Example scenarios: Decentralised traffic management for constrained urban airspace: dynamically generating and acting upon aggregate flow data

TU Delft

1 Example scenario 1

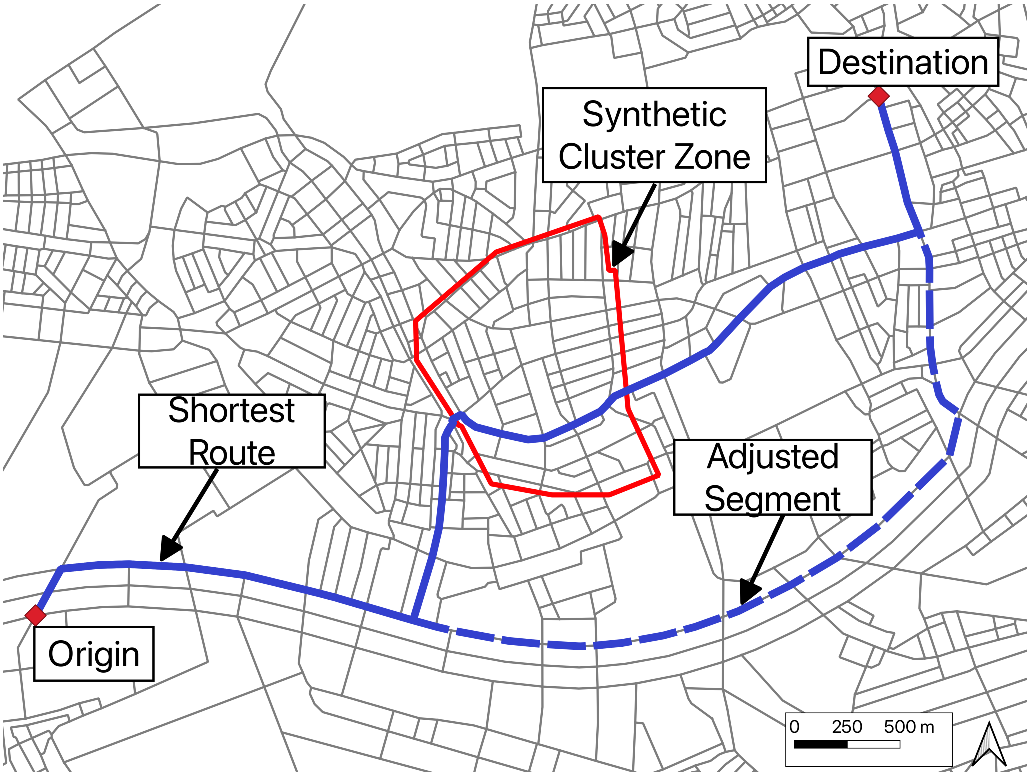


Fig. 1. Example Scenario No. 1

1.0.1 Scenario set-up

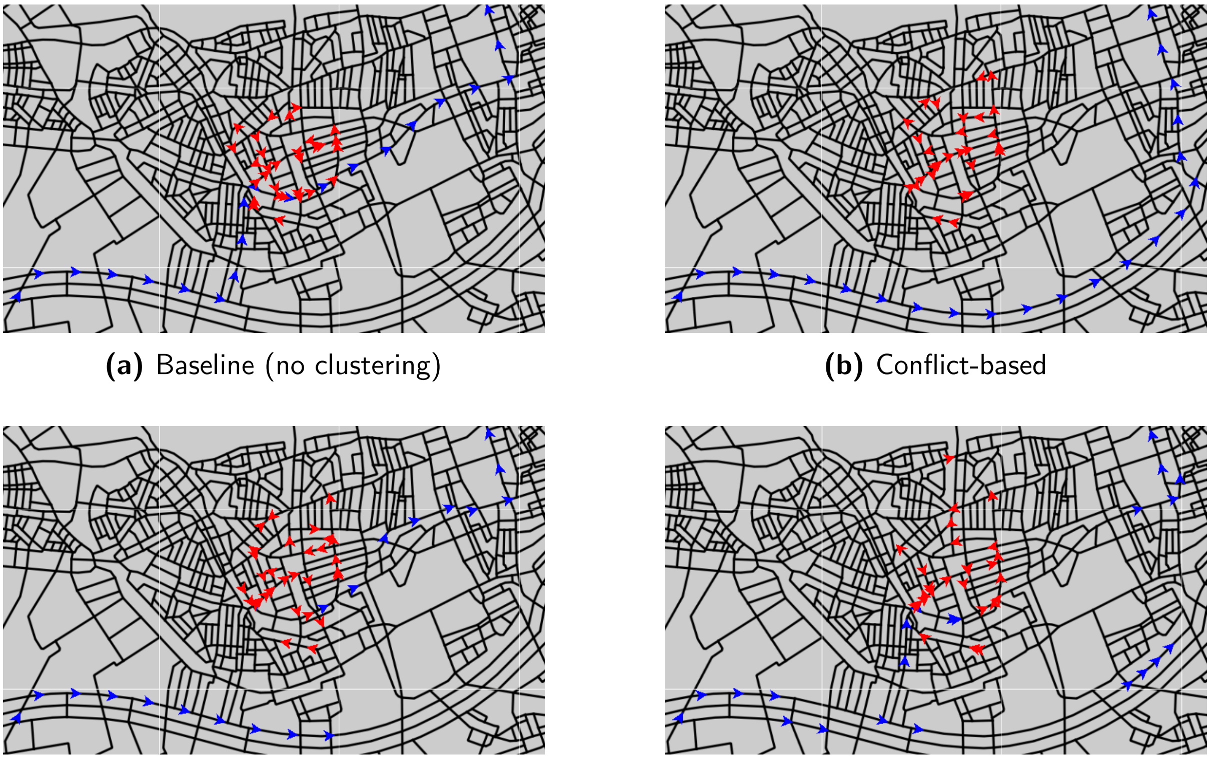
Fig. 1 shows an illustration of the scenario. In this scenario, there are 50 instantaneous aircraft and two types of missions. On average, 40 percent of traffic follows a path with a plan shown by the solid blue line, and a new aircraft is spawned every 30 seconds. Note that this route travels through a red zone labelled "Synthetic Cluster Zone". The other 60 percent of aircraft only travel within the Synthetic Cluster Zone, with the aim of generating a busy zone. Note that for the blue route, there is an alternate route that is 7 percent longer than the shortest route, that does not go through the synthetic cluster zone (seen in the dashed blue line).

This scenario is tested with the three observations strategies plus a Baseline case without any dynamic traffic management. The additional cost multiplier of travelling through a high density cluster is 1.5. The alternate route has a lower cost than the original route when the length of the blue segment that is contained in the synthetic cluster zone is multiplied by 1.5.

Note that the conflict resolution module is not used in the first example scenario. The simulation runs for two hours.

1.0.2 Results

Fig. 2 shows a snapshot of the simulation at around 30 minutes into the simulation for each clustering strategy. Fig. 2a shows how aircraft travel when there is no dynamic traffic management. Fig. 2b shows how the conflict-based clustering generally manages to keep aircraft away from the synthetic cluster zone. Fig. 2c shows that the intrusion-based strategy does manage to keep some aircraft away from the synthetic cluster zone, but there are still aircraft following the original blue route. Finally, Fig. 2d shows that the position-based strategy also forces aircraft to take some paths that are neither the original route nor the alternate route.



(a) Baseline (no clustering)

(b) Conflict-based

(c) Intrusion-based

(d) Position-based

Fig. 2. Overall cluster process from observation to replanning.

Table 1
This table summarizes the results of the example scenario. Each row represents a different clustering strategy.

	Conflicts per flight	Intrusions per flight	Replans per flight	Distance per flight (m)
Baseline (no clustering)	5.4	1.9	0	6130
Conflict-based	1.0	0.3	0.8	6490
Intrusion-based	4.5	1.8	0.6	6221
Position-based	3.4	1.3	1.3	6536

The results of the example simulation are presented in Table. 1. Note that only data is presented for aircraft following the blue route is shown. The results show that all observation strategies are able to improve upon the Baseline case. Moreover, it is clear that the conflict-based strategy creates the lowest number of conflicts and intrusions per flight. The intrusion-based strategy has the largest number of conflicts and intrusions per flight when comparing the three strategies. This is because there are generally fewer observed conflicts than intrusions, and because conflicts tend to occur before intrusions. Therefore, fewer streets get an additional cost multiplier, which translates to a lower number of replans per flight and less distance travelled. Finally, the position-based strategy is the second best in terms of conflicts and intrusions per flight. However, it has the highest number of replans per flight and distance travelled. In the conflict-based and intrusion-based strategies, the significant majority of the clusters are in the synthetic cluster zone. This is not the case for the position-based strategy. Since there are some aircraft travelling along the shortest route, these are part of the clusters, so they force aircraft to replan and use nearby streets near the alternate route.

2 Example scenario 2

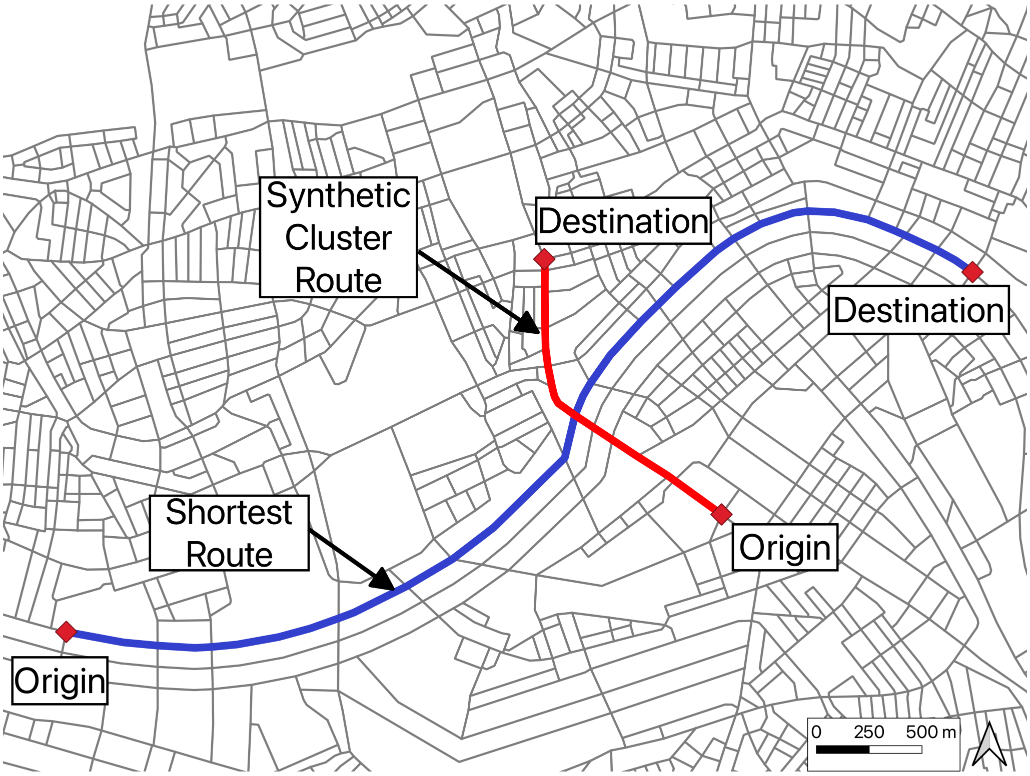


Fig. 3. Example scenario No. 2

2.1 Scenario set-up

Fig. 3 shows an illustration of the second example scenario. In this scenario, there are 66 instantaneous aircraft and two types of missions. On average, 73 percent of traffic is following a path with a plan shown by the solid blue line, and a new aircraft is spawned every 10 seconds. The other 27 percent of aircraft follow the shorter red route. The aim of this scenario is to create two intersecting paths in a way that makes it difficult for the aircraft in blue to plan around the red.

This scenario is tested with only the conflict-based clustering strategy and the Baseline case without the dynamic traffic management. The additional cost multiplier of travelling through a high density cluster is 1.5. This was chosen because it ensured that the optimal route for aircraft in blue is always through the red route.

Note that both strategies are tested with and without conflict resolution to show the effect that it has on the method. The simulation runs for two hours.

2.2 Results

Fig. 4 shows a snapshot of the simulation at 30 minutes into the simulation for each strategy with conflict resolution turned on. Fig. 4a shows how aircraft travel when there is no dynamic traffic management. Fig. 4b shows the scenario as it looks with the conflict-based clustering strategy. Note how some aircraft are travelling on a parallel street to the blue route, but still do not avoid the red lines.

(a) Baseline (no clustering) **(b)** Conflict-based

Fig. 4. Overall cluster process from observation to replanning.

The results of the example simulation are presented in Table 2 and Table 3. Table 2 shows the results when conflict resolution is off and Table 3 shows the results when conflict resolution is on. For this scenario, the conflicts and intrusions per flight are divided into those between blue-red aircraft and those between blue-blue aircraft. The number of replans and distance per flight is shown only for blue aircraft.

When conflict resolution is off, it is clear that using the conflict-based strategy creates more conflicts and intrusions per flight. This is mostly shown by an increase in the blue-blue interactions. The blue aircraft cannot avoid crossing the red aircraft, so the additional turns create an increase in blue-blue interactions. Note that in the Baseline, the blue-blue conflicts never lead to blue-blue intrusions. This is because during the mission of the blue aircraft, there are some turns that generate some false conflicts.

However, when conflict resolution is on, the dynamic traffic management method is able to reduce the total number of intrusions observed. Note that the increase in conflicts is mostly due to blue-blue interactions. With conflict resolution on, aircraft are able to use the extra space created by the dynamic traffic management method to reduce the number of conflicts that actually become an intrusion. This shows that in difficult situations, pairing conflict resolution with the dynamic traffic management method helps safety due to the extra space created.

Table 2

This table summarizes the results of the example scenario with conflict resolution off. Each row represents a different observation strategy.

	Conflicts per flight		Intrusions per flight		Replans per flight	Distance per flight (m)
	blue-red	blue-blue	blue-red	blue-blue	blue	blue
Baseline (no clustering)	1.0	2.1	1.0	0	0	5194
Conflict-based	1.1	2.9	1.0	0.1	0.5	5262

Table 3

This table summarizes the results of the example scenario with conflict resolution on. Each row represents a different clustering strategy.

	Conflicts per flight		Intrusions per flight		Replans per flight	Distance per flight (m)
	blue-red	blue-blue	blue-red	blue-blue	blue	blue
Baseline (no clustering)	2.1	2.1	1.0	0	0	5194
Conflict-based	2.1	3.6	0.7	0.1	0.8	5273