556	-87.43516666666667	20
11	35	3	CALCO	34.34525777777777	-86.01936666666667	20
12	36	4	HERKO	33.06907500000005	-86.84538055555555	20
13	37	5	KATL/26L	33.64680099487305	-84.40550231933594	20

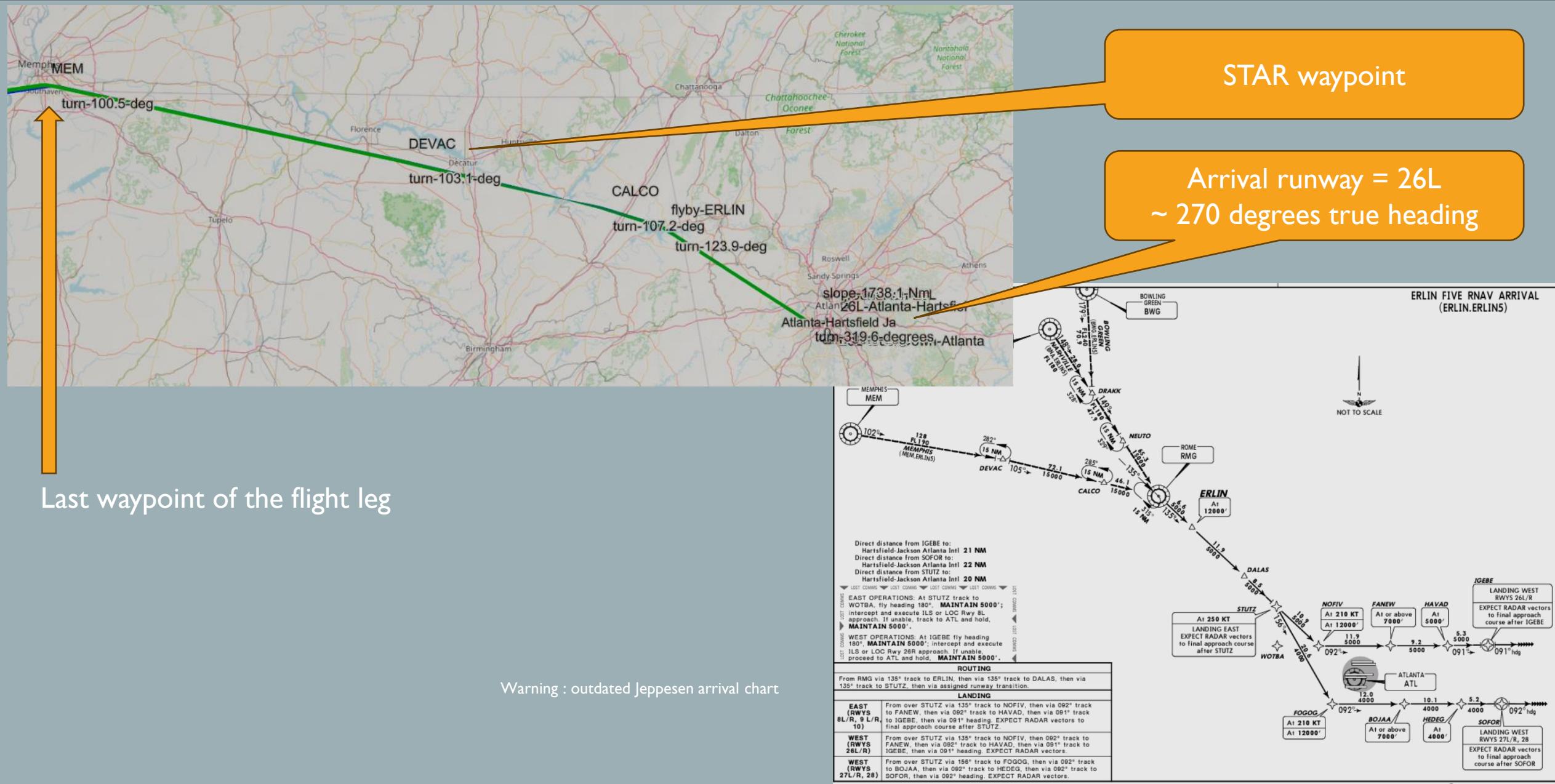
STANDARD DEPARTURE SID (LOS ANGELES KLAX/24R)



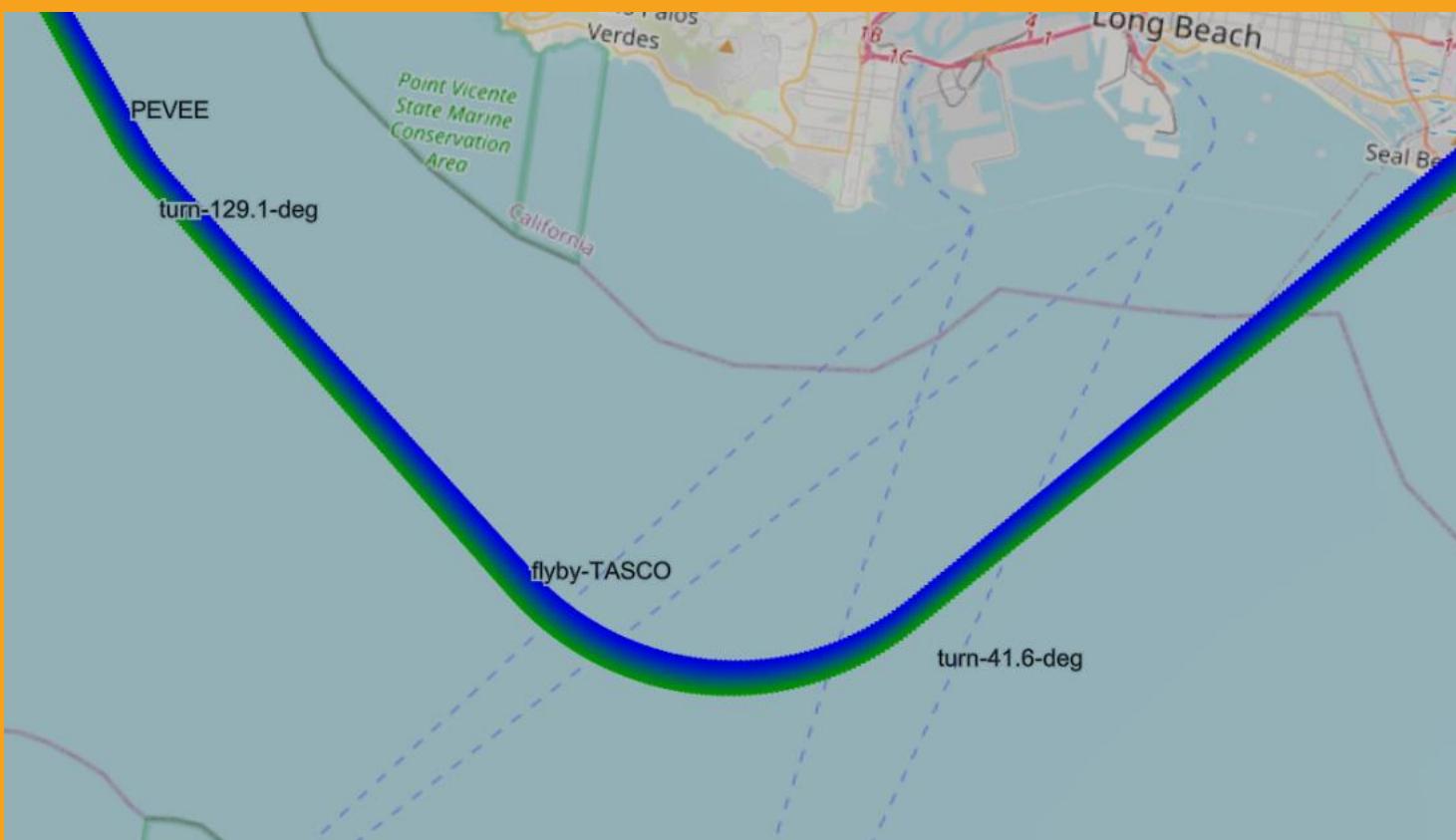
Warning : outdated Jeppesen departure chart



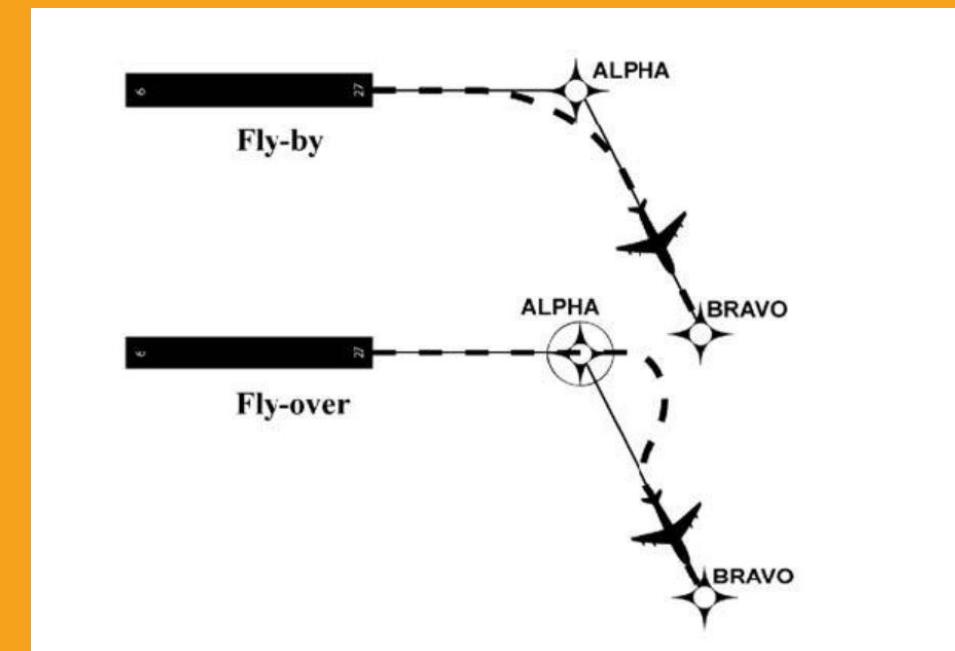
STANDARD ARRIVAL STAR (ATLANTA KATL/26L)



TURN LEG



Fly-by waypoints. Fly-by waypoints are used when an aircraft should begin a turn to the next course prior to reaching the waypoint separating the two route segments. This is known as turn anticipation.



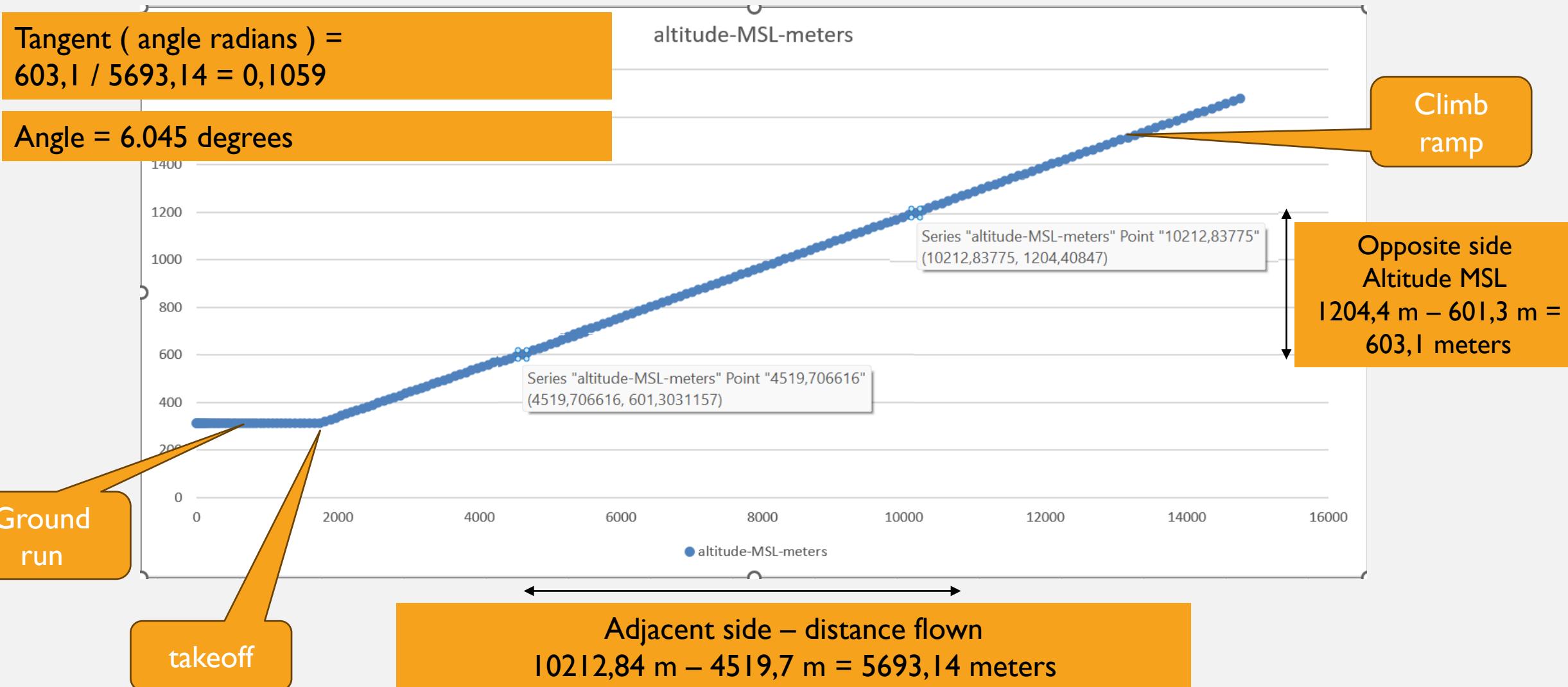
TURN LEG

Turn leg radius is a function of True Air Speed and bank angle.

[Aerospaceweb.org | Ask Us - Bank Angle and G's](https://www.aerospaceweb.org/ask-us/bank-angle-and-gs/)

TAS [knots]	Radius in NM for a bank angle of 15 degrees	Radius in NM for a bank angle of 25 degrees
150	1.2	0.7
180	1.8	1.0
210	2.4	1.4
250	3.4	2.0
300	4.9	2.8
480	12.5	7.2

CLIMB RAMP (~6 DEGREES – 5 NAUTICAL MILES LENGTH)



COMPUTE COSTS FOR ONE LEG

Select

Click here to move -> Flight Profile Computation Click to hide

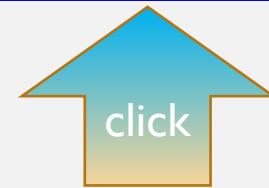
Aircraft -> Airbus A320 TakeOff Weight (kg) -> 77000 Flight Level (feet) -> 39000
Route -> Los Angeles Intl -> Atlanta-Hartsfield Jackson Intl
Departure RunWay -> 24R -> 263 degrees True Heading
Arrival RunWay -> 26L -> 270 degrees True Heading

Compute Flight Profile Compute Costs Download Vertical Profile Download KML

Inputs are checked against acceptable ranges

Take Off Mass and Flight Level can be modified

Hint : Best Runways are available through the Routes tab



Get the results

Click here to move -> Flight Leg Costs Computation Click to hide

Airline	Aircraft	Seats	Adep	RunWay	Ades	RunWay	Is Aborted	Initial Mass Kg	Final Mass Kg	Lost Mass Kg	Fuel Costs US\$	Flight Duration Hours	Flying Costs US\$	Crew Costs US\$	Total Costs US\$
AmericanWings	A320	157	KATL	08L	KLAX	06L	false	77000	66360.9	10639.1	11410	4.3623	12389	7228	31028
AmericanWings	A320	157	KATL	08L	KLAX	06L	false	64000	54126.7	9873.3	10589	3.8598	10962	6396	27947

Costs are computed for one aircraft type, one leg, selected runways, a takeoff mass and a flight level

In order to obtain these results a full trajectory computation is launched

Fuel Costs US dollars = mass loss kg * kerosene kg to US gallons * US gallon to US dollars

DOWNLOAD VERTICAL PROFILE (EXCEL FORMAT)

Click here to move > Flight Profile Computation Click to hide

Aircraft -> Airbus A320 TakeOff Weight (kg) -> 77000 Flight Level (feet) -> 39000
 Route -> Los Angeles Intl -> Atlanta-Hartsfield Jackson Intl
 Departure RunWay -> 24R -> 263 degrees True Heading
 Arrival RunWay -> 26L -> 270 degrees True Heading

Compute Flight Profile **Compute Costs** **Download Vertical Profile** **Download KML**

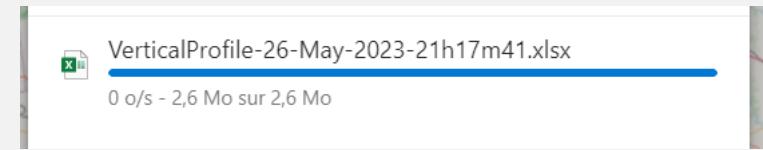
Inputs are checked against acceptable ranges

Take Off Mass and Flight Level can be modified

Hint : Best Runways are available through the Routes tab



Results to download



In order to obtain these results a full trajectory computation is launched

elapsed-time-seconds	altitude-MSL-meters	altitude-MSL-feet	true-air-speed-meters-second	true-air-speed-knots	calibrated-air-speed-knots	mach	rate-of-climb-descent-feet-minute	distance-flown-nautical-miles	distance-to-fly-nautical-miles	aircraft-mass-kilograms	flight-path-angle-degrees	thrust-newtons	drag-newtons	lift-newtons	load-factor-g	simulation
0	312,7248	1026,000002	0,1	0,194384	0,191647	0,000295	0	0	0	64000	0	0	0	0	0 False	
1	312,7248	1026,000002	1,914728	3,721934	3,669519	0,005647	0	0,001034	1694,945	63998,54	0	138091,5	0,029093	0,07329	1,15E-06 False	
2	312,7248	1026,000002	3,729354	7,249284	7,147198	0,010998	0	0,003048	1694,944	63997,07	0	138091,5	10,66614	26,86957	0,00042 False	
3	312,7248	1026,000002	5,543605	10,77591	10,62416	0,016349	0	0,006041	1694,942	63995,59	0	138091,5	40,46322	101,9327	0,001593 False	
4	312,7248	1026,000002	7,357208	14,30127	14,09989	0,021698	0	0,010013	1694,939	63994,11	0	138091,5	89,40829	225,2325	0,00352 False	
5	312,7248	1026,000002	9,169892	17,82484	17,57387	0,027043	0	0,014965	1694,935	63992,62	0	138091,5	157,4778	396,7095	0,006199 False	
6	312,7248	1026,000002	10,98138	21,3461	21,04558	0,032386	0	0,020894	1694,93	63991,13	0	138091,5	244,6367	616,2755	0,009631 False	
7	312,7248	1026,000002	12,79141	24,86451	24,5145	0,037724	0	0,027801	1694,924	63989,63	0	138091,5	350,8386	883,8134	0,013812 False	
8	312,7248	1026,000002	14,59971	28,37956	27,98011	0,043057	0	0,035684	1694,917	63988,12	0	138091,5	476,0254	1199,177	0,018741 False	
9	312,7248	1026,000002	16,406	31,89071	31,44191	0,048384	0	0,044543	1694,909	63986,61	0	138091,5	620,1282	1562,193	0,024414 False	
10	312,7248	1026,000002	18,21002	35,39745	34,89938	0,053704	0	0,054375	1694,9	63985,09	0	138091,5	783,0664	1972,658	0,03083 False	



DOWNLOAD KML FILE

KML : Keyhole Markup Language

Click here to move → Flight Profile Computation Click to hide

Aircraft → Airbus A320 TakeOff Weight (kg) → 77000 Flight Level (feet) → 39000

Route → Los Angeles Intl → Atlanta-Hartsfield Jackson Intl

Departure RunWay → 24R → 263 degrees True Heading

Arrival RunWay → 26L → 270 degrees True Heading

[Compute Flight Profile](#) [Compute Costs](#) [Download Vertical Profile](#) [Download KML](#)



If you have Google Earth installed
->
downloading will open Google Earth

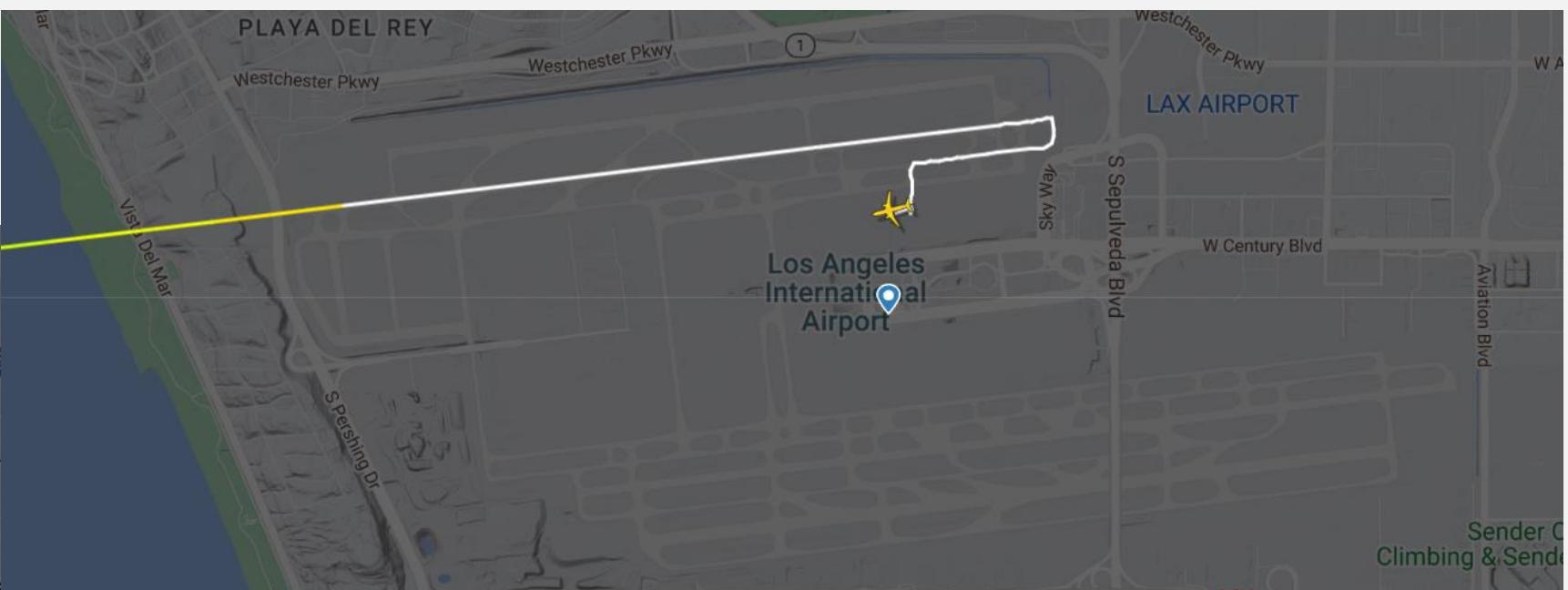
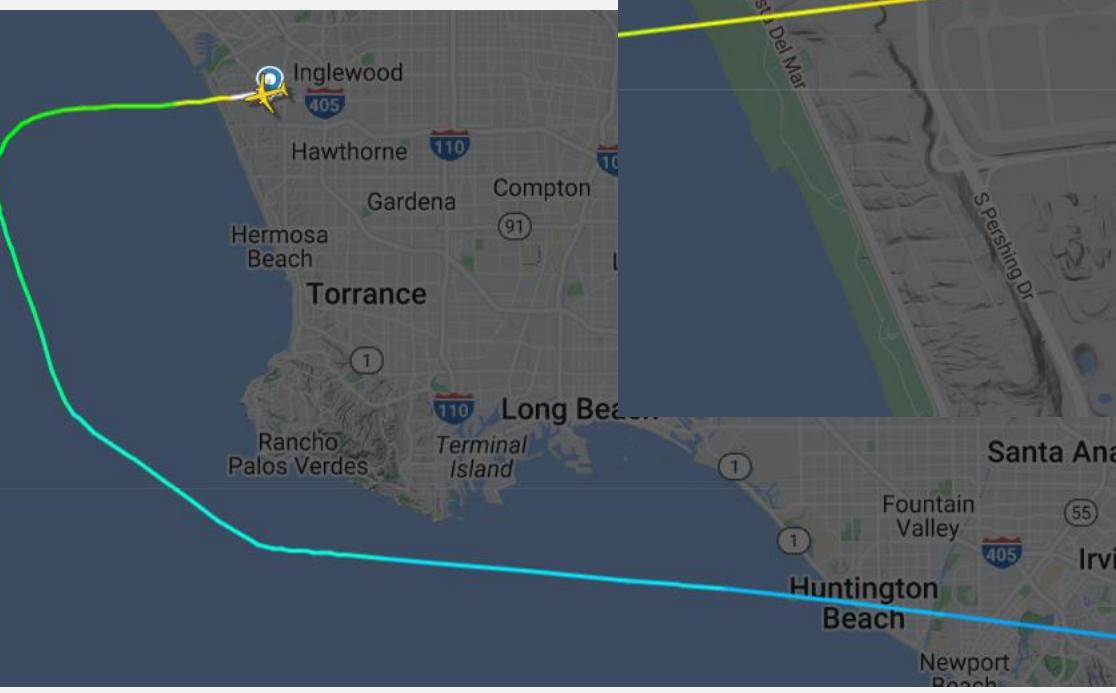


COMPARISON KLAX-KATL (FLIGHT RADAR)

DL395



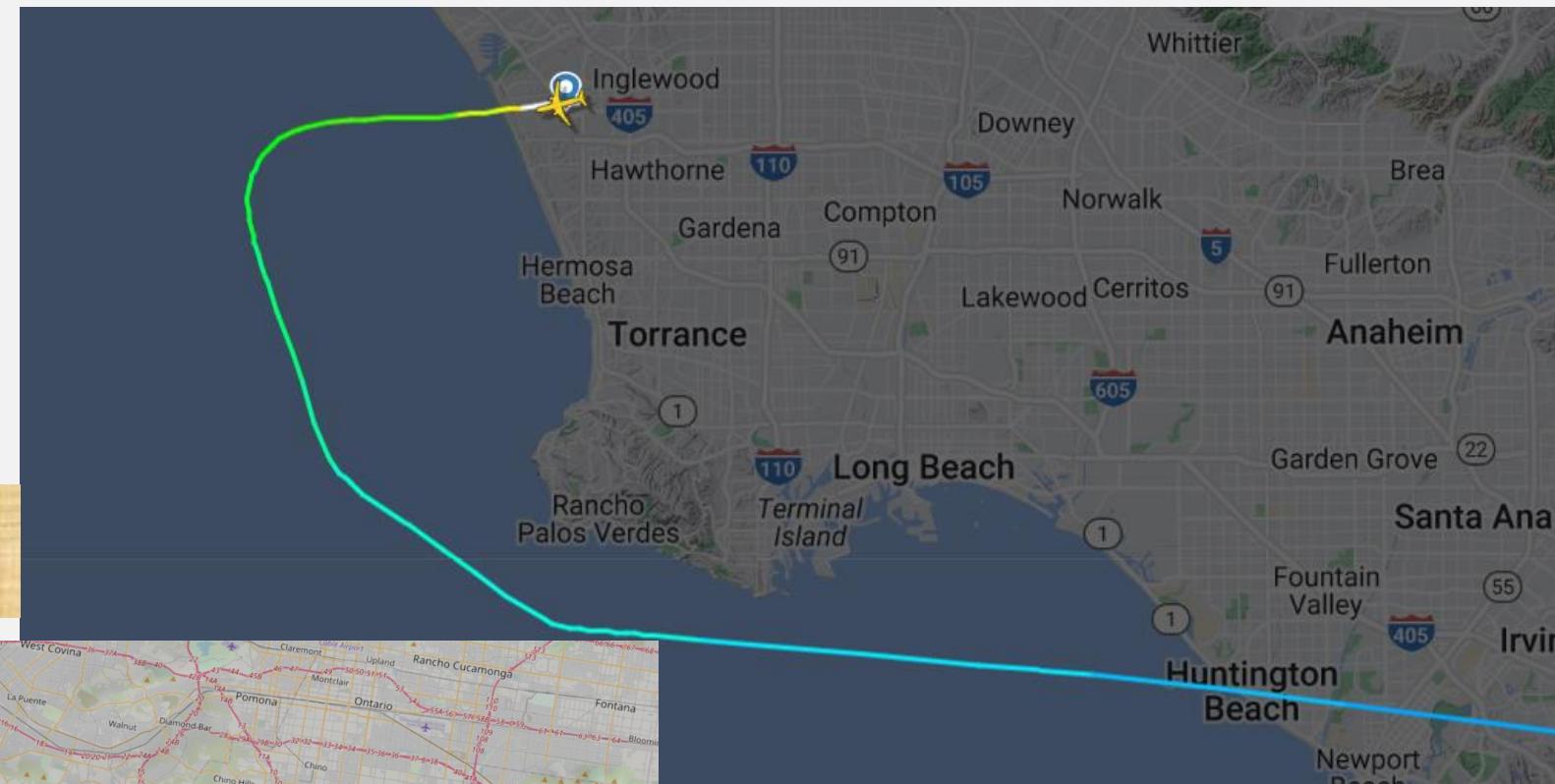
24L



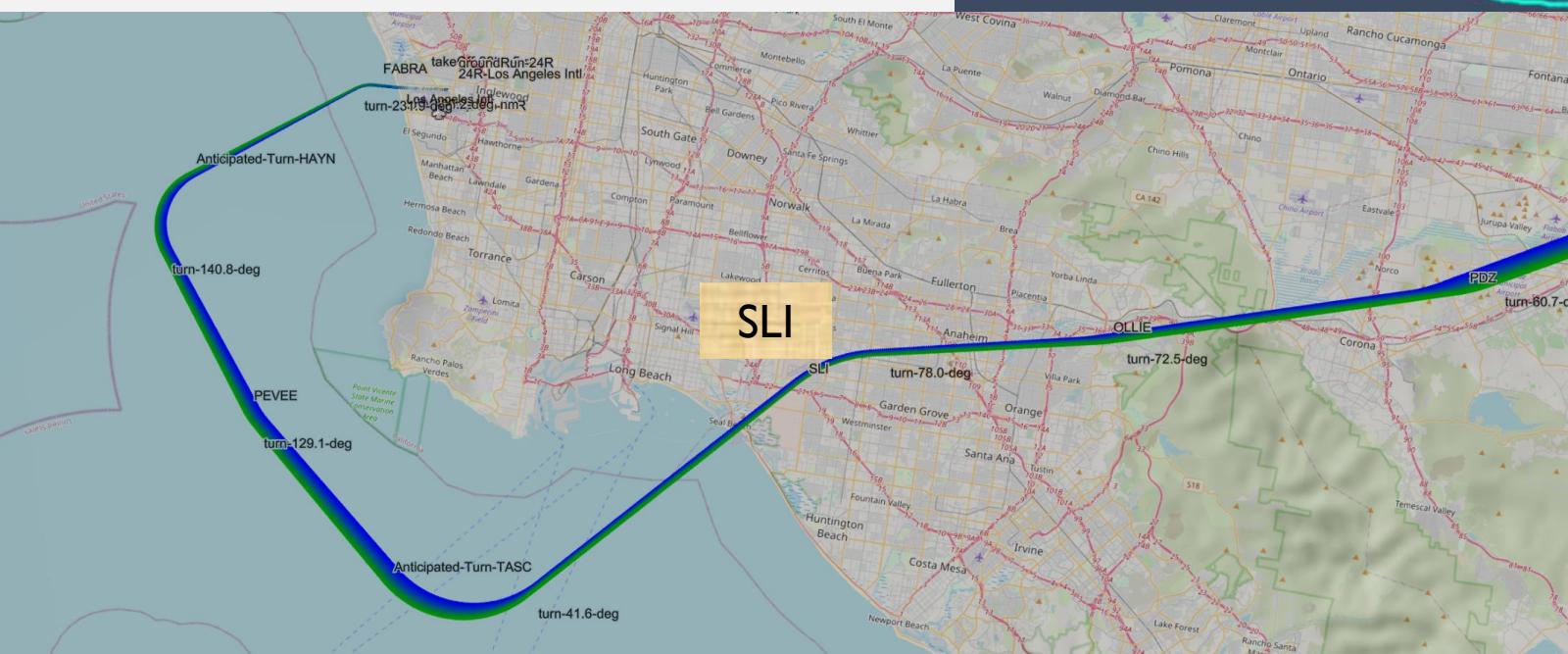
COMPARISON DEPARTURE KLAX-KATL (FLIGHT RADAR)

DL395

KLAX/24L -> SID -> southern route towards Huntington Beach



KLAX/24R -> SID -> SLI -> northern route towards MEMPHIS -> KATL



MINIMIZATIONS (COSTS)

All Optimizations are based upon computing costs beforehand – costs are computed offline

Costs are computed once for all defined routes and results are stored in the database

For each aircraft type, each flight leg a trajectory is computed, and a cost matrix is created and stored offline in the database

Costs minimizations compute the minimal SUM of costs for all the defined flight legs

Assumption : have an adequate fleet in order to assign one aircraft type to only one flight leg

Only one aircraft type
assigned to one leg

Leg = oriented pair of departure and arrival airports

airline	Solver Status	aircraft	departureAirport	adepRunway	arrivalAirport	adesRunway	totalCostsUSdollars
AmericanWings	Optimal	A320	PANC	07L	KATL	26R	46607,34
AmericanWings	Optimal	A320	KJFK	13R	LFPG	27L	49660,15
AmericanWings	Optimal	A320	KSEA	16L	KJFK	31L	33997,88
AmericanWings	Optimal	A320	KATL	26R	PANC	07L	46366,89
AmericanWings	Optimal	A320	KSFO	01R	KIAD	30	33886,5
AmericanWings	Optimal	A332	KATL	08L	KBOS	27	23442,15
AmericanWings	Optimal	A332	KATL	26R	KMSP	17	23408,56
AmericanWings	Optimal	A332	KORD	22L	KIAH	08L	23438,39
AmericanWings	Optimal	A332	KIAH	08L	KORD	22L	23003,15
AmericanWings	Optimal	A332	KMSP	12R	KATL	26R	23426,2
AmericanWings	Optimal	B738	KJFK	31L	KSEA	34R	34935,35
AmericanWings	Optimal	B738	KBOS	27	KATL	08L	15615,51
AmericanWings	Optimal	B738	KATL	27R	KLAX	07L	28065,68
AmericanWings	Optimal	B738	KIAD	30	KSFO	10L	34473,85
AmericanWings	Optimal	B738	KLAX	07L	KATL	27R	28436,94
							468764,54

Computation are using the PULP optimization library -> [pulp — PuLP 2.7.0 documentation \(coin-or.github.io\)](https://coin-or.github.io/pulp/)

Objective function - Minimize Sum of Costs -US\$ 468764,54

sum

MINIMIZATIONS (COSTS PER AVAILABLE SEAT MILES)

All Optimizations are based upon computing costs beforehand

For each aircraft type, each flight leg a trajectory is computed and a cost matrix is created

CASM minimizations compute the minimal SUM of CASM for all the defined flight legs

Assumption : have an adequate fleet in order to assign one aircraft type to only one flight leg

Click here to move - Costs per Available Seat Miles											Click to hide	
Airline	Solver Status	Aircraft	assigned	Departure	Arrival	Seats	Flight Distance Miles	Costs US\$	CASM US\$			
AmericanWings	Optimal	A320	yes	General Edward Lawrence Logan Intl	Atlanta-Hartsfield Jackson Intl	157	832.41	15277.38	0.1169			
AmericanWings	Optimal	A320	yes	Minneapolis	Atlanta-Hartsfield Jackson Intl	157	819.99	15049.41	0.1169			
AmericanWings	Optimal	A320	yes	Atlanta-Hartsfield Jackson Intl	General Edward Lawrence Logan Intl	157	829.11	15070.87	0.1158			
AmericanWings	Optimal	A320	yes	Houston George Bush Intl	Chicago O'Hare Intl	157	814.42	14816.56	0.1159			
AmericanWings	Optimal	A320	yes	Chicago O'Hare Intl	Houston George Bush Intl	157	815.24	15047.09	0.1176			
AmericanWings	Optimal	A332	yes	Alaska Anchorage-Ted Stevens Intl	Atlanta-Hartsfield Jackson Intl	234	2996.41	69855.88	0.0996			
AmericanWings	Optimal	A332	yes	New York-John F Kennedy Intl	Seattle Tacoma Intl	234	2128.27	51767.68	0.1039			
AmericanWings	Optimal	A332	yes	Atlanta-Hartsfield Jackson Intl	Minneapolis	234	835.29	23408.56	0.1198			
AmericanWings	Optimal	A332	yes	New York-John F Kennedy Intl	Paris Charles-De-Gaulle France Intl	234	3214.07	74198.29	0.0987			
AmericanWings	Optimal	A332	yes	San Francisco Intl	Washington Dulles Airport Intl	234	2112.14	50876.38	0.1029			
AmericanWings	Optimal	B738	yes	Atlanta-Hartsfield Jackson Intl	Los Angeles Intl	160	1695.85	28065.68	0.1034			
AmericanWings	Optimal	B738	yes	Washington Dulles Airport Intl	San Francisco Intl	160	2114.26	34473.85	0.1019			
AmericanWings	Optimal	B738	yes	Los Angeles Intl	Atlanta-Hartsfield Jackson Intl	160	1706.94	28436.94	0.1041			
AmericanWings	Optimal	B738	yes	Atlanta-Hartsfield Jackson Intl	Alaska Anchorage-Ted Stevens Intl	160	3063.69	48116.39	0.0982			
AmericanWings	Optimal	B738	yes	Seattle Tacoma Intl	New York-John F Kennedy Intl	160	2127.29	34482.87	0.1013			

Only one aircraft type assigned to one leg

Min of sum

MAXIMIZATIONS (SEAT MILES)

All Optimizations are based upon computing costs beforehand

For each aircraft type, each flight leg a trajectory is computed and a cost matrix is created

Seat Miles maximizations compute the Maximal SUM of Seat Miles for all the defined flight legs

Assumption : have an adequate fleet in order to assign one aircraft type to only one flight leg



Airline	Aircraft	Solver Status	Assigned	Departure	Arrival	nb Seats	Aircraft Turn Around Times Seconds	Leg Duration Seconds	Leg Distance (miles)	Nb Rotations in 20 hours	Seat Miles Flown 20 hours (miles)
AmericanWings	A320	Optimal	yes	KATL	KMSP	157	1500	8288,8	854,8156123	3	805236,3068
AmericanWings	A320	Optimal	yes	KMSP	KATL	157	1500	7396,1	819,9907771	3	772431,312
AmericanWings	A320	Optimal	yes	KATL	KBOS	157	1500	7502,7	829,1098923	3	781021,5186
AmericanWings	A320	Optimal	yes	KIAH	KORD	157	1500	7213	814,4242528	3	767187,6462
AmericanWings	A320	Optimal	yes	KORD	KIAH	157	1500	7362,8	815,2396302	3	767955,7316
AmericanWings	A332	Optimal	yes	PANC	KATL	234	2100	21963,6	2996,40901	1	1402319,417
AmericanWings	A332	Optimal	yes	KJFK	LFGP	234	2100	23340,9	3214,073888	1	1504186,579
AmericanWings	A332	Optimal	yes	KATL	PANC	234	2100	22621,5	3007,623939	1	1407568,004
AmericanWings	A332	Optimal	yes	KATL	KLAX	234	2100	13452,4	1695,882484	2	1587346,005
AmericanWings	A332	Optimal	yes	KLAX	KATL	234	2100	13208,8	1707,433335	2	1598157,602
AmericanWings	B738	Optimal	yes	KJFK	KSEA	160	1500	15892,4	2128,22742	2	1362065,549
AmericanWings	B738	Optimal	yes	KBOS	KATL	160	1500	7096,5	832,4002601	3	799104,2497
AmericanWings	B738	Optimal	yes	KSEA	KJFK	160	1500	15893,3	2127,289211	2	1361465,095
AmericanWings	B738	Optimal	yes	KIAD	KSFO	160	1500	15819,8	2114,261328	2	1353127,25
AmericanWings	B738	Optimal	yes	KSFO	KIAD	160	1500	15688,3	2112,111338	2	1351751,256
											17620923,52

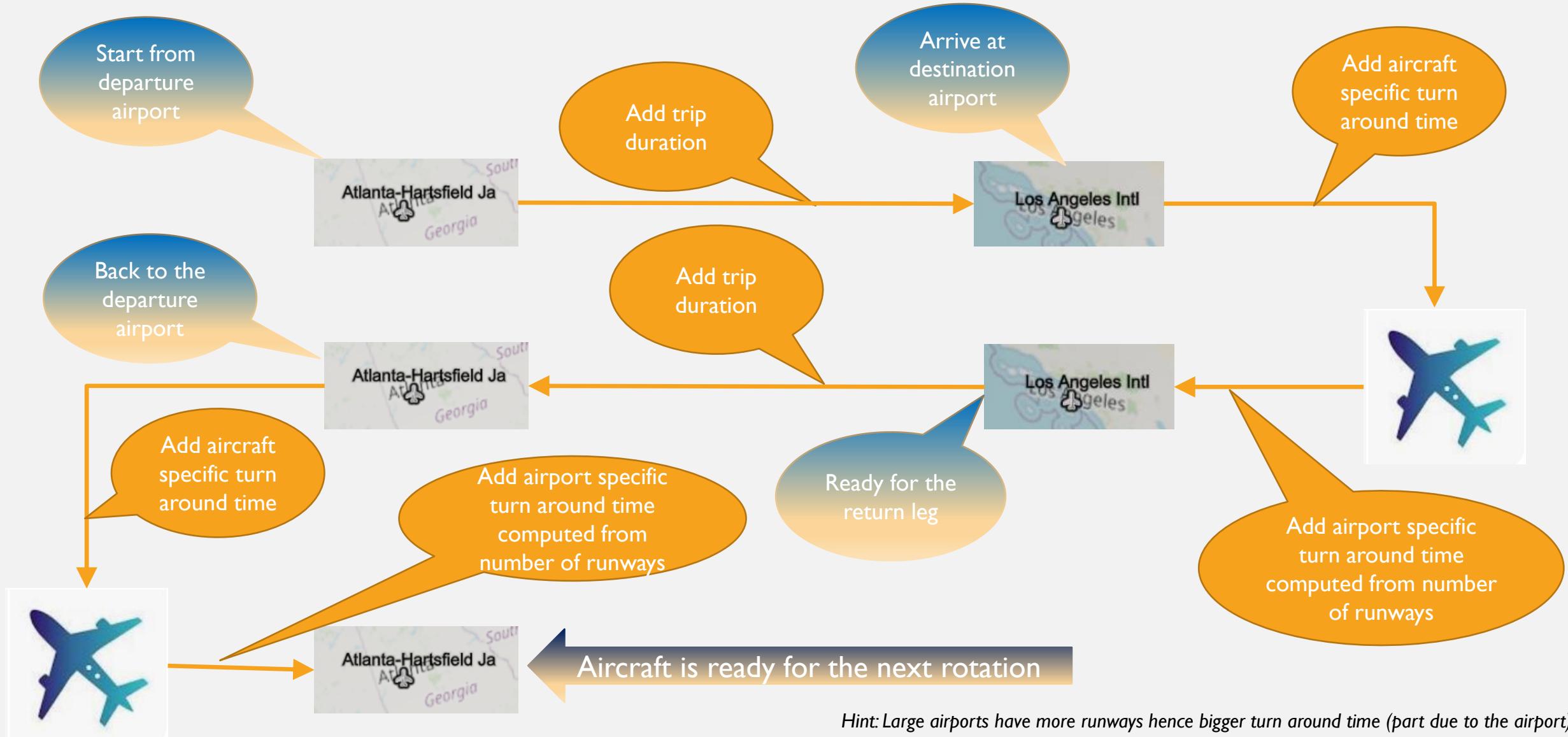
Hint: compute number of rotations in a day, based upon trip duration, plus turn around time

Objective function - max Sum Seat Miles 17620923,52

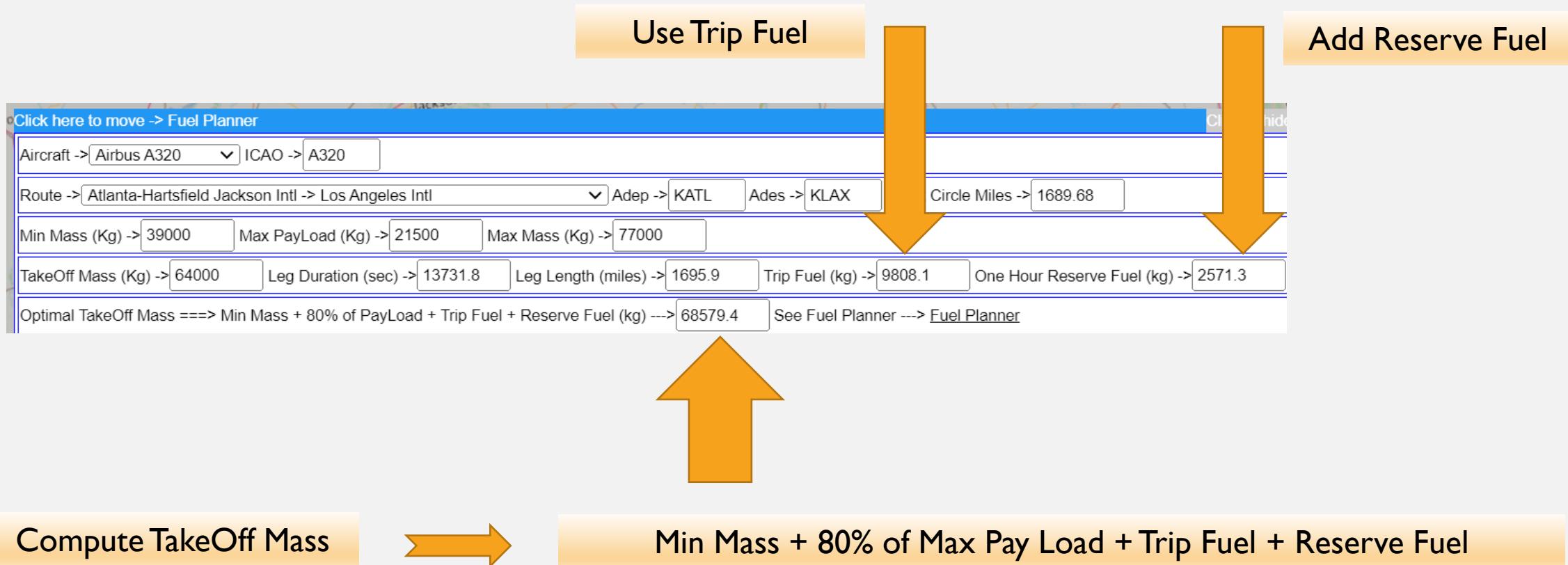


MAXIMIZATIONS (SEAT MILES)

How to compute a rotation – example for a KATL -> KLAX leg



FUEL PLANNER (TAKEOFF MASS ESTIMATION)



DEPARTURE RUNWAY OVERSHOOT (PROGRAMMATIC FEATURE)

Enter an URL in the browser -> Feature to be used programmatically

Modify arguments such as aircraft, airport, departure runway, takeoff mass

Aircraft TakeOff mass = 230 tons



<https://airlineservices.eu.pythonanywhere.com/trajectory/computeRunwayOvershoot/A332/KATL/08L/230>

Aircraft ICAO = A332

Receive an answer in JSON format

```
{  
    "aircraft": "A332-AIRBUS-A330-200",  
    "aircraftReferenceMassKg": "190000.0",  
    "aircraftInitialMassKg": "230000.0",  
    "airport": "Airport: Airport: KATL - Atlanta-Hartsfield Jackson Atlanta Intl - lat= 33.64 degrees - long= -84.43 degrees - field elevation= 312.72 meters",  
    "runway": "RunWay: runway= 08L - airport ICAO code= KATL - length= 9000.00 feet - true heading= 90.00 degrees - latitude= 33.65 degrees - longitude= -84.44 degrees",  
    "runwayLengthMeters": "2743.2",  
    "TakeOffStallSpeedCasKnots": "128.73",  
    "groundRunLengthMeters": "2915.39"  
}
```

Ground Run length **Greater** than Runway Length -> overshoot -> Choose another departure runway

APPLICATION PROGRAMMING INTERFACE

Benefits of API : tool may be queried programmatically & inserted in an eco-system of a more larger tool set



Click on Help Button

In the last Help section, see examples of URL to retrieve a JSON answer in the browser

▼API - Application Programming Interface

It is possible to query programmatically the service and retrieve a result in Json format.

Use the following URL : [Fleet Definition](#) to retrieve the fleet definition.

Use the following URL : [Routes Definition](#) to retrieve the routes.

Use the following URL : [Costs](#) to retrieve the costs.

Use the following URL : [WayPoints](#) to retrieve the wayPoints.

Use the following URL : [Airports](#) to retrieve the airports of the airline.

Use the following URL : [Runway overshoot](#) to retrieve the ground run length.

Links to be clicked

PERFORMANCES

Processor = 13th Gen Intel(R) Core(TM) i7-1360P 2.20 GHz
RAM = 32,0 Go (31,7 Go usable)

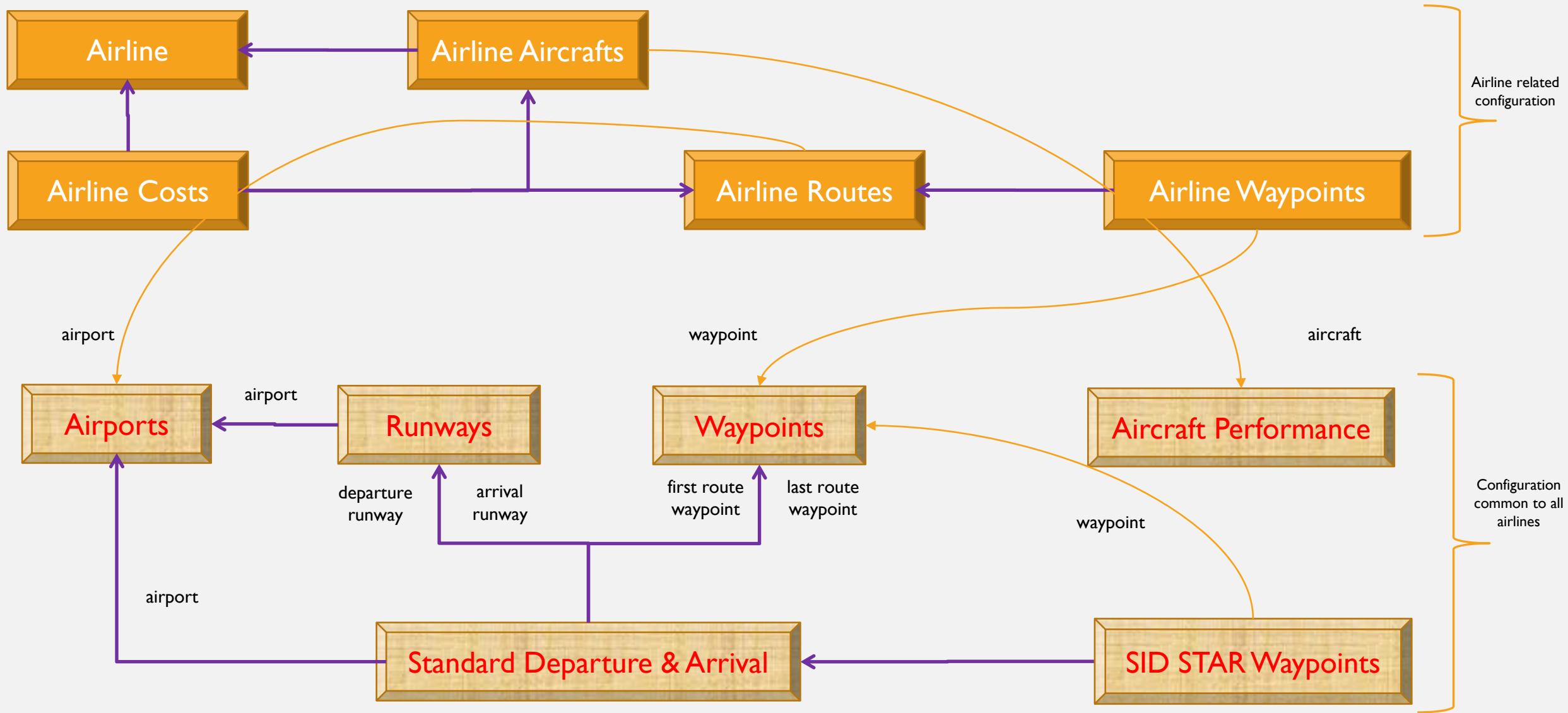
Only 4D trajectory computations only

Aircraft	Initial mass	Cruise Mach / Ceiling (feet)	Flight leg	Distance flown (nautical miles)	4D Computation duration / real time flight duration
A320	67000 kg	0,82 / 39000	Madrid LEMD/36R -> Berlin EDDB/25L	1070 NM	0,86 sec / 9664 sec / 2 hours 41 minutes
A320	67000 kg	0,82 / 39000	Los Angeles KLAX/24R -> Atlanta KATL/27R	1755 NM	1.0 sec / 15804 sec / 4 hours 23 minutes
A320	67000 kg	0,82 / 39000	Mexico MMMX/05L -> Seattle KSEA/16C	2161 NM	2.83 sec / 18276 sec / 5 hours 4 minutes

Performances are mostly dependent upon number of waypoints in the fix list

Performances are reduced when code is deployed on PythonAnyWhere

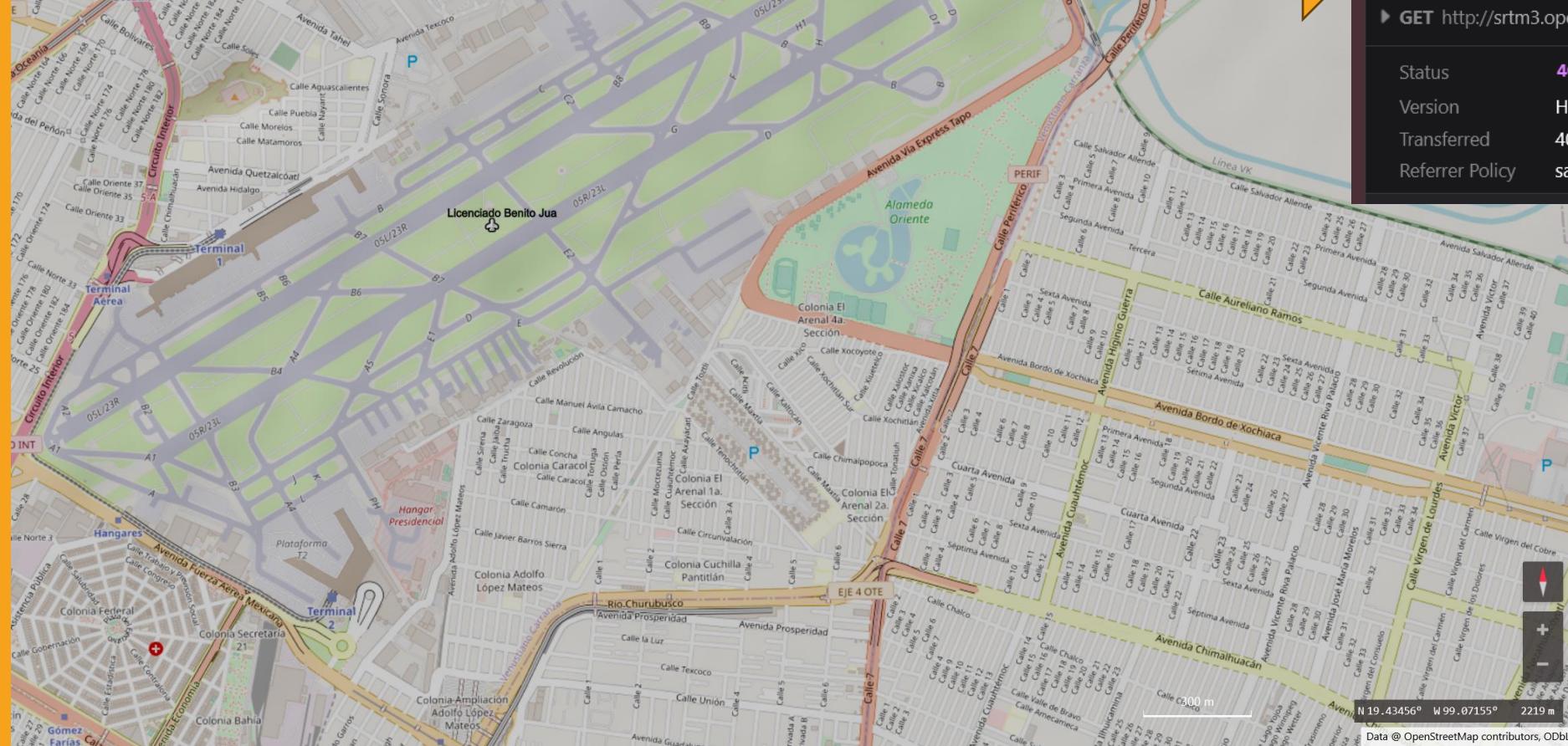
DATABASE SCHEMA



OPENGLOBUS JAVASCRIPT LIBRARY

Featuring : KML format, rays, events, ruler, etc.

Case where there is no data for terrain in the coordinates z=7, y=56, x=30, where z is the zoom level, and x, y - Mercator grid coordinates



XHR GET <http://srtm3.openglobus.org/7/56/30.ddm>

Headers Cookies Request Response Timings Stack Trace

 Filter Headers

▶ GET <http://srtm3.openglobus.org/7/56/30.ddm>

Version HTTP/1.

Transferred 408 B (178 B size)

Referrer Policy same-origin

Zoom using
mouse wheel

Turn / orientation

Zoom

Ground altitude above Sea Level

Tile provider

Wgs84 - Universal Transverse Mercator coordinate system



AIRLINE SERVICES
THANK YOU

For any question, please follow this link
<https://www.appsintellect.org/contact-card>