

# How resilient is Scotland's air infrastructure?

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## 1 Introduction

This project seeks understand the direct internal flight routes between airports in Scotland. It asks, which airports are most critical to Scotland's air infrastructure and how the network can be strengthened?

## 2 Visualising Scotland's Air Network

Here is a map of the domestic flight routes within Scotland.

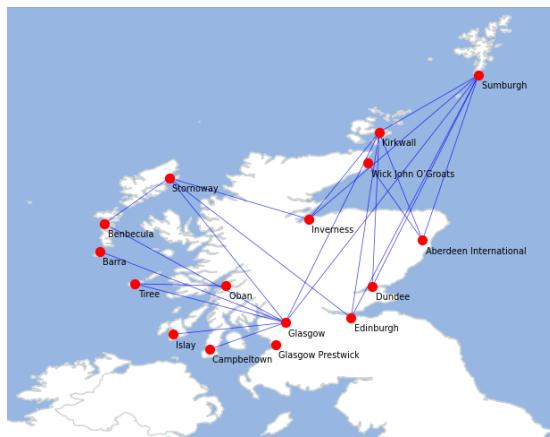


Figure 1: Scottish airports

Note that Glasgow Prestwick is an isolate - it has no flight connections to any other airport in Scotland. This is because Prestwick serves short-haul international destinations to mainland Europe. Because of this, Glasgow Airport is responsible for air connections within the country.

### 3 Discussion

In order to understand which airports are most critical for Scotland's air infrastructure, we must first gain an understanding of centrality statistics. Centrality statistics can be used to measure each airport's importance in the network.

Degree centrality tells us the number of direct connections each airport has. This can inform us about which airports are locally most significant.

Closeness centrality tells us how efficiently a node can reach every other node. This tells us which airports can reach other airports in the fewest number of flights. This is perhaps not too useful in country the size of Scotland, since individuals may opt to travel by car or train to reach locations most efficiently. However, it could indicate good points to station emergency air services or mail couriers, because all other locations can be quickly accessed.

Betweenness centrality tells us how often an airport lies on the shortest path (the shortest route) between other airports. Thus, this statistic can identify the most important hubs, as well as bottlenecks where too many routes pass through one airport. This may be important in a Scottish context, since some islands are quite isolated and the primary route from these islands to major population centre may go through another airport. In the case that there is a disruption at one of these hubs, it could affect flight routes across the whole country - indicating a weakness in the air infrastructure.

Below is a table showing the centrality scores for the different airports in Scotland.

Airport	Degree Centrality	Closeness Centrality	Betweenness Centrality
Aberdeen International Airport	0.200000	0.395960	0.123810
Edinburgh Airport	0.200000	0.408333	0.015873
Glasgow Airport	0.533333	0.622222	0.577778
Glasgow Prestwick Airport	0.000000	0.000000	0.000000
Oban Airport	0.066667	0.290370	0.000000
Barra Airport	0.066667	0.384314	0.000000
Benbecula Airport	0.133333	0.421505	0.000000
Campbeltown Airport	0.066667	0.384314	0.000000
Dundee Airport	0.133333	0.373333	0.000000
Inverness Airport	0.200000	0.408333	0.015873
Islay Airport	0.066667	0.384314	0.000000
Kirkwall Airport	0.400000	0.568116	0.193651
Stornoway Airport	0.266667	0.450575	0.060317
Sumburgh Airport	0.400000	0.568116	0.193651
Tiree Airport	0.133333	0.408333	0.123810
Wick John O'Groats Airport	0.066667	0.284058	0.000000

Here we can see that the airports with the greatest degree centrality are Glasgow Airport (0.53), Kirkwall Airport (0.40), and Sumburgh Airport (0.40). We can see on the map that these airports do indeed have the most direct connec-

tions to other airports, meaning they are locally quite important in connecting their region.

We can also see that several airports have a high closeness centrality including Glasgow Airport (0.62), Kirkwall (0.57), and Sumburgh (0.57). These three airports have the best access to other airports in the network, indicating that critical services could be based at these locations.

Finally, we can see that the airport with by far the greatest betweenness centrality is Glasgow (0.58). Many routes must travel through this airport. This means Glasgow Airport is structurally the most critical point in Scotland's airport infrastructure.

If trying to travel, for instance, between Oban Airport and Campbeltown Airport you would have to pass through Glasgow Airport. Since there is currently no alternative route, a disruption at Glasgow Airport could affect the whole country's air network. For this reason, it would make sense to direct some flights through another airport, for example Edinburgh, Dundee or Inverness, which have comparatively low betweenness centralities (0.02, 0.00 and 0.02 respectively). This is known as increasing redundancy, and would make the whole network more resilient.

Making such changes may be quite costly, since airports would have to prepare for a higher amount of air traffic. It is up to regional planners to decide whether to strengthen local infrastructure though improved flight routes or by other means, like regular boat services between islands and more train services on the mainland.