AIRLINE SERVICES

Proposed by https://www.appsintellect.org

4th June 2023

Version 2.0

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 best aircraft
 - to minimize Costs,
 - to minimize Costs per Available Seat Miles,
 - to maximize Seat Miles
- Support flight leg planning through fuel estimation

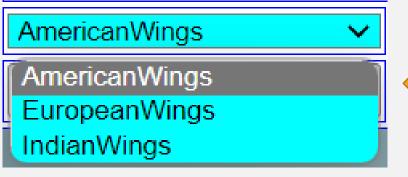
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Benefits of a full-fledged interactive 3D Globe with street maps hence runways

TOOL MAIN CONFIGURATION

For the sake of the demo, 3 different airlines have been configured with different parameters

Configuration data is stored in a database



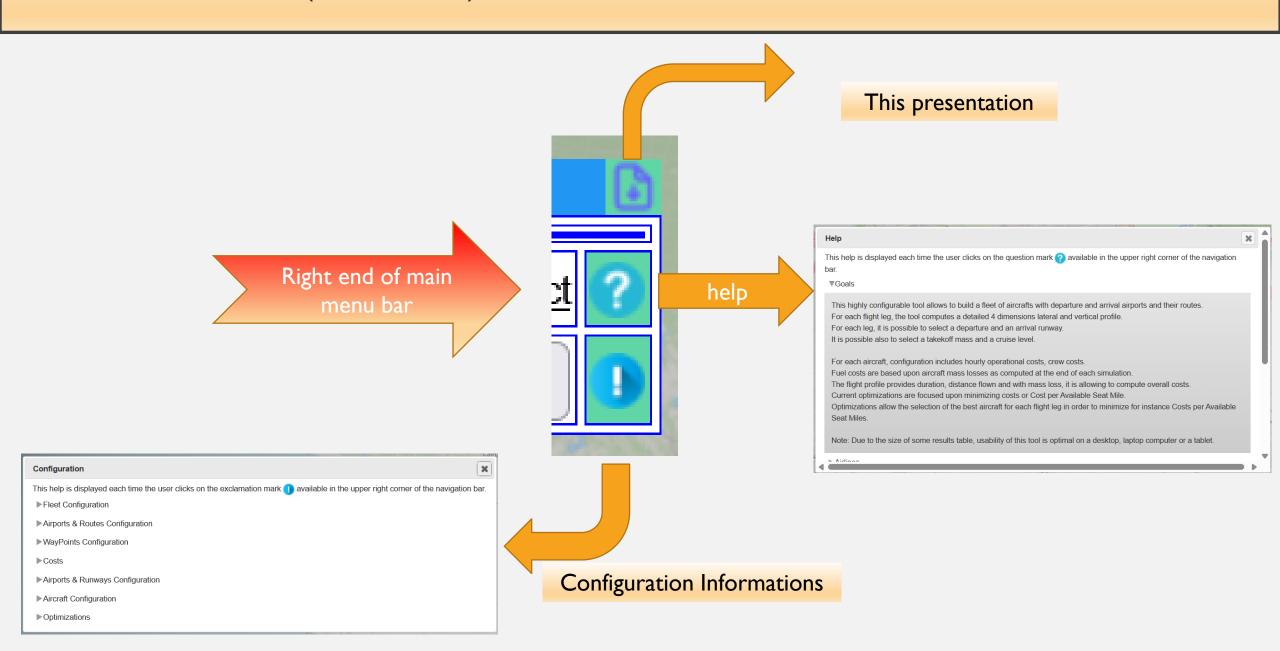
Each airline has its own map subset



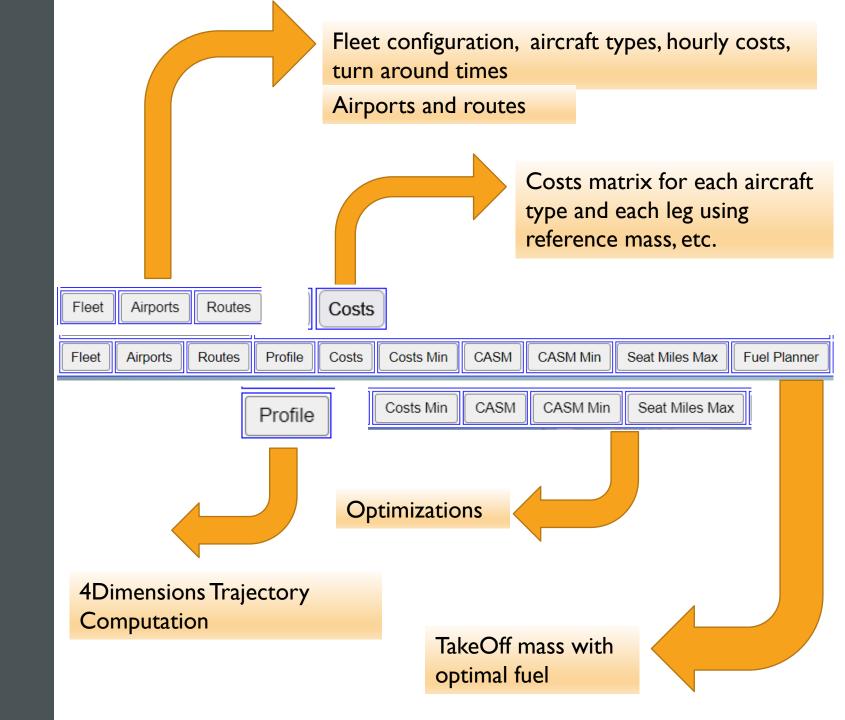




(ONLINE) HELP & CONFIGURATION



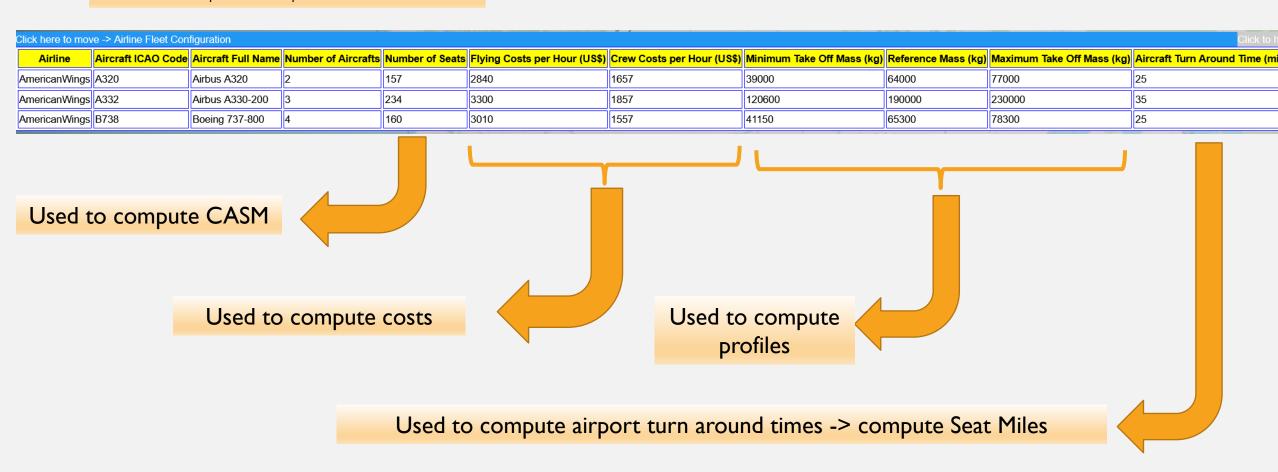
MAIN MENU BAR



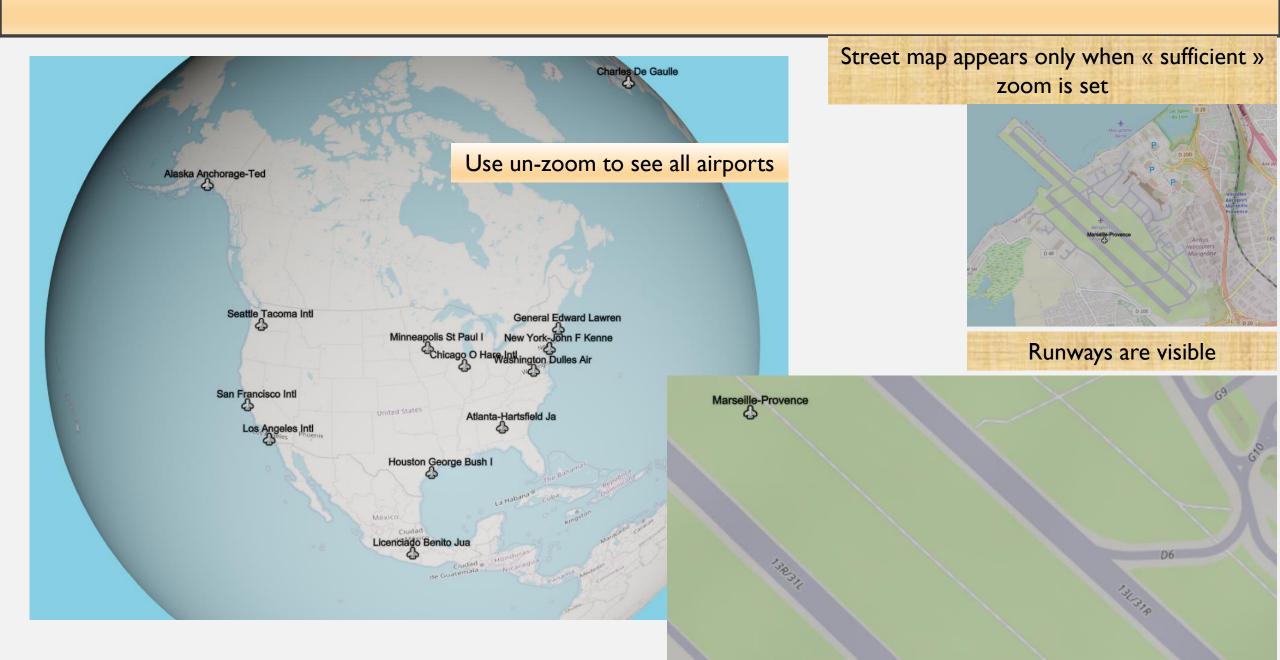
FLEET CONFIGURATION

Values are specific to each airline

Values are read from an EXCEL file and loaded into a database



AIRPORTS

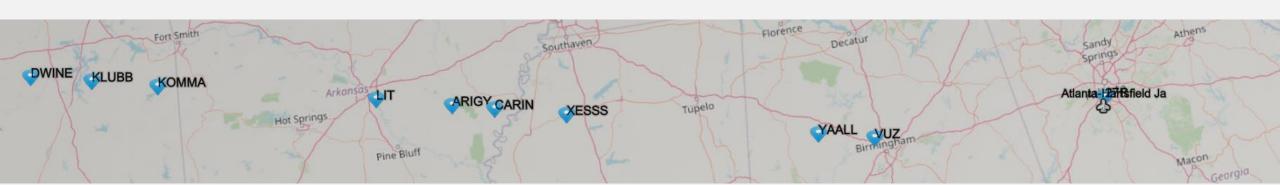


ROUTES

Right click on an airport



Click on the link to see the way Points



ROUTES



Click to show / hide the way points on the map

Best runway also displayed on the map

EXCEL configuration file

	order	wayPoint	latitude	longitude
ı		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"

Database view

distance from runway end to first / last waypoint of the route

343	WayPointName [PK] character varying VLN	Type character varying wayPoint	Latitude double precision 50.66/0055555555	Longitude double precision	Continent character varying North America
344	VORIN	WayPoint	41.54800277777775	-89.336375	North America
345	VUZ	WayPoint	33.67013055555555	-86.89983611111111	North America



AIRPORTS DATA

Example of database content for Airports of one Airline

	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

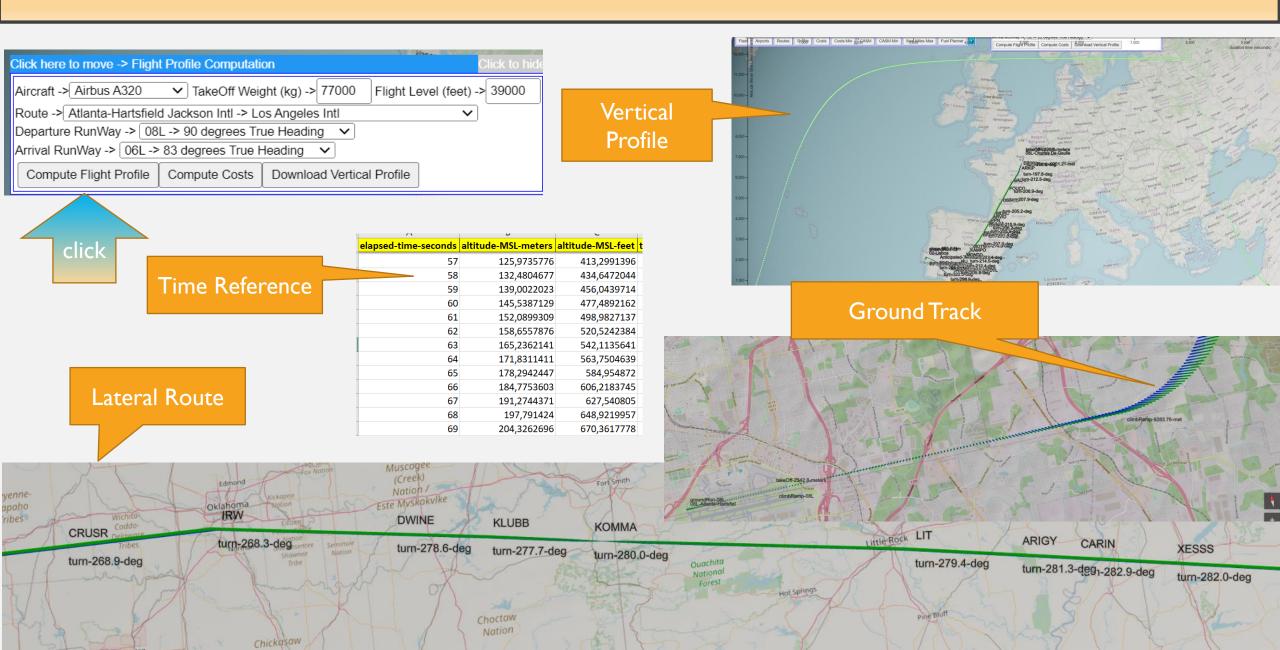
WAYPOINTS DATA

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

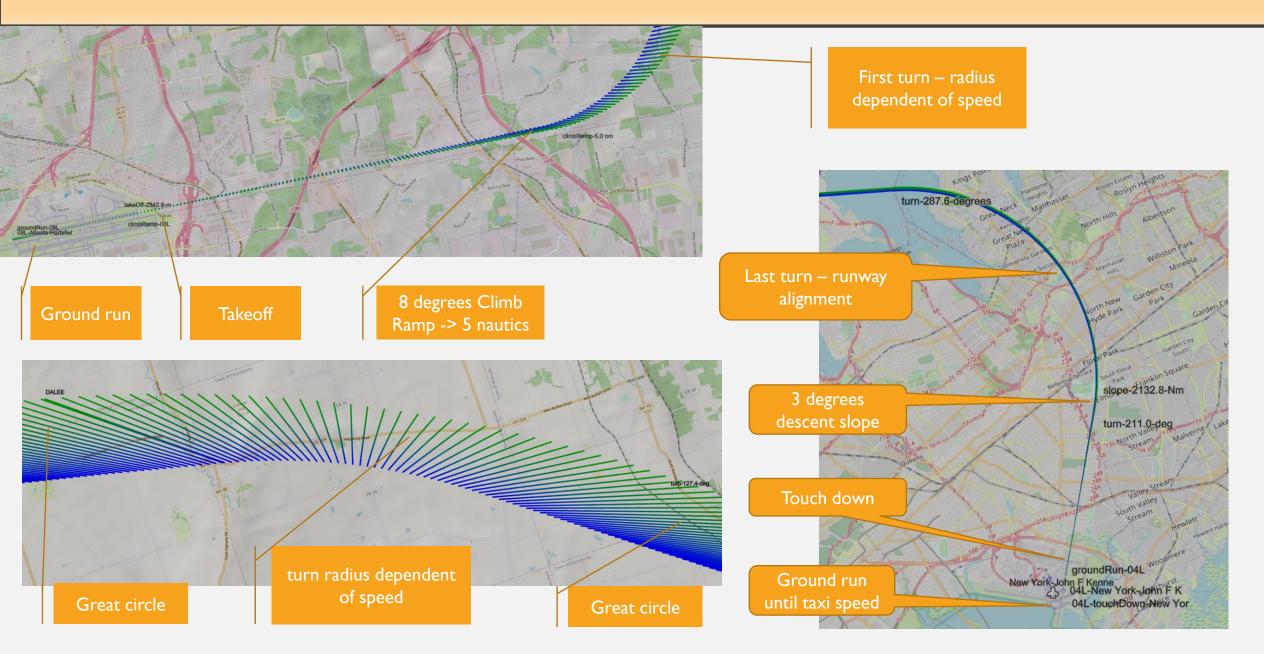
	WayPointName [PK] character varying	Type character varying	Latitude double precision	Longitude double precision	Continent character varying
1	47N050W	WayPoint	47.5	-50	Europe
2	49N040W	WayPoint	49.5	-40	Europe
3	51N030W	WayPoint	51.5	-30	Europe
4	52N020W	WayPoint	52.5	-20	Europe
5	ABQ	WayPoint	35.043794444444444	-106.81631111111112	North America
6	ABR	WayPoint	45.4173527777778	-98.3687194444444	North America
7	ADUKE	WayPoint	31.882430555555555	-94.21646666666666	North America
8	AGROM	WayPoint	22.529163888888888	84.83333055555555	India
9	AHEIM	WayPoint	33.82031388888889	-117.9119722222222	North America
10	ALBED	WayPoint	18.117219444444444	78.6566638888889	India
11	ALEPO	WayPoint	42.3436083333333336	-1.96333333333333334	Europe
12	AMDID	WayPoint	48.0972194444445	12.39694444444443	Europe
13	ANDAV	WayPoint	17.471666666666664	78.81361111111111	India

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

4 DIMENSIONS TRAJECTORY (CORE FEATURE)



4 DIMENSIONS TRAJECTORY (CORE FEATURE)



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

Airbus A330-200 - TakeOff Mass = 190 tons

JF Kennedy – Mean Sea Level = 4 meters

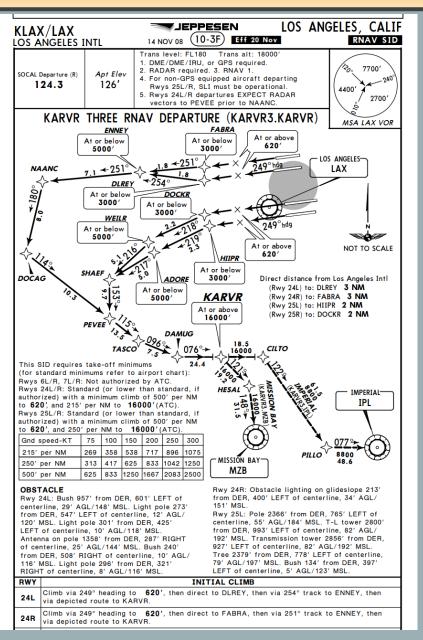
Ground Run = 1779,3 meters

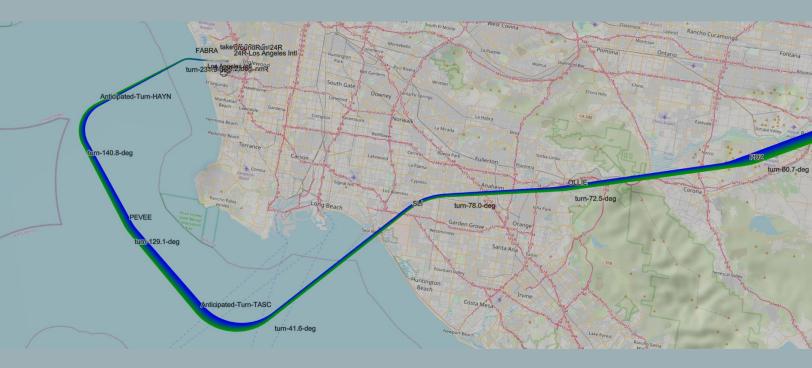
TakeOff Speed CAS = 117 knots

TakeOff True Air Speed = 72,67 m/s

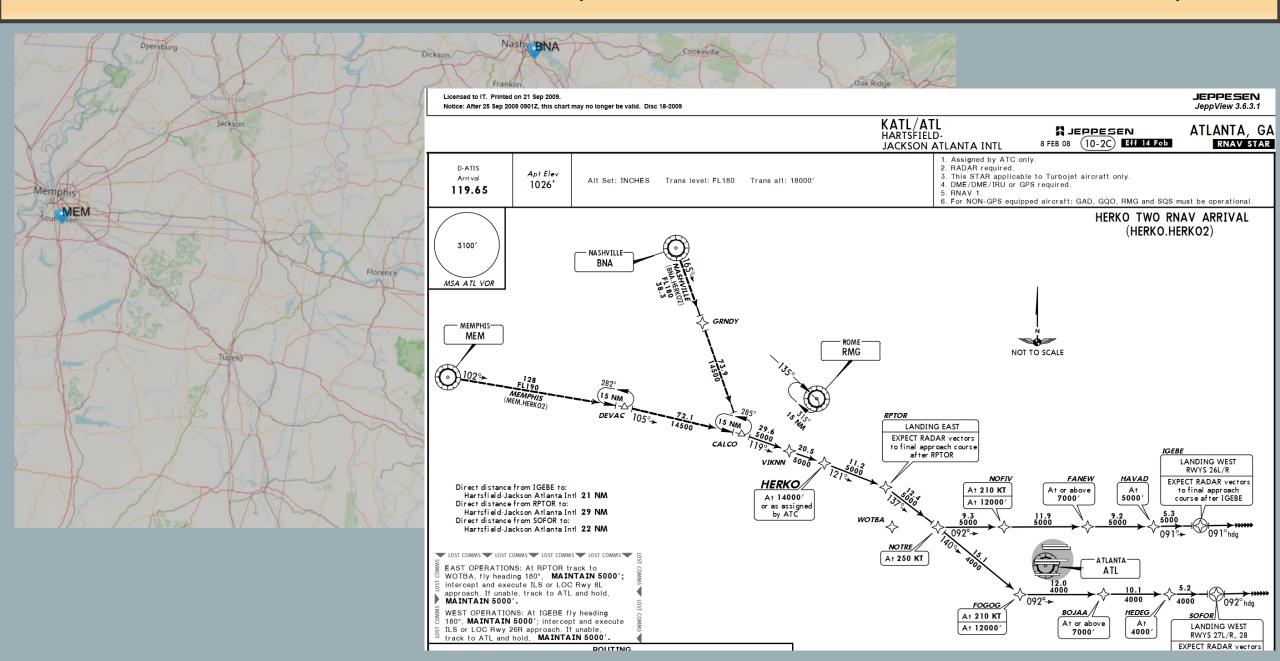


STANDARD DEPARTURE (LOS ANGELES KLAX/24R)





STANDARD ARRIVAL (ATLANTA GEORGIA KATL)



COMPUTE COSTS FOR ONE LEG

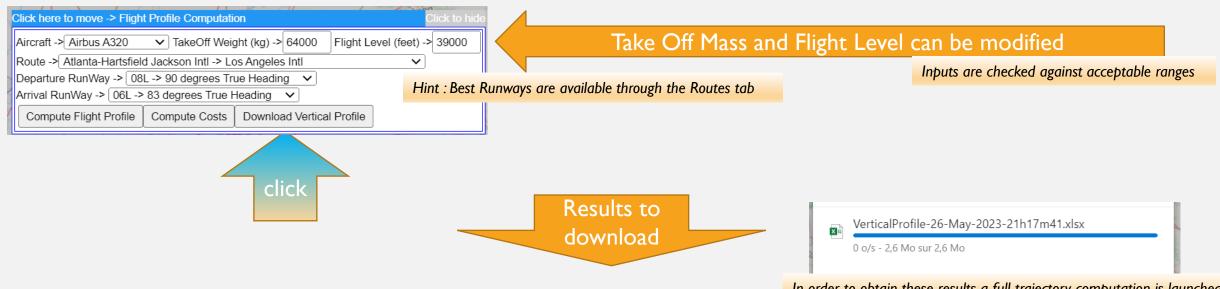


Costs are computed for one aircraft type, one leg, selected runways, a takeoff mass and a flight level

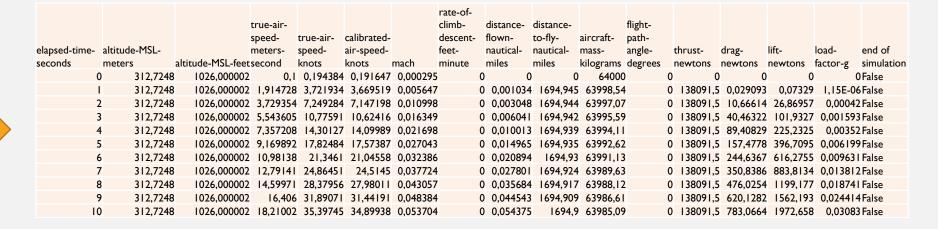
In order to obtain these results a full trajectory computation is launched

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

DOWNLOAD VERTICAL PROFILE (EXCEL FORMAT)

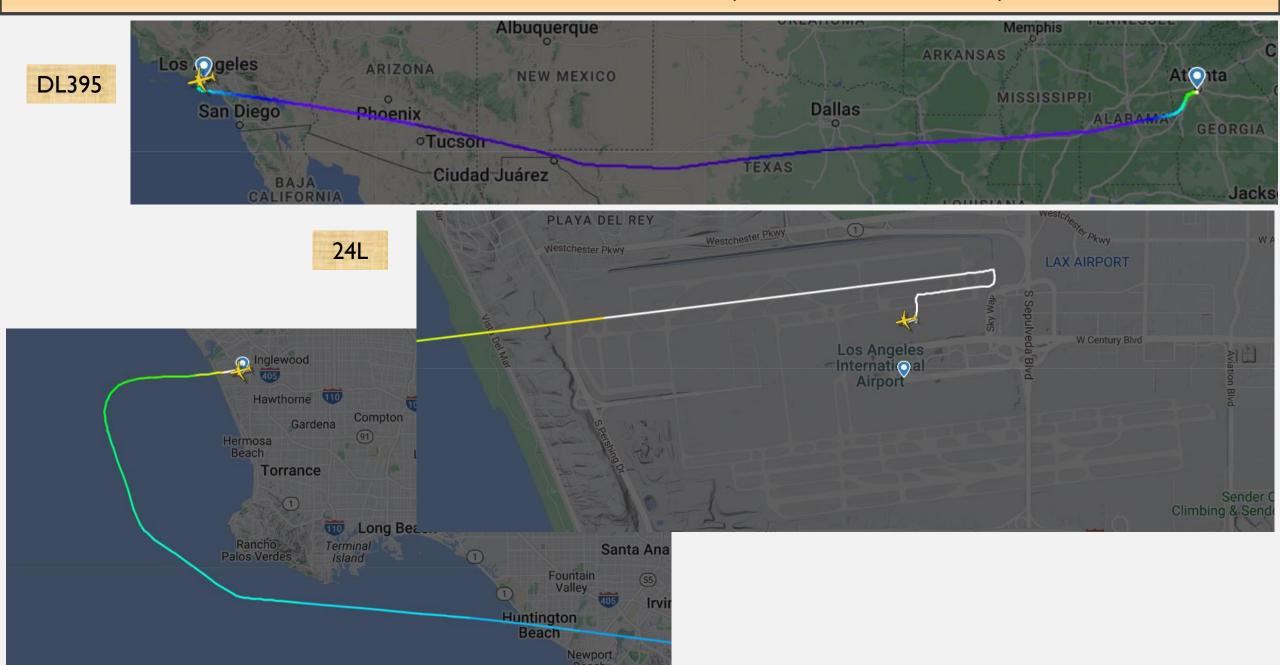


In order to obtain these results a full trajectory computation is launched



State vector

COMPARISON KLAX-KATL (FLIGHT RADAR)



COMPARISON DEPARTURE KLAX-KATL (FLIGHT RADAR)

Inglewood

Hermosa

Beach

Hawthorne 110

Torrance

Gardena

Whittier

Fullerton

Anaheim

Garden Grove 22

Newport

Fountain

Huntington Beach Santa Ana

Downey

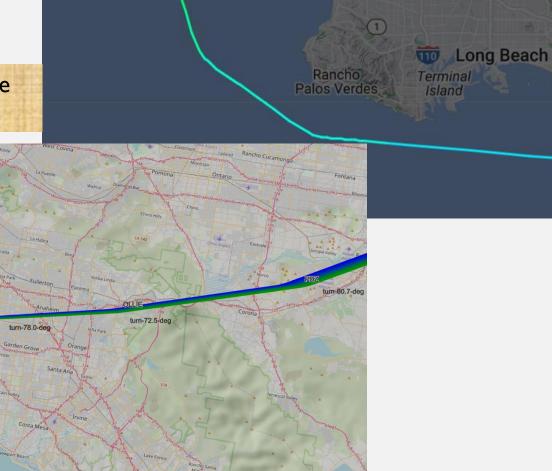
Norwalk

Lakewood Cerritos

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

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

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

airline	Solver Status	aircraft	departureAirport	adepRunway	arrivalAirport	adesRunway	totalCostsUSdollars
American Wings	Optimal	A320	PANC	07L	KATL	26R	46607,34
American Wings	Optimal	A320	KJFK	I3R	LFPG	27L	49660,15
American Wings	Optimal	A320	KSEA	I6L	KJFK	31L	33997,88
American Wings	Optimal	A320	KATL	26R	PANC	07L	46366,89
American Wings	Optimal	A320	KSFO	OIR	KIAD	30	33886,5
American Wings	Optimal	A332	KATL	08L	KBOS	27	23442,15
American Wings	Optimal	A332	KATL	26R	KMSP	17	23408,56
American Wings	Optimal	A332	KORD	22L	KIAH	08L	23438,39
American Wings	Optimal	A332	KIAH	08L	KORD	22L	23003,15
American Wings	Optimal	A332	KMSP	I2R	KATL	26R	23426,2
American Wings	Optimal	B738	KJFK	31L	KSEA	34R	34935,35
American Wings	Optimal	B738	KBOS	27	KATL	08L	15615,51
American Wings	Optimal	B738	KATL	27R	KLAX	07L	28065,68
American Wings	Optimal	B738	KIAD	30	KSFO	IOL	34473,85
American Wings	Optimal	B738	KLAX	07L	KATL	27R	28436,94
							468764,54



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

Only one aircraft type assigned to one leg

Click here to mov	e - Costs per A	vailable S	Seat Miles	a genu					Click to hide
Airline	Solver Status	Aircraft	assigned	Departure	Arrival		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
vricanWings	Optimal	A332	yes	Alaska Anchorage-Ted Stevens Intl	Atlanta-Hartsfield Jackson Intl	234	2996.41	69855.88	0.0996
canWings	Optimal	A332	yes	New York-John F Kennedy Intl	Seattle Tacoma Intl	234	2128.27	51767.68	0.1039
mericanWings	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

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

Only one aircraft

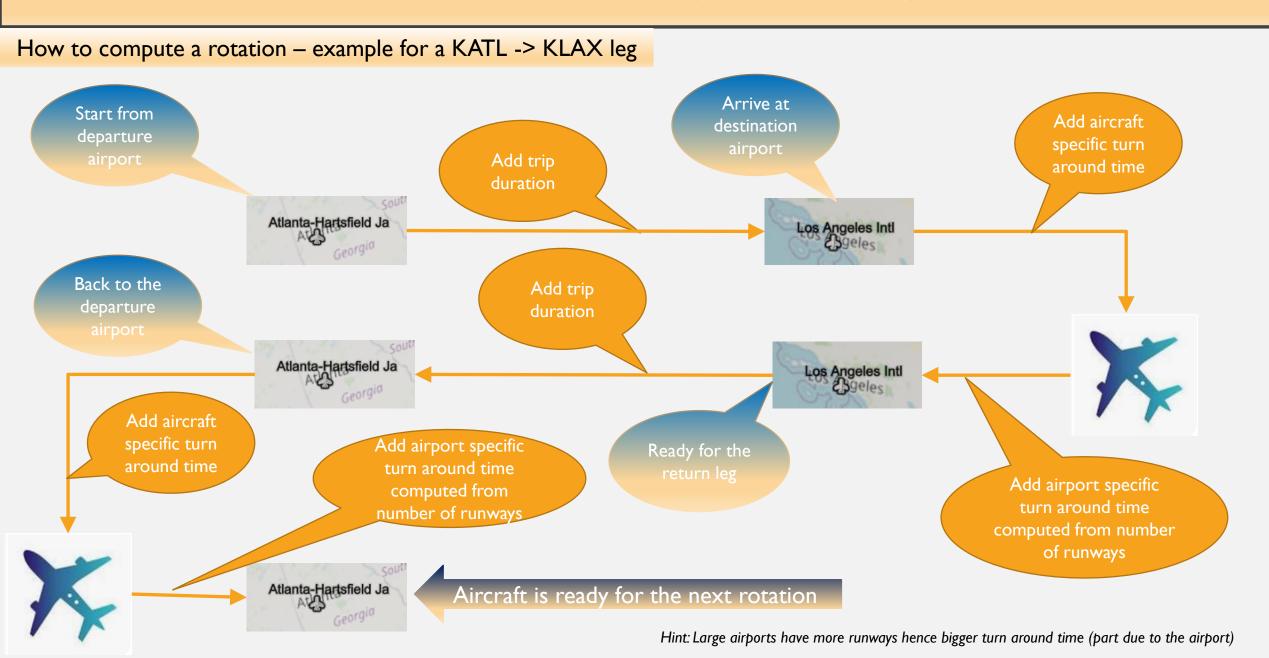
Airline	Aircraft	Solver Status	Assigned	Departure	Arrival	nb Seats	Aircraft Turn Around Times Seconds	Leg Duration Seconds	Leg Distance (miles)	Nb Rotations in 20 hours	Seat Miles Flown 20 hours (miles)
AmericanWings	A320	Optimal	yes	KATL	KMSP	157	150	8288,	854,8156123	3	805236,3068
AmericanWings	A320	Optimal	yes	KMSP	KATL	157	150	7396,	819,990777	3	772431,312
AmericanWings	A320	Optimal	yes	KATL	KBOS	157	150	7502,	7 829,1098923	3	781021,5186
AmericanWings	A320	Optimal	yes	KIAH	KORD	157	150	721:	814,4242528	3	767187,6462
AmericanWings	A320	Optimal	yes	KORD	KIAH	157	150	7362,	815,2396302	2	767955,7316
mericanWings	A332	Optimal	yes	PANC	KATL	234	210	21963,	2996,4090	ı	1402319,417
anWings	A332	Optimal	yes	KJFK	LFPG	234	210	23340,	3214,073888	3	1504186,579
ericanWings	A332	Optimal	yes	KATL	PANC	234	210	22621,	3007,623939)	1407568,004
AmericanWings	A332	Optimal	yes	KATL	KLAX	234	210	13452,4	1 1695,882484	2	1587346,005
AmericanWings	A332	Optimal	yes	KLAX	KATL	234	210	13208,	3 1707,433335	5 2	1598157,602
AmericanWings	B738	Optimal	yes	KJFK	KSEA	160	150	15892,	1 2128,22742	2	1362065,549
AmericanWings	B738	Optimal	yes	KBOS	KATL	160	150	7096,	832,4002601	3	799104,2497
AmericanWings	B738	Optimal	yes	KSEA	KJFK	160	150	15893,	3 2127,289211	2	1361465,095
AmericanWings	B738	Optimal	yes	KIAD	KSFO	160	150	15819,	3 2114,261328	3	1353127,25
AmericanWings	B738	Optimal	yes	KSFO	KIAD	160	150	15688,	3 2112,111338	3	1351751,256
											17620923.52

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

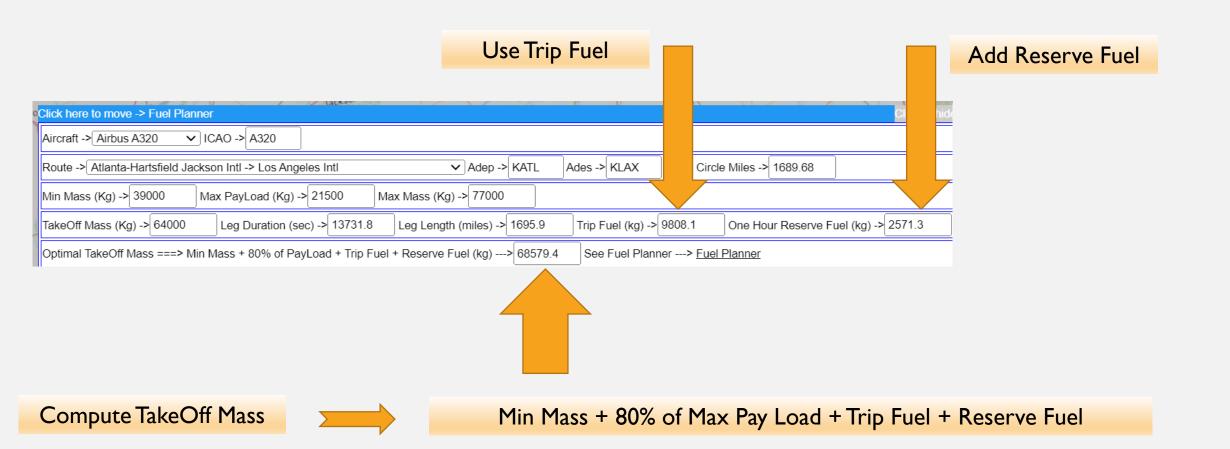
Max Objective function - max Sum Seat Miles 17620923,52 sum



MAXIMIZATIONS (SEAT MILES)



FUEL PLANNER (TAKEOFF MASS ESTIMATION)



DEPARTURE RUNWAY OVERSHOOT (PROGRAMMATIC FEATURE)

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

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



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.

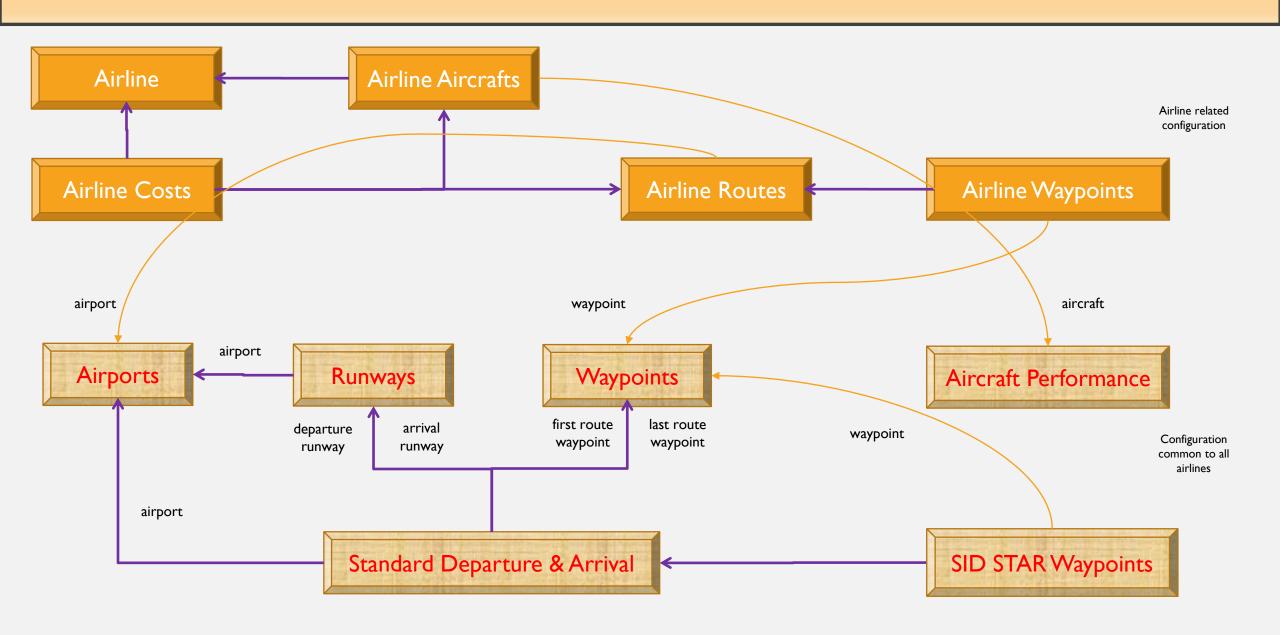
Use the following URL: WayPoints to retrieve the wayPoints.

Use the following URL: <u>Airports</u> to retrieve the airports of the airline.

Use the following URL: Runway overshoot to retrieve the ground run length.

Links to be clicked

DATABASE SCHEMA



AIRLINE SERVICES THANK YOU