

Tactical Re-Planning Algorithms for 4D Contracts in Air Traffic Control

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Tactical re-planning



- ▶ The effect on the surrounding traffic
- ▶ Fuel consumption, timetables
- ▶ Tactical re-planning is performed in real time
- ▶ Inputs: 4D FMS trajectory of the aircraft and its call sign
- ▶ Outputs: call signs of all re-planned flights and their new bone trajectories



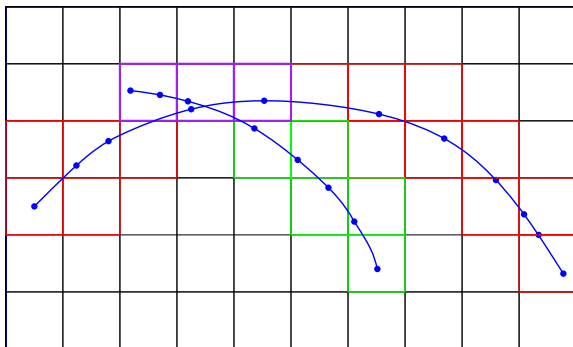
Algorithm components



- ▶ Trajectory sorting/Pre-clustering
- ▶ Re-planning
- ▶ Update of the pre-clustering lists



Pre-clustering

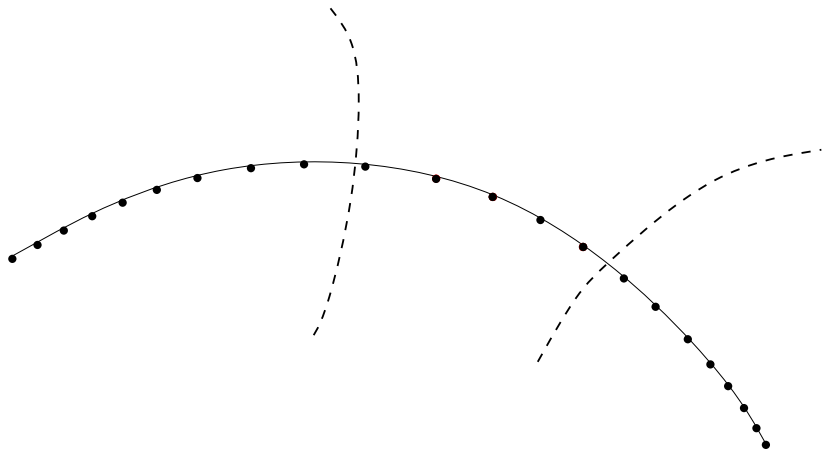


Re-planning

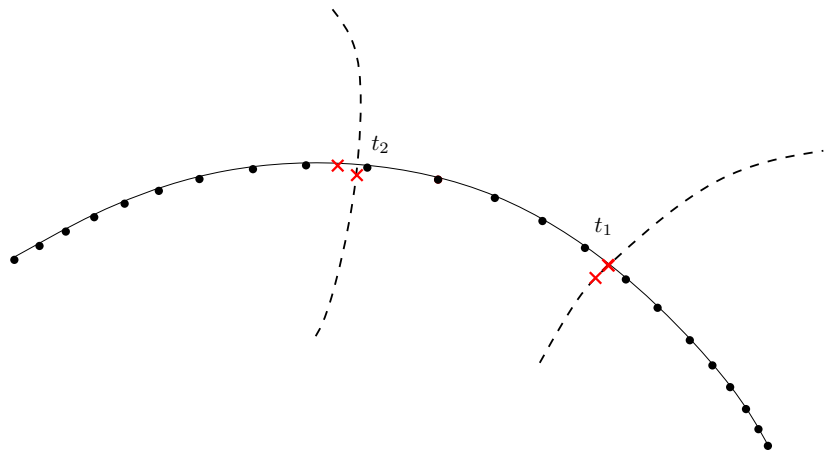
- ▶ Cluster computation for the request aircraft
- ▶ Finding all separation violations within the cluster
- ▶ Trajectory update and optimization



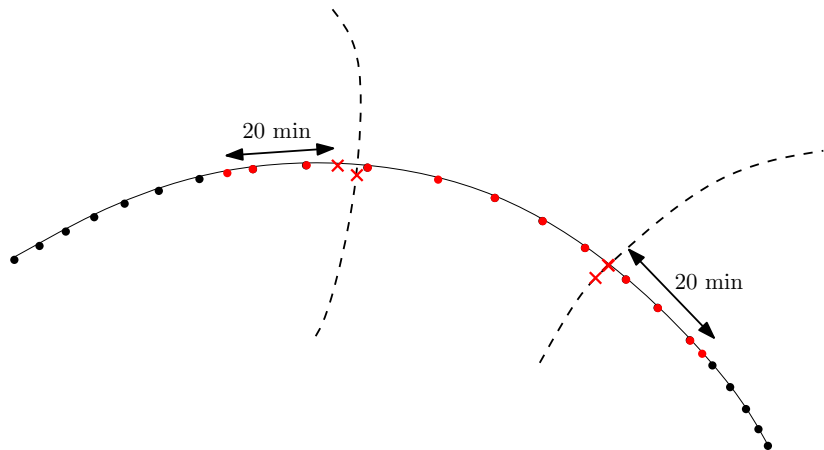
Re-planning (cont.)



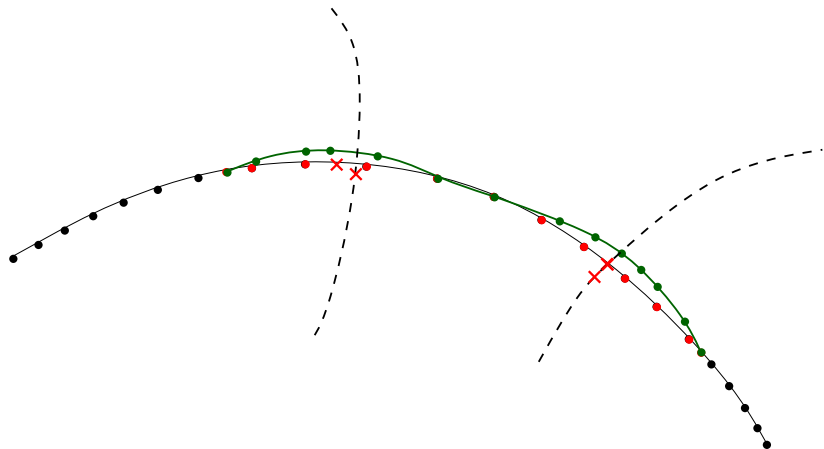
Re-planning (cont.)



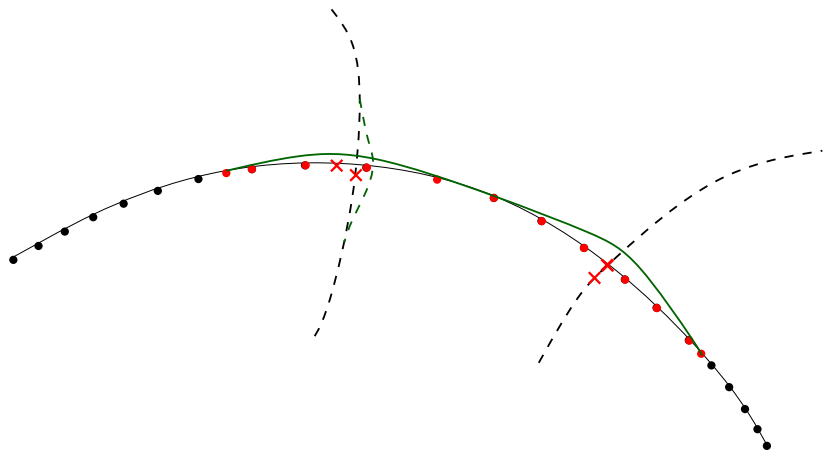
Re-planning (cont.)



Re-planning (cont.)



Re-planning (cont.)



Re-planning (cont.)

The optimization problem:

- ▶ The cost: Change in the arrival time
- ▶ Constraints:
 - ▶ Separation constraints
 - ▶ Turn rate constraints
- ▶ Optimization parameters: planar coordinates of the relevant points
- ▶ The optimization problem is solved using SQP algorithm



Update of the preliminary sorting data

- ▶ Remove the re-planned aircraft from the 3D grid
- ▶ Clear the cluster and trajectory sorting list
- ▶ Generate a new sorting list for the aircraft



Local Re-planning

- ▶ The local re-planning algorithm is similar to the on-ground module
- ▶ Re-planning only the contract of the aircraft itself
- ▶ The aircraft will keep small database containing 4D contracts of all aircraft in its cluster
- ▶ During normal operation at the stage of cluster update also the on-board data of the relevant aircraft should be changed
- ▶ When the communication to the ground is restored, locally re-planned contract should be tested and approved or changed by the ground re-planning module



Summary



The algorithm was successfully tested on different re-planning scenarios:

- ▶ Simple re-planning scenarios, when only one 4D contract was modified
- ▶ Multi-aircraft re-planning scenarios
- ▶ Emergency scenario, when aircraft were re-routed to an alternative airport

