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Hybrid Meta-heuristics For Departure Runway Scheduling At London Heathrow Airport

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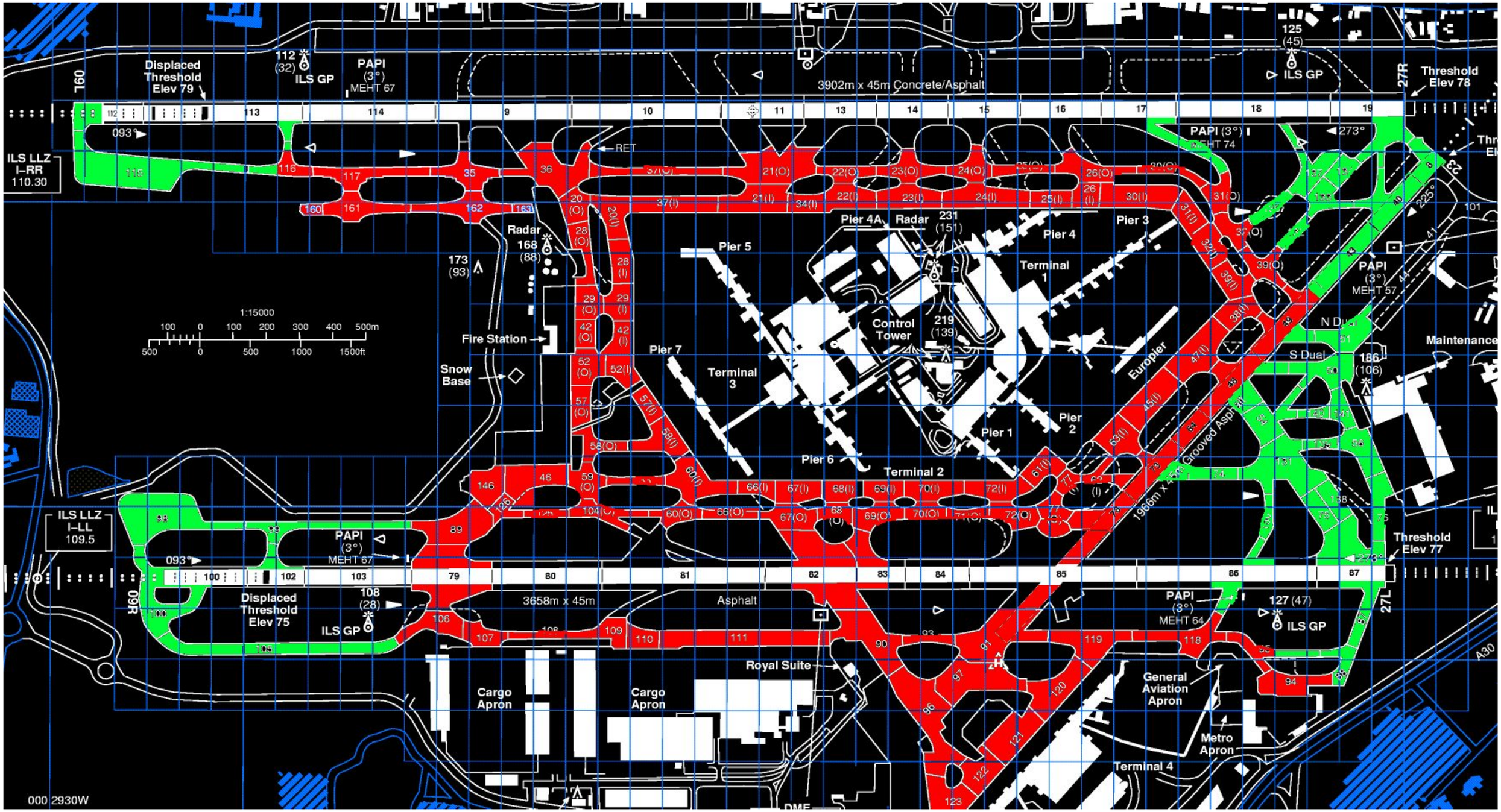
Aim: To reduce delay and improve the throughput of the departure runway while meeting all real-world constraints

Departure System

Aircraft taxi from the stands, by the terminals, along the taxiways (coloured red), to the holding points (coloured green) by the runways (two horizontal white lines).

Within the holding points aircraft are re-ordered to get the best take-off order.

Terminals 1, 2 and 3 are between the runways. Terminal 4 is near the lower right corner.



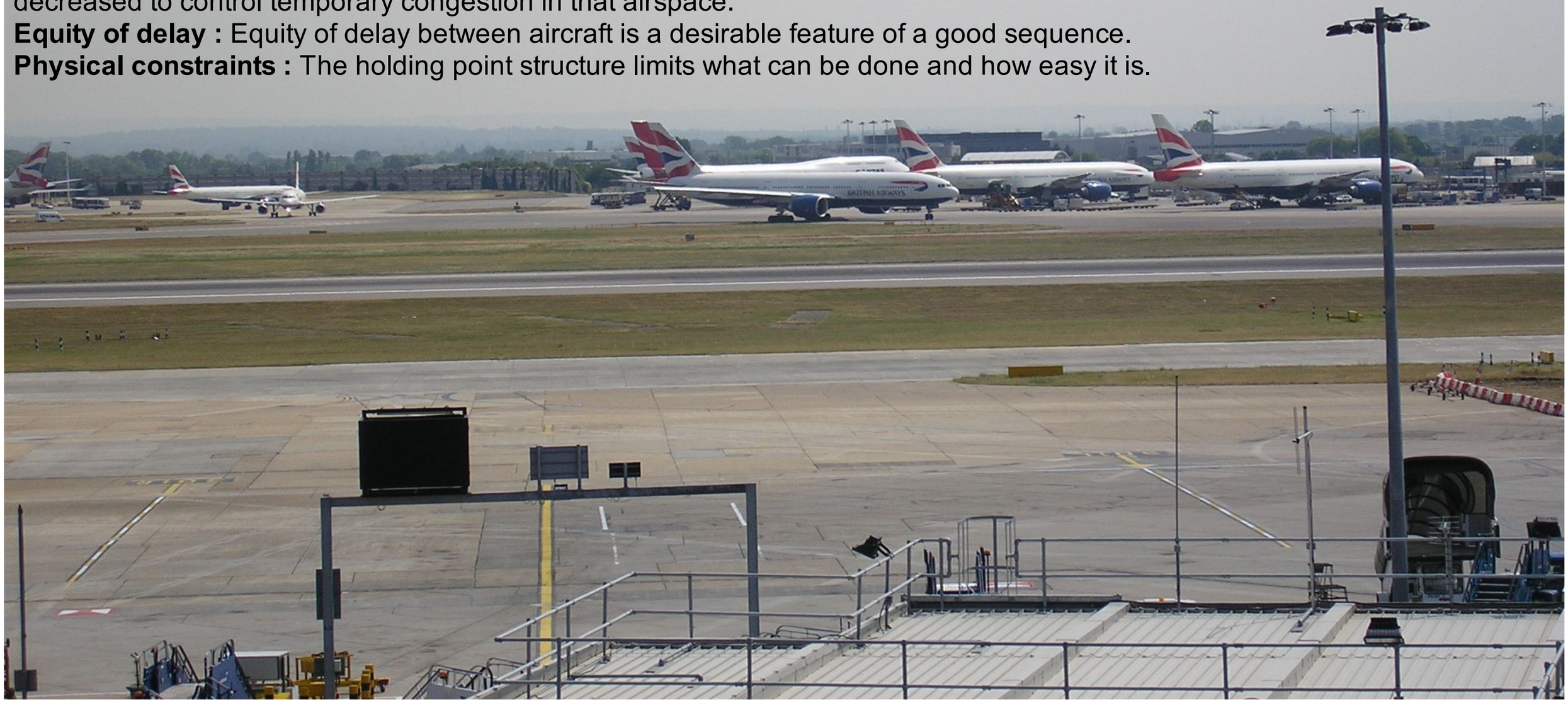
Map of London Heathrow airport showing the terminals, taxi paths, holding points and runways.

Separation Rules

• A delay may need to be imposed on an aircraft taking off, to maintain a separation time from previous take-offs. This ensures that wake vortices have time to dissipate and in-flight separation distances are maintained.
• The separation required depends upon the aircraft weight class, speed group and departure route.
• Reordering aircraft may reduce the separations that are needed.
• To control airspace congestion the required separation for some routes may be increased at times.

Other considerations

Calculated Time Of Take-off (CTOT) : Some aircraft have a fifteen minute take-off timeslot within which the controller must ensure the aircraft takes off. This is assigned to control congestion in busy airspace and at busy destination airports.
Minimum Departure Interval (MDI) : At times the frequency aircraft can fly along certain departure routes is temporarily decreased to control temporary congestion in that airspace.
Equity of delay : Equity of delay between aircraft is a desirable feature of a good sequence.
Physical constraints : The holding point structure limits what can be done and how easy it is.

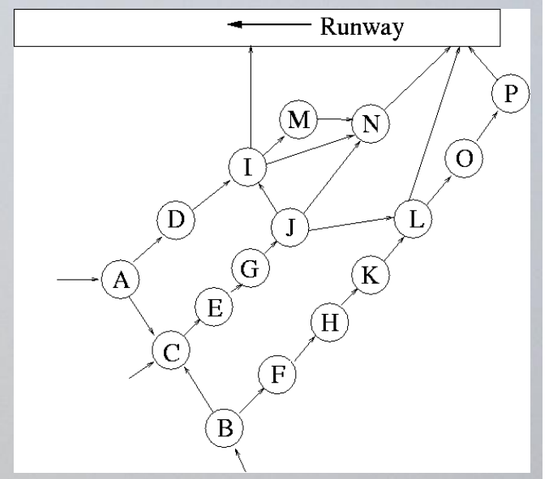


Components of the solution system:

Meta-heuristic tabu search to find good (not-necessarily optimal) take-off orders.

Objective function, evaluate each potential solution to determine how good it is. This includes predicting take-off times and determining a numeric value for the worth of the schedule.

Determine the feasibility of achieving the desired take-off order, given the structure of the holding point. This includes the use of heuristics to allocate paths through the holding point to aircraft and a directed graph model of the holding point to check the ability to re-order aircraft.



Model of the 27R holding point.

Testing via simulation:

A simulation of the departure system at Heathrow has been built.

The simulation must provide a realistic level of information to the solution system. The solution system is given only the information a real system would have had. Prediction errors are applied where data would not be known exactly.

The simulation must provide information about the current positions of aircraft in the holding point, any instructions the pilots would be assumed to have received (e.g. about paths to take through the holding point) and any timing for aircraft (e.g. the time the aircraft left its stand, arrived at or is predicted to arrive at the holding point, and is predicted to take off).

As each solution is returned the suggested take-off order is enacted and the simulation data modified accordingly.

As the situation changes over time the new situation is given to the system to determine what to do next.

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