



Evaluating technologies and mechanisms for the automated/autonomous operation of UAS in non-segregated airspace

ICARUS Research Group

Department of Computer Architecture

Technical University of Catalonia (UPC)

enric@ac.upc.edu

www.icarus.upc.edu

<http://www.youtube.com/user/ICARUSgroup>



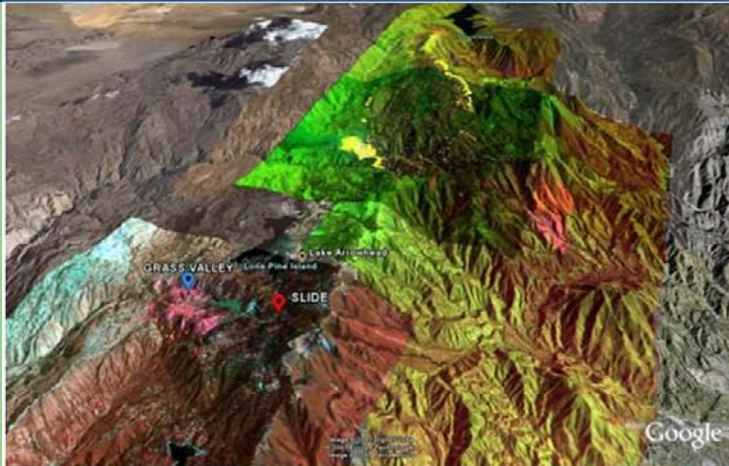
Smooth UAS, an EEC Project



- Project ***smooth UAS***:
 - Create an environment to evaluate simulated mission-oriented UAS coupled with realistic traffic and ATC interactions.
 - Followed by the evaluation of contingencies, separation, conflicts, ATC and pilot work-load, lost-link, etc...
 - Focus on collaborative environments.
 - Project currently beginning its fourth year.
- Motivation: UAS are not point-to-point aircraft
 - Little realistic experience exists beyond military.
 - Some “civil” applications exists mainly by NASA and NOAA.
 - Experience is needed before defining operational issues.

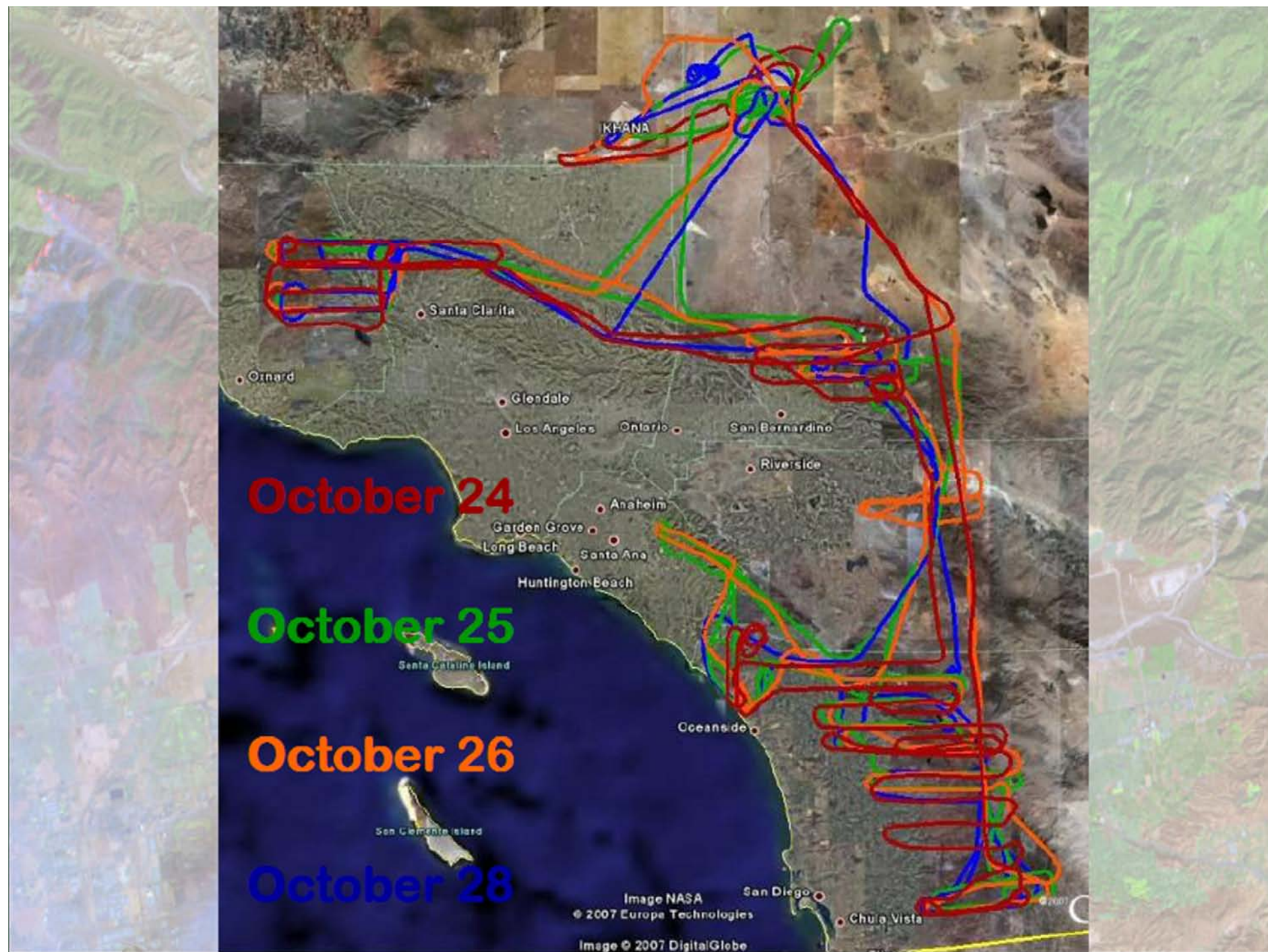


Western States Fire Mission





Flight Plan with MODIS RRS Fire Detects



Smooth UAS Project



Guess, who is the real pilot?



UNIVERSITAT POLITÈCNICA
DE CATALUNYA

Smooth UAS Project



- Conclusions from existing experience:
 - The complexity of UAS operations will require an increased degree of automation so that the pilot can safely fly.
 - Manual control seems not an option due to the reduced situational awareness and workload of the pilot.
 - All evaluated operations required really large set of crews.
 - Contingencies, separation and ATC factors not yet addressed, “sense and avoid” still dominates.



Flight Plan Specification



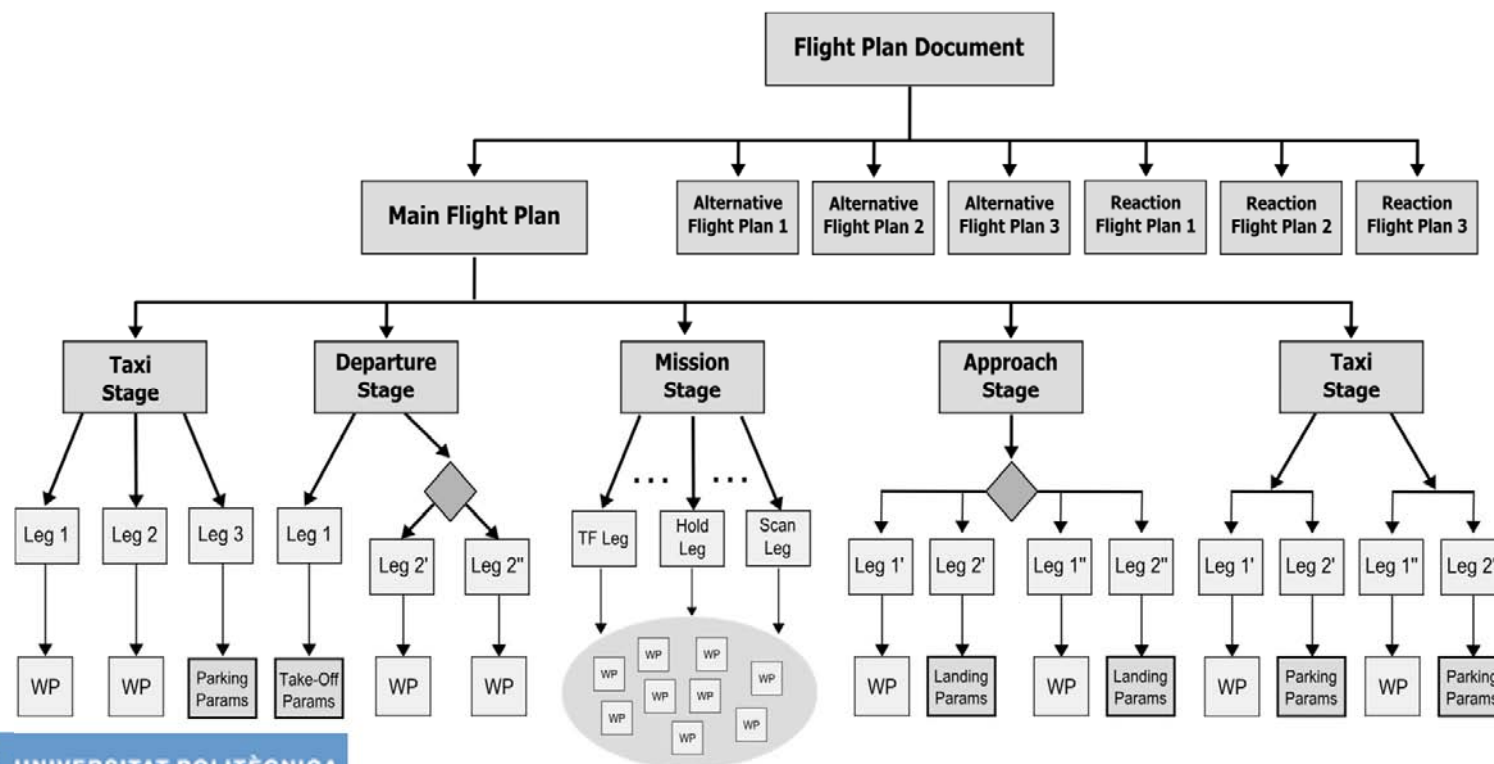
- The Flight Plan sets the path that the UAS will follow.
- It is usually specified as a list of waypoints:
 - It is difficult to specify complex paths.
 - It is not aware of mission time circumstances.
 - Alternative is to build an “intelligent” system that decides the route on the fly (avoid because is non-deterministic).
- Our specification mechanism provides:
 - Leg constructs based on Area Navigation (RNAV)
 - Control structures for iterating and forking
 - High-level flight patterns defined through parameters
 - Alternate plans specification to react to contingencies
 - Separation manoeuvres



Flight Plan Specification



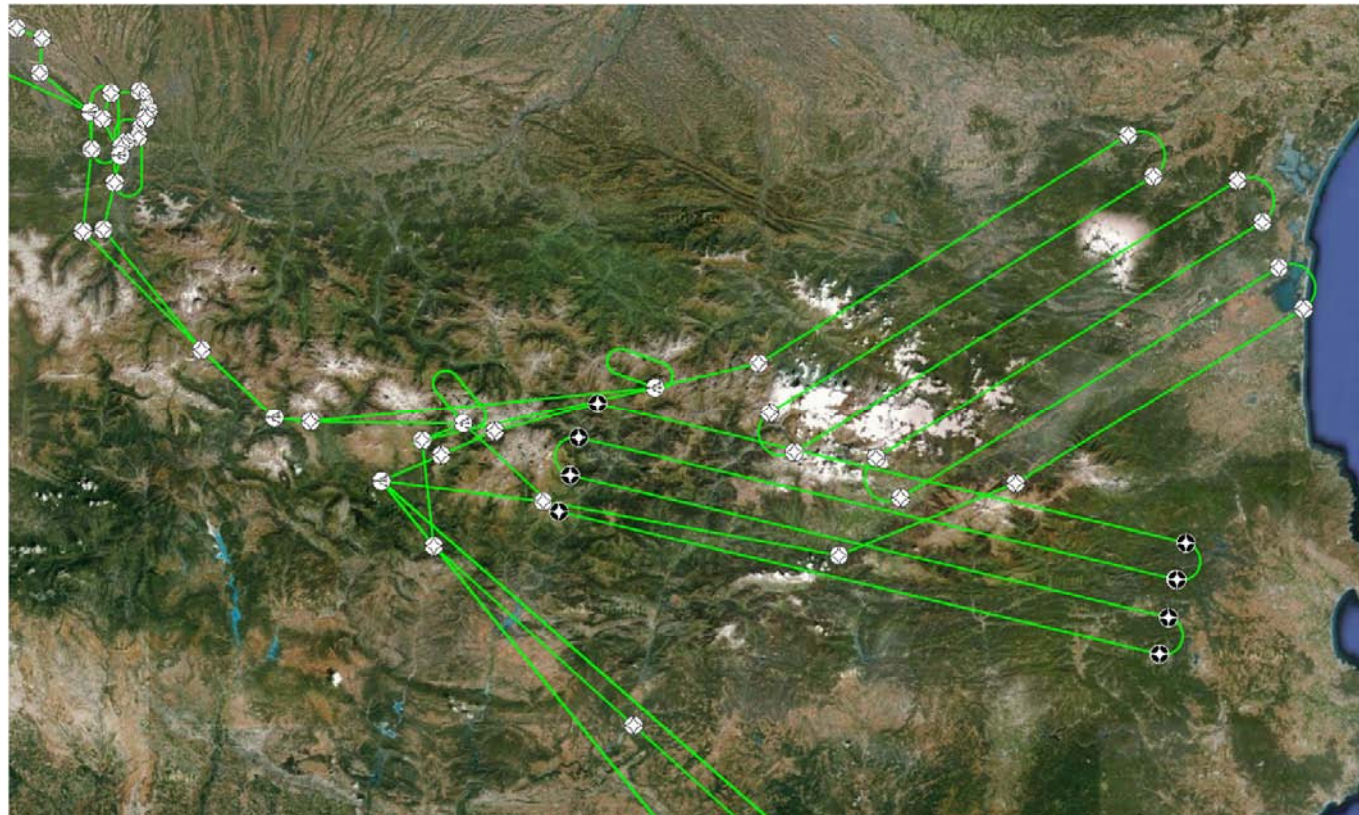
- Flight plan becomes a tree-like structure.
- Stages are followed sequentially, while at certain points we need to select specific sub-branches.
- Jump to an alternative branches to manage contingencies.



Flight Plan Specification



- Complexity of mission-oriented flight plans.
- How can we support the pilot?
- Will ATC's be able to manage them?



Smooth UAS Project



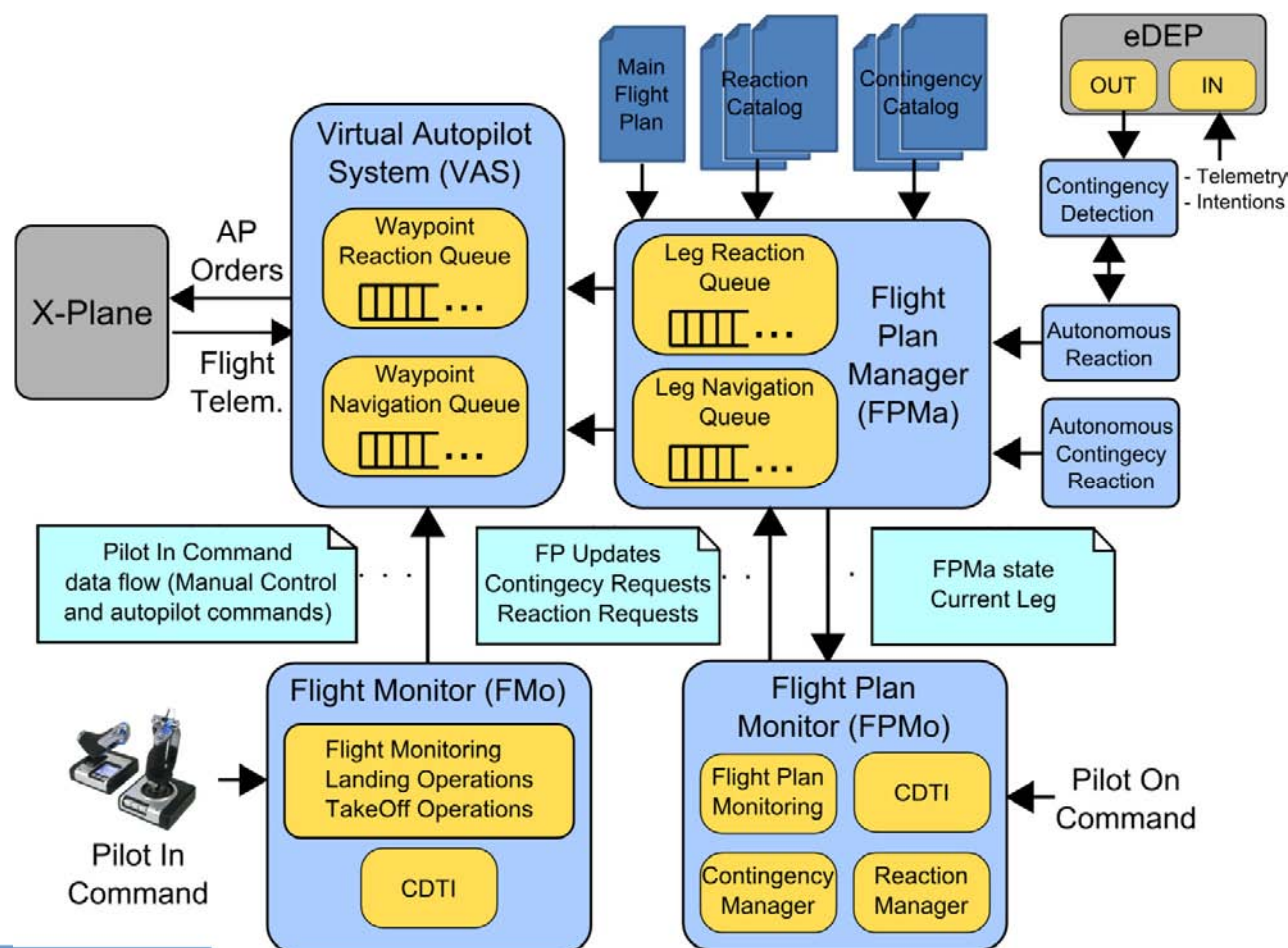
- Current project activities:
 - Create a simulation environment in which realistic UAS missions can be implemented in real-time.
 - Design mission-oriented concepts of operation and systems that support UAS under high levels of automation.
 - Link the simulator with an ATC environment with actual traffic and controller interaction (eDEP simulator).
 - Use the environment to evaluate and measure the factors that critically impact UAS operations:
 - Automated/autonomous pre-planned contingencies.
 - En-route/mission separation maneuvers.
 - Lost-link scenarios and the benefits of ADS-B.



ISIS Simulation environment



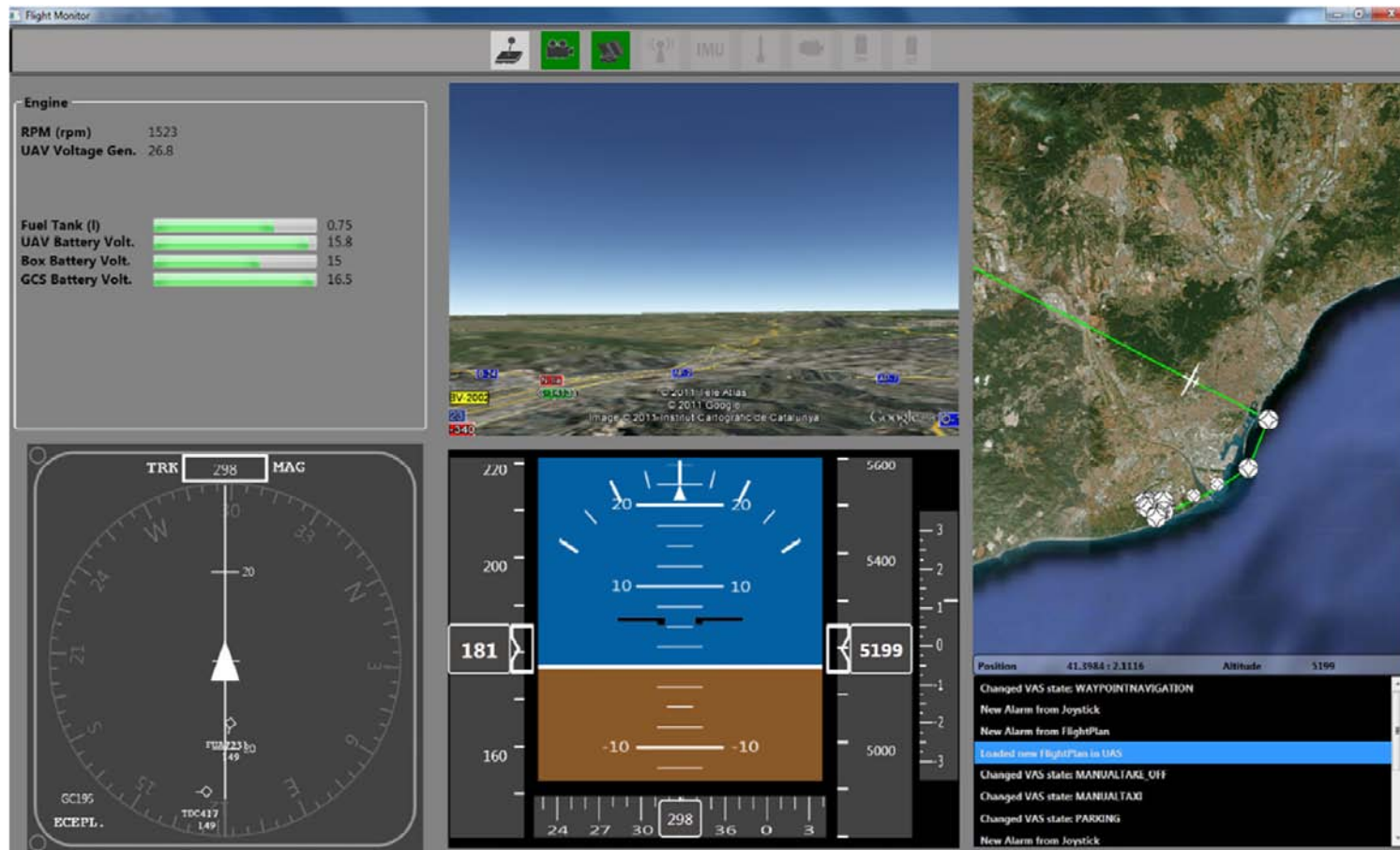
- Overview of the current ISIS components:



ISIS Simulation environment



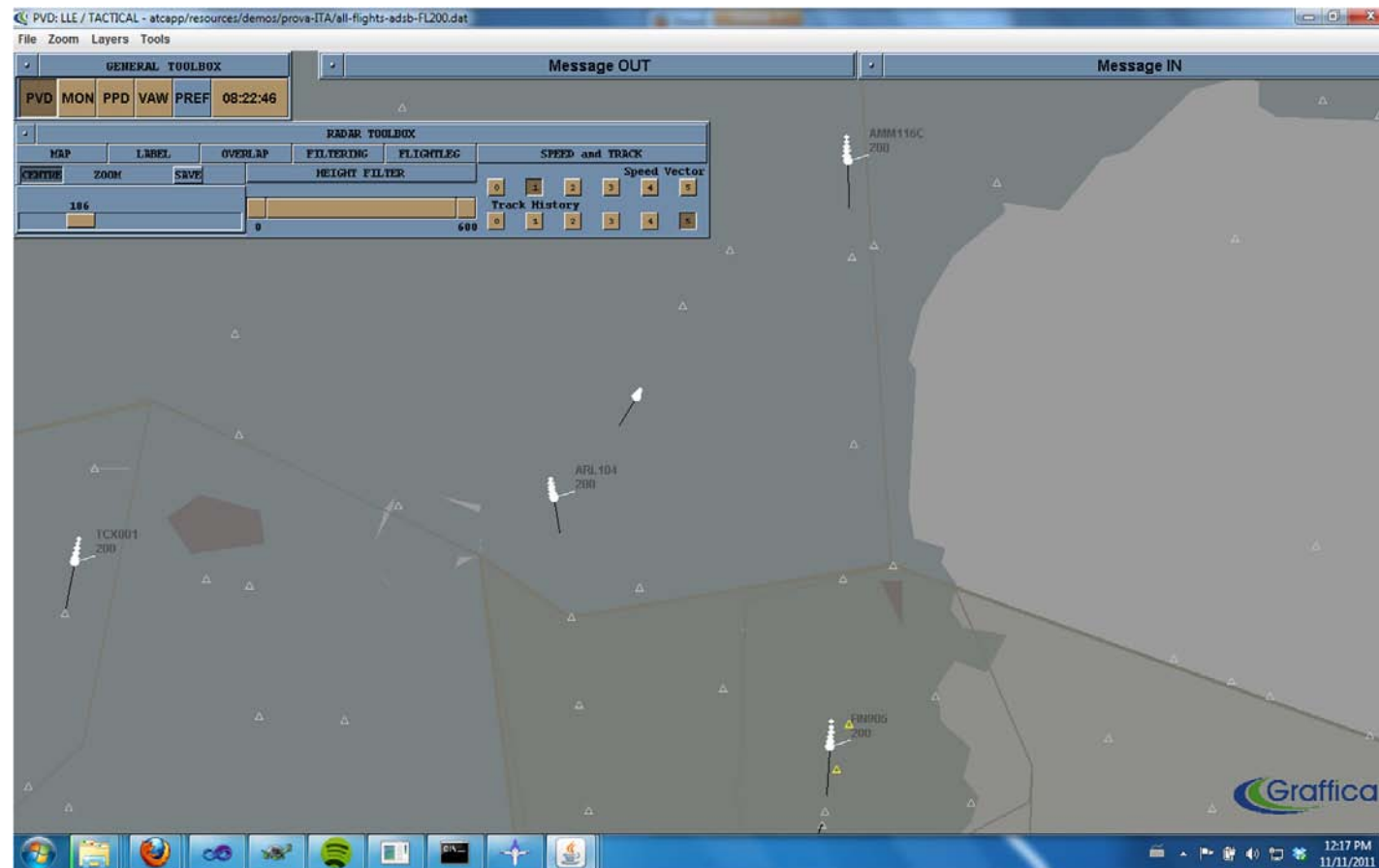
- Flight Monitor (primary display):



ISIS Simulation environment



- Partial integration with eDEP:



ISIS Simulation environment

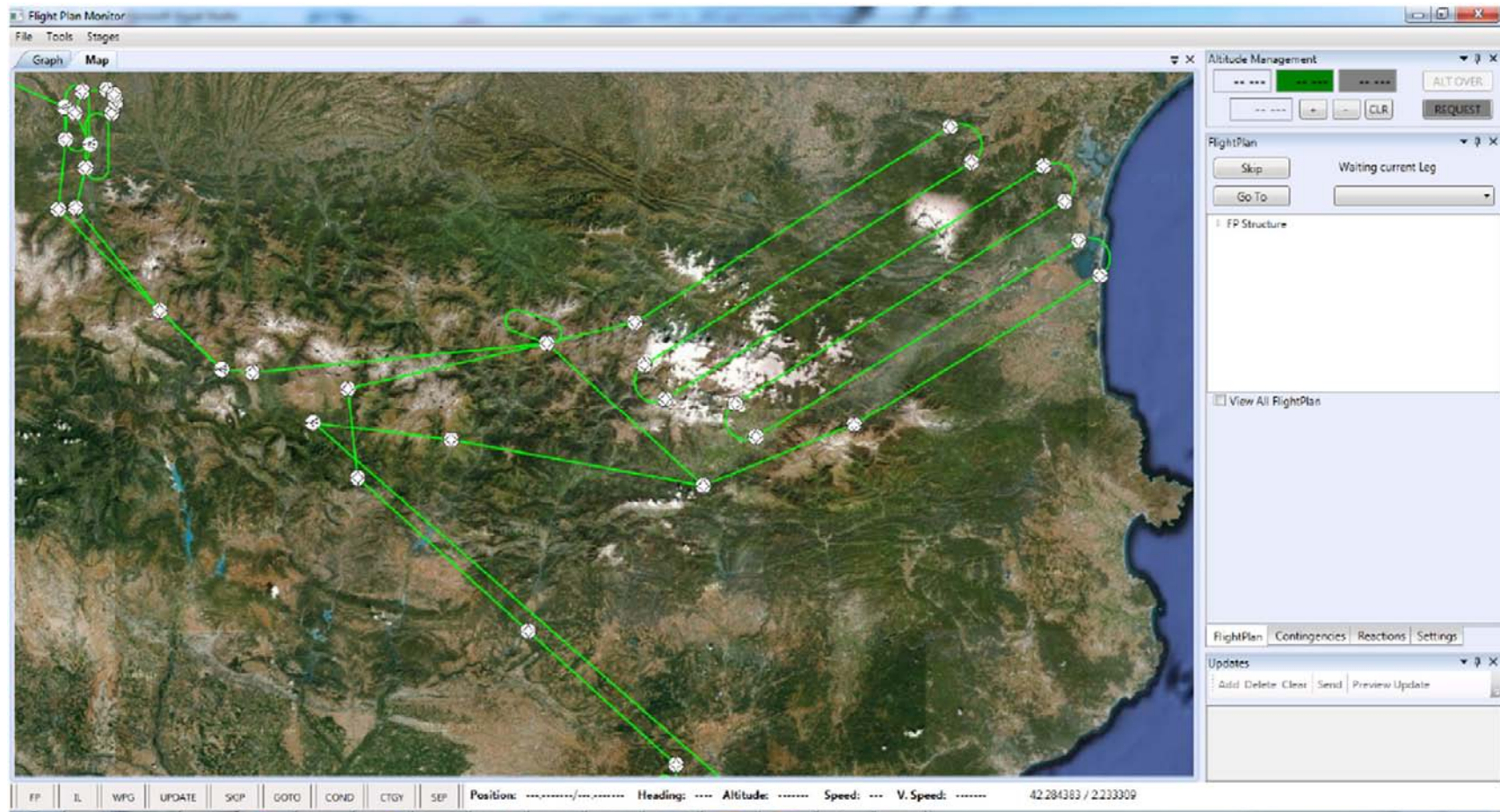


ISIS Simulation environment

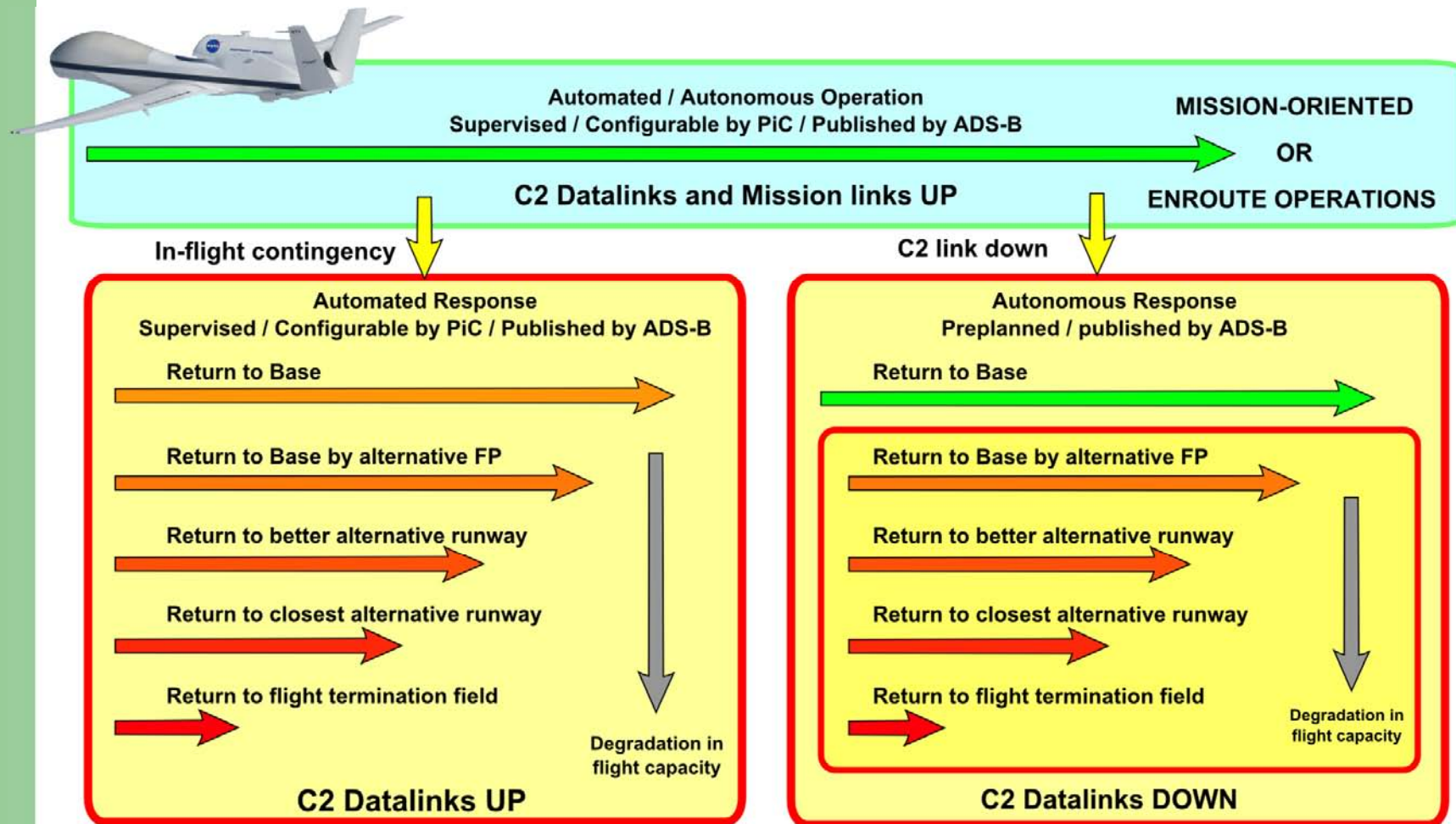


UNIVERSITAT POLITÈCNICA
DE CATALUNYA

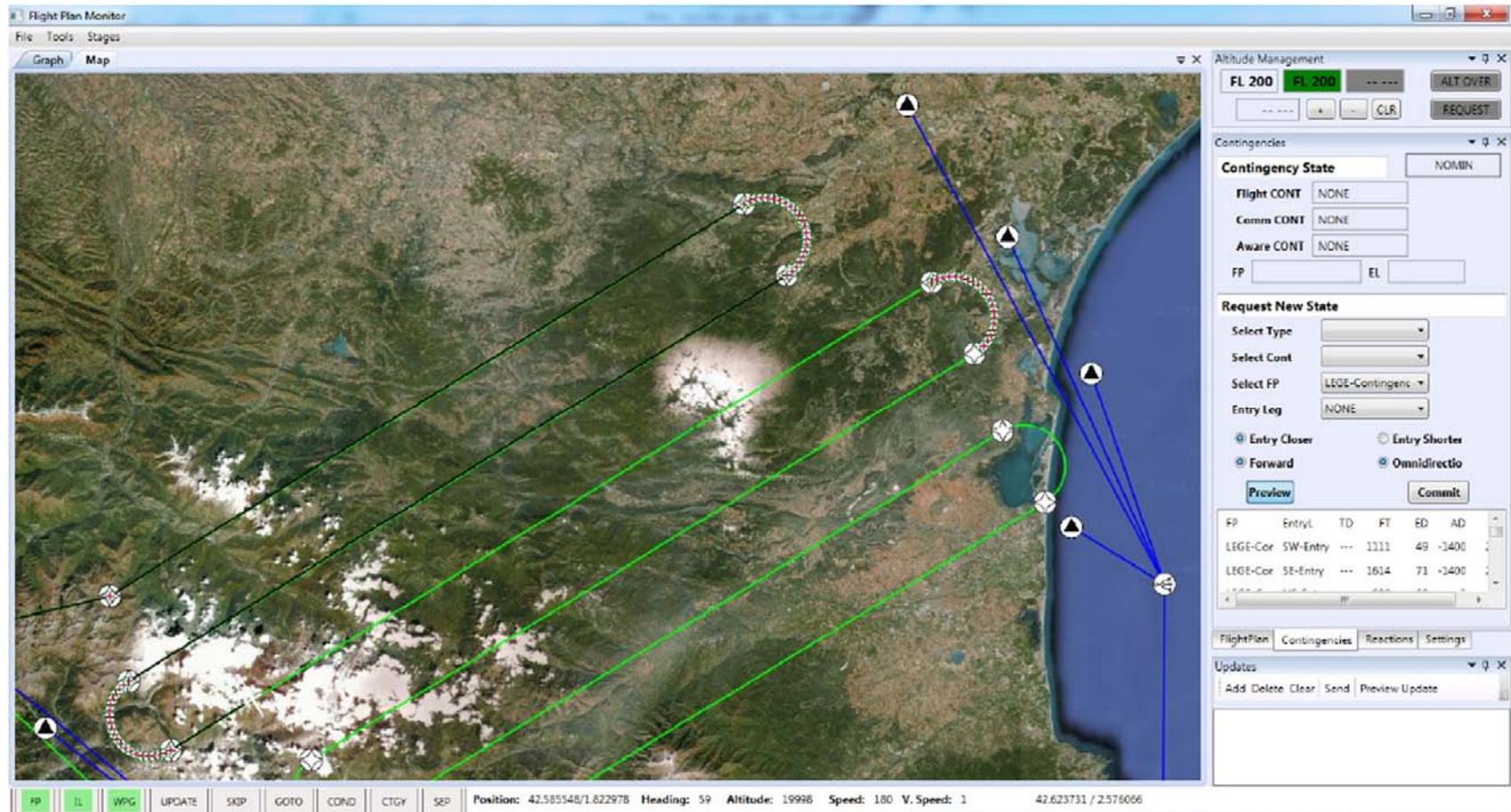
ISIS Simulation environment



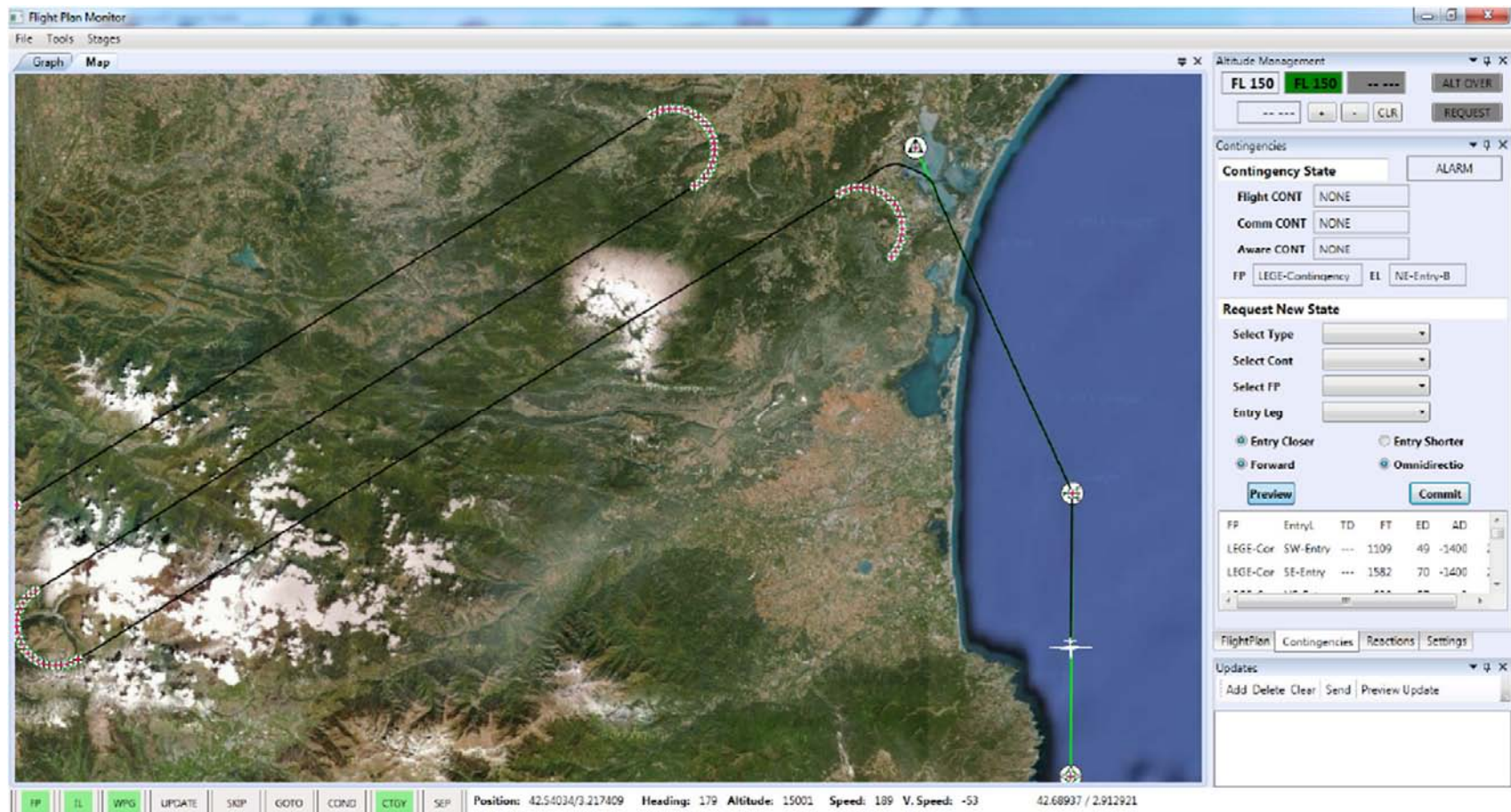
UAS Contingency Management



UAS Contingency Management



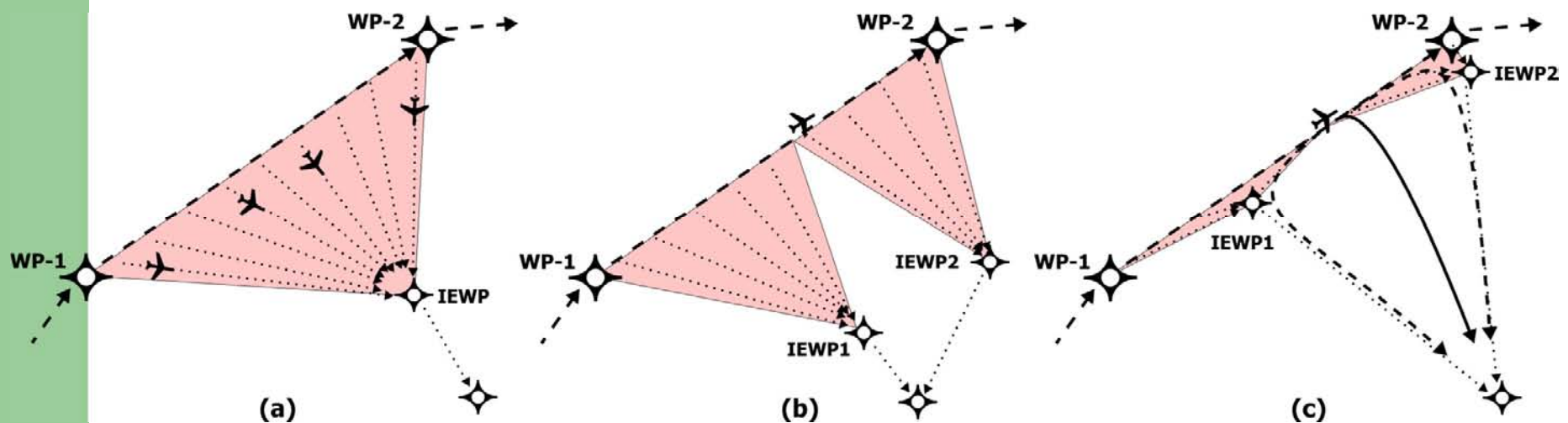
UAS Contingency Management



UAS Contingency Management



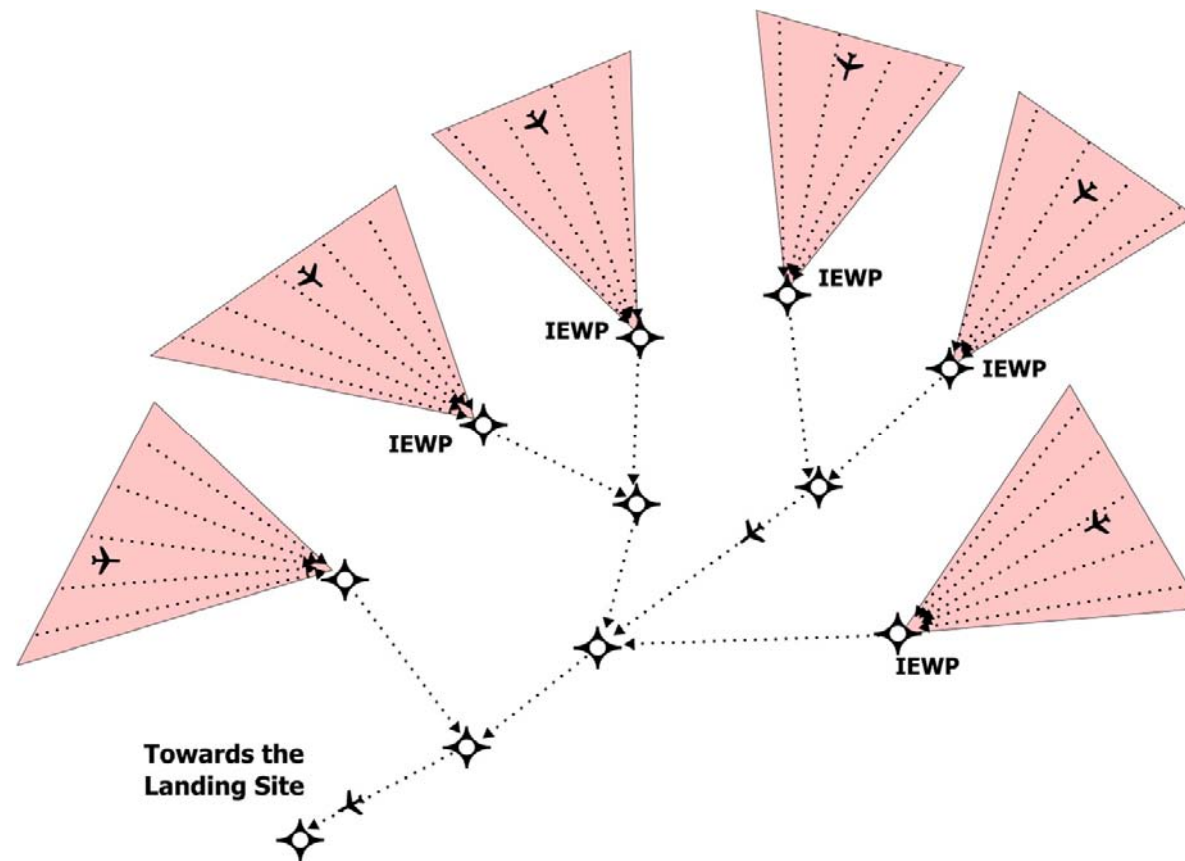
- Uncertainty levels during contingency reactions:
 - Pre-planned reaction to contingencies may produce a trade-off between uncertainty and efficiency of the trajectory.
 - UAS performances need to be taken into account.



UAS Contingency Management



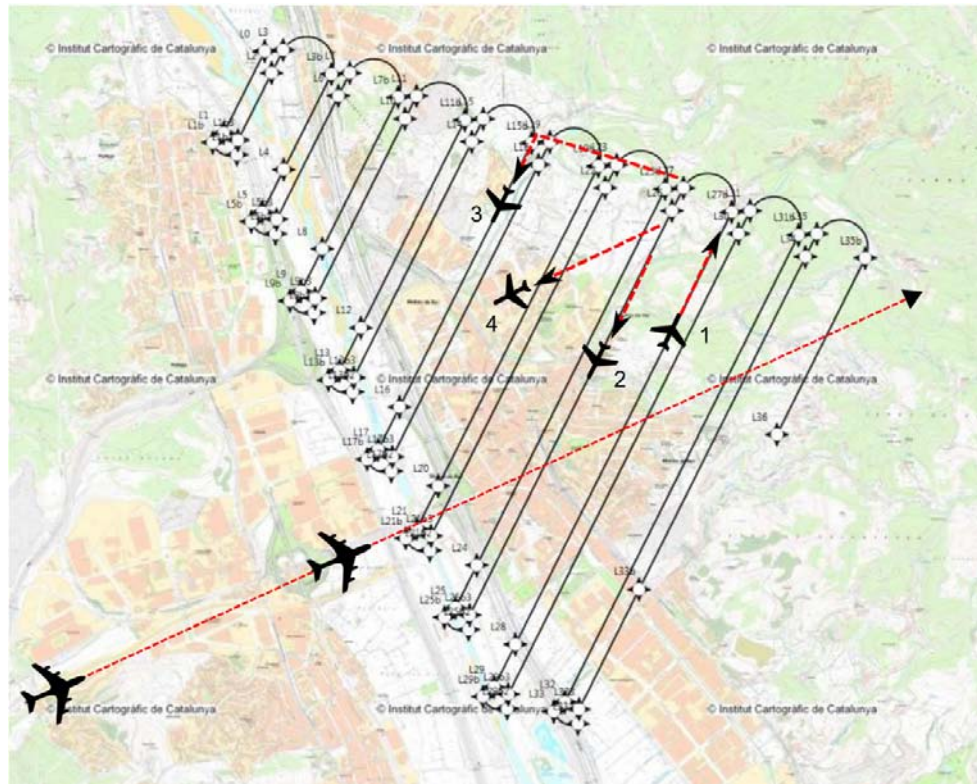
- Multiple initial WP allows reusing the same contingency flight plan, that can be designed at convenience.



UAS Conflict Avoidance



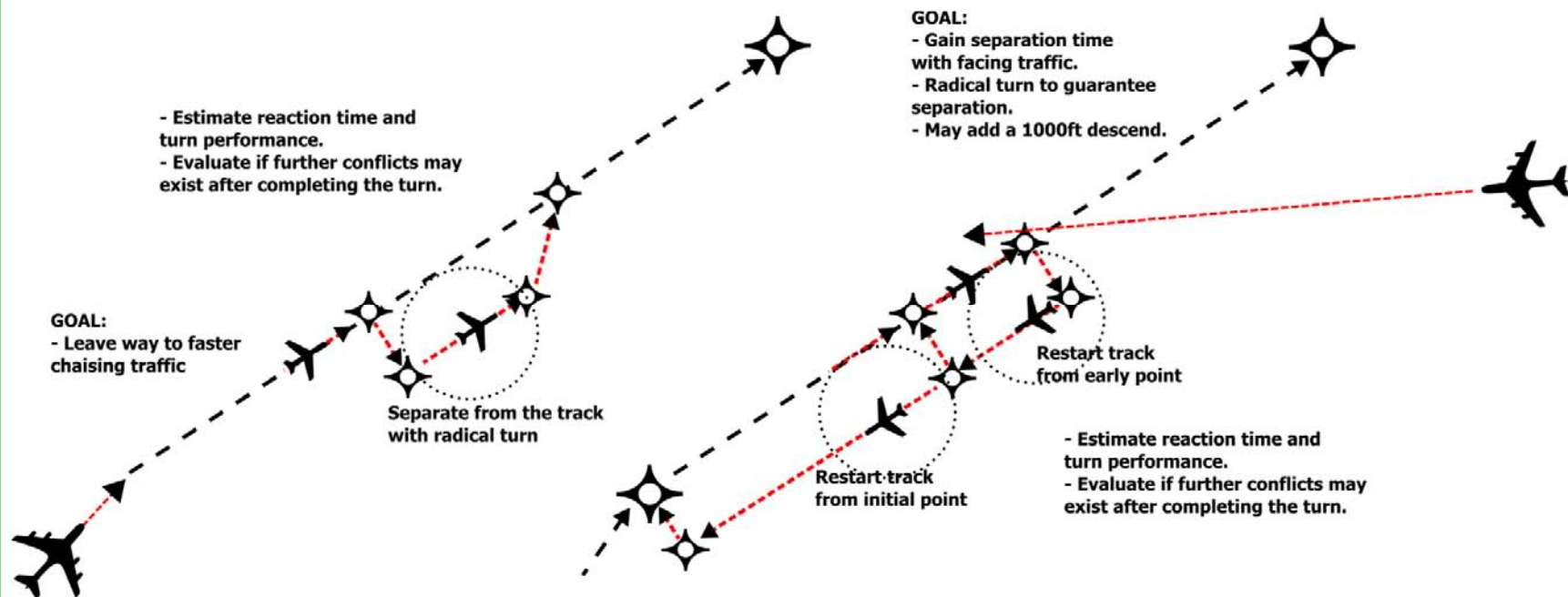
- Evaluate UAS – ATC interaction:
 - UAS profiles completely different from other traffic.
 - UAS interests focused in the mission: may collaborate with ATC to identify best possible separation maneuver.



UAS Conflict Avoidance



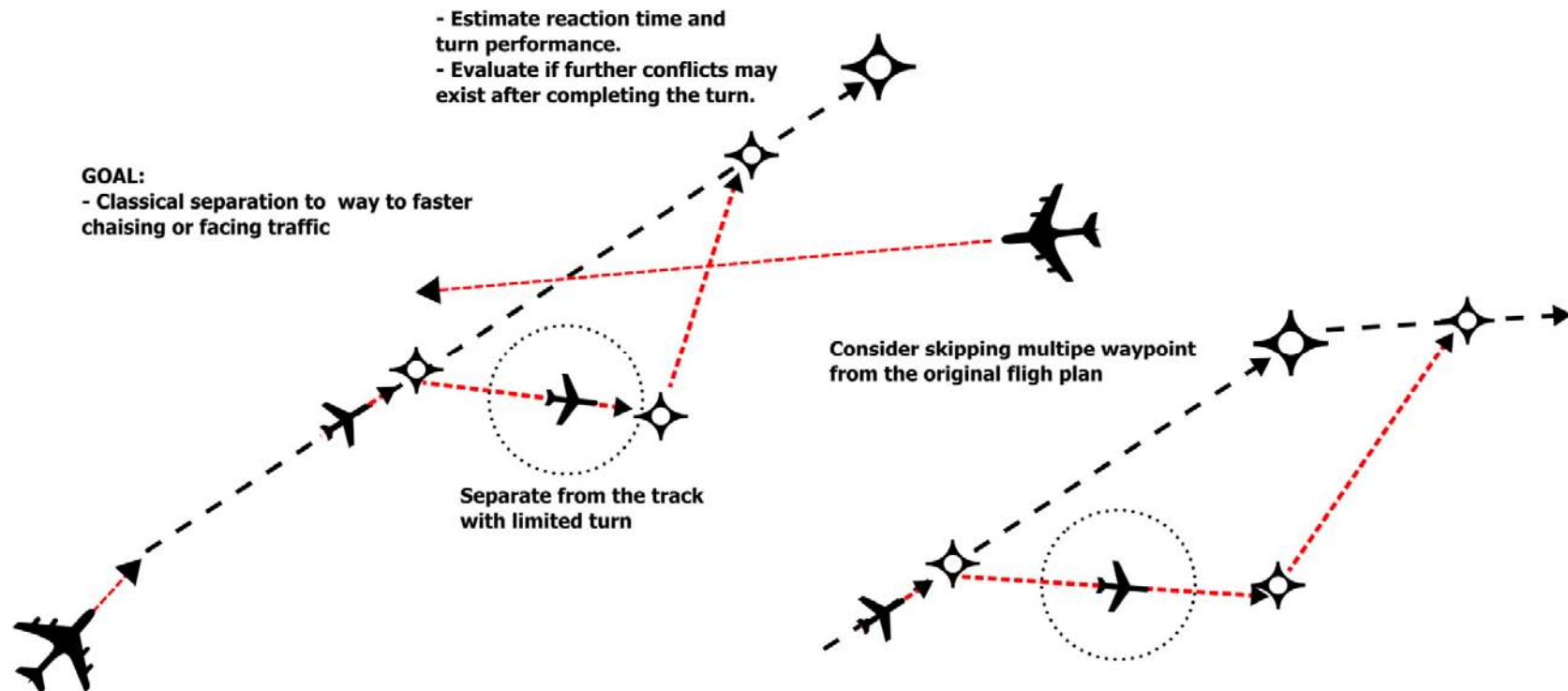
- A number of closed maneuvers are being investigated:
 - Both facing and chasing traffic.
 - Assume proactive UAS reaction.



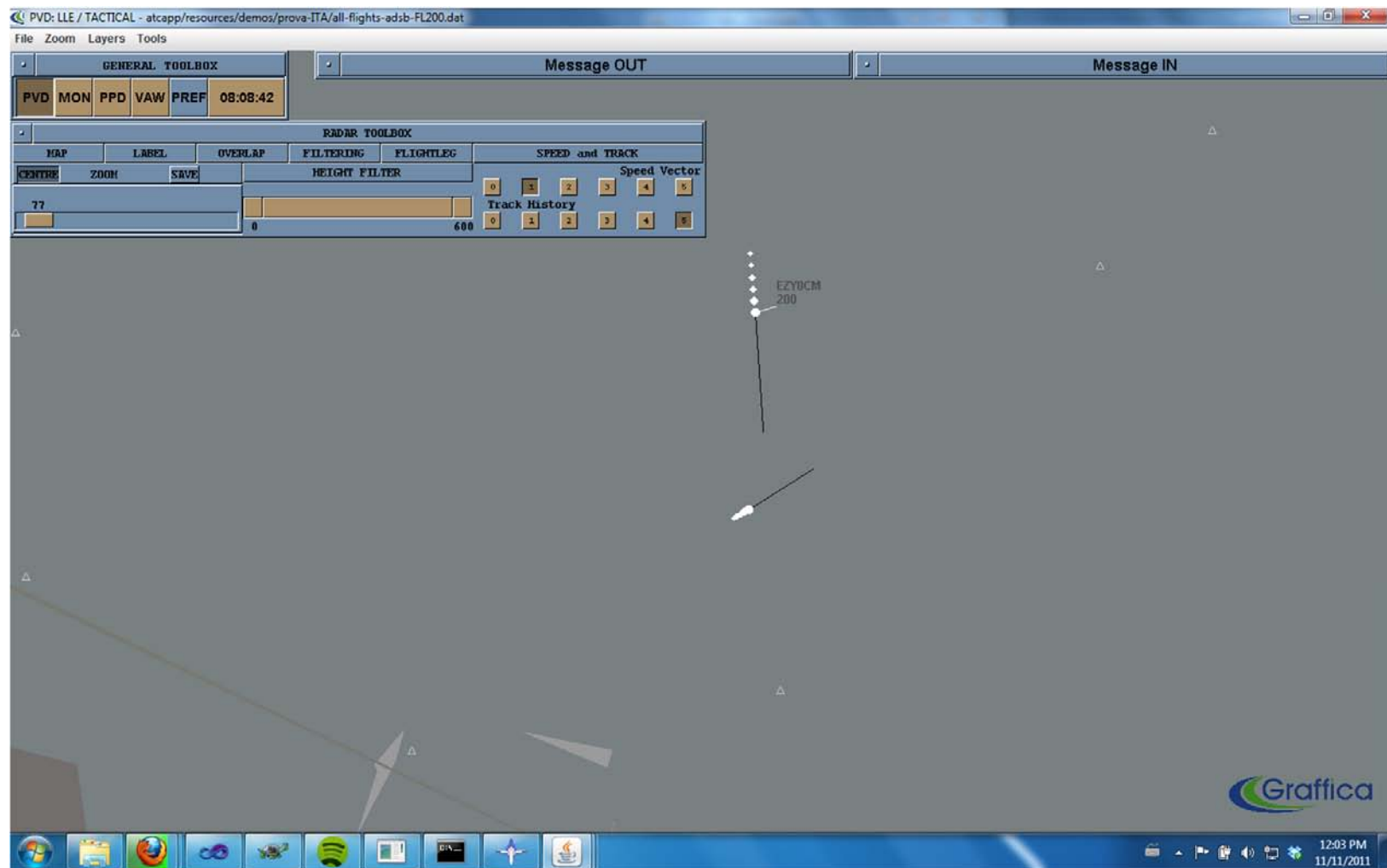
UAS Conflict Avoidance



- Open instructions required by the ATC are also explored:
 - Pilot may need extra support to implement them and get back to its original flight plan.



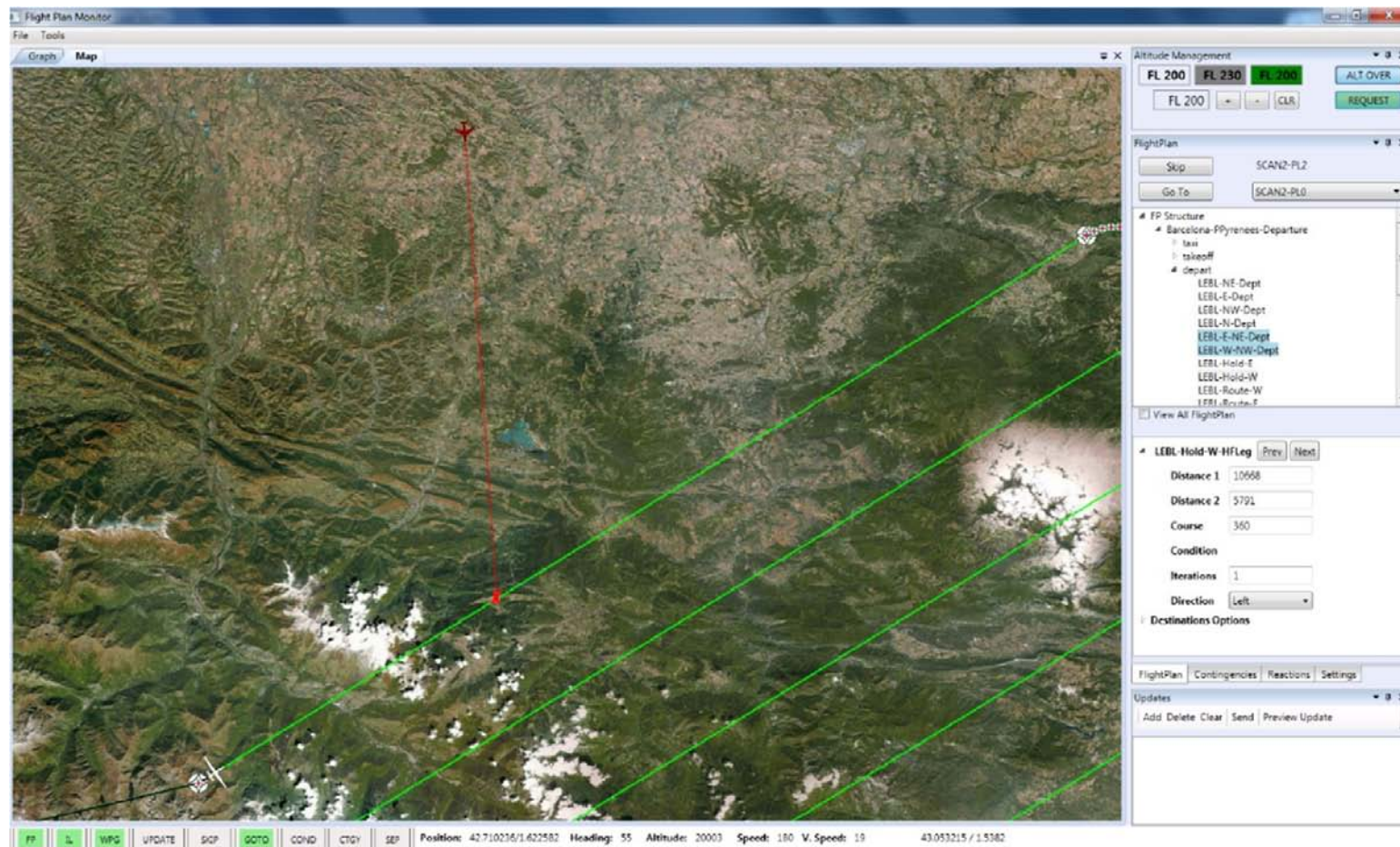
UAS Conflict Avoidance



UAS Conflict Avoidance



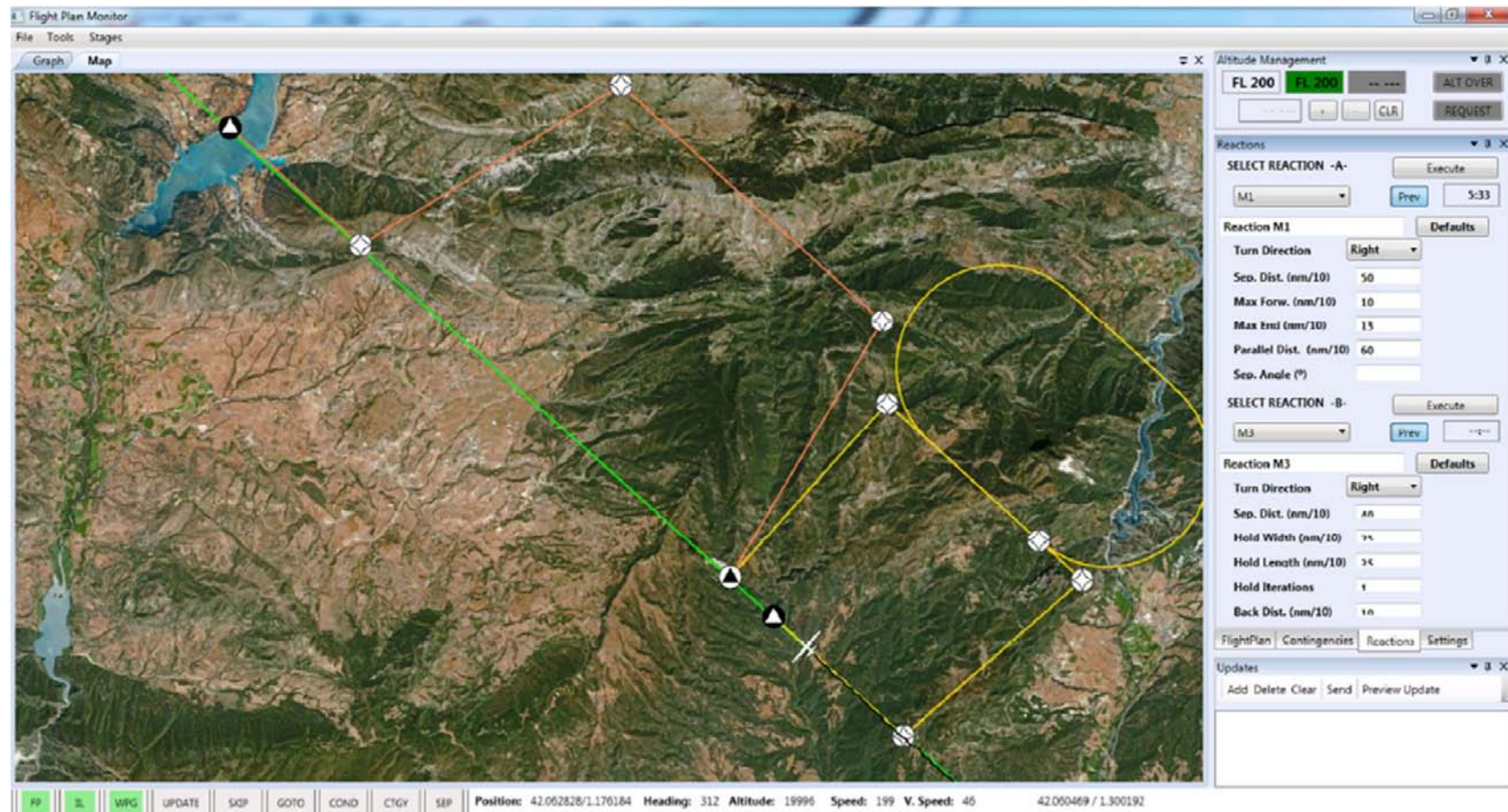
- Interface with eDEP via ADS-B intentions:



UAS Conflict Avoidance



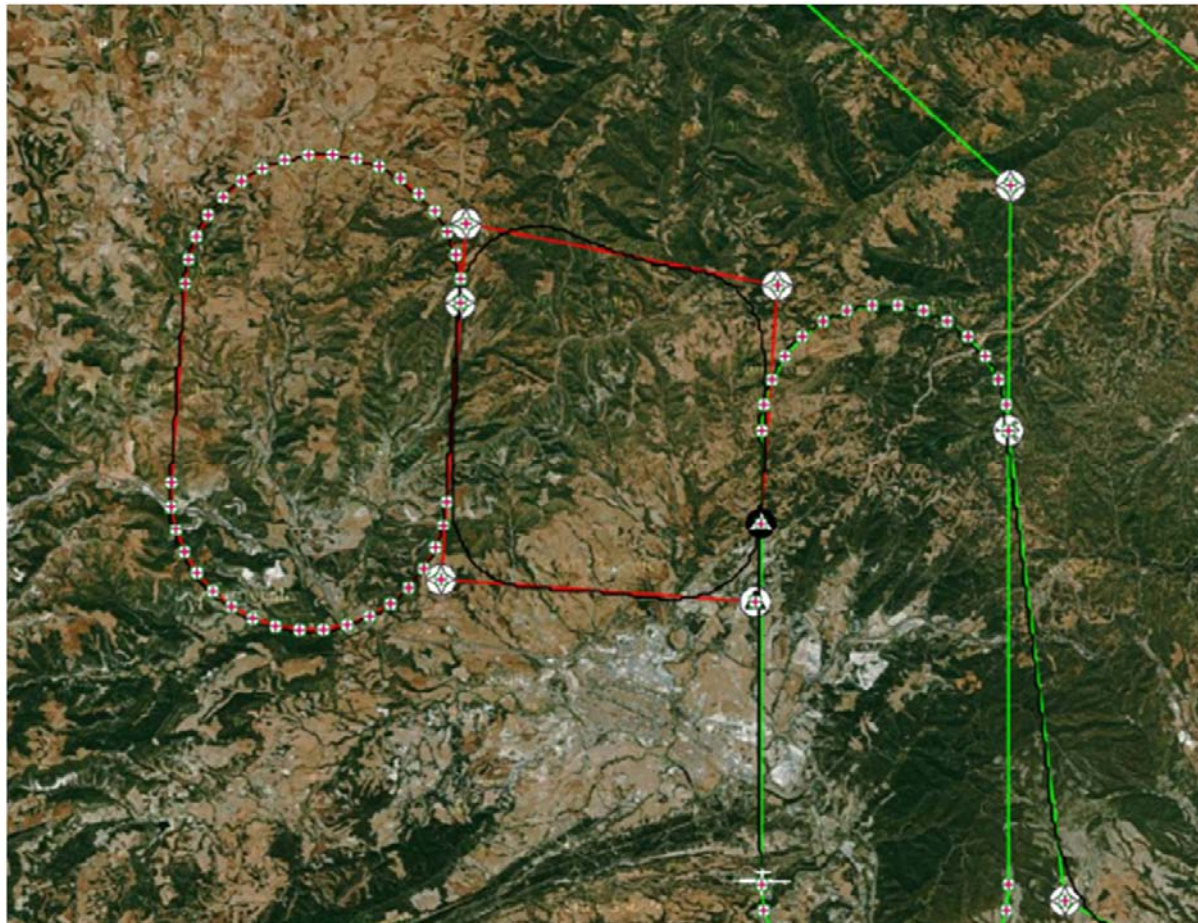
- HMI interface for maneuver selection:



UAS Conflict Avoidance



- Some preliminary results:



UAS Conflict Avoidance



- Some preliminary results:



Conclusions and future work



- Lots of work to be done:
 - UAS performance models to improve trajectory prediction, specially for contingencies and conflicts (BADA-based?).
 - Collection of “active” separation strategies/maneuvers to be employed by the pilot or autonomously.
 - Evaluation of the pilot - ATC interaction under a number of relevant increasingly complex scenarios:
 - UAS with in-flight contingency
 - En-route and mission separation conflicts
 - Lost-link? Will ADS-B give confidence to ATC?
 - Measure UAS reaction capability to all possible ATC requests
 - Measure the capacity of ATC to manage the situations

