Sensitivity Analysis: Decentralised separation for urban airspace: dynamically generating and acting upon aggregate flow data

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1   Parameters

The dynamic traffic management method describes several parameters that are set in the method. The following list shows the possible values of these parameters:

1. Cluster distance threshold: 1000, 4000, 8000, 12000.

2. Percentile of clusters classified as high density: 25th, 50th, 75th, 100th.

3. Additional cost value applied to the street network: 1.5, 2.0, 2.5, 3.0.

Each of these three parameters will be studied in a sensitivity analysis in order to see their effect on the method. A traffic demand level of 300 aircraft is chosen for this analysis. Also, as the results of the method showed that the Conflict observations strategy had the least number of intrusions, only that strategy will be compared to the Baseline. Finally, the missions routes are randomly generated and do not take into account the demand. Two hundred randomly selected nodes are chosen, and all other nodes have the same probability of being a potential destination. The following section will describe the effects of each parameter on the intrusions per flight and distance travelled percentage when compared to the Baseline case.

The sensitivity analysis shows the results for 320 scenarios (4 cluster distances x 4 percentiles x 4 additional costs x 5 repetitions).
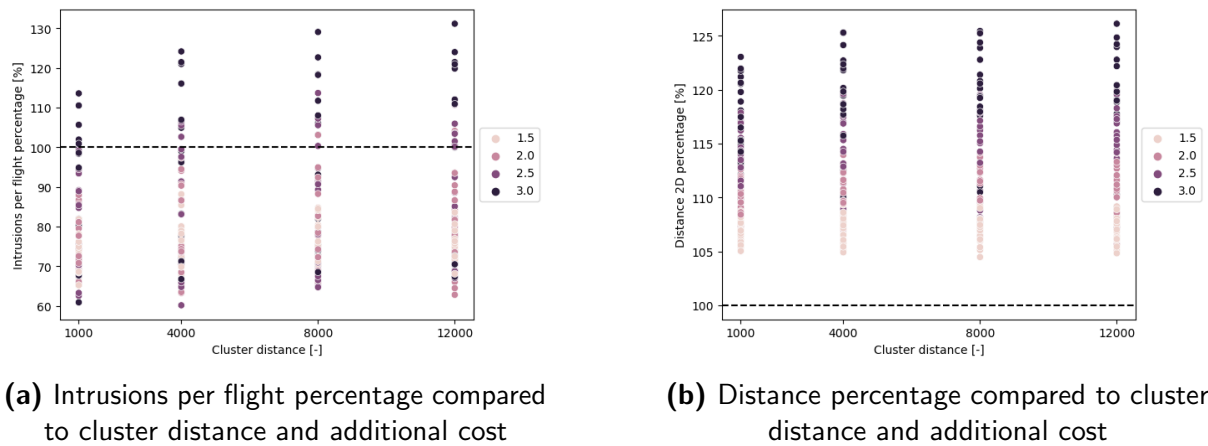
2   Selecting the cluster distance

Figs. 1a and 1b show the Intrusion per flight and distance travelled as a percentage of the baseline in the vertical axis, respectively. The horizontal axis represents the cluster distances. Each dot in the scatter plot represents one simulation. the colour of the dot represents the additional cost multiplier. The dashed line at 100 percent represents the Baseline case.

The intrusions per flight percentage do not vary across cluster distance. Interestingly, this suggests that the cluster distance do not greatly affect the parameter. The difference is that at 1000 and 4000 the lowest value reaches around 60 percent. However, the plot does show that higher additional weights tend to have higher intrusions per flight percentages.

In the distance travelled as percentage of the baseline plot, it can also be seen that the cluster distance doesn't have a great effect. However, in this case, it is quite clear that higher additional costs correspond to higher distance travelled. In the case with a multiplier of 3, the distance travelled increases by 25 percent.

Since the cluster distance threshold does not have a great effect on the safety and distance travelled, this work selects 4000 as it is about 3 times the separation minima. This distance of about 100 metres is near the lookahead distance of the conflict detection algorithm.

(a) Intrusions per flight percentage compared to cluster distance and additional cost

(b) Distance percentage compared to cluster distance and additional cost

Fig. 1. This plot shows the intrusions per flight and distance travelled as a percentage of Baseline.

3 Selecting the percentile

Figs. 2a and 2b show the Intrusion per flight and distance travelled as a percentage of the baseline in the vertical axis, respectively. The horizontal axis represents the upper percentile of clusters that get an additional cost multiplier. Each dot in the scatter plot represents one simulation. the colour of the dot represents the additional cost multiplier. The dashed line at 100 percent represents the Baseline case. Note that these results are only shown for the case with a cluster distance of 4000.

It can be seen that the intrusions per flight percentile decreases as the percentile increases. However, this is not the case when going from 75 percent to 100. This actually increases a bit when 100 percent of observed clusters receive the additional weight.

In the distance travelled as percentage of the baseline plot, it is seen that there isn't a great effect on the distance travelled on the percentile. However, it is clear that when 100 percent of clusters receive the additional weight, the variance of the distance travelled is lower. This shows that by adding weights to the whole airspace is better than, aircraft tend to travel less when compared to 75th percentile, but they aren't able to go as low in the 75th percentile in terms of intrusions per flight.
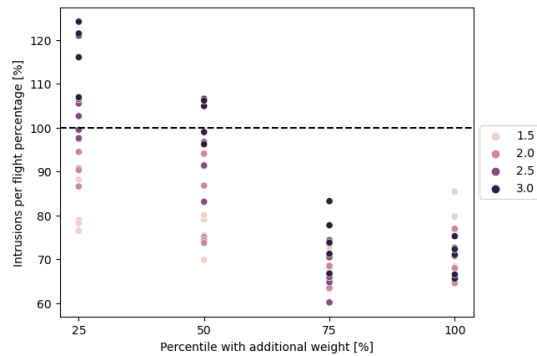
Therefore, this work selects uses the 75th percentile for the experiments.

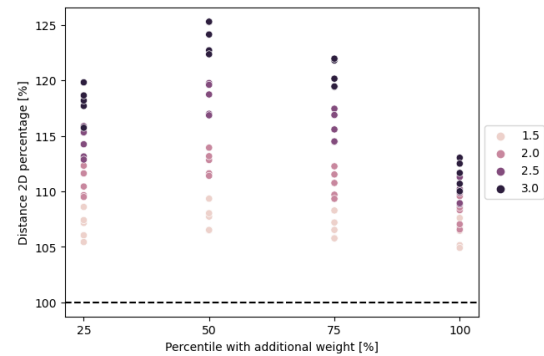# 4 Selecting the additional cost to high density areas

Figs. 3a and 3b show the Intrusion per flight and distance travelled as a percentage of the baseline in the vertical axis, respectively. The horizontal axis represents the additional cost multiplier. The dashed line at 100 percent represents the Baseline case. Note that these results are only shown for the case with a cluster distance of 4000 and 75th percentile.

It can be seen that the intrusions per flight percentages are quite low for all cases. However, the cases with 2.0 and 2.5 have slightly lower averages than the case with 1.5. However, in the distance plot, it can be seen that the additional cost of 1.5 travels about 5 percent less than the case with an additional multiplier of 2.0

Therefore, this work selects uses the case with an additional case of 2.0. This is a tradeoff between safety and distance travelled in the airspace.
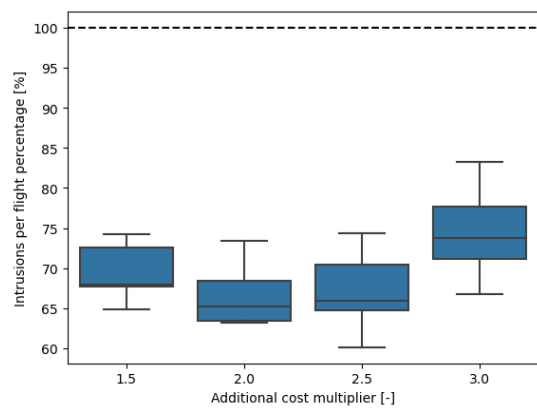
(a) Intrusions per flight percentage compared to percentile of clusters with the additional cost for the scenarios with a cluster distance of 4000.
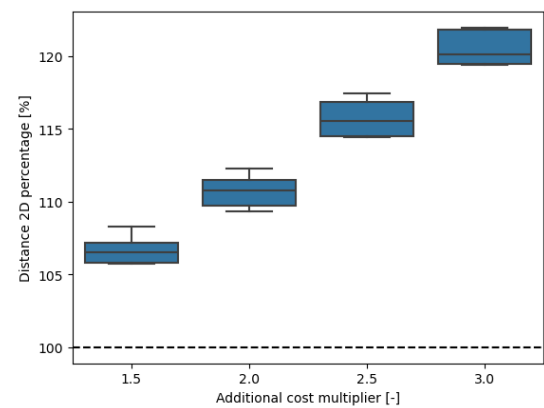
(b) Distance percentage compared to percentile of clusters with the additional cost for the scenarios with a cluster distance of 4000.

Fig. 2. This plot shows the intrusions per flight and distance travelled as a percentage of Baseline versus percentile of clusters with an additional cost multiplier. The data is only plotted for a cluster distance of 4000.

(a) Intrusions per flight percentage compared to additional cost for the scenarios with cluster distance of 4000 and 75th percentile.

(b) Distance percentage compared to additional cost for the scenarios with cluster distance of 4000 and 75th percentile.

Fig. 3. This plot shows the intrusions per flight and distance travelled as a percentage of Baseline versus the additional cost multiplier. The data is only plotted for a cluster distance of 4000 and the 75th percentile.