Trajectory Data Storage

Jose Manuel Cordero

Introduction

- Data as enabler
- Data in ATM
  - Not too easy to access (propietary, confidential)
  - Many different datasources, not obvious to integrate
  - Different degress of confidence/reliability
  - Not usually massively stored

Introduction

- Some DATACRON/DART strengths:
  - Access to a full dataset of 5+ years available, containing a wide range of different datasources fully stored
  - Experience in the use of such datasets, integration, curation, etc…
  - Operational quality data
- Dataset definition is dependant on the use case (TBO, here)

SCENARIOS

Scenarios considered

- Flight Planning
  - Individual TP
- Flow Management
  - Multiple TP

Flight Planning Scenario

Digits in Field 10a & b

Up to 20 chars in Field 10b !

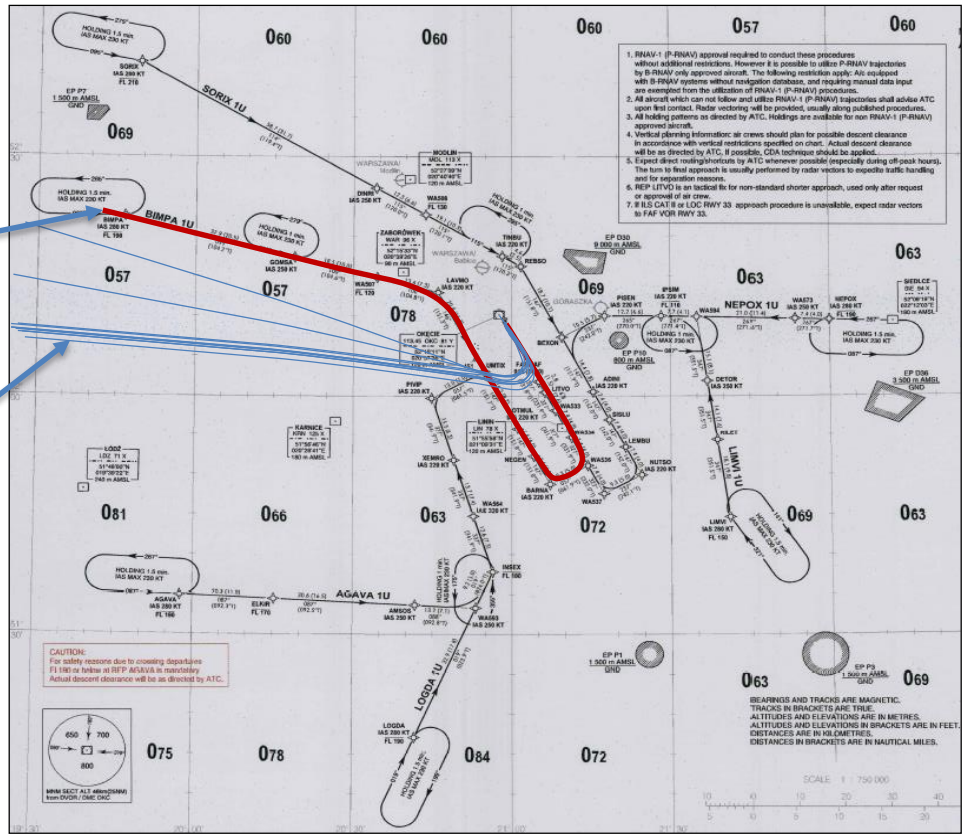
(FPL-EIN105-IS
-B763/H-E3J4M2SRYWX/HB2U2V2G1
-ZZZZ1200
-N0400F100 DENUT UL610 LAM UL10 BPK UN601 LESTA UP6
MIMKU/M082F320 NATB YAY/N0464F320 N188B YRI/N0462F340 DCT NOTAP
DCT TVC PMM5
-KORD0700 KATL
-STS/ATFMX MARSA FLTCK PBN/A1C3L1 NAV/GBAS SBAS DAT/NO
SPECIFIC DESIGNATORS SUR/ADDITIONAL INFO DEP/MALAHIDE
5327N00609W DOF/ 080622 TYP/2F15 3F5 DLE/ NTM0130
ORGN/ EBBDZMFP PER/A TALT/ EIDW RMK/PRESSURISATION PROB
UNABLE ABOVE F120)

New Field or Element
New or Modified content

Model Base Trajectory prediction

≠

Surveillance Data



Flight Planning Scenario

(FPL-EIN105-IS
-B763/H-E3J4M2SRYWX/HB2U2V2G1
-ZZZZ1200
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MIMKU/M082F320 NATB YAY/N0464F320 N188B YRI/N0462F340 DCT NOTAP
DCT TVC PMM5
-KORD0700 KATL
-STS/ATFMX MARSA FLTCK PBN/A1C3L1 NAV/GBAS SBAS DAT/NO
SPECIFIC DESIGNATORS SUR/ADDITIONAL INFO DEP/MALAHIDE
5327N00609W DOF/080622 TYP/2F15 3F5 DLE/NTM0130
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UNABLE ABOVE F120)

Digits in Field 10a & b

Up to 20 chars in Field 10b !

New Field or Element
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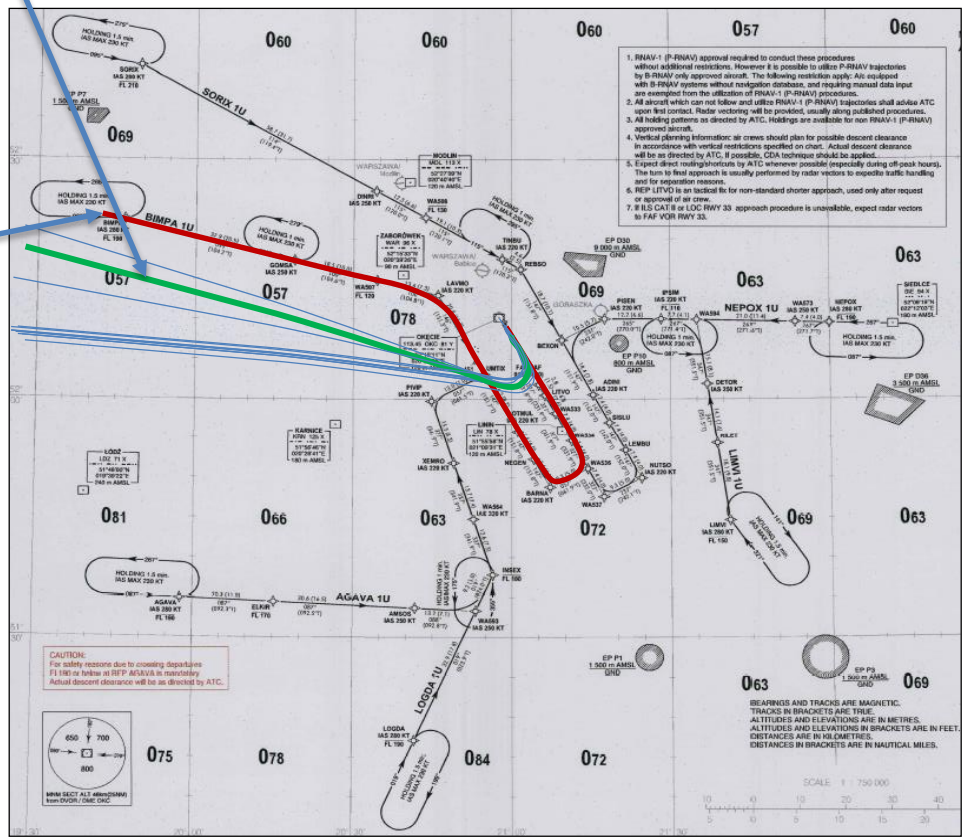
DatACRON Trajectory prediction

Historical data + context data

Model Base Trajectory prediction

≠

Surveillance Data



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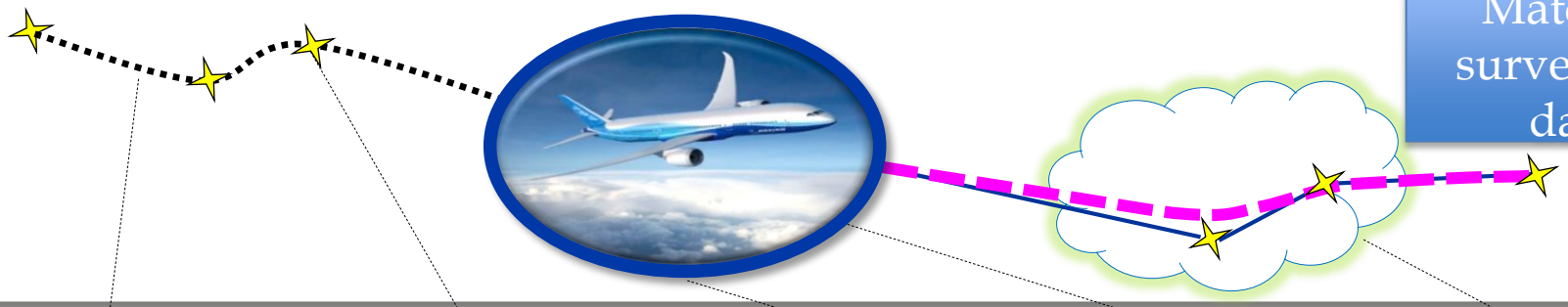
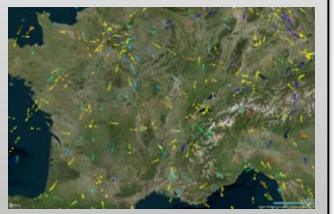
Datasets involved in **model based** Trajectory Prediction

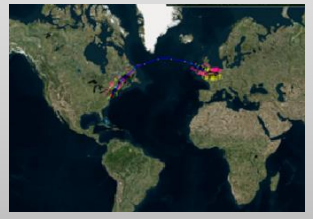


Trajectory Not Matching surveillance data!

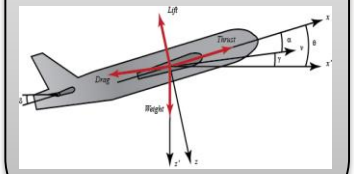
Surveillance



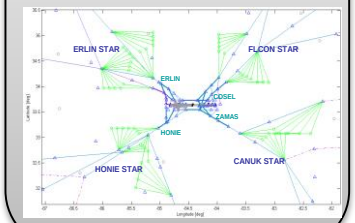
Flight Plan



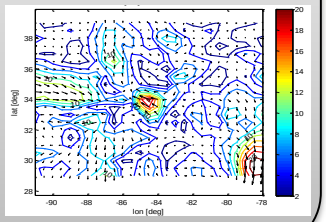
Aircraft Physical Model



Context Information



Meteo Data

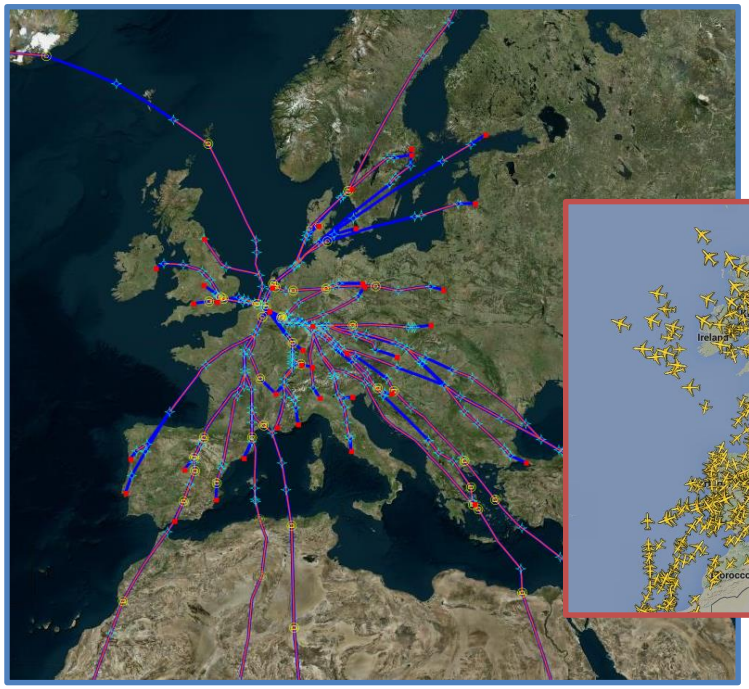


No historical data

Flight Planning Scenario

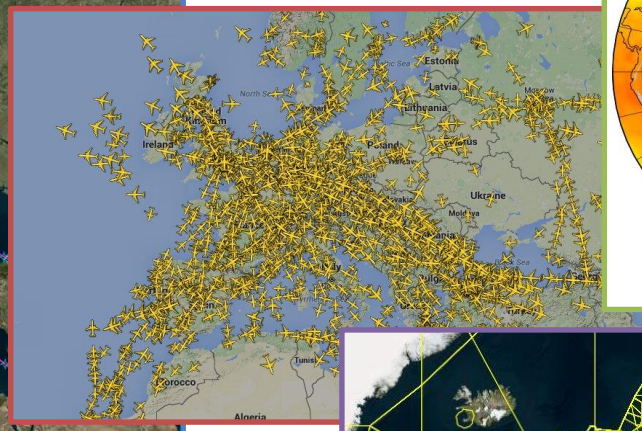
DataSets:

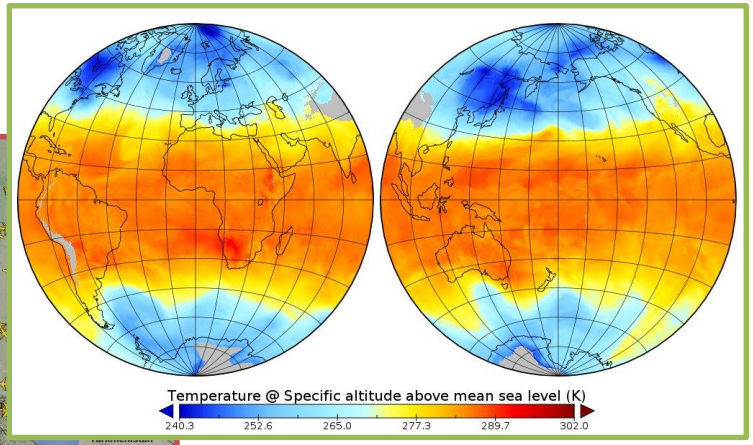
- Collection of initial **Flight Plans**
- Real final trajectories from **Surveillance**
- **Weather forecasts -and real-** and other **context data**

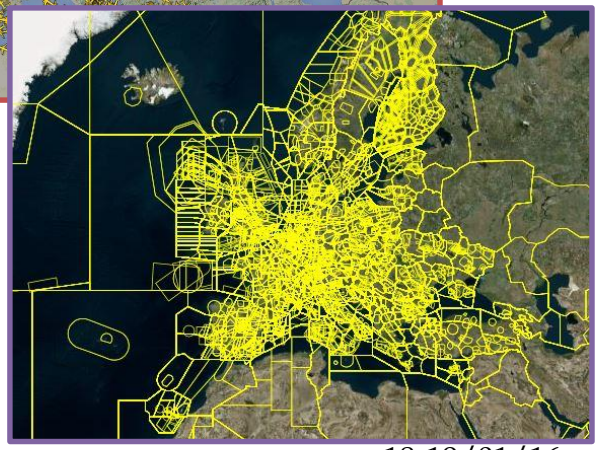


EBBR Outbound Fligh Plans for a 2 hour timeslot

ADS-B Surveillance traffic







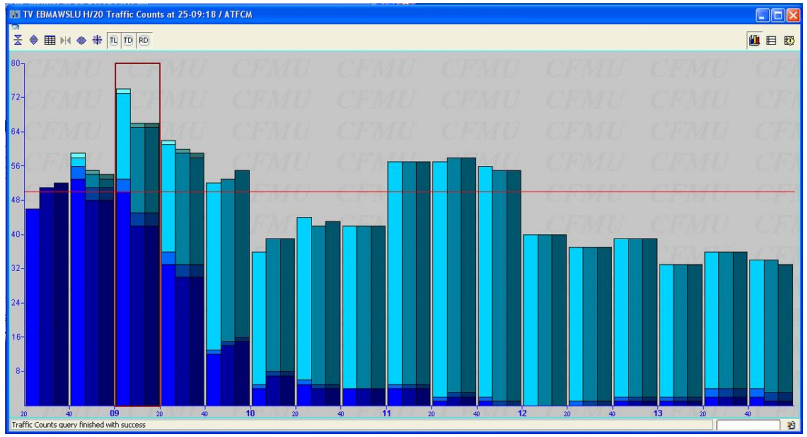
European Sector static information

Flow Management Scenario

- Demand Capacity Balancing problem

- Traffic forecast are inaccurate, relying on partial information, usually deviated. Repetitive events happen and are not used.
- Pattern detection for enhanced Flow Management (objective)
- Consequences:
  - Inefficient Capacity Plan
  - Inefficient Flow Management

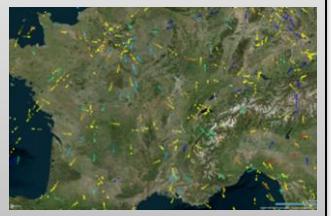
Datasets involved in **current** Flow Management



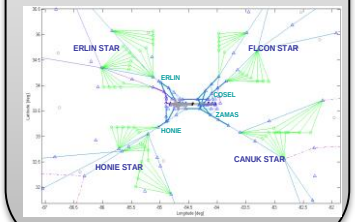
Demand deviates from expected/planned

DatACRON Pattern detection

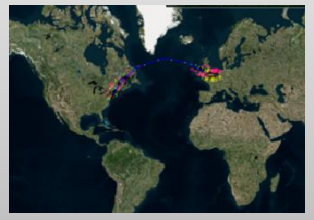
Surveillance



Context Information



Flight Plan



Historic Data

Meteo Data

Not fully used

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Flow Management Scenario

- Datasets:
  - Collection of Flight Plans (current and future)
  - Current trajectories (radar tracks)
  - Context information: Airspace current configuration + catalog of sectorizations
  - Weather forecasts
  - Historical data *(same format as the above ones, stored in a database)*

DATASETS

Overall Sources description: DATACRON

Weather	NOAA
Surveillance	IFS
	ADSB
	DDR
Airspace	DDR
Network Management	CFMU (NM)
Synthetic Trajectories	Synthetic Trajectories
Aircraft Identification	Aircraft Identification
Flight Plan	Network Manager
	DDR
Context Information	Network Manager

ECAC area datasources

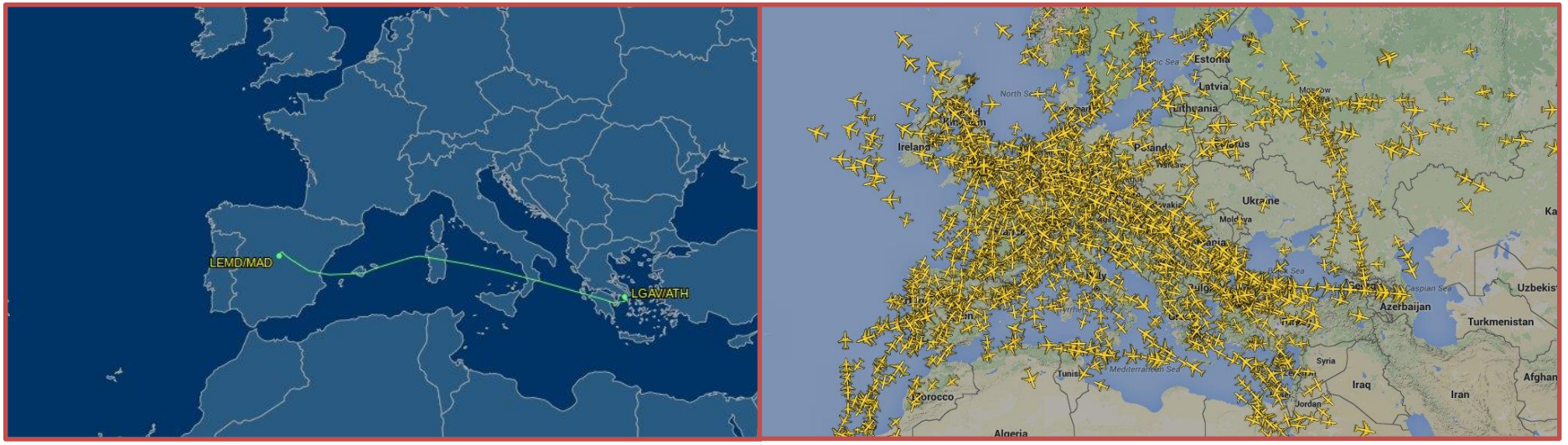
Overall Sources description: DART

Weather	NOAA
	METAR
	SIGMET
Surveillance	IFS
Airspace	Sector configuration
	Link Sectors SC <->GIPV
Flight Plan	GIPV
Network Management	CFMU (NM)

Spain local area datasources (operational data quality)

Data Sources - Surveillance

Detection and measurement of aircraft position, range and bearing combined in some cases with additional information as identity and altitude.



Standards and data format

- ASTERIX CATXX depending on sensor type
- ASDI
- Plain ADS-B (RTCA DO-260)

Sources	Description	Data Structure	Comments
Spanish ATC Radar Data	Radar tracks for all the flights in Spanish airspace	Asterix Cat XX	Historically stored for 7 years
ADSB	Global network of 70 ADS-B stations (53 in Europe)	DO-260 and decoded CSV text	Hundreds of flights 3D position, velocity… etc (all ADS-B message fields) each 0.5 seconds

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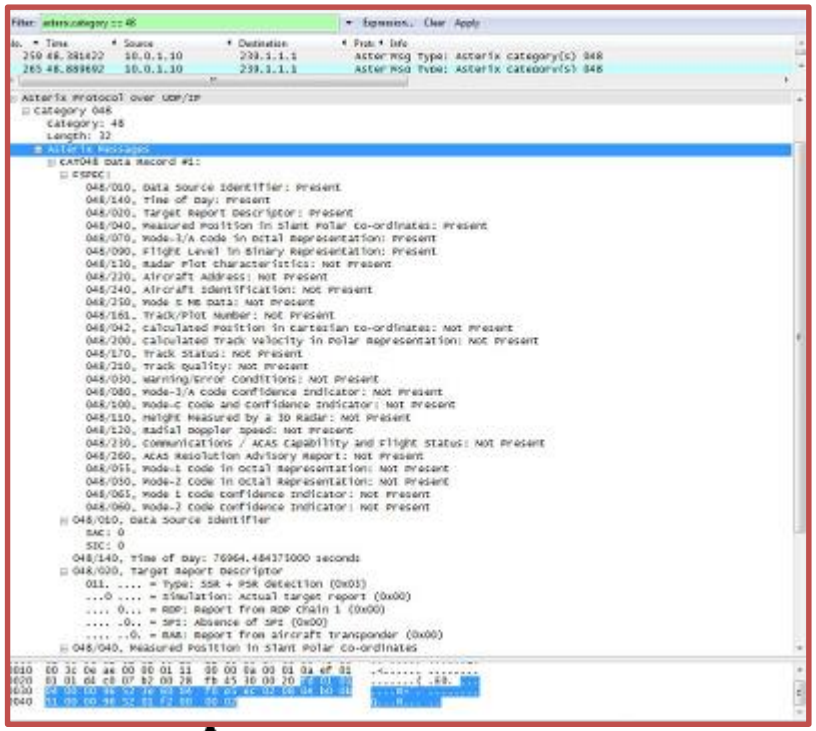
Data Sources - Surveillance

- Update interval is different depending on used sensor or aircraft configuration
- Binary formats, sometimes stored as decoded text
- Individual sensor or combineddata can be analyzed
- ATC systems can provide correlation between Flight Plan and radar data

Data looks like…



Asterix cat 48 Binary decoding

```
MSG,7,111,11111,344146,111111,2015/05/22,11:11:37.888,2015/05/22,11:11:37.853,,8000,,,,,,,,0
MSG,7,111,11111,35350B,111111,2015/05/22,11:11:37.897,2015/05/22,11:11:37.855,,31025,,,,,,,,0
MSG,3,111,11111,4CA258,111111,2015/05/22,11:11:37.900,2015/05/22,11:11:37.904,,2925,,,40.58243,-3.55982,,,,,0
MSG,7,111,11111,4CA258,111111,2015/05/22,11:11:37.912,2015/05/22,11:11:37.907,,2925,,,,,,,,0
MSG,3,111,11111,3964E3,111111,2015/05/22,11:11:37.918,2015/05/22,11:11:37.909,,37000,,,40.34571,-3.51644,,,,,0
MSG,2,111,11111,400490,111111,2015/05/22,11:11:37.930,2015/05/22,11:11:37.911,,0,7,163,40.49609,-3.57005,,,,,,-1
MSG,6,111,11111,4CA6FE,111111,2015/05/22,11:11:37.935,2015/05/22,11:11:37.913,,,,,,4674,0,0,0,0
MSG,8,111,11111,34250C,111111,2015/05/22,11:11:37.936,2015/05/22,11:11:37.914,,,,,,,,,,0
MSG,5,111,11111,4CA6FE,111111,2015/05/22,11:11:37.940,2015/05/22,11:11:37.915,,38000,,,,,,0,,0,0
MSG,3,111,11111,02007A,111111,2015/05/22,11:11:37.959,2015/05/22,11:11:37.918,,40000,,,41.07632,-3.19666,,,,,0
```

Hex	Mode	Sqwk	Flight	Alt	Spd	Hdg	Lat	Long	Sig	Msgs	Ti|
48ada0	S	3443		37000					4	4	0
4ca6a7	S a	3464	RYR3206	28375	434	106			6	101	1
489787	S a	4544	LOT269	32325					4	207	1
ff4504	A	4504							10	5	16
48ad03	S ac	4625	LOT333	36000					6	78	0
4b1618	S ac	4514	SWR1353	36000	412	253	51.414	17.454	19	2111	0
49d063	S ac	6276	CSA903	38000	416	246	51.665	17.725	8	1888	0
4ca811	S a	4762	RYR527D	28525	505	091	52.493	18.004	5	543	5
ff4000	A	4000							14	5	5
ff7004	A	7004							13	7	45
ff1000	A	1000							19	7	16
4ca1ff	S ac	3531	RYR456X	10200	314	153	51.301	17.123	40	3706	0
4b9856	S ac	4704	FHY346	35025	542	142	51.893	18.023	7	1985	0
461f35	S ac	4642	FIN768J	39000	389	028	52.166	17.056	5	1960	5
3c4a23	S a	4510	BER266V	21200					4	1895	7

Decoded ADS-B in CSV format

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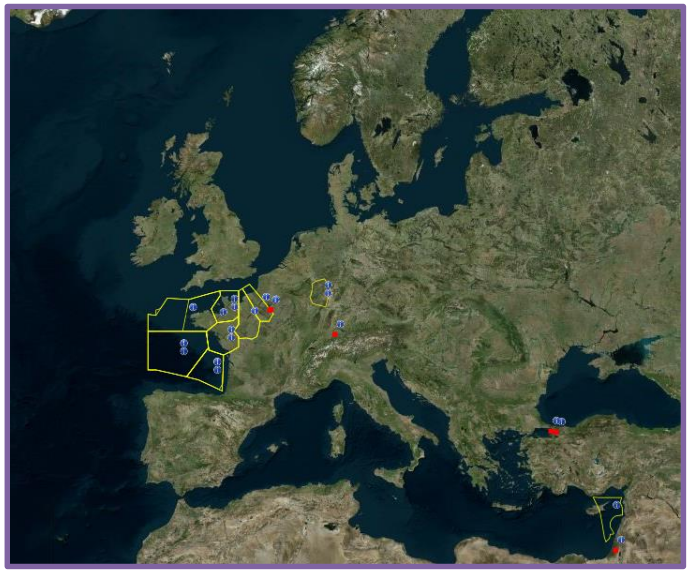
Data sources-Surveillance

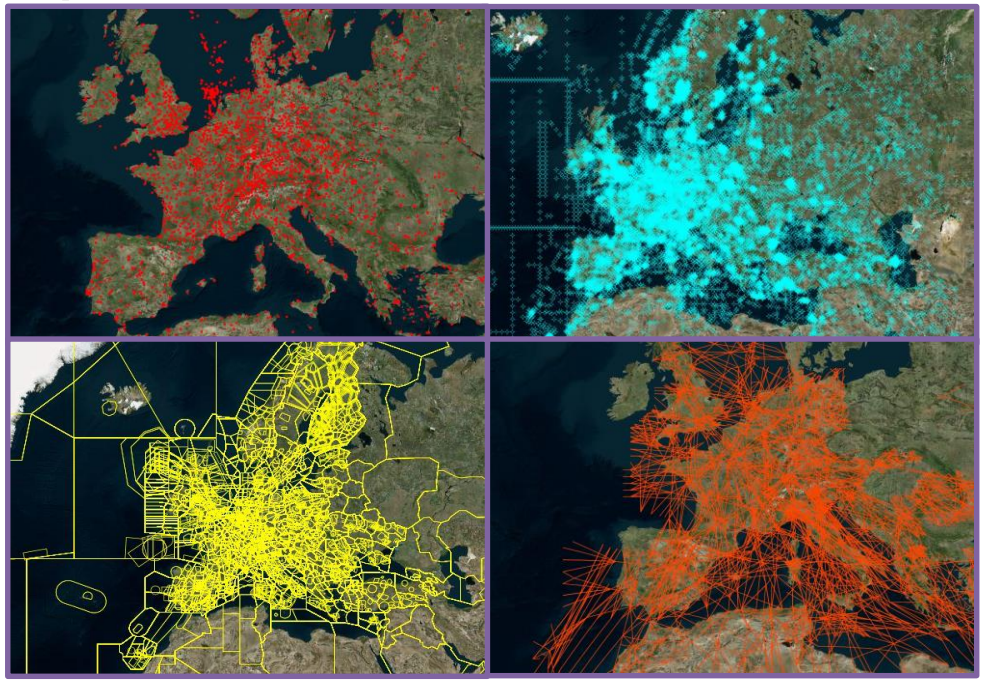
- In DART, and also in DATACRON for calibration: IFS, Spanish operational radars (high quality)
- It includes the flight call sign, altitude, speed, position, direction and time. The information is updated every 5 seconds.
- There is overlap in the limits of the IFS regions
- Callsigns are not unique
- Highest quality, but still presents some issues

Data Sources – Airspace (Context)

Its airspace definition and configuration data. Can be divided in static and dynamic data.
Static data includes (Points, Routes, Aerodromes, procedures and Airspaces)
Dynamic data includes NOTAM, sectorization, flow information



Dynamic Data: Regulation



Static Data: Airports, fixpoints and navaids
Sectors, routes and procedures

Sources	Description	Data Structure	Comments
Spanish ATC Sector Configurations and adaptation Data	Spanish airspace georeferenced data	File and DB. Propietary format.	Historically stored for 7 years
EUROCONTROL Network Manager Airspace Information	Static information	AIXM	Baselines and amendments can be published
EUROCONTROL Network Manager Flow Information	Regulations, hotspots, traffic counts, NOTAM	XML with references to Airspace Information	

Standards and Data Format
- AIXM
- GML

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Data Sources - Airspace (Context)

- Usually static data is loaded into relational databases
- Dynamic reports reference static aerospace data
- Static data is used to decode fligh plan information

Static data is dynamic too… every AIRAC cycle

Data looks like…

```
<flow:TrafficCountsByAircraftOperatorReply xmlns:flight="eurocontrol/cfmu/b2b/FlightServices" xmlns:common="eurocontrol/cfmu/b2b/CommonServices"
xmlns:airspace="eurocontrol/cfmu/b2b/AirspaceServices" xmlns:flow="eurocontrol/cfmu/b2b/FlowServices">
    <requestReceptionTime>2015-02-20 18:47:47</requestReceptionTime>
    <requestId>123456</requestId>
    <sendTime>2015-02-20 18:47:47</sendTime>
    <status>OK</status>
    <data>
        <effectiveTrafficWindow>
            <wef>2014-04-02 12:00</wef>
            <unt>2014-04-03 00:00</unt>
        </effectiveTrafficWindow>
        <counts>
            <item>
                <key>
                    <wef>2014-04-02 12:00</wef>
                    <unt>2014-04-02 12:05</unt>
                </key>
                <value>
                    <item>
                        <key>DEMAND</key>
                        <value>
                            <totalCounts>100</totalCounts>
                            <subTotalsCounts>
                                <item>
                                    <key>ATC_ACTIVATED</key>
                                    <value>10</value>
                                </item>
                                <item>
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                                <item>
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                                </item>
                                <item>
                                    <key>TACT_ACTIVATED_WITHOUT_FSA</key>
                                    <value>0</value>
                                </item>
                                <item>
                                    <key>IFPL</key>
                                    <value>30</value>
```

Regulations

```
- <generalinformation:AIMRetrievalReply>
    <requestReceptionTime>2016-01-13 08:40:16</requestReceptionTime>
    <requestId>B2B_CUR:2015696</requestId>
    <sendTime>2016-01-13 08:40:16</sendTime>
    <status>OK</status>
  - <data>
    - <aim>
      - <summary>
          <id>00001585</id>
        - <validityPeriod>
            <wef>2016-01-13</wef>
            <unt>2016-01-13</unt>
          </validityPeriod>
          <releaseTime>2016-01-13 01:25</releaseTime>
          <description>TAXI TIME EHAM</description>
        </summary>
      - <message>
          TAXI TIME EHAM Valid from : 2016-01-13 Valid until : 2016-01-13 Released : 2016-01-13 01:25:26
          TACT/CASA INFORMATION MESSAGE . 1 REF : TAXI TIME EHAM . 2 VALID : WEF 13-01:20
          UNTIL 13-05:12 UTC TAXI TIME 18 MIN . 3 REMARK : CTOT FOR FLIGHTS DEPARTING IN THE
          ABOVE PERIOD WILL BE CALCULATED ACCORDING TO THE NEW TAXI TIME AND SLOT
          REVISION MESSAGES MAY BE ISSUED. . 4 THE INDIVIDUAL TAXI-TIMES PER FLIGHT THAT
          ARE PROVIDED BY AIRPORTS SUCH AS CDM AIRPORTS KEEP PRIORITY OVER DEFAULT OR
          UPDATED GLOBAL TAXI-TIMES AS SPECIFIED ABOVE. . NETWORK OPERATIONS - BRUSSELS
        </message>
      </aim>
    </data>
  </generalinformation:AIMRetrievalReply>
```

Taxi times report

```
<?xml version='1.0' encoding='utf-8'?><adrmsg:ADRMessage gml:id="ID_293_1445479478399_1" xmlns:adrmsg="http://www.eurocontrol.int/cfmu/b2b/ADRMessage" xmlns:adrext="http://www.aixm.aero/schema/5.1/extensions/EUR/ADR"
xmlns:gml="http://www.opengis.net/gml/3.2" xmlns:aixm="http://www.aixm.aero/schema/5.1" xmlns:xlink="http://www.w3.org/1999/xlink">
<adrmsg:hasMember><aixm:DesignatedPoint gml:id="ID_293_1445479478399_2"><gml:identifier codeSpace="urn:uuid:">cd89af27-1290-463c-a70d-88ae5885520b</gml:identifier><aixm:timeSlice><aixm:DesignatedPointTimeSlice
gml:id="ID_293_1445479478399_3"><gml:validTime><gml:TimePeriod gml:id="ID_293_1445479478399_4"><gml:beginPosition>2006-06-08T00:00:00</gml:beginPosition><gml:endPosition
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gml:id="ID_293_1445479478399_5"><gml:beginPosition>2006-06-08T00:00:00</gml:beginPosition><gml:endPosition
indeterminatePosition="unknown"></gml:endPosition></gml:TimePeriod></aixm:featureLifetime><aixm:type>COORD</aixm:type><aixm:name>23N040W</aixm:name><aixm:location><aixm:Point gml:id="ID_293_1445479478399_6"><gml:pos
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<adrmsg:hasMember><aixm:DesignatedPoint gml:id="ID_293_1445479478399_7"><gml:identifier codeSpace="urn:uuid:">5c624967-f279-4113-81a3-3cec7e868b85</gml:identifier><aixm:timeSlice><aixm:DesignatedPointTimeSlice
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gml:id="ID_293_1445479478399_10"><gml:beginPosition>2006-06-08T00:00:00</gml:beginPosition><gml:endPosition
indeterminatePosition="unknown"></gml:endPosition></gml:TimePeriod></aixm:featureLifetime><aixm:type>COORD</aixm:type><aixm:name>26N045W</aixm:name><aixm:location><aixm:Point gml:id="ID_293_1445479478399_11"><gml:pos
srsName="urn:ogc:def:crs:EPSG::4326">26.0 -45.0</gml:pos></aixm:Point></aixm:location></aixm:DesignatedPointTimeSlice></aixm:timeSlice></aixm:DesignatedPoint></adrmsg:hasMember>
```

AIXM fixpoins

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HORIZON 2020

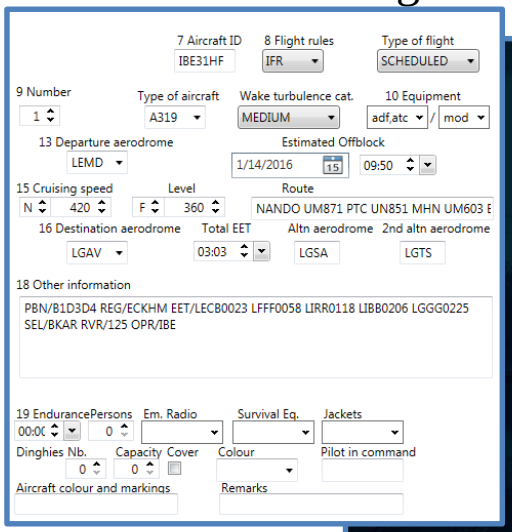
Data sources-Airspace (Context)

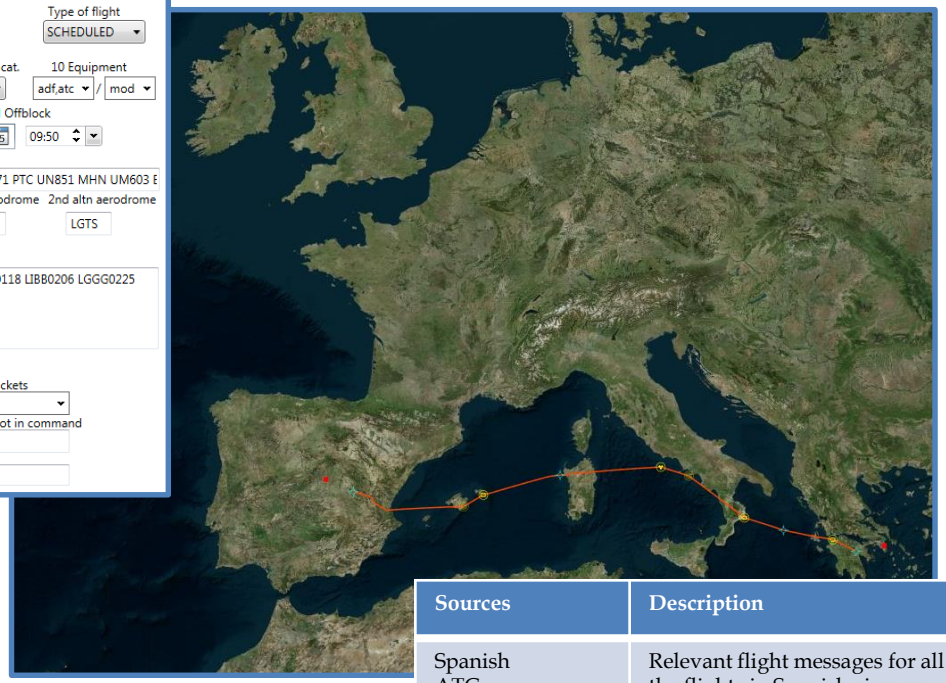
In DART, Spanish operational Datasource: ISE

- Addressing both airspace design and Schedule of sector configurations deployed
- **Sector configuration**:
    1. Table of volumes, sectors and configurations (catalog)
    2. Schedule of actual configurations in place per day
- Spanish operational information (ISE), presents some roblems in the transitions
- **Link Sectors SC <-> GIPV:**
    - "synthetic" datasource, produced in-house to facilitate the link between flight plan info and sector configurations
    - Due to particularities of Spanish ATC system, the operational sectors are not used, but volumes (SACTA sector)
    - This allows data users to know for each flight plan point related to a sector-volume SACTA the corresponding official sector

Data Sources - Flight Plan

Specified information provided to air traffic services units, relative to an intended flight or portion of a flight of an aircraft.





Sources	Description	Data Structure	Comments
Spanish ATC Platform Flight Plan Data	Relevant flight messages for all the flights in Spanish airspace (Flight plan creation, deletion and major updates, sector entry, sector leave,…)	ICAO 4444 + Amendments (FPL 2012)	For all the Spanish airspace, 1 Gb/day. Historically stored for 7 years. Streaming can be emulated
Network Manager Flight Information	Flight history for inbound and outbound flights in European Airspace	NM 19.0.0 - NOP/B2B Reference Manuals – FlightServices	

Standards and Data Format
- ICAO 4444 + amendments
- NM 19.0.0 - NOP/B2B Reference Manuals – FlightServices
- FIXM

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Data Sources – Flight Plan

- FP envolves in time
- Text easy to parse
- Normally not directly georeferenced, but links to Airspace information that is

Data looks like…

```
<flight:FlightRetrievalReply xmlns:flight="eurocontrol/cfmu/b2b/FlightServices" xmlns:common="eurocontrol/cfmu/b2b/CommonServices" xmlns:airspace="eurocontrol/cfmu/b2b/AirspaceServices"
xmlns:flow="eurocontrol/cfmu/b2b/FlowServices">
    <requestReceptionTime>2015-02-20 18:47:48</requestReceptionTime>
    <requestId>123456</requestId>
    <sendTime>2015-02-20 18:47:48</sendTime>
    <status>OK</status>
    <data>
        <flightPlan>
            <aerodromeOfDeparture>
                <icaoId>EBBR</icaoId>
            </aerodromeOfDeparture>
            <aerodromesOfDestination>
                <aerodromeOfDestination>
                    <icaoId>LBSF</icaoId>
                </aerodromeOfDestination>
                <alternate1>
                    <icaoId>LBPD</icaoId>
                </alternate1>
                <alternate2>
                    <icaoId>LBBG</icaoId>
                </alternate2>
            </aerodromesOfDestination>
            <aircraftId>
                <aircraftId>LZB406</aircraftId>
            </aircraftId>
            <numberOfAircraft>1</numberOfAircraft>
            <aircraftType>
                <icaoId>A319</icaoId>
            </aircraftType>
            <totalEstimatedElapsedTime>0225</totalEstimatedElapsedTime>
            <wakeTurbulenceCategory>MEDIUM</wakeTurbulenceCategory>
            <flightType>SCHEDULED</flightType>
            <flightRules>IFR</flightRules>
            <estimatedOffBlockTime>2010-04-29 07:50</estimatedOffBlockTime>
            <icaoRoute>N0455F390 SOPOK UY863 ETENO Y863 RUDUS UL984 ESATI UL603 OBEDI UN739 NISVA</icaoRoute>
            <equipmentCapabilityAndStatus>
                <dme>EQUIPPED</dme>
                <hfRtf>EQUIPPED</hfRtf>
                <inertialNavigation>EQUIPPED</inertialNavigation>
                <standard>EQUIPPED</standard>
                <rvsm>EQUIPPED</rvsm>
                <khz833>EQUIPPED</khz833>
            </equipmentCapabilityAndStatus>
            <surveillanceEquipment>
                <modeS>NOT_EQUIPPED</modeS>
            </surveillanceEquipment>
            <otherInformation>
                <nameOfOperator>LZB</nameOfOperator>
                <otherRemarks>REG/LZFBA</otherRemarks>
            </otherInformation>
        </flightPlan>
    </data>
</flight:FlightRetrievalReply>
```

NM XML Flight Plan

```
(FPL-AAL69-IS
-B772/H-SDE1E3FGHIJ4J5M1RWXYZ/D1L
-LEMD1120
-N0487F290 ZMR UL155 ADORO DCT EPOPO DCT ARMED/M084F300 DCT
43N020W 43N030W 42N040W 41N050W DCT SOORY/N0485F360 M204 SUMRS
A699 PERMT DCT OSOGY HILEY6
-KMIA0949 KPBI
-PBN/A1B1C1D1L1O1S2T1 NAV/RNVD1E2A1 DOF/160114 REG/N783AN
 EET/LPPC0028 LPPO0119 020W0158 030W0255 KZWY0351 050W0451
 SOORY0608 LUNKR0706 BEXUM0743 KZMA0856 SEL/JLRS
RMK/NRP)
```

ICAO 4444 FPL 2012 Flight Plan

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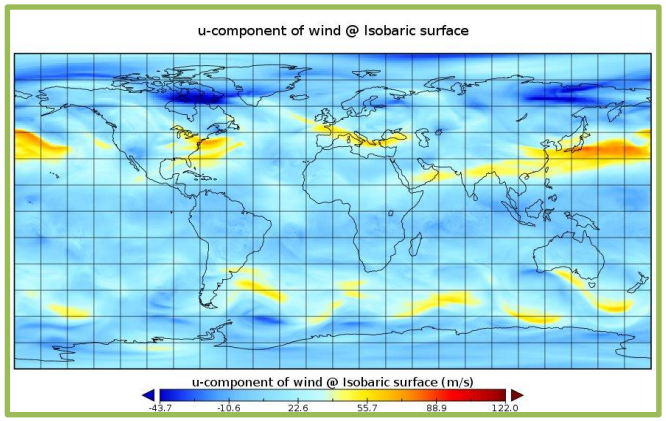
Data Sources-Flight Plan

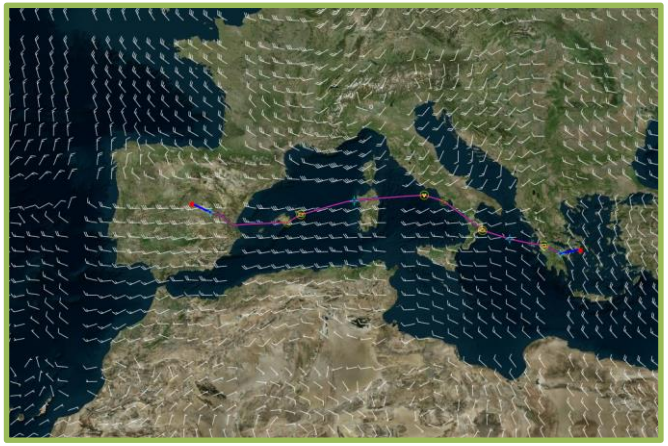
- ***What if you need all the changes in Flight Plan, not just initial and final?***

- Single data source (GIPV, *Flight Plan Information Management System*) used, a subsystem of the Spanish ATC platform.
- Contains information on every flight plan currently in flight or scheduled to fly. All the changes and cancellations that affect flight plans are constantly updated and registered in the system.
- Contains all intermediate Flight Plans per flight, allowing snapshots
- Covers all flight plans which are flying or going to fly in the near future (to 15 hours) in the responsibility airspace

Data Sources: Weather

Involving predictions and observations





Sources	Description	Data Structure	Comments
ECMWF	Re-analyses from 1979 to date. Useful for climatological purposes	Original data: 6-hourly Analyses from 1979 to date. 0.72 degree horizontal resolution, over Surface and 37 vertical pressure levels. Climatological data: means, medians and standard deviations for all relevant variables at surface	Limited by ECMWF data Policy The Statistical variable might be daily, monthly or number of occurrences per month or… depending upon the variable type. On demand other statistical indicators can be calculated.
ECMWF	Simultaneous forecast of the same model run with slightly different initial conditions High Resolution Global Model	15 days forecasts with 3 hourly time step of 51 parallel forecasts (ensemble members). 0.25 degrees horizontal resolution, several vertical pressure levels . Two drops a day (00,12Z) Up to 10 days forecast time range and 3 hourly /hourly time step. 0.125 degrees horizontal resolution, several vertical levels both pressure and hybrid. Two drops a day (00,12Z)	Derived quantities like Ensemble means, STD, probabilities can be made available over the period and area requested. Need to decide which variable and which level make available.
NCEP	Simultaneous forecast of the same model run with slightly different initial conditions High Resolution Global Model	15 days forecasts with 3 hourly time step of 20 parallel forecasts (ensemble members). 0.50 degrees horizontal resolution, several vertical pressure levels . Four drops a day (00,06,12,18Z) Up to 10 days forecast time range and 3 hourly /hourly time step. 0.25 degrees horizontal resolution, several vertical levels both pressure and hybrid. Four drops a day (00,06,12,18Z)	Derived quantities like Ensemble means, STD, probabilities can be made available over the period and area requested. Need to decide which variable and which level make available.
Boeing	High Resolution Regional Model	Up to 72 hours forecast time range with hourly time steps. 0.1 degrees horizontal resolution, several vertical levels both pressure and hybrid. Nested on: ECMWF Global model (two drops a day 00Z and 12Z) NCEP Global Model (4 drops a day - 00, 06,12, 18Z)	
Several Public Insitution	TAF: official forecasts for airposts METAR: officially weather variables measured at airports	TAFs are valid for a 30 hour time period and are issued 4 times a day at 6 hour intervals. The forecast includes forecasted wind speed, wind direction, visibility, ceiling, type of precipitation (i.e. snow, rain, etc.) and/or weather phenomenon. METAR are issued hourly and also whenever there is specific phenomena to be highlighted.	A few years of data are already available

Standards and Data Format

- GRIB / GRIB-2
- netCDF
- TAF
- METAR

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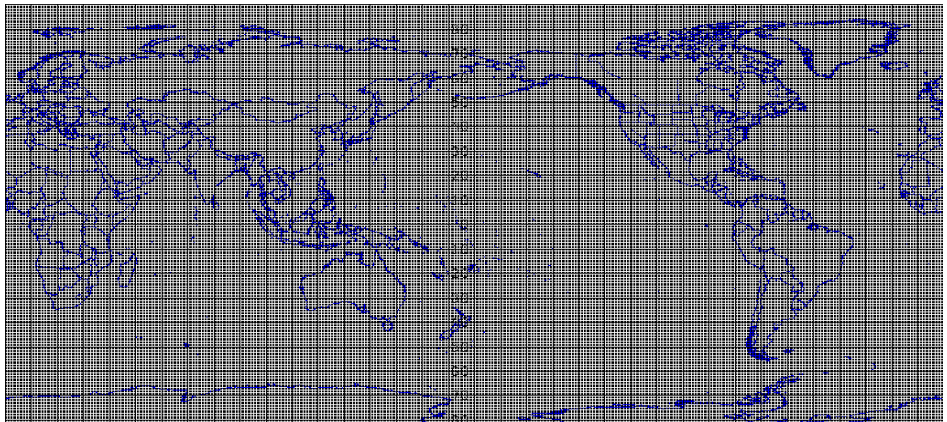
Data sources-Weather

- Three weather datasources considered: NOAA, METAR, SIGMET

- **NOAA** *(National Oceanic and Atmospheric Administration)*: Weather predictions at world level, every 6 hours with information 7 days in advance. Used mainly to obtain the weather conditions at the position an aircraft is at any given time of the flight.
- Most relevant variables: Temperature, Pressure, the two horizontal components of the Wind Speed, since they affect the performance of the aircraft.
- NCEP Grid 4 which has a resolution of 0.5°



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Data sources-Weather

- **METAR**: Airports' weather information (Spanish airports).

- METARs typically come from airports or permanent weather observation stations. Reports are generated once an hour or half-hour, but if conditions change significantly, a report known as a special (SPECI) may be issued.
- Raw METAR is the most common format in the world for the transmission of observational weather data (ICAO standardized)

Data sources -Weather

- **SIGMET**: Information of actual or anticipated adverse weather conditions/phenomena (en-route or at the airports approach, in Spain).

- SIGMET data are weather advisory that contains meteorological information concerning the safety of all aircrafts. This information is usually broadcast on the ATIS at ATC facilities.

- SIGMETs are issued as needed, and are valid up to four hours. SIGMETS for hurricanes and volcanic ash are valid up to six hours.

Data Sources - Weather

- TAF and METAR are formatted text. The rest of formats are binary
- Most relevant in model based trajectory prediction are winds and temperatura that are the ones the pilot inputs in the Flight Management Computer.

Data looks like…

```
TAKE-OFF AND LANDING REPORT BER8765 EDDN-EDDH
TOPCAT 2.71 26SEP11 16:21Z
A/C D-ABLA B737-800 CFM56-7B26

ALL WEIGHTS IN KILOGRAMS

//////// AIRPORTS ////////

TAKEOFF: EDDN/NUE  NURNBERG          RWY 28 FLAPS 5        ELEV. 1046FT (  319M)
LANDING: EDDH/HAM  HAMBURG           RWY 33 FLAPS 30       ELEV.   53FT (   16M)

//////// WEATHER ////////

EDDN 261550Z VRB02KT CAVOK 23/12 Q1025 NOSIG <- METAR
EDDN 261100Z 2612/2712 12003KT CAVOK
     BECMG 2623/2701 2000 BCFG
     TEMPO 2701/2707 0400 FG VV002          <- TAF
     BECMG 2707/2709 CAVOK

EDDH 261550Z 25006KT 9999 FEW042TCU SCT250 23/
EDDH 261100Z 2612/2718 20005KT CAVOK
     BECMG 2616/2619 VRB03KT BKN012
     TEMPO 2617/2709 3500 SHRA BKN007 PROB30
     TEMPO 2623/2707 1200 BR BKN004
     BECMG 2709/2711 BKN015
```

TAF and METAR

Pressure_tropopause	Pressure @ Tropopause	Geo2D
reftime	GRIB reference time	—
Relative_humidity_entire_atmosphere_single_layer	Relative humidity @ Entire atmosphere la...	Geo2D
Relative_humidity_height_above_ground	Relative humidity @ Specified height level...	Geo2D
Relative_humidity_highest_tropospheric_freezing	Relative humidity @ Highest tropospheric...	Geo2D
Relative_humidity_isobaric	Relative humidity @ Isobaric surface	Geo2D
Relative_humidity_pressure_difference_layer	Relative humidity @ Level at specified pre...	Geo2D
Relative_humidity_sigma	Relative humidity @ Sigma level	Geo2D
Relative_humidity_sigma_layer	Relative humidity @ Sigma level layer	Geo2D
Relative_humidity_zeroDegC_isotherm	Relative humidity @ Level of 0°C isotherm	Geo2D
sigma	Sigma level	—
sigma_layer	Sigma level	1D
sigma_layer_bounds	bounds for sigma layer	2D
Snow_depth_surface	Snow depth @ Ground or water surface	Geo2D
Soil_temperature_depth_below_surface_layer	Soil temperature @ Depth below land sur...	Geo2D
Specific_humidity_height_above_ground	Specific humidity @ Specified height level...	Geo2D
Specific_humidity_pressure_difference_layer	Specific humidity @ Level at specified pre...	Geo2D
Storm_relative_helicity_height_above_ground_layer	Storm relative helicity @ Specified height ...	Geo2D
Sunshine_Duration_surface	Sunshine Duration @ Ground or water su...	Geo2D
Surface_Lifted_Index_surface	Surface Lifted Index @ Ground or water s...	Geo2D
Temperature_altitude_above_msl	Temperature @ Specific altitude above m...	Geo2D
Temperature_height_above_ground	Temperature @ Specified height level ab...	Geo2D
Temperature_isobaric	Temperature @ Isobaric surface	Geo2D
Temperature_maximum_wind	Temperature @ Maximum wind level	Geo2D
Temperature_potential_vorticity_surface	Temperature @ Potential vorticity surface	Geo2D
Temperature_pressure_difference_layer	Temperature @ Level at specified pressu...	Geo2D
Temperature_sigma	Temperature @ Sigma level	Geo2D
Temperature_surface	Temperature @ Ground or water surface	Geo2D
Temperature_tropopause	Temperature @ Tropopause	Geo2D
time	GRIB forecast or observation time	—

Available datasets in a GRIB-2 binary file

X-Axis: lon (degrees_east)

Y-Axis: lat (degrees_north)	0.0000	0.250	0.500	0.750	1.000	1.250	1.500	1.750	2.000	2.250	2.500	2.7	Avg.
90.000	-43.4	-43.4	-43.4	-43.4	-43.4	-43.5	-43.5	-43.5	-43.5	-43.5	-43.6		0.0
89.750	-42.0	-42.0	-42.0	-42.0	-42.0	-42.0	-42.1	-42.1	-42.1	-42.1	-42.1		0.8
89.500	-40.6	-40.6	-40.6	-40.6	-40.7	-40.7	-40.7	-40.7	-40.7	-40.7	-40.7		1.6
89.250	-39.2	-39.2	-39.3	-39.3	-39.3	-39.3	-39.3	-39.3	-39.3	-39.3	-39.3		2.4
89.000	-37.9	-37.9	-37.9	-37.9	-37.9	-38.0	-38.0	-38.0	-38.0	-38.0	-38.0		3.2
88.750	-36.6	-36.6	-36.6	-36.6	-36.6	-36.7	-36.7	-36.7	-36.7	-36.7	-36.7		4.1
88.500	-35.4	-35.4	-35.4	-35.4	-35.4	-35.4	-35.4	-35.4	-35.4	-35.4	-35.4		4.9
88.250	-34.2	-34.2	-34.2	-34.2	-34.2	-34.2	-34.2	-34.2	-34.2	-34.2	-34.2		5.7
88.000	-33.0	-33.0	-33.1	-33.1	-33.1	-33.1	-33.1	-33.1	-33.1	-33.1	-33.1		6.5
87.750	-31.9	-31.9	-31.9	-32.0	-32.0	-32.0	-32.0	-32.0	-31.9	-31.9	-31.9		7.3
87.500	-30.9	-30.9	-30.9	-30.9	-30.9	-30.9	-30.9	-30.9	-30.9	-30.9	-30.9		8.1
87.250	-29.8	-29.8	-29.8	-29.8	-29.8	-29.8	-29.8	-29.8	-29.8	-29.8	-29.8		8.9
87.000	-28.7	-28.7	-28.7	-28.7	-28.7	-28.7	-28.7	-28.7	-28.7	-28.7	-28.7		9.6
86.750	-27.7	-27.7	-27.7	-27.7	-27.7	-27.7	-27.7	-27.7	-27.7	-27.7	-27.7		10.4
86.500	-26.7	-26.7	-26.7	-26.7	-26.7	-26.6	-26.6	-26.6	-26.6	-26.6	-26.6		11.2
86.250	-25.7	-25.7	-25.7	-25.7	-25.7	-25.7	-25.7	-25.7	-25.7	-25.6	-25.6		12.0
86.000	-24.7	-24.7	-24.7	-24.7	-24.7	-24.7	-24.7	-24.7	-24.7	-24.7	-24.7		12.8
85.750	-23.8	-23.8	-23.8	-23.8	-23.8	-23.8	-23.8	-23.8	-23.8	-23.8	-23.8		13.5
85.500	-22.9	-22.9	-22.9	-22.9	-22.9	-22.9	-22.9	-22.9	-22.9	-22.9	-22.9		14.3
85.250	-22.0	-22.0	-22.0	-22.0	-22.0	-22.0	-22.0	-22.0	-22.0	-22.0	-21.9		15.1
85.000	-21.0	-21.0	-21.0	-21.0	-21.0	-21.0	-21.0	-21.0	-21.0	-21.0	-21.0		15.8
84.750	-20.1	-20.1	-20.1	-20.1	-20.1	-20.1	-20.1	-20.1	-20.1	-20.1	-20.1		16.6
84.500	-19.1	-19.1	-19.1	-19.1	-19.1	-19.1	-19.1	-19.1	-19.1	-19.1	-19.1		17.3
84.250	-18.2	-18.2	-18.2	-18.2	-18.2	-18.2	-18.2	-18.2	-18.2	-18.2	-18.2		18.0
84.000	-17.2	-17.2	-17.2	-17.2	-17.2	-17.2	-17.2	-17.2	-17.2	-17.2	-17.2		18.8
83.750	-16.3	-16.3	-16.3	-16.3	-16.3	-16.3	-16.3	-16.3	-16.3	-16.3	-16.3		19.5
83.500	-15.4	-15.4	-15.4	-15.4	-15.4	-15.4	-15.4	-15.4	-15.4	-15.4	-15.4		20.2

GRID-2 Dataset 2D table decoded from Binary

Data sources-Network

- CFMU, coming from the Network Management, thus covering European airspace. CFMU is the former name of the current Network Manager
- Addresses the regulations put in place to ensure a proper Demand Capacity balance in a tactical way.
- The source is one table for flights. When a flight has a regulation, the code of the regulation applied is provided on the row.

Other data sources

- Synthetic data: Trajectories generated by TP

- Aircraft identifier: Details of the aircraft in known trajectory.
  - In ADSB sources the aircraft is identified by ICAO 24-bit address or (informally) Mode-S "hex code".
  - Model of the aircraft, or more specifically, the ICAO Type Designator, according to DOC 8643.

Datasets: An example

AirspaceStructures-SC	354.6 MB
FlightPlans-GIPV	52.81 GB
NetworkManagement-CFMU	908 MB
RadarTracks-IFS	95 GB
SC_vs_FP	1 MB
Weather-METAR	106 MB
Weather-NOAA	13 TB
Weather-SIGMET	15 MB
TOTAL	**14 TB**

DART: 2 years of operational data in Spain

- 2 years of operational data
- 4 Millions of Flights (4106320 flights)
- 2.5 Billions of Radar points (2714042496 points)
- 1 Billion of Flight Plan Route points (1003734563 points)
- 89 Millions of Flight Plan messages (89903772 messages)

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Conclussions

- The vast datasets available have allowed to develop DATACRON & DART results
- Heterogeneity of data
- It has also presented challenges in terms of integration and management (next presentation)