



# START “a Stable and resilient ATM by integrating Robust airline operations into the network”



Andrés Muñoz  
Boeing Deutschland GmbH  
WP2 leader of START Project

Dr. Manuel Soler  
Associate Professor, Aerospace Engineering at UC3M  
Coordinator of START Project

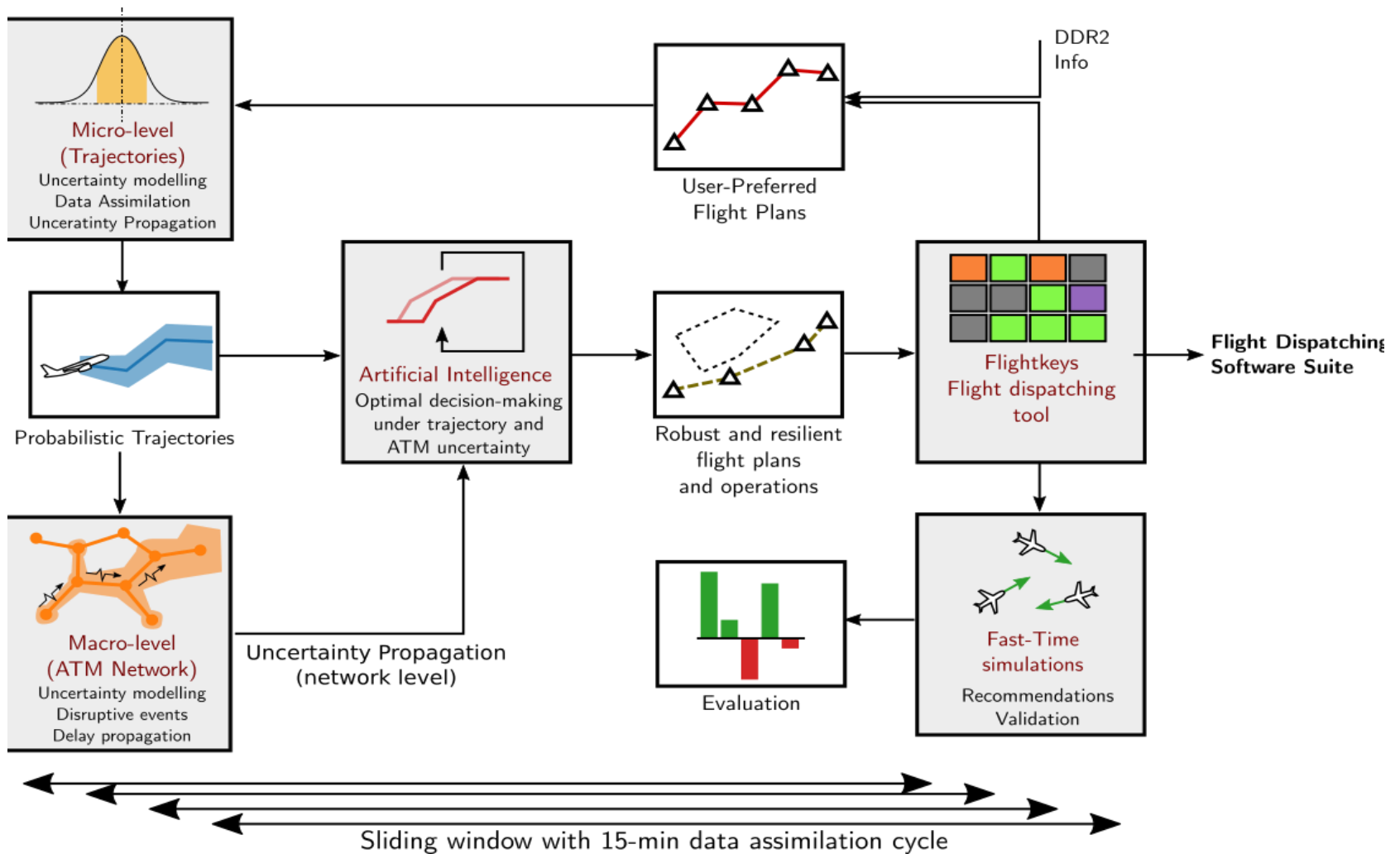
25<sup>th</sup> of January 2021








Founding Members



# Project Overview: Overall Concept



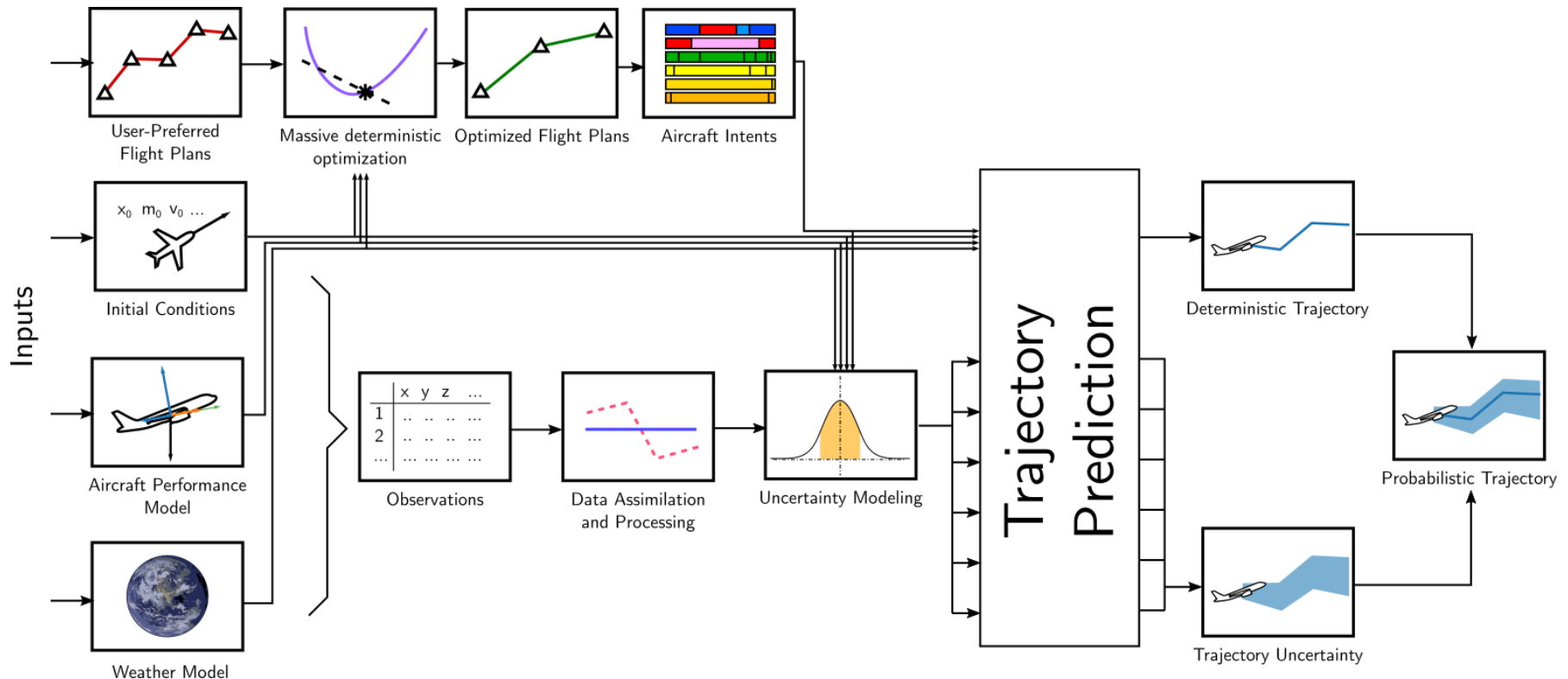
# Project Overview: Partners

Participant No	Participant organisation name	Country
1 - BRTE	 Boeing Research and Technology Germany (BRTE)	Germany
2 - DLR	 German Aerospace Center (DLR)	Germany
3- ENAC	 Ecole Nationale de l'Aviation Civile (ENAC)	France
4- FK	 FlightKeys (FLIGHTKEYS)	Austria
5- ITU	 Istambul Teknik Universitesi (ITU)	Turkey
6 – UC3M (Coordinator)	 Universidad Carlos III de Madrid Universidad Carlos III de Madrid (UC3M)	Spain
7 - UPC	 UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH Universitat Politecnica de Catalunya (UPC)	Spain

# Uncertainty modelling for trajectory prediction

## Objectives

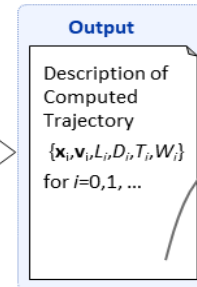
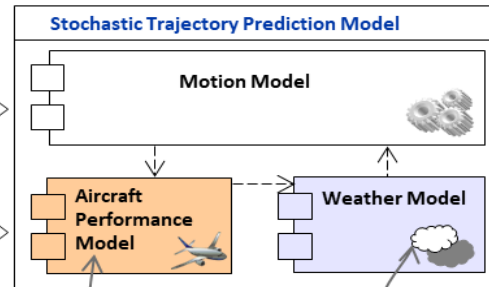
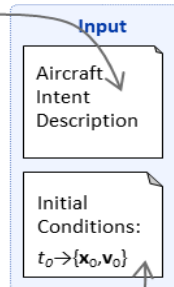
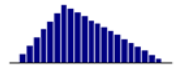
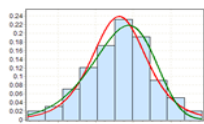
The main objective of WP2 within START is to implement the models and processes required to capture the influence of the micro-level uncertainties that are present in the development of an aircraft trajectory.



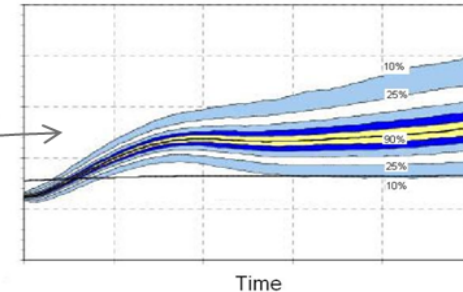
# Uncertainty modelling for trajectory prediction

## Proposed approach

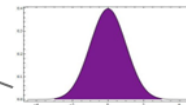
*Operational stochastic factors, e.g. differences between the pilot/FMS behavior models used in trajectory prediction and that actual guidance strategy of the pilot/FMS.*



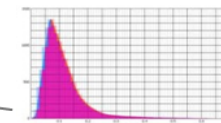
### Stochastic Trajectory



*Stochastic factors related to the modeling of aircraft performance, e.g. random differences between real aircraft performance characteristics such as thrust, drag or fuel consumption and the aircraft performance models used for trajectory prediction.*



*Environmental stochastic factors, e.g. wind and temperature modeling or forecast errors.*



### Initial Conditions:

- Initial time
- Initial mass
- Initial speed
- Initial position
- Initial altitude

### Aircraft Intent:

- Climb speed
- TOC (speed & altitude)
- Cruise (speed & altitude)
- TOD (speed & altitude)
- Descent speed

### Aircraft Performance:

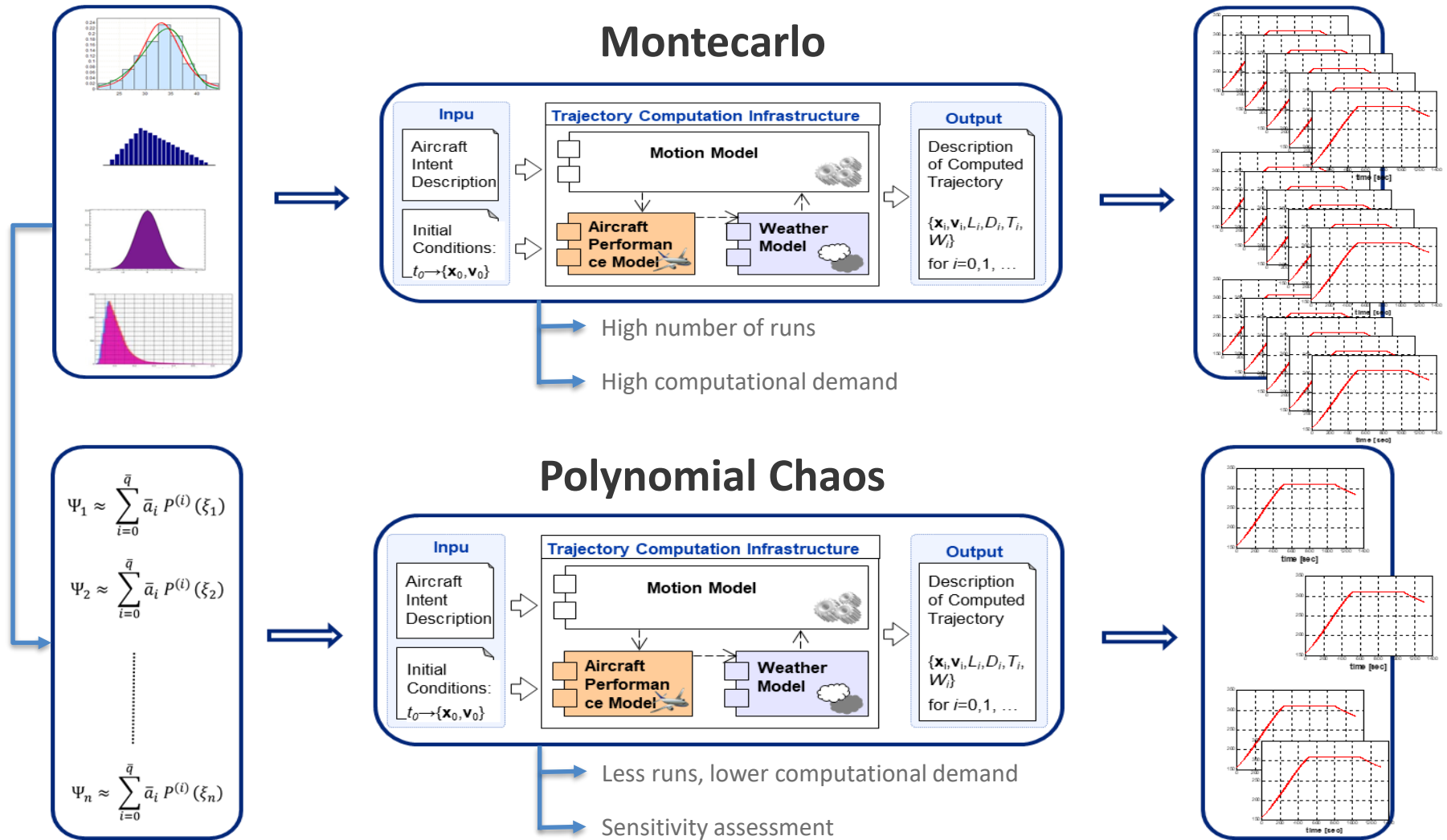
- Fuel
- Drag

### Weather:

- Temperature
- Pressure
- Wind speed
- Wind direction

# Uncertainty modelling for trajectory prediction

## Proposed approach



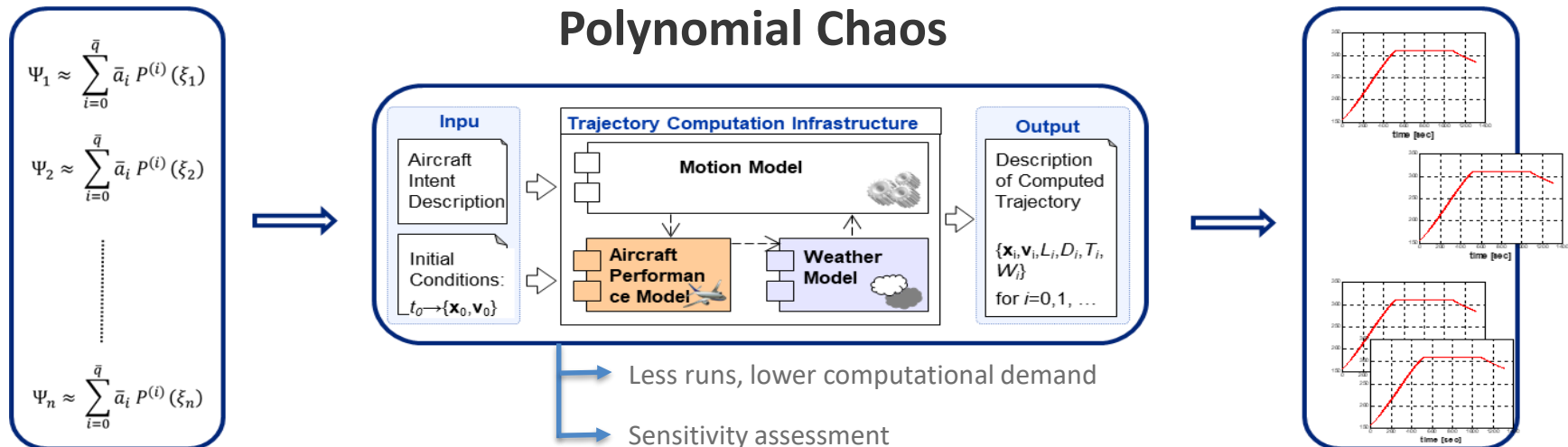
# Uncertainty modelling for trajectory prediction

## Proposed approach

- Application of **Polynomial Chaos Expansion (PCE)** to quantify the propagation of uncertainty in dynamic systems, like an aircraft trajectory.
  - Arbitrary PCE (aPCE)** generalizes chaos expansion techniques towards arbitrary probability distributions.
    - > **Data-driven process** to characterize the uncertainty in the trajectory prediction inputs
  - Multivariate time-dependent PCE application

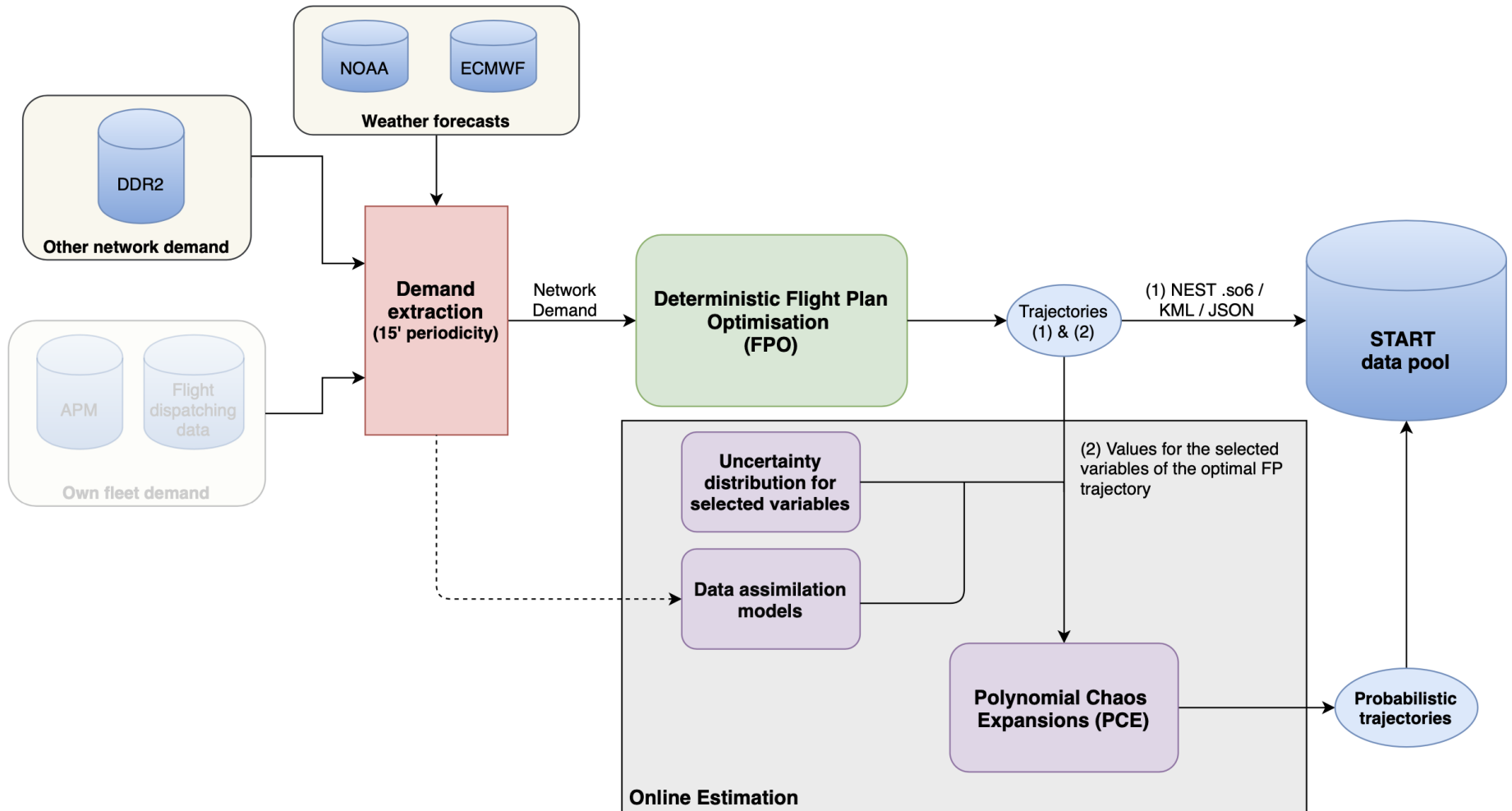
$$z(t, \xi_1, \xi_2, \dots, \xi_N) = \sum_{i=1}^{\infty} b_i(t) \phi_i(\xi_1, \xi_2, \dots, \xi_N)$$

- Implementation of **data assimilation models** that capture estimates of input values in the pre-tactical phase.



# Uncertainty modelling for trajectory prediction

## Proposed structure



Whole process to be repeated for each selected air traffic / airspace segmentation  
(i.e. city pair, airline, aircraft type, etc.)



# START-Web and Social Media



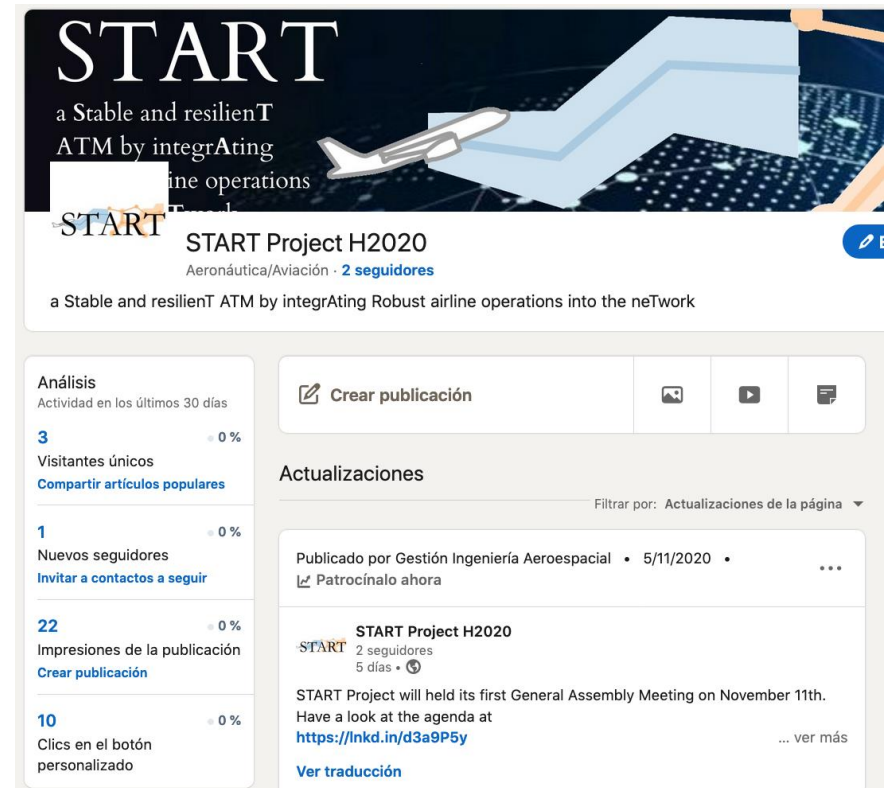
Web: <https://start-atm.com/>



Twitter: [@START\\_ATM](https://twitter.com/START_ATM)



Linked-in: [START Project H2020](#)





## START

“a Stable and resilient ATM by integrating Robust airline operations into the network”

ENGAGE TC2 2021

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# Thank you very much for your attention!



This project has received funding from the SESAR Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under grant agreement No [number]



Founding Members



The opinions expressed herein reflect the author's view only.

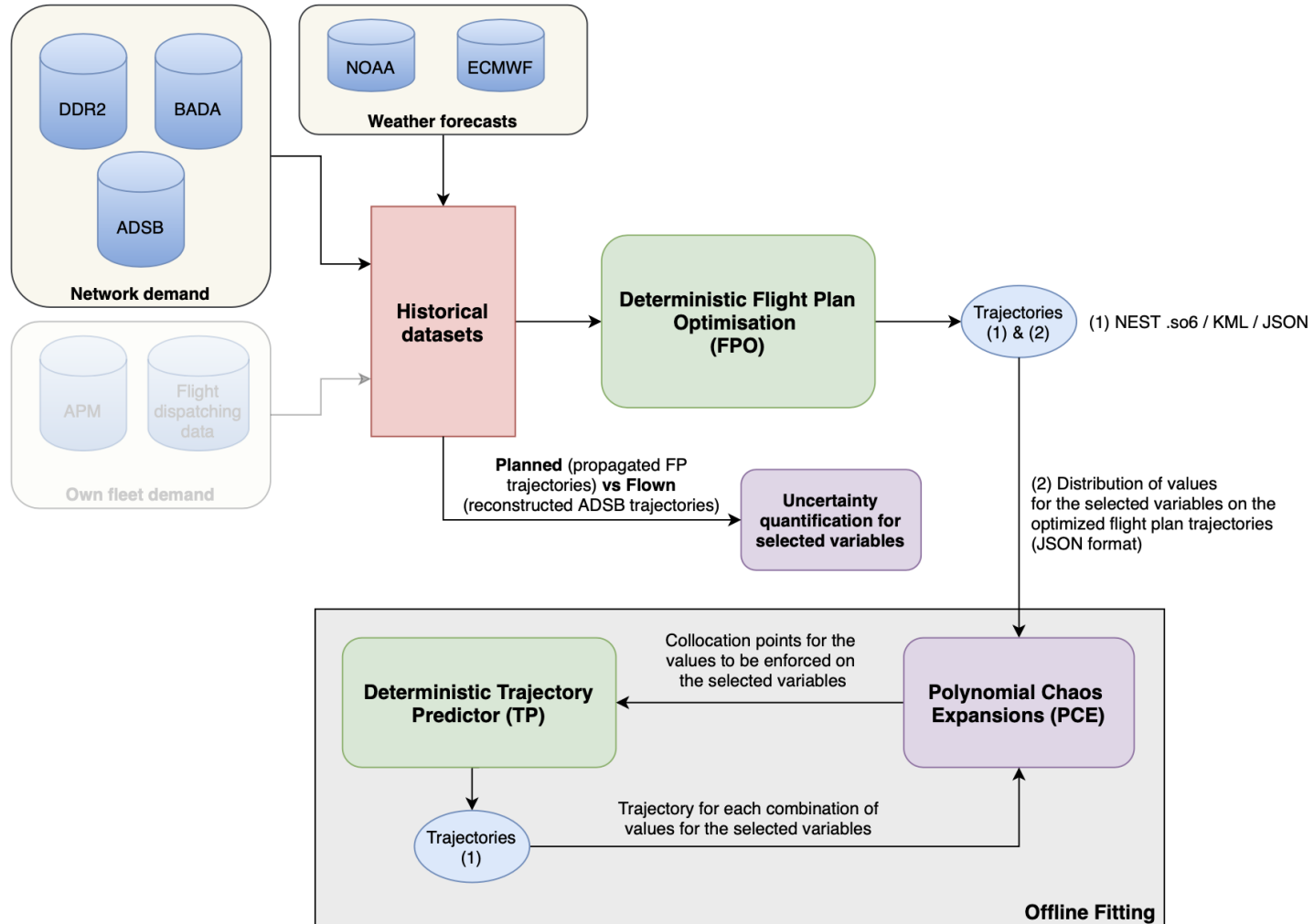
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# BACK-UP SLIDES



# Uncertainty modelling for trajectory prediction

## Two-fold framework – Offline Phase



# Uncertainty modelling for trajectory prediction

## The weather challenge

What about the uncertainty coming from the weather?

Different problems come up from including weather uncertainty within the aPCE implementation

### 1. How can we quantify the uncertainty in the weather?

- Comparing reanalysis with forecasts? Which forecasts?

### 2. The dimensionality issue:

The number of collocation points ( $M$ ) required to fit aPCE is defined as:  
with  $N$  as number of variables and  $d$  as polynomial expansion degree

$$M = \frac{(N + d)!}{N! d!}$$

Polynomial degree $d$	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
4	5	15	35	70	126	210	330	495	715	1001	1365	1820	2380	3060	3876
3	4	10	20	35	56	84	120	165	220	286	364	455	560	680	816
2	3	6	10	15	21	28	36	45	55	66	78	91	105	120	136
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

Weather variables in .GRIB ( $\sim O(10^5)$ ) **UNFEASIBLE**

# Uncertainty modelling for trajectory prediction

## The weather challenge

The weather would be then included in the aPCE offline loop as follows (Using POD as example):

1. Collect  $N$  weather *.GRIB* files (reanalysis from ECMWF)

$$W = \begin{bmatrix} 1^{st} \text{ weather sample as row vector} \\ \vdots \\ N^{th} \text{ weather sample} \end{bmatrix}$$

2. Transform each weather into a reduced-space sample  $\Psi^*$

$$W = \Psi \Sigma \Phi$$

**Truncated  $\Psi$  is the reduced – space sample  $\Psi^*$**

3. Compute the collocations points based on the trajectory + reduced-space weather variables
4. Transform the reduced-space weather variables  $\Psi^{CP}$  provided in the collocation points to a full-dimensional-state weather

$$W^{CP} = \Psi^{CP} \Sigma \Phi$$

**IMPORTANT:** The weather conformed by the collocation points has not existed in the past  
The better the weather model, the more realistic the generated weather will be

5. Provide UPC with the trajectory variables collocation points + the synthetic weather *.GRIB*  $W^{CP}$
6. Fit aPCE coefficients based on the trajectory predictions provided by UPC

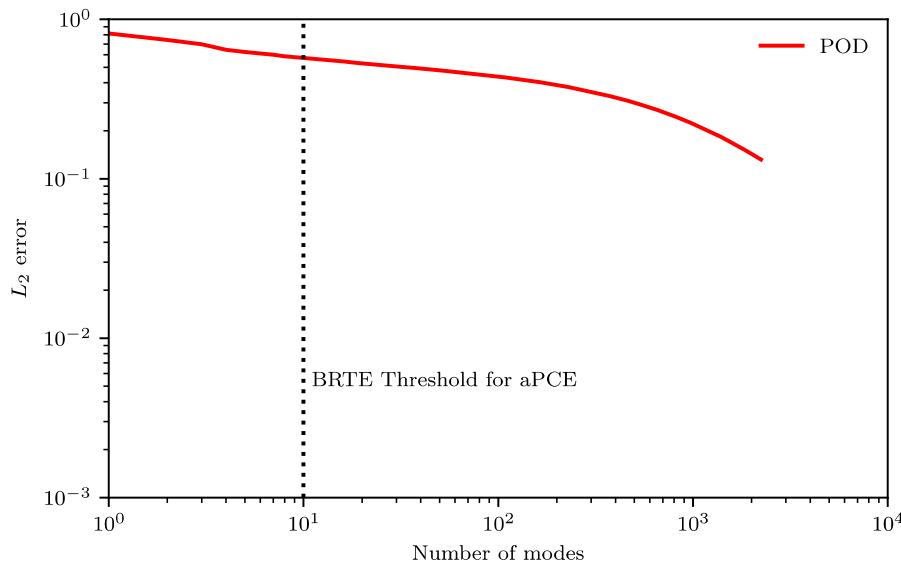
# Uncertainty modelling for trajectory prediction

## The weather challenge

To overcome the weather integration in aPCE framework, we propose to reduce its dimensionality to reduced number of variables ( $\sim O(10^1)$ ). Three data-driven techniques are proposed:

- **Proper Orthogonal Decomposition** (a.k.a Karhunen–Loève decomposition or PCA)
- **K-Nearest Neighbours**
- **Convolutional-Neural-Network Autoencoder** (or more sophisticated Variational Autoencoder)

The three techniques allow us to **compress the weather data into few variables to be fed to aPCE and recover back the original weather data.**



POD results:

- Training data from 01-01-2017 to 31-12-2017
- Testing data from 01-06-2018 to 31-08-2018
- $L_2$  error for 10 reduced-space variables  $\rightarrow 0.6$

Trajectory variables

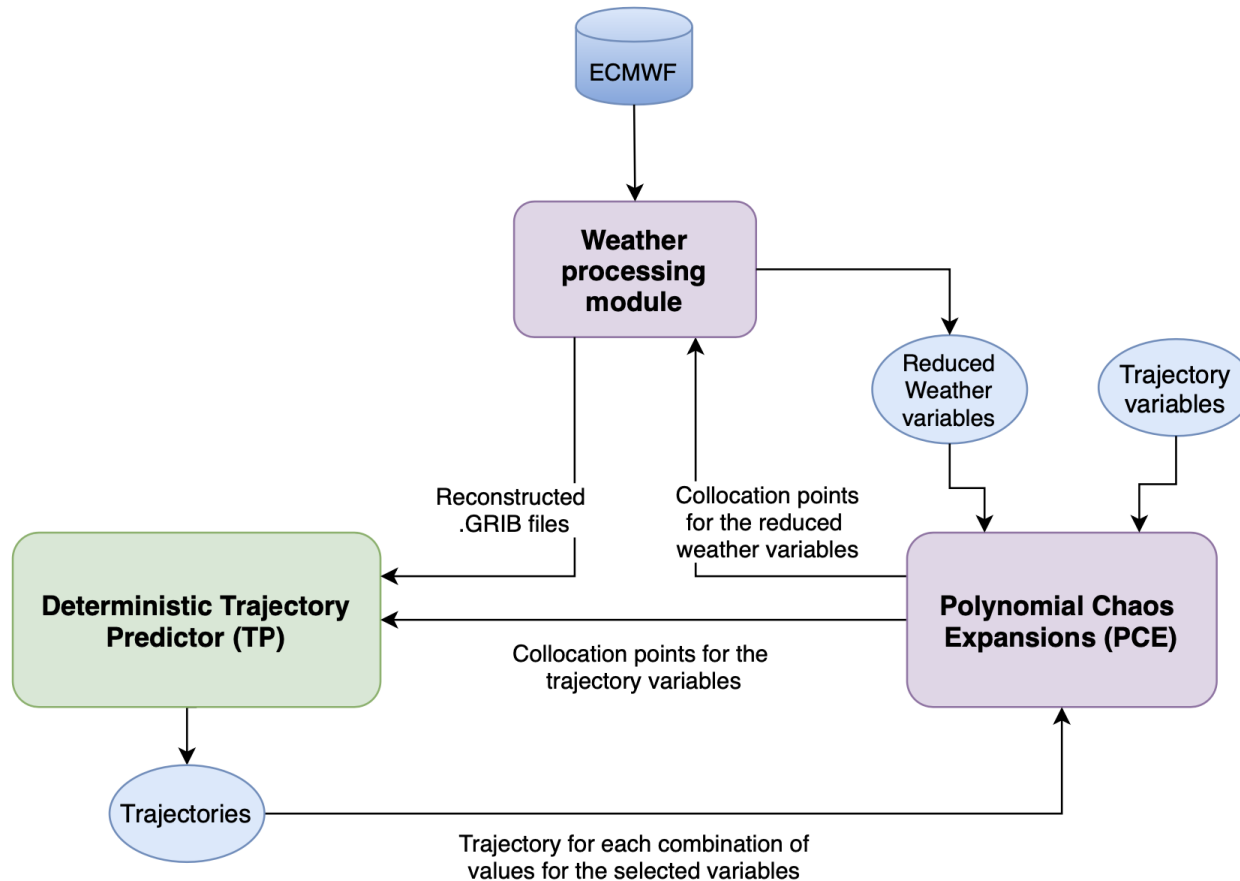
+

$\sim O(10^1)$  Weather  
variables

**FEASIBLE**

# Uncertainty modelling for trajectory prediction

## The weather challenge



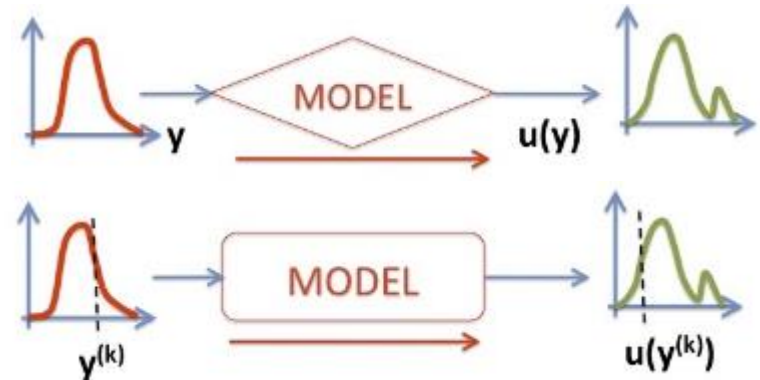


## PCE theory

- PCE was originally applied to systems whose input variables showed a Gaussian behavior. Generalized PCE (gPCE) expanded its usability to other different known distributions. **Arbitrary PCE** (aPCE) generalizes chaos expansion techniques towards arbitrary probability distributions.
  - Data-driven process** that only demands the existence of a finite number of statistical moments and does not require the complete knowledge or even the existence of an explicit probability density function.
- The system response  $u$  can be represented as a function of the variability  $\xi$  of the inputs  $x$  with the time  $t$ .

$$u(x, t, \xi) = \sum_{i=0}^{\infty} \underbrace{u_i(x, t)}_{\text{deterministic}} \underbrace{\psi_i(\xi)}_{\text{stochastic}}$$

- There are two alternatives to obtain  $u$ 
  - Intrusive Method**, which requires the stochastic formulation of the original model.
  - Non-Intrusive Method**, which requires a set of deterministic solutions of the original model.



## PCE theory

- **Univariate:**  $z(t, \xi) = \sum_{i=1}^{\infty} a_i(t) \psi_i(\xi)$

$z$ : stochastic random variable

$\xi$ : other random variable

$a_i$ : mode strengths

$\psi_i$ : mode function. Orthonormal basis of polynomials

- **Multivariate**  $z(t, \xi_1, \xi_2, \dots, \xi_N) = \sum_{i=1}^{\infty} b_i(t) \phi_i(\xi_1, \xi_2, \dots, \xi_N)$

$b_i$ : mode strengths

$\phi_i$ : Tensor product of the univariate polynomial bases regarding each  $\xi_j$

$$\phi_i(\xi_1, \xi_2, \dots, \xi_N) = \prod_{j=1}^N \psi_j^{\alpha_j^i}(\xi_j)$$

$\alpha_j^i$ : Represents the combinatorial of all possible products of  $\psi_j^k$  (polynomial of order  $k$  belonging to the polynomial basis of germ  $\xi_j$ )

$$\sum_{j=1}^N \alpha_j^i \leq M, \quad i = 1, \dots, N$$

$$M = \frac{(N + d)!}{N! d!}$$

## PCE theory

- The construction of the polynomial basis representing the stochastic behaviour of each germ  $\xi_j$  is done by means of the statistical moments calculated from the data.

- Having:  $\psi_i^k = \sum_{m=0}^k c_m^{(k)} \xi_i^m$ , Forcing that  $c_k^{(k)} = 1$  and imposing orthogonality

- The basis is constructed for all polynomials of the basis by solving the system of equations:

$$\int \left[ \sum_{m=0}^{k-1} c_m^{(k-1)} \xi_i^m \right] \cdot \left[ \sum_{m=0}^k c_m^{(k)} \xi_i^m \right] \cdot \Gamma(\xi_i) d\xi_i = 0$$

- Defining the ***k-th*** statistical moment of the germ  $\xi_j$  as:

$$\mu_k = \int \xi_i^k \Gamma(\xi_i) d\xi_i$$

- The system of equations can be written as:

- Solving this system will give us the coefficients

$$\begin{bmatrix} \mu_0 & \mu_1 & \cdots & \mu_k \\ \mu_1 & \mu_2 & \cdots & \mu_{k+1} \\ \vdots & \vdots & \vdots & \vdots \\ \mu_{k-1} & \mu_k & \cdots & \mu_{2k-1} \\ 0 & 0 & \cdots & 1 \end{bmatrix} \begin{bmatrix} c_0^{(k)} \\ c_1^{(k)} \\ \vdots \\ c_{k-1}^{(k)} \\ c_k^{(k)} \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ \vdots \\ 0 \\ 1 \end{bmatrix}$$

- The roots of the ***k+1*** order polynomial are the collocation points used to obtain the system's response and obtain the coefficients  $b_i(t)$ , thus obtaining our stochastic random variable  $\mathbf{z}$ .

# WP2 - Goals and Methods

## Trajectory level: Uncertainty modelling, data assimilation and uncertainty propagation.

**GOALS:** Develop uncertainty propagation models at trajectory level; identify and characterize potential sources of trajectory level uncertainty following a data-driven approach.; build and develop methods for the cyclic ingestion of data inputs that will feed the uncertainty propagation models at the trajectory level.

Task 2.1 **Massive deterministic trajectory optimization** (Task leader: UPC)

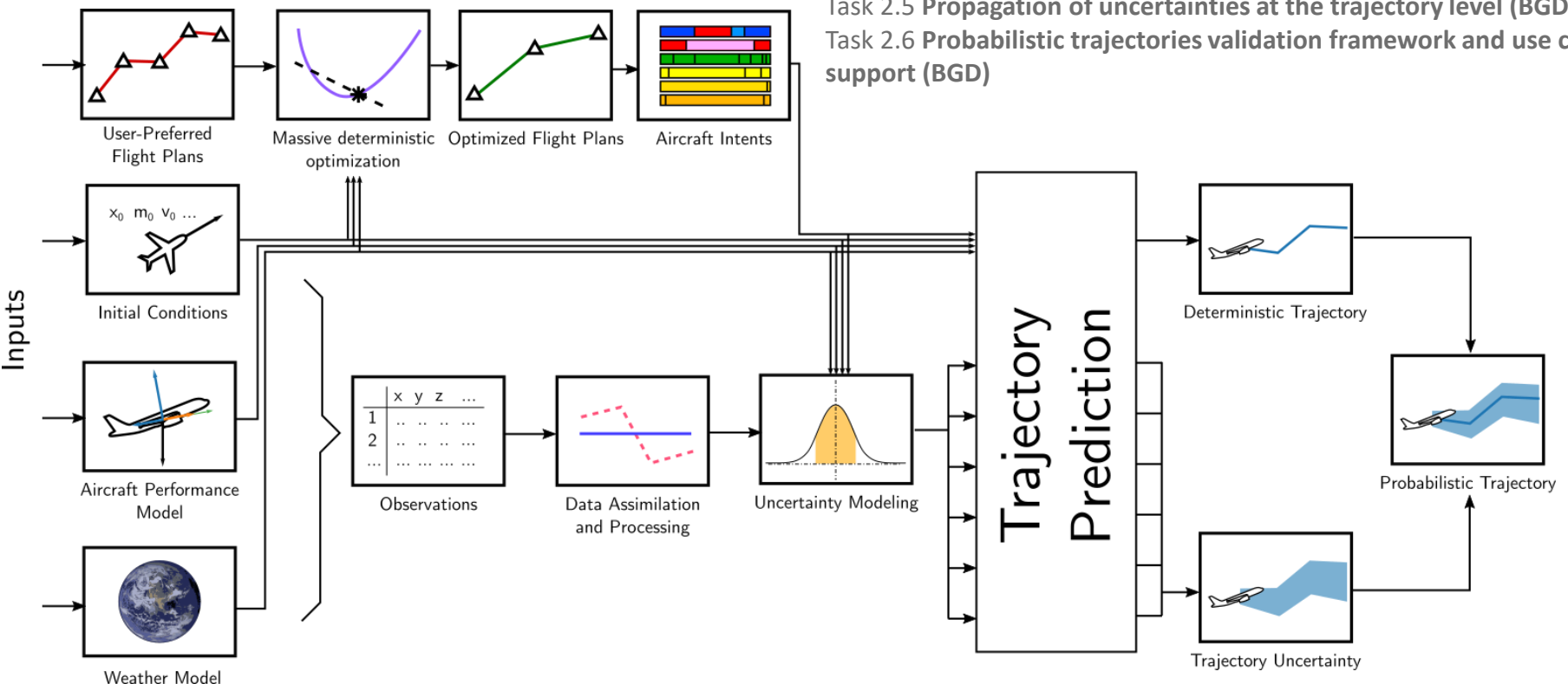
Task 2.2 **Modelling of uncertainties at the trajectory level** (BGD)

Task 2.3 **Data sources** (BGD)

Task 2.4 **Data assimilation models** (ITU)

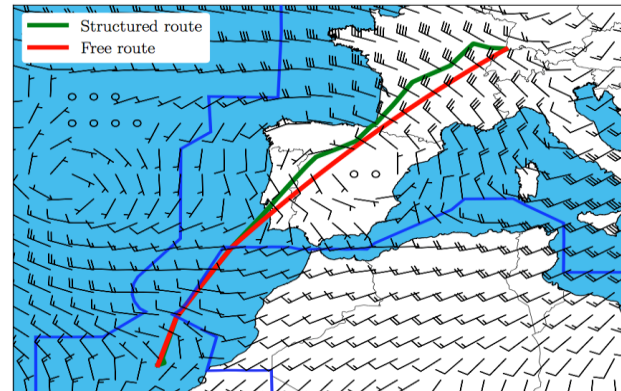
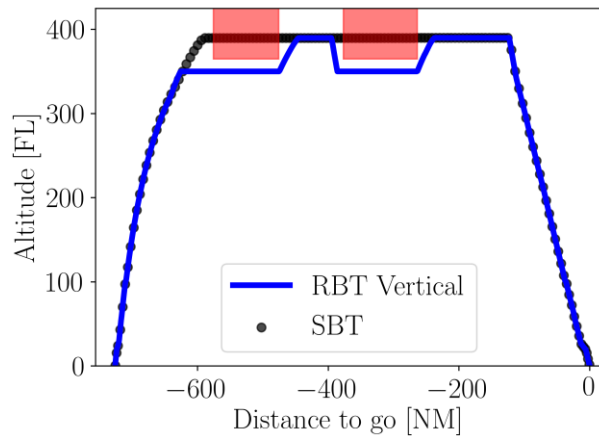
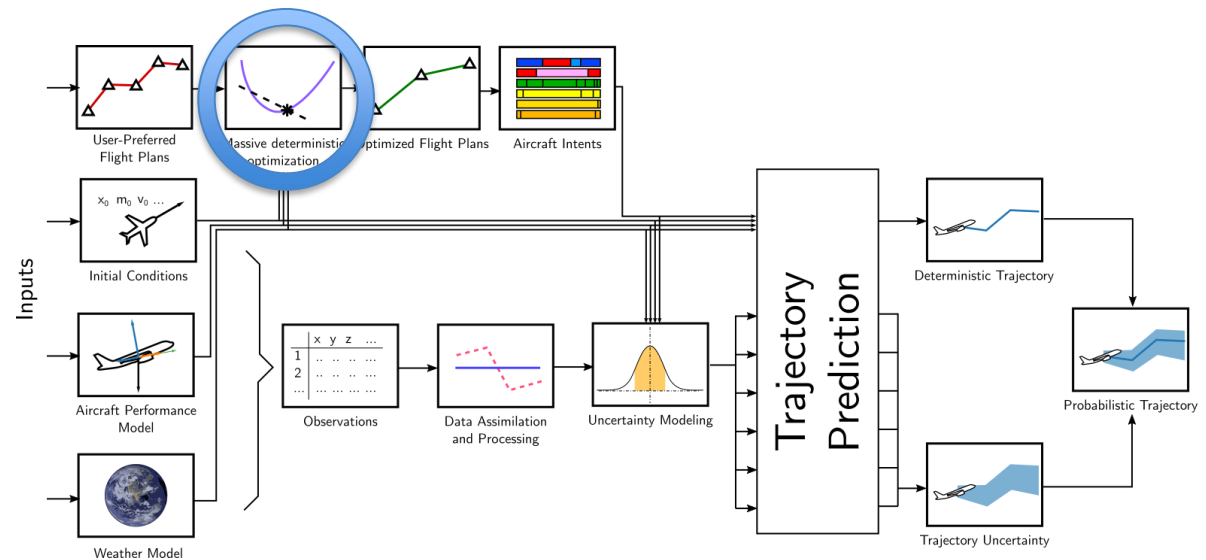
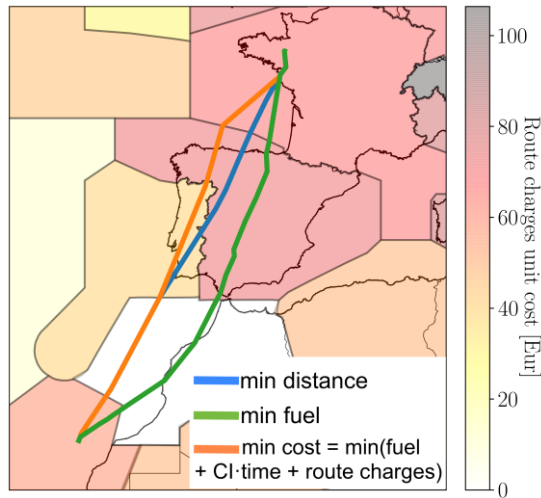
Task 2.5 **Propagation of uncertainties at the trajectory level** (BGD)

Task 2.6 **Probabilistic trajectories validation framework and use case support** (BGD)



# WP2 - Task 2.1

## Massive deterministic trajectory optimization (Task leader: UPC)



Use of Dynamo tool

Dalmau, R., Melgosa, M., Vilardaga, S., & Prats, X. (2018, Jun). A fast and flexible aircraft trajectory predictor and optimiser for ATM research applications. Proceedings of the 8th International Congress on Research in Air Transportation (ICRAT).

# WP2 - Task 2.2, 2.3, 2.4

## Task 2.2 Modelling of uncertainties at the trajectory level (BGD)

## Task 2.3 Data sources (BGD) and Task 2.4 Data assimilation models (ITU)

### Uncertainty Models

- Aircraft Intent Uncertainties
- Weather Forecast Uncertainties
- Aircraft Performance Model Uncertainties
- Aircraft Motion Modelling Uncertainties
- Initial conditions uncertainties

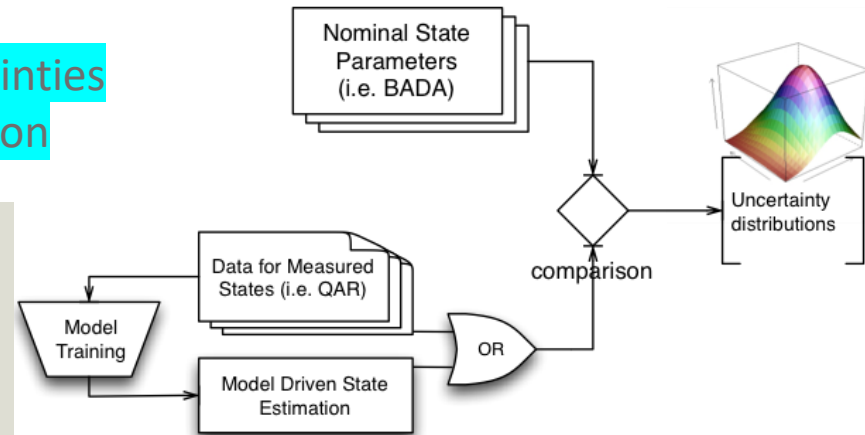
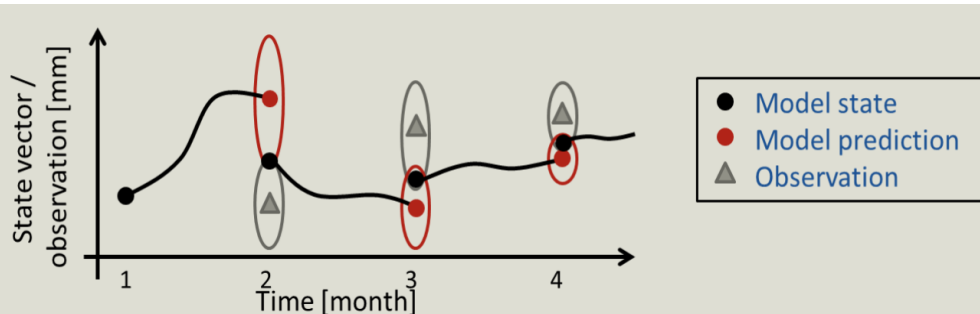
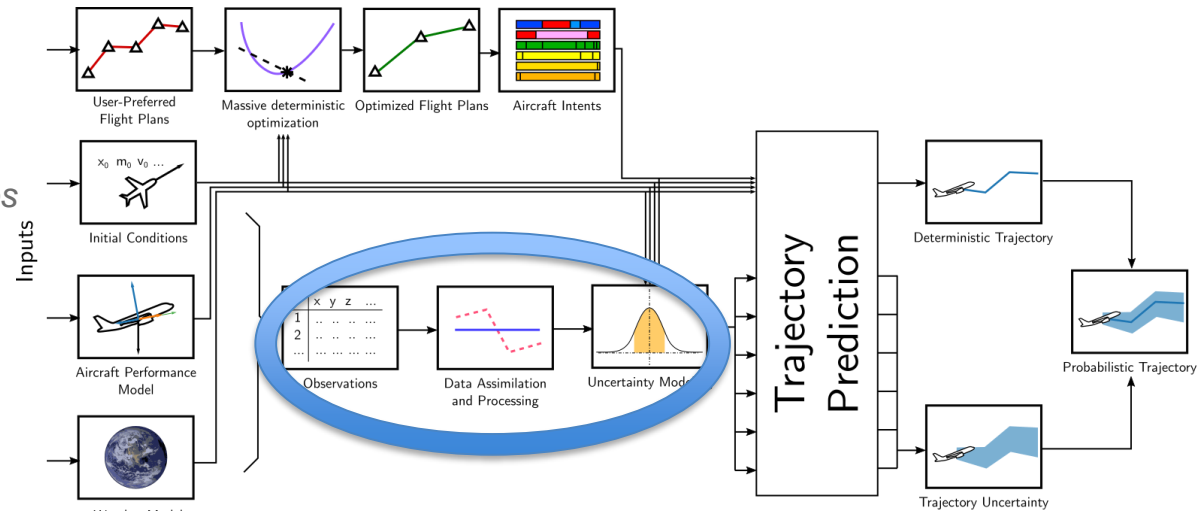
### COPTRA & TBO-Met

### Data Sources

- Radar Tracks
- ADS-B
- DDR-2
- Reanalysis
- ...

### Main novelties:

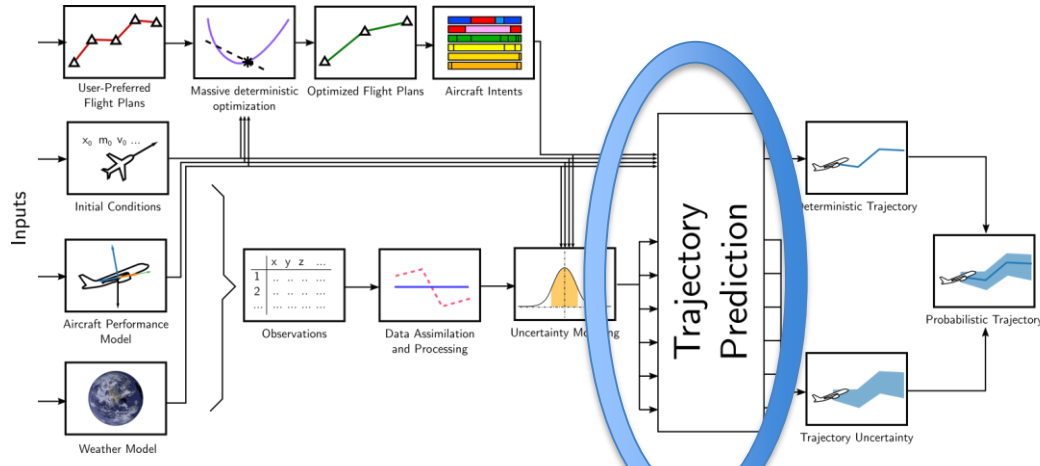
- Integration of Met Uncertainties
- Data-Driven data assimilation



# WP2 - 2.5 and 2.6

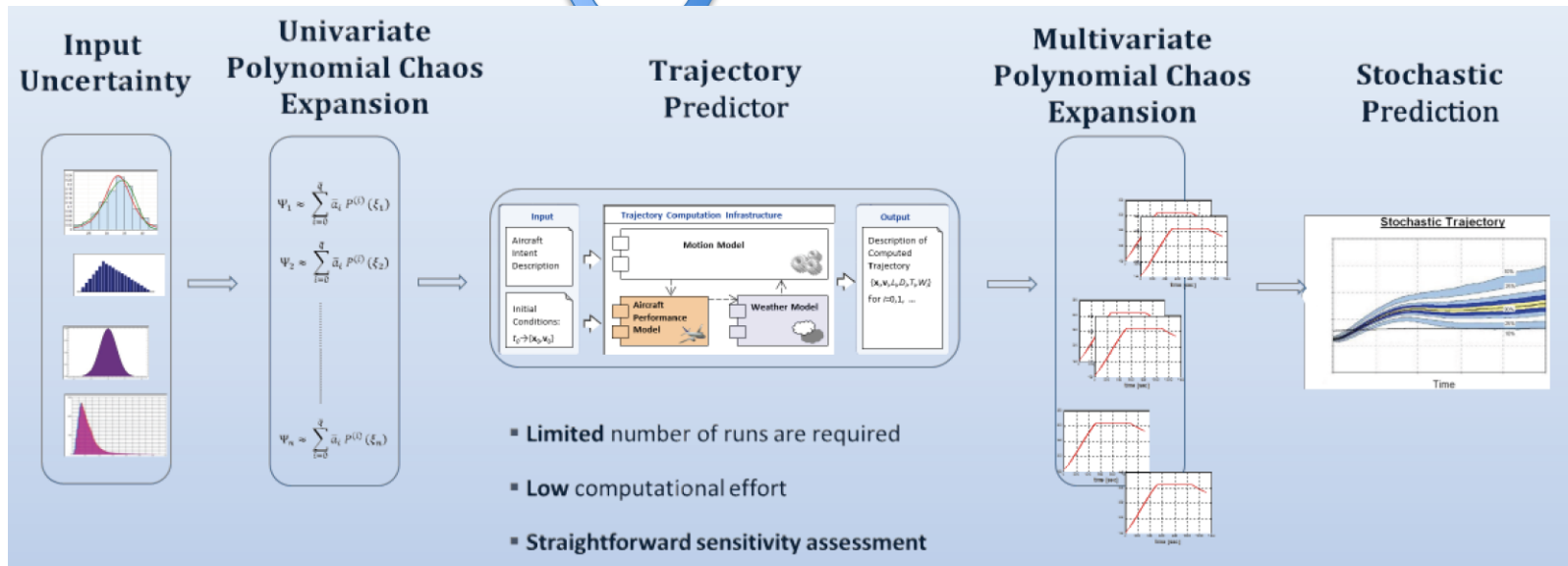
## Task 2.5 Propagation of uncertainties at the trajectory level (BGD)

## Task 2.6 Probabilistic trajectories validation framework and use case support (BGD)



Two main novelties:

- Time-dependent PC expansions
- CPU time for data assimilation



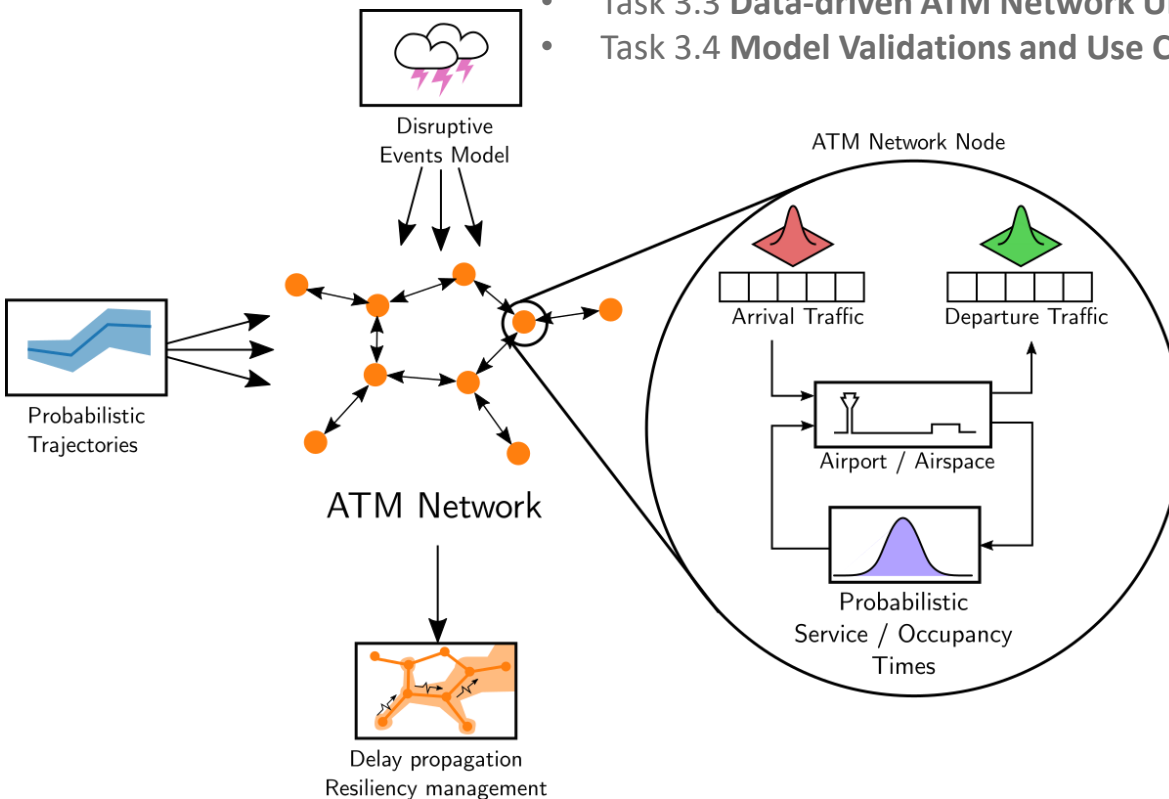
E. Casado. Trajectory prediction uncertainty modelling for Air Traffic Management. PhD Thesis. University of Glasgow, 2016

# WP3: goal and methods

## ATM Network level: network modelling, uncertainty propagation with disruptive events

**Objectives:** Develop an approximate ATM network model from the historical data enabling to simulate and analyse uncertainty and delay propagation; integrate individual trajectory uncertainties into the network model; provide models for disruptive events and integrate them into the network-wide model; validate the model, procedures and provide a simulation environment/tool for use case analyses.

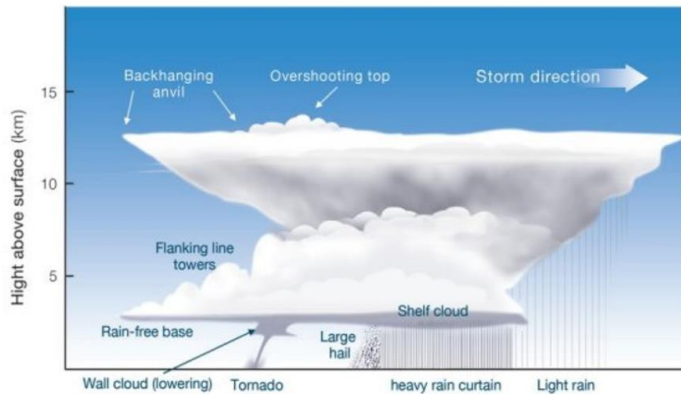
- Task 3.1: **Integration of Probabilistic Trajectory Uncertainty Models (leader: ITU)**
- Task 3.2: **Modelling Disruptive Events in ATM Network (UC3M)**
- Task 3.3 **Data-driven ATM Network Uncertainty Propagation Model (ITU)**
- Task 3.4 **Model Validations and Use Case Simulations (ITU)**



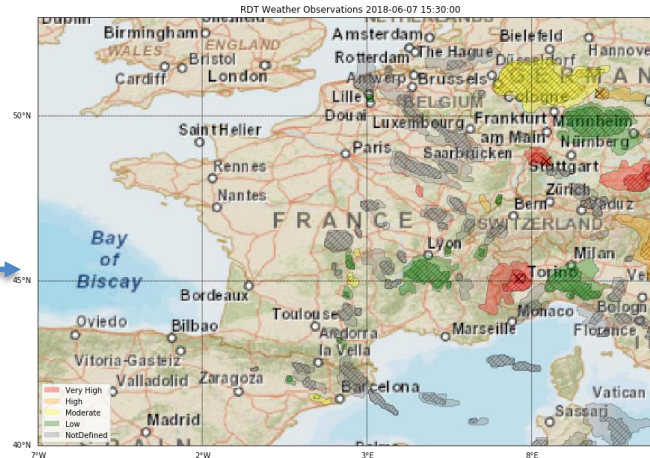
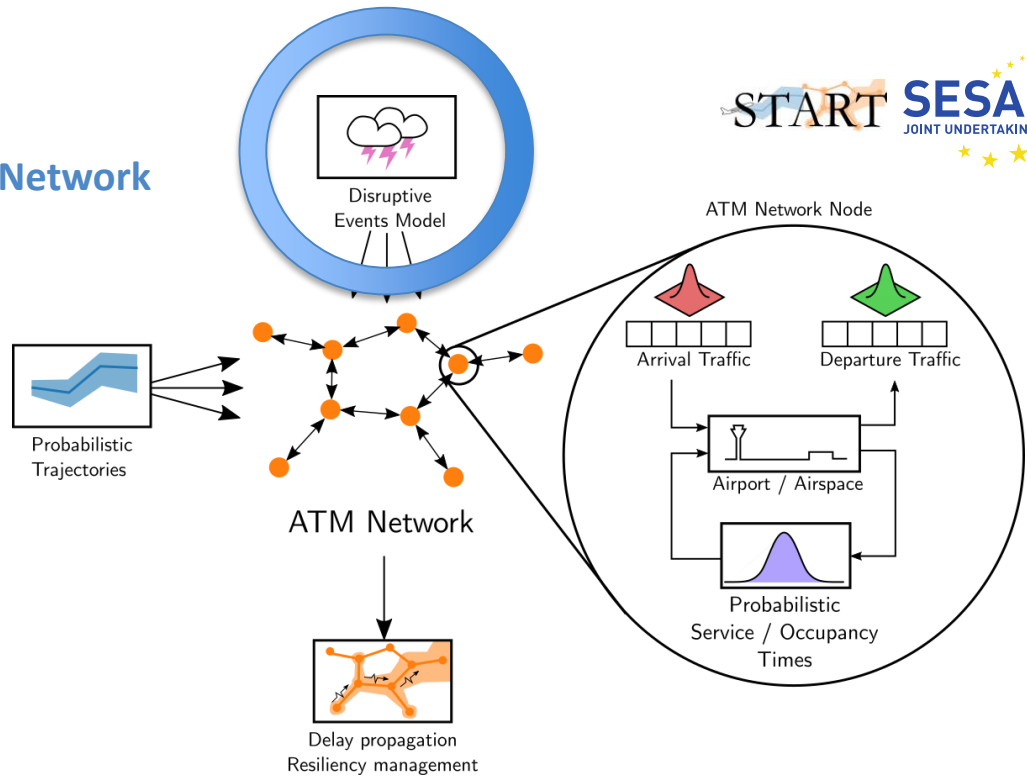
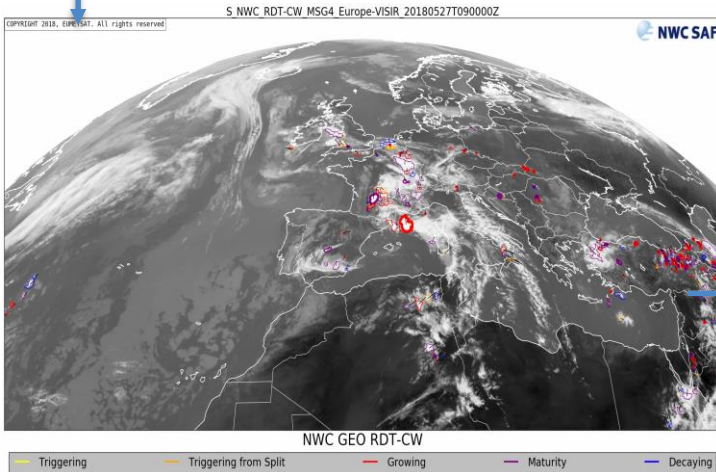


# WP3: Task 3.2

## Modelling Disruptive Events in ATM Network



### Observations via RDT Sat data



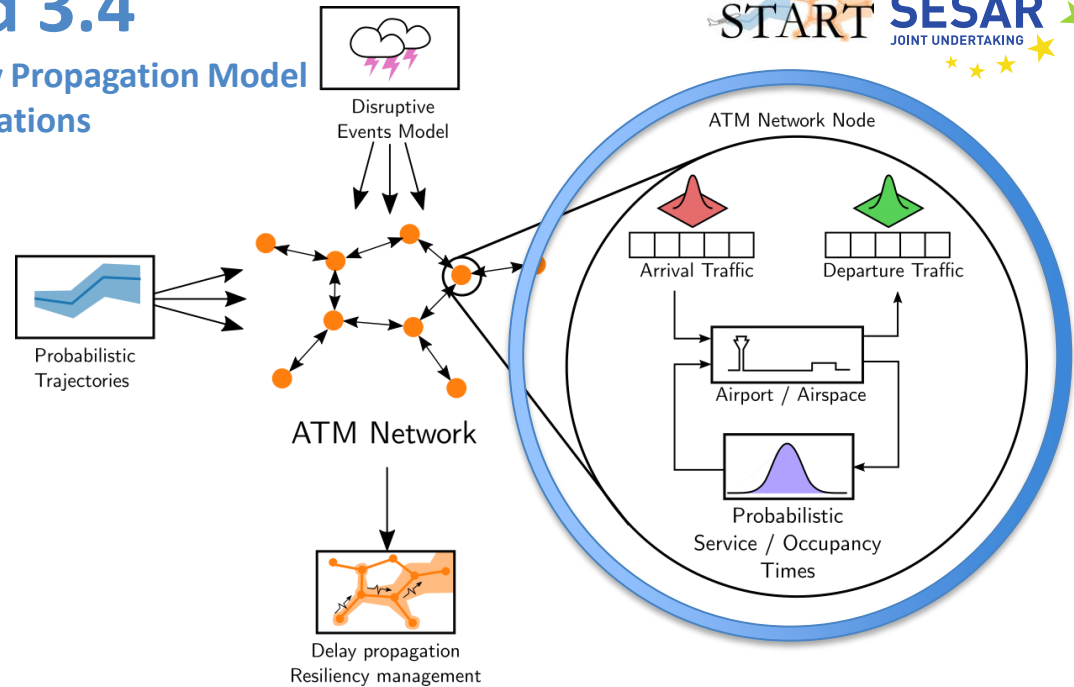
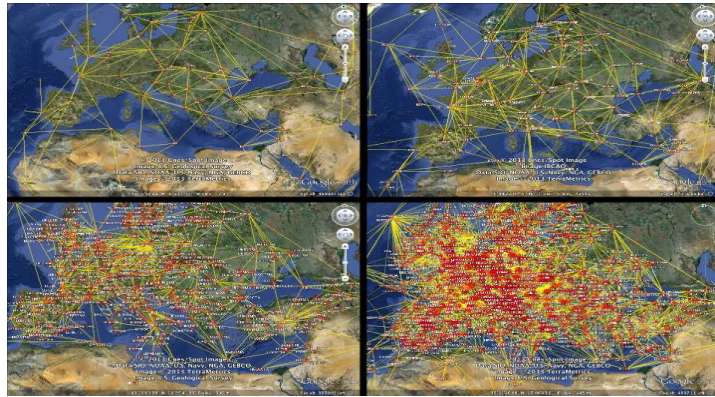
**Novelty: Probabilistic  
Nowcasting/Forecasting  
Model using Data Assim**

**Robust aircraft trajectory planning under uncertain convective environments with optimal control and rapidly developing thunderstorms.** Daniel González-Arribas, Manuel Soler, Manuel Sanjurjo, Maryam Kamgarpour, and Juan Simarro. *Aerospace Science and Technology*. Volume 89, June 2019, Pages 445-459.

<https://doi.org/10.1016/j.ast.2019.03.051>

# • WP3: Tasks 3.3 and 3.4

## Data-driven ATM Network Uncertainty Propagation Model Model Validations and Use Case Simulations



### Novelties:

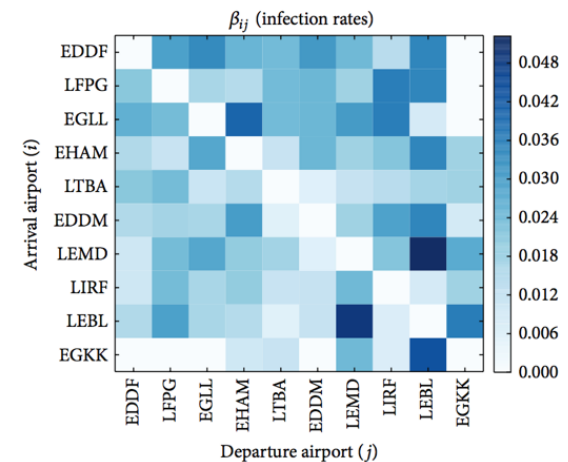
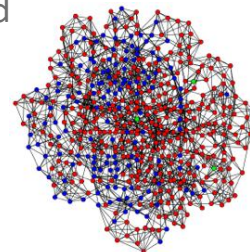
- + Prob. Trajectories
- + Disruptive Events

Can we use epidemic processes formulation in modeling delay propagation?

- Behavioral characteristics of disease spreading and delay or/and uncertainty propagation are similar.

Model of the air transportation delay propagation through Epidemic Process

- Aircraft – Individuals: susceptible, **infected** or recovered
- Airports – Cities with **recovery** rates
- OD pairs – Interactions with **infection** rates

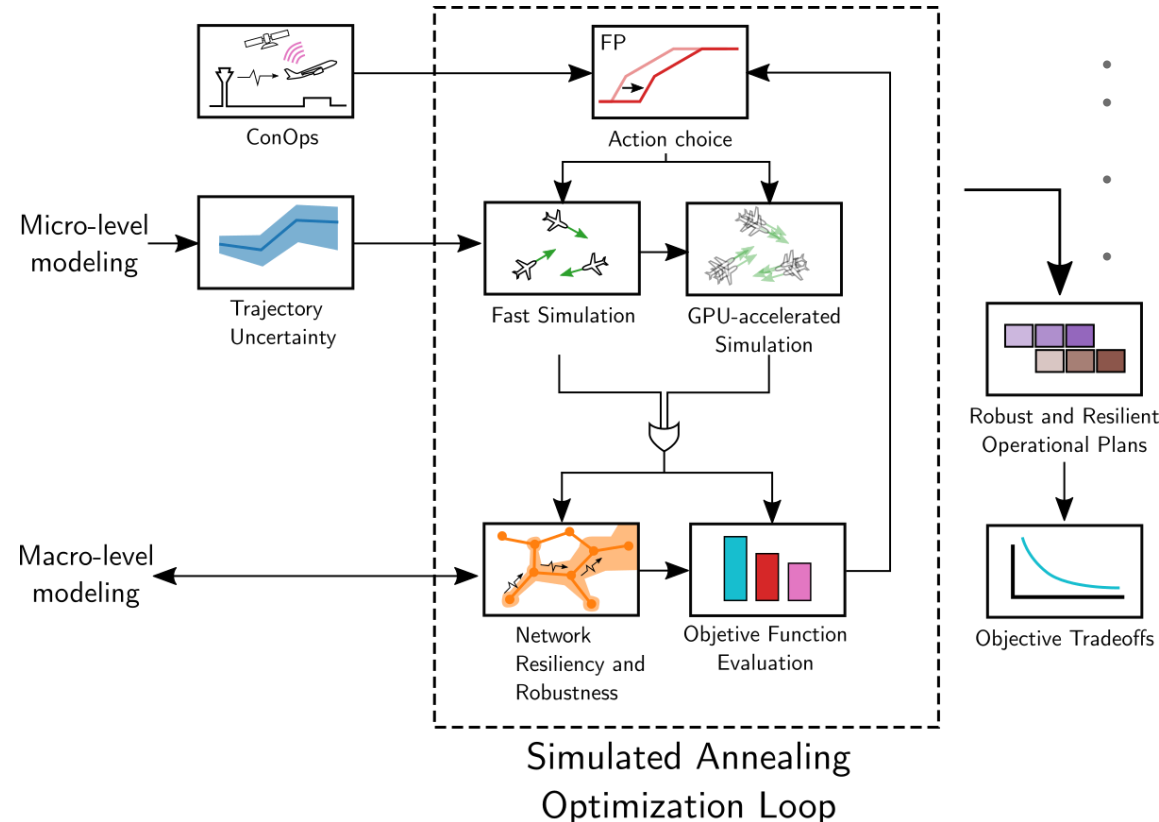


# WP4: Goals and methods

## Network-wide Robust Trajectory Planning and Resiliency Management based on Simulating Annealing

**Objectives:** Formulate a concept of operations implementing Trajectory Based Operations allowing for the appropriate management of uncertainty; formulate the network resiliency and develop network resiliency management procedures in case of disruptive events; develop optimization algorithms for the determination of efficient strategic interventions that increase the predictability and resiliency of ATM operations; validate the proposed methods through use case simulation and analysis.

- **Task 4.1: Development of ConOps based on TBO** (Task leader: UPC)
- **Task 4.2: ATM Network Resiliency Management under Disturbances and Disruptive Events** (ITU).
- **Task 4.3: Simulation Environment** (ENAC)
- **Task 4.4: Robust metaheuristic Simulating Annealing (SA) algorithm** (ENAC)
- **Task 4.5: Parallel, GPGPU robust metaheuristic Simulating Annealing algorithm** (UC3M)
- **Task 4.6: Use case simulations** (ENAC)



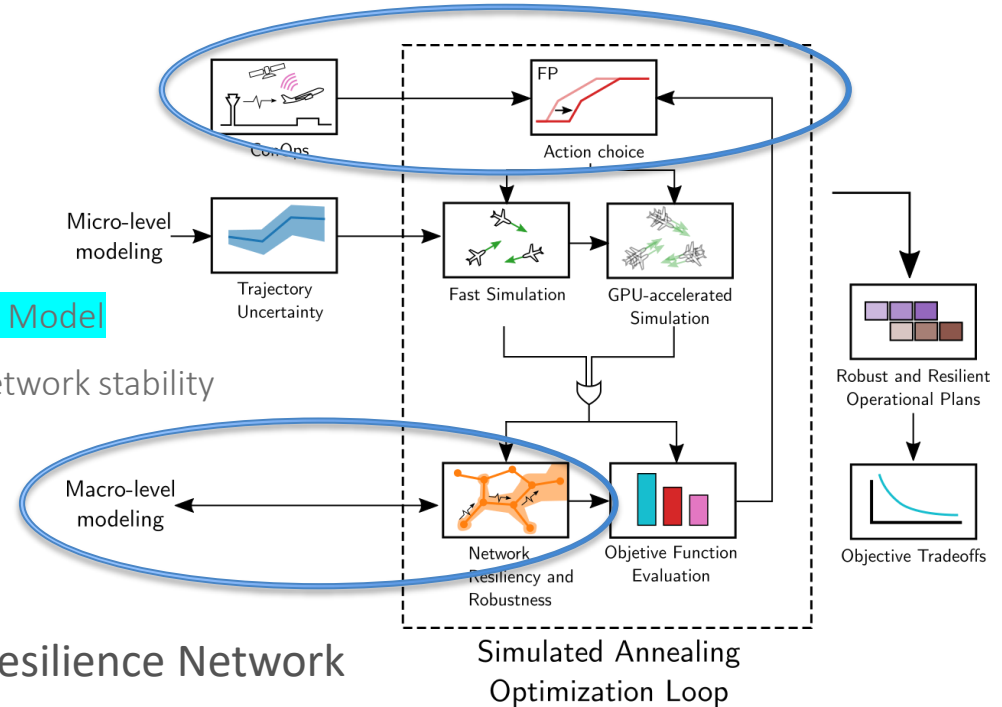
# WP4: Task 4.1 and 4.2

Task 4.1: Development of ConOps based on TBO (UPC)

Task 4.2: ATM Network Resiliency Management under Disturbances and Disruptive Events (ITU).

## Novelty:

- Solve network stability problem via Epidemic Process Model
- ML-based determination of best actions to ensure network stability
  - Traffic flow/infection rate management
    - ground holdings
    - flight cancellations



## Robust Trajectory

### Trajectory Actions (TA)

- CAS or Mach modification
- FL changes
- Re-routings
- **ToD changes**

## Resilience Network

### ATFM Actions:

- Flight holdings - ToD changes
- Flight Cancellations

Trade off?

# WP4: Task 4.3, 4.4

## Task 4.3: Simulation Environment (ENAC)

## Task 4.4: Robust metaheuristic Simulating Annealing (SA) algorithm (ENAC)

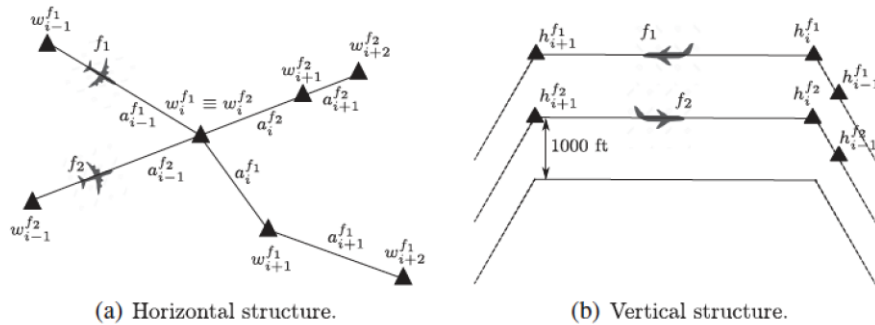


Fig. 1. Horizontal route and vertical profile of flights  $f_1$  and  $f_2 \in \mathcal{F}$ .

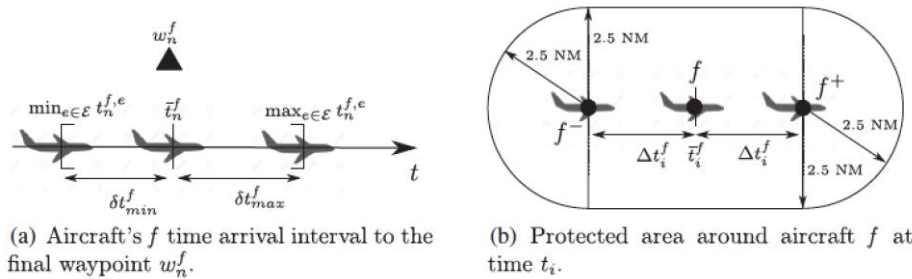
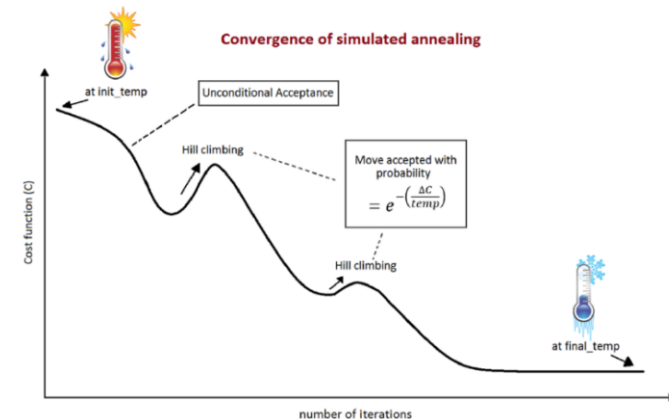
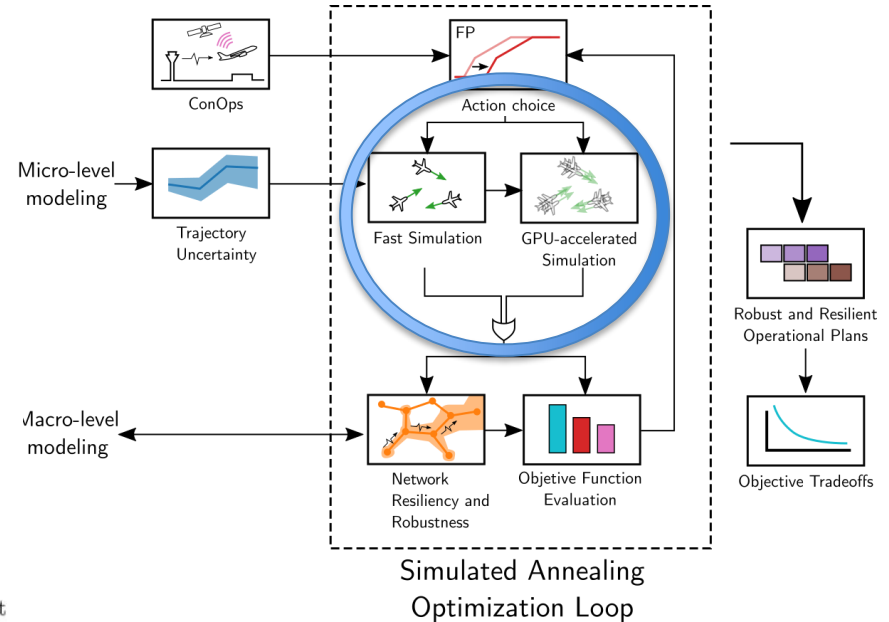


Fig. 2. Aircraft's time uncertainty and protected area.

## Novelty: SA-based Metaheuristic Algo



Valentin Courchelle, Manuel Soler, Daniel González-Arribas, and Daniel Delahaye. Strategic Aircraft Deconfliction under Wind Uncertainties: A Simulated Annealing Metaheuristic Approach based on Speed Changes. Transportation Research Part C: Emerging Technologies. Volume 103, June 2019, Pages 194-210. 10.1016/j.trc.2019.03.024

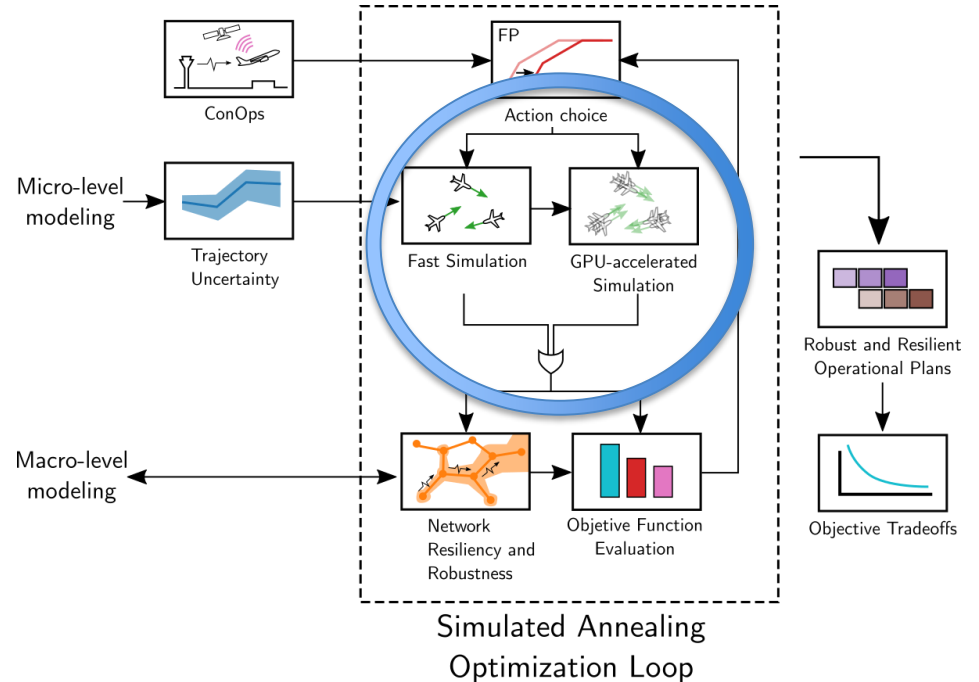
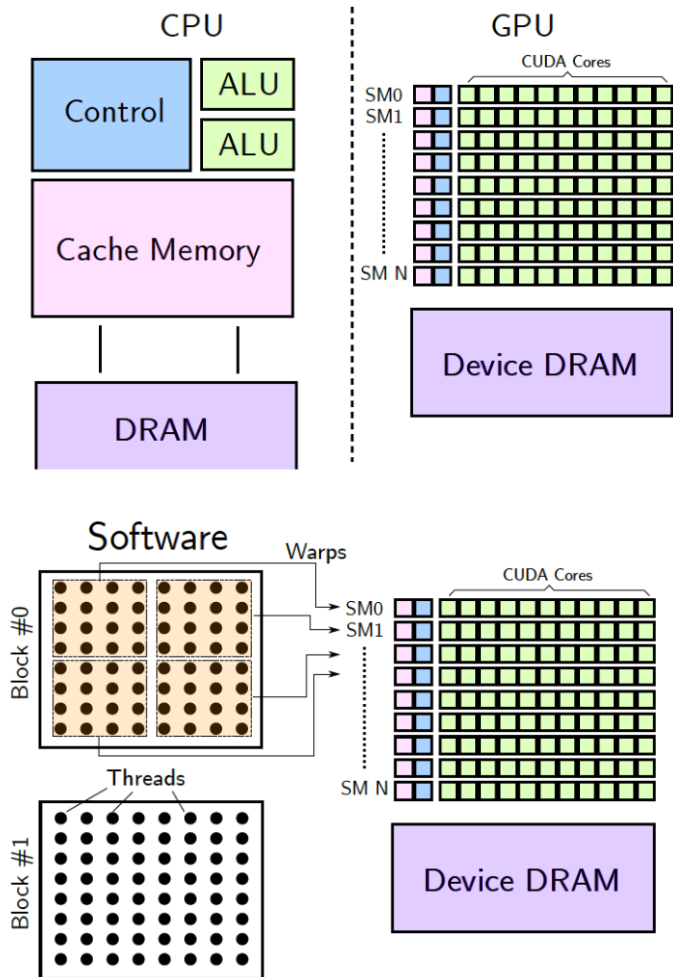


# WP4: Tasks 4.5 and 4.6

Task 4.5: Parallel, GPGPU robust metaheuristic Simulating Annealing algorithm (UC3M)

Task 4.6: Use case simulations (ENAC)

Computational times are paramount!!!



**Novelty: GP-GPU SA-based Metaheuristic Algo**

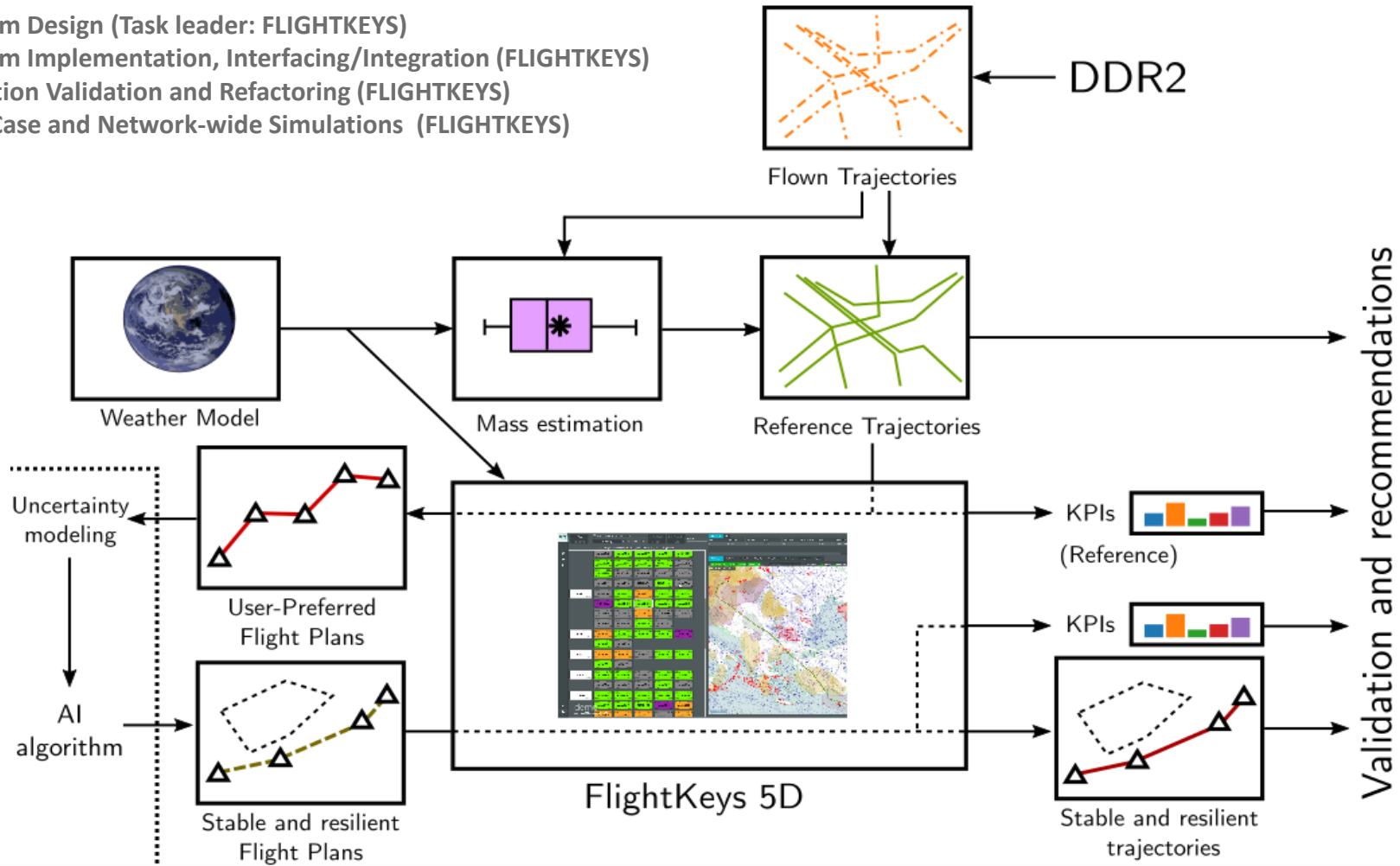
Daniel González-Arribas, Aniel Jardines, Manuel Soler, Javier García-Heras, and Eduardo Andrés-Enderiz. Probabilistic 4D Flight Planning in Structured Airspaces through Parallelized Simulation on GPU. ICRAT 2020. Accepted.

# WP5: goal and methods

## Flight dispatching prototype tool

**Objectives:** The goal of this work package is to validate the concept in a simulated dispatch environment of one or more airline operators, utilizing the FK5D flight management system

- Task 5.1: **System Design** (Task leader: FLIGHTKEYS)
- Task 5.2: **System Implementation, Interfacing/Integration** (FLIGHTKEYS)
- Task 5.3: **Function Validation and Refactoring** (FLIGHTKEYS)
- Task 5.4: **Use Case and Network-wide Simulations** (FLIGHTKEYS)



# WP5: Flight dispatching prototype tool

Let's see a (quick) Demo by Raimund Zoop

**5D**

AUA

Flight Date (UTC, 10:00-22:00)

2019-08-26

-12h now +12h

DEPARTURE

DESTINATION

Desks

FLIGHT

FUFI

312 flights match the filter. Only the first 250 flights are displayed!

AUA4EG AUA553 AUA12V AUA37L AUA11M

AUA17B AUA35G AUA30S AUA565R AUA862

AUA15P AUA792N AUA30KE AUA374 AUA428

AUA132 AUA410 AUA2026 AUA51LX AUA554

AUA41G AUA80P AUA452 AUA80P AUA80P

AUA8EW AUA83BH AUA83BH AUA86L AUA73Z

AUA75V AUA80V AUA73E AUA75M AUA5BF

AUA864 AUA83H AUA455 AUA417N

AUA64 AUA12L AUA89 AUA73 AUA93

AUA87 AUA130

AUA82 AUA76 AUA52 AUA81 AUA65

AUA75 AUA26

AUA705 AUA80H AUA706 AUA655 AUA741

AUA656 AUA742 AUA735 AUA54E AUA736

AUA54P AUA20MV AUA903 AUA93T7 AUA71R

**A321** 19/19

**B763** 7/7

**B772** 7/7

**CRJ9** 10/10

**demo**

**FP: 0**

FP#	Trip Time	Cost Index	Fuel	Total Costs	ΔFuel to Best	Delay	Time Cost
0	03:05	3	7386	4399	0	00:04	com.flightkeys...

**Flightplan** Flightdata Suitability Flightlog Filing History Briefing Development SysLog

**AUTO-CFMU** **ECN** **FILED** **NONRCP** **NEW TAG** **Optimize** **airport** **enroute**

**LOWW** VIE VIENNA/SCHWECHAT

**RW16 - RUPET2B**

**LCLK** LCA LARNAKA INTL

**RW22 - BONEK1A**

**2019-08-26 AUA83BH**

Costindex (kg/min): 3

Tankering: -52.749 USD/T

S 0900 03:01 1201

L 0900 03:05 1205

TRIP	CFMIN	ALTN	FINRES	ADDNL	MAF	LRSV	BALST	TKOFF	MTKOFF	TAXI	MINBL	BLOCKF	REMF
7386	02:55 C	400	00:09 C	471	00:10 C	1091	00:30 H	0	00:00 H	0	00:00 H	0	00:00 C
9348	03:45 C	9348	03:45 C	9348	03:45 C	9348	03:45 C	9348	03:45 C	9348	03:45 C	9348	03:45 C
1962	00:46 H	1962	00:46 H	1962	00:46 H	1962	00:46 H	1962	00:46 H	1962	00:46 H	1962	00:46 H

**Destination Alternates**

LCEN	34 NM	471	00:10	
LCKK	39 NM	497	00:11	
LCPH	74 NM	794	00:19	

**OE-LBE** ... **A321** kg

**Profile** Notam Met Route DEST2 ETOPS Avoid Rem(0)

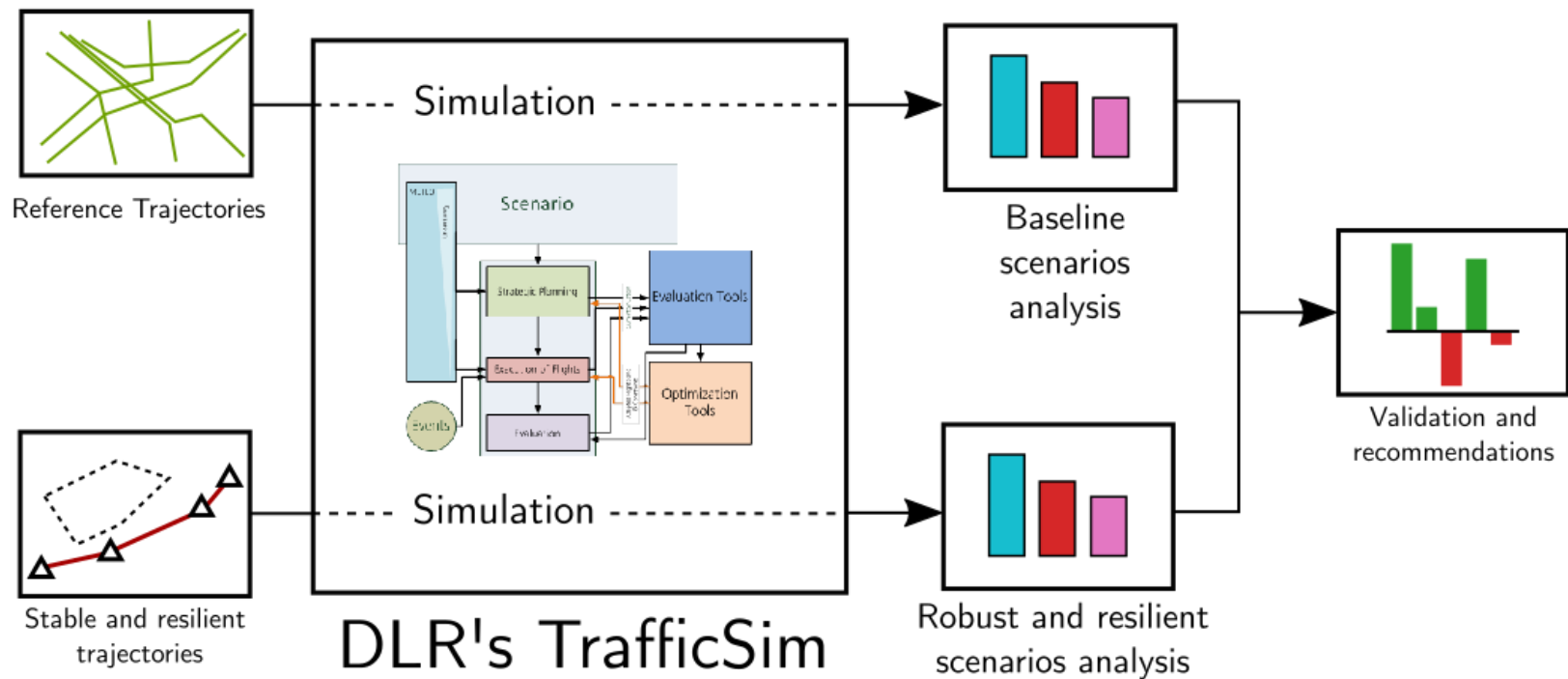
MinFL 0 MaxFL 0



# WP6: goal and methods

## Simulation and Validation

**Objectives:** Definition of Validation Metrics. Integration of new models in simulator and execution of system wide simulations. Analysis of results and recommendations.



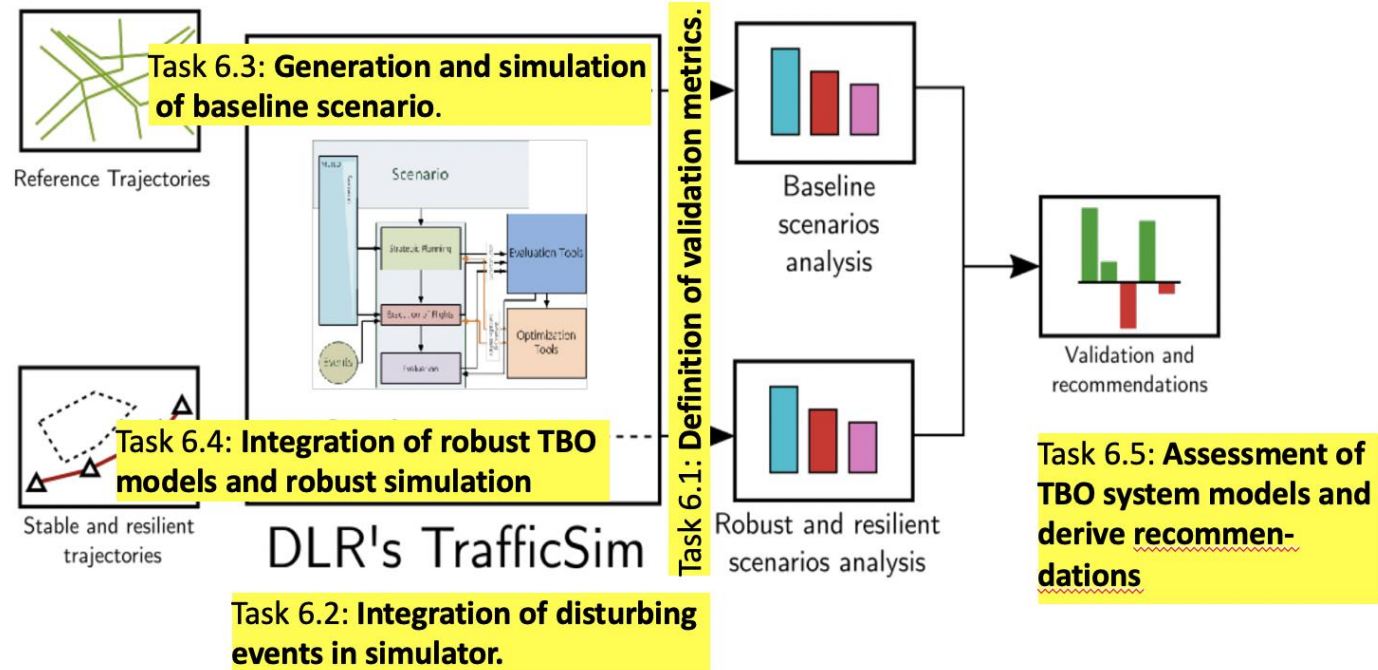
- Task 6.1: **Definition of validation metrics** (Task leader: DLR)
- Task 6.2: **Integration of disruptive events in simulator** (DLR)
- Task 6.3: **Generation and simulation of baseline scenario** (DLR)
- Task 6.4: **Integration of robust TBO models and robust simulation** (DLR)
- Task 6.5: **Assessment of TBO system models and derive recommendations** (DLR)

# WP6: Tasks 6.1 to 6.5

## Simulation and Validation

Validation metrics (T6.1):

- the number of replannings,
- the collision risk,
- Delay minutes,
- CO2/Fuel savings
- throughput,
- etc.

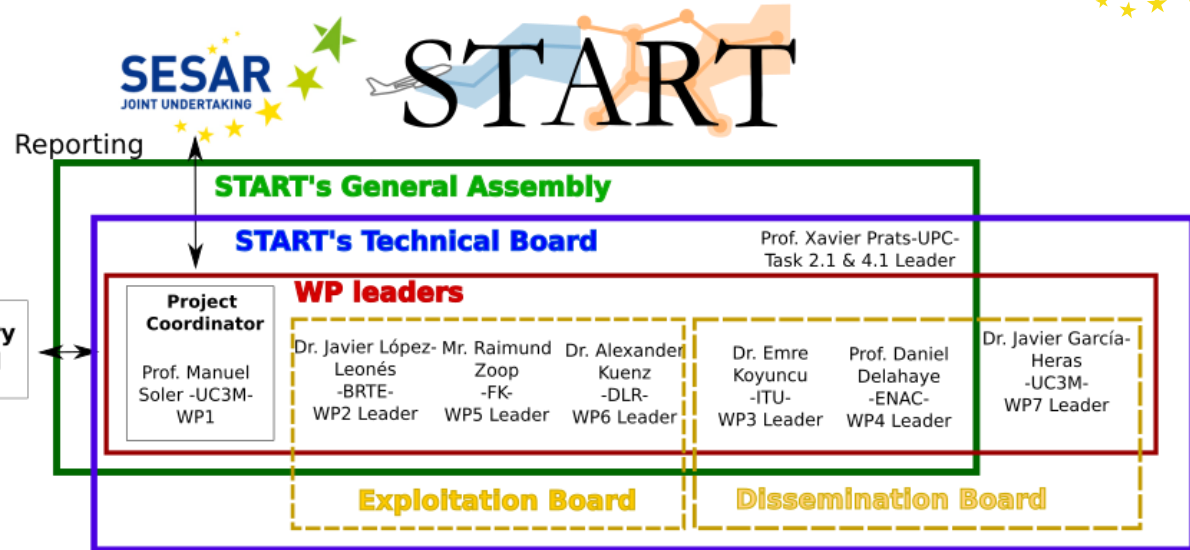


Task 6.2 → Implement and integrate disturbing events in system-wide simulator for a single trajectory as well as for TBO systems.

Result: On demand, the simulator can disturb a scenario by disruptions.

**Task 6.5 → Assessment of Hypothesis 1 and Hypothesis 2**

# Ways of Working: structure



General Assembly Meetings	Date	Place
Kick off Meeting (Start of execution)	T0	Madrid-(TELCO)
2-Days-WS of partners incl. Intermediate Progress Meeting 1	M6 –Nov. 2020--	München –TBA-
Intermediate Progress Meeting 2	M12 –May 2021--	Istanbul –TBA-
2-Days-WS of partners incl. Intermediate Progress Meeting 3	M18 –Nov. 2021--	Wien –TBA-
Intermediate Progress Meeting 4	M24 –May 2022--	Braunschweig –TBA-
Workshop and final meeting	M30 --Nov 2022--	Madrid –TBA-

- Technical/Exp./Dissemination Board will have monthly telco meetings to monitor progress
- Daily activity (more important than ever)

# Ways of Working: technical monitoring

## Collaborative Wiki (Microsoft Teams) for daily activity

The screenshot displays the Microsoft Teams interface for the 'START Project' team. The left sidebar shows navigation options: Activity, Chat, Teams, Assignments, Calls, Files, and Apps. The main chat area is titled 'General' and shows a list of channels: WP2, WP3, WP4, WP5, WP6, and WP7. The chat history includes a message from 'MANuel Soler' stating: 'MANuel Soler has changed the team name from Prueba to START Project.' Below this, a series of messages from 'MANuel Soler' announce the creation of channels WP2 through WP7, each with a 'Hide channel' link. Two recent messages from 'MANuel Soler' are highlighted, each showing a link added to the top of the channel. The first link is labeled 'Wiki' and the second is labeled 'START Web'. The bottom of the interface shows a text input field with the prompt 'Start a new conversation. Type @ to mention someone.' and a row of icons for actions like reply, edit, add attachments, and more options.

# Ways of Working: technical monitoring

## Code in the cloud (Bitbucket and others) for daily activity

START Project

Repositories

Project settings

ASAP / START Project

### Repositories

Add repositories

Repository	Last updated	Builds
WP1	4 minutes ago	
WP2	a minute ago	
WP3	a minute ago	
WP4	a minute ago	
WP5	36 seconds ago	
WP7	15 seconds ago	

ASAP / START Project

## WP1

Here's where you'll find this repository's source files. To give your users an idea of what they'll find here, [add a description to your repository](#).

master Filter files

Name	Size	Last commit	Message
README.md	565 B	25 seconds ago	Initial commit

### README.md

#### README

This README would normally document whatever steps are necessary to get your application up and running.

#### What is this repository for?

- Quick summary
- Version
- [Learn Markdown](#)

#### How do I get set up?

- Summary of set up
- Configuration
- Dependencies
- Database configuration
- How to run tests

### Repository details

Last updated  
23 seconds ago

Open pull requests	Branches
0	1

Watchers	Forks
2	0

Version control system  
Git

Access level  
Admin

0 builds

Give feedback



## START

**“a Stable and resilient ATM by integrating Robust airline operations into the network”**

**ENGAGE Technical Challenge 2 2021**

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# Back-up Slides



This project has received funding from the SESAR Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under grant agreement No [number]



Founding Members



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