SEG PROJECT DEFINITION: RUNWAY REDECLARATION

1. INTRODUCTION

Commercial airports are busy places. Ideally runways will be fully open at all times, but this is not always possible. When there is an obstruction (such as a broken down aircraft or surface damage) on the runway, it may need to be closed. However it may still be possible to keep the runway open, albeit with reduced distances available for landing and taking off.

All runways have a published set of parameters. When an obstacle is present on the runway, these parameters must be recalculated and a commercial decision made whether to continue operations on the runway. If (limited) operations are to continue, the published data about the runway must be recalculated and republished. The final decision about whether to land/take off rests with the pilot.

2. PROBLEM

The calculations and process to determine runway parameters are specified by the CAA. The calculations must be completed independently by two competent (qualified) people who must then reconcile their results making the task involved and time consuming.

The customer desires a tool which, given standard runway information and information about an obstacle, provides the revised runway parameters together with a visualisation of the obstacle and a summary of the calculations. The tool will be used to obtain a rapid indication of the effect of an obstruction on the runway parameters as an aid to deciding whether operations can continue, and whether performing the calculations in accord with the official process is worthwhile. The tool will be used as an aid/guide. It cannot replace the official process.

3. DEFINITIONS AND BACKGROUND

Runway – this is formally a defined rectangular area on a land aerodrome prepared for the landing and take-off of aircraft.

A runway is named with a number from 01 to 36, which is based on the degree of the runway's heading direction. For example, runway 09 points to the East (90 degrees to the North) whereas runway 27 points to the West (270 degrees to the North). Normally, a physical runway can be used in both directions, creating two logical runways with a difference in 18 points (180 degrees). In the case of parallel runways, a character is appended to the names of the runways to identify its position. The characters can be L (Left), R (Right), or C (Centre). In the example above, 09 will become 09L and its reciprocal runway will be 27R. Another physical runway will have 09R and 27L as its logical runways. In the case of a single runway, no character is required.

For each runway, there are four published parameters that are affected during the re-declaration process, which are listed and explained below (full and formal definitions can be found in [1]):

Take-Off Run Available (TORA) - the length of the runway available for take-off. This is the total distance from the point where an aircraft can commence its take-off to the point where the runway can no longer support the weight of the aircraft under normal conditions (and where it should have left the runway during a normal take-off).

Take-Off Distance Available (TODA) - the length of the runway (TORA) plus any *Clearway* (area beyond the runway that is considered free from obstructions). This is the total distance an aircraft can safely utilise for its take-off and initial ascent.

Accelerate-Stop Distance Available (ASDA) - the length of the runway (TORA) plus any *Stopway* (area that is not part of the TORA, but that can be used to safely stop an aircraft in an emergency). This is the total distance available to the aircraft in case of an aborted take-off.

Landing Distance Available (LDA) --- the length of the runway available for landing. The start of this is called the *threshold* and is typically the same as the start of the TORA. A threshold may be *displaced* for operational reasons or because of a temporary obstacle, in which case LDA and TORA can differ.

Other important terms used here and in the remainder of the specification are listed in the following:

Displaced Threshold --- A runway threshold located at a point other than the physical beginning or the end of the runway. The displaced portion can be used for take-off but not for landing. A landing aircraft can use the displaced area on the opposite end of the runway.

Clearway --- An area beyond the end of the TORA, which may be used during an aircraft's initial climb to a specified height.

Stopway --- An area beyond the end of the TORA, which may be used in the case of an abandoned take-off so that an aircraft can be safely brought to a stop.

Runway End Safety Area (RESA) --- An area symmetrical about the extended runway centreline and adjacent to the end of the strip primarily intended to reduce the risk of damage to an aircraft undershooting or overrunning the runway.

Strip end --- An area between the end of the runway and the end of the runway strip.

Blast Protection --- A safety area behind an aircraft to prevent the engine blast from affecting any obstacles located behind it.

Approach Landing Surface (ALS) --- The surface formed between the top of the obstacle and the runway when taking into account the airport's minimum angle of descent.

Take-Off Climb Surface (TOCS) - The surface formed between the runway and the top of the obstacle when taking into account the airport's minimum angle of ascent.

Runway Strip --- An area enclosing a runway and any associated stopway. Its purpose is to reduce the risk of damage to an aeroplane running off the runway and also to protect aeroplanes flying over it during landing, balked landing or take-off. An image of this can be seen in Figure 1.

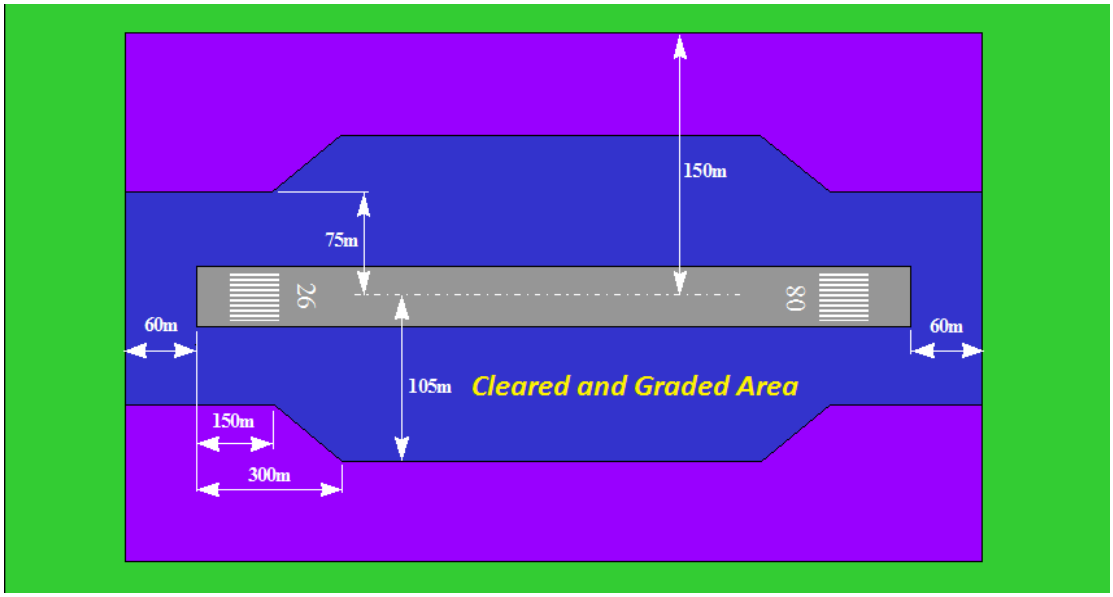

Figure 1 -- A runway strip

The above figure of a runway strip contains the distances defining the different areas of the runway strip. The distances of two runway strip ends are marked as 60m, also 75m and 105m are the distances from the centreline to the edge of the Cleared and Graded Area, which are required based on the satisfactory safety assessment. In case of having an obstacle within 75m from the centreline and 60m from the runway, the runway parameters need to be re-declared. Otherwise, no re-declaration is required

In case of a re-declaration, the TODA, TORA, ASDA and LDA must be recalculated in both directions of the runway. Figure 2 summarises the declared distances and how other parameters affect them.

When carrying out the recalculations, a number of important safety constraints must be satisfied:

1) A new RESA may need to be declared around the obstacle, potentially affecting the usable length of the runway. The minimum RESA is typically 240m wide.
2) The ALS and TOCS over any obstacle need to be calculated and may similarly affect the parameters. Typically, a slope of 1:50 is assumed (i.e., the aircraft will gain or lose 1m of altitude for every 50m travelled horizontally).
3) If the runway parameters are adjusted due to constraints 1 or 2 above, a new strip end is declared and deducted from the usable runway. This is typically 60m.
4) When an aircraft is on the ground, any obstacles behind the aircraft must be at least the given engine blast allowance away from it, typically 300-500m (depending on the aircraft).

In the following, the recalculations are illustrated through examples.

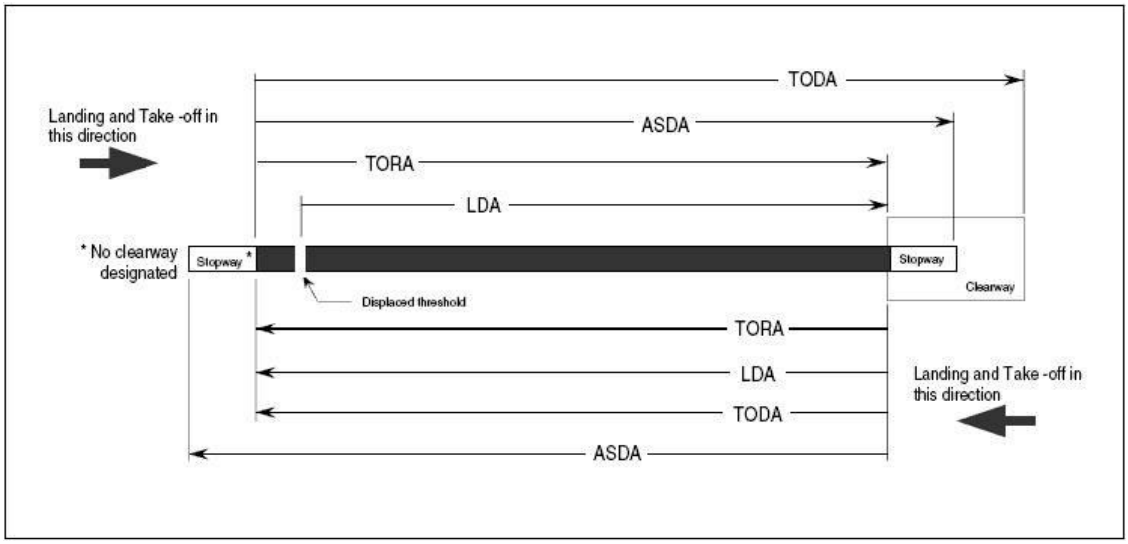

Figure 2 -- Diagram showing the declared distances of a runway

CALCULATIONS

To illustrate the recalculations, examples of an obstruction occurring on the 09L/27R runway at Heathrow Airport will be used. The declared parameters of the runways at Heathrow (without obstacle) are given below.

Runway Designator	TORA (m)	TODA (m)	ASDA (m)	LDA (m)	Displaced Threshold (m)
09L	3902	3902	3902	3595	306
27R	3884	3962	3884	3884	0
09R	3660	3660	3660	3353	307
27L	3660	3660	3660	3660	0

LANDING OVER THE OBSTACLE

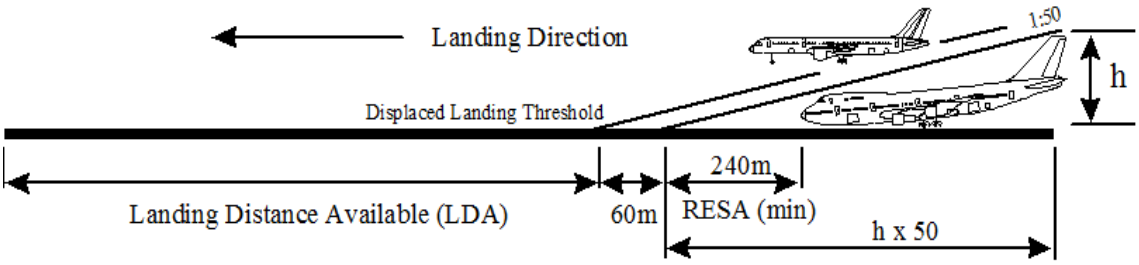

Figure 3 - A diagram showing how LDA is re-declared when the aircraft is landing over the obstacle

This case occurs when an aircraft is trying to land over an obstacle, whereby the obstacle is close to the threshold that the plane is approaching. When an aircraft is trying to land over a obstacle,

the LDA is the only declared distance that will need to be re-calculated. This is calculated by establishing a temporary threshold with a 1 in 50 slope (ALS) from the highest point of the obstacle (or by establishing a new RESA if this is larger) plus the strip end value. This must be larger than the blast protection value of the aircraft, otherwise the blast protection value must be taken into account instead.

For example, if an obstacle that is 25m tall occurs 500m from the runway 27R threshold, the reduced LDA will be:

$$(R)\ LDA = 3884 - 500 - (25 * 50) - 60 = 2074m$$

LANDING TOWARDS THE OBSTACLE

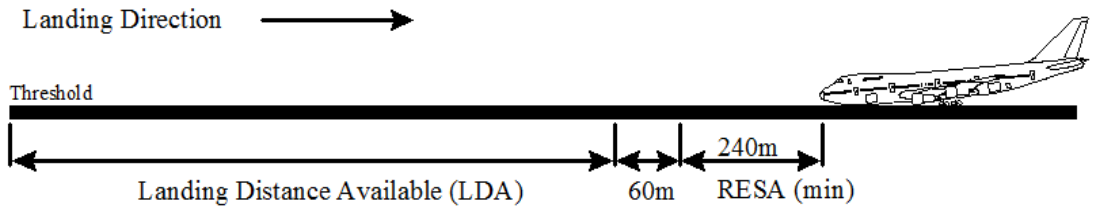

Figure 4 - A diagram showing how the LDA is re-declared when the aircraft is landing towards the obstacle

This case occurs when an aircraft is trying to land on a runway where the obstacle is closer to the far end. Similar to the previous case, this only affects the LDA. The distance is from the threshold to the obstacle, with the requirement of the RESA plus the strip end value.

In the case of an obstacle occurring on the 09L runway 2600m from its threshold, then the reduced LDA will be:

$$(R)\ LDA = 2600 - 240 - 60 = 2300m$$

TAKE-OFF TOWARDS THE OBSTACLE

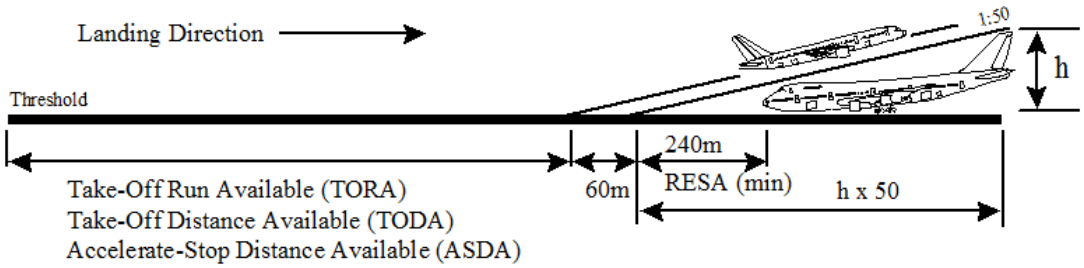

Figure 5 - A diagram showing how TORA, TODA and ASDA are re-declared when an aircraft is taking off towards the obstacle

This case occurs when an aircraft is trying to take off from a runway, whereby taking off from this runway means that the aircraft is required to fly over the obstacle. This case requires a temporary end of TORA to be established with the 1 in 50 slope (TOCS) from the highest point of the obstacle and this value must be larger than the RESA value, otherwise the RESA value is taken into account instead. The value of the strip end must also be deducted.

As the obstacle is obstructing any previously available Stopway or Clearway, the ASDA and TODA values are equal to the TORA here.

For example, if there is an obstacle 2500m from the 09L threshold of height 25m and the plane is taking off towards it, the reduced TORA will be:

*(R) TORA = 2500 + 306 – 25*50 – 60 = 1496m*

(R) ASDA = (R) TODA = (R) TORA

TAKE-OFF AWAY FROM THE OBSTACLE

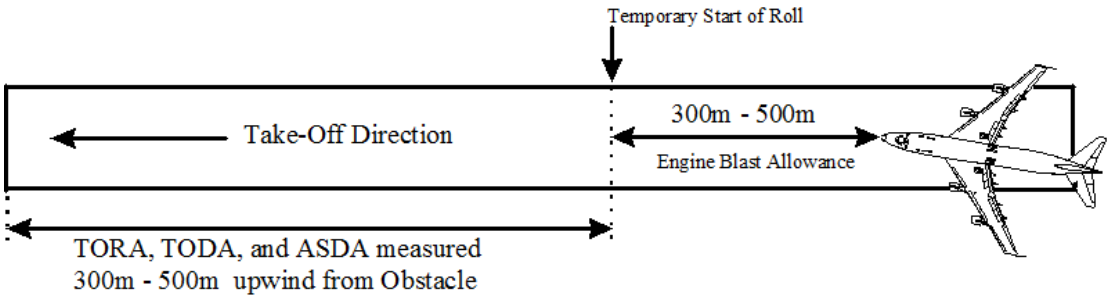

Figure 6 - A diagram showing how the TODA, TODA and ASDA are re-declared when an aircraft is taking off away from an obstacle

This occurs when the obstacle is closest to the start of the runway, and an aircraft is taking off away from the obstacle. In this case the blast protection allowance is deducted from the distance. If there exist any Clearway and/or Stopway then those values should be added to the reduced TORA for the TODA and ASDA values.

With an obstacle 500m from the 27R threshold, the reduced distances are calculated as below:

(R) TORA = 3884 – 500 – 300 = 3084m

(R) TODA = 3962 – 500 – 300 = 3162m

(R) ASDA = 3884 – 500 – 300 = 3084m

4. CUSTOMER REQUIREMENTS

The mandatory requirements are as follows:

1) The system should be configurable to permit its use at any UK commercial airport.

2) The tool must provide at least two visualisations of each of the airports, including 2D top-down and side-on views. These may be displayed simultaneously or individually.

3) The system must calculate the new runway distances available when ONE obstacle is present, given the obstacle's distances from each threshold, distance from the centreline and height.

4) The program should come with a list of predefined obstacles.

5) The user must be able to view the re-calculated values and the originals.

6) The user must be able to view a breakdown of the calculations so they may be compared with the paper results.

7) The system should be able to import and export details of obstacles, airports and other data using appropriate XML files.

8) Both views must be able to display:
   a. The runway strip.
   b. Threshold indicators.
   c. Threshold designators e.g. 27R or 09L, with the letter below the number.
   d. Any displaced thresholds that are present.
   e. Stopway/Clearway for both ends of the runway.
   f. Indication of the take-off / landing direction.
   g. All re-declared distances, with indicators showing where they start and end relative to the runway strip.
   h. The distances should be broken down into their respective parts, including RESA/Blast Allowance.
   i. The obstacle, if one is present upon the runway.
   j. The offset caused by the RESA and slope angles relative to the obstacle on the runway.

   The top-down view must be able to display:

   k. The runway centreline.

9) The lower threshold, which is the threshold that has the lowest value, should always be located on the left. For example, in runway 09L/27R, 09L must be on the left.

10) There should be an option to automatically rotate the runway strip to match its compass heading.

11) The top-down view must also display the Cleared and Graded areas around the runway strip.

12) The side-on view must also display a representation of the TOCS (Take-Off Climb Surface) / ALS (Approach / Landing Surface) slope caused over the obstacle when one is present.

13) The user must be able to select different runways and thresholds, with the views updating upon their selection.

14) The system must be able to display notifications to the user indicating any actions that have taken place e.g. obstacle added, runways re-declared, values changed, etc.

15) Allow users to export visualisations, reports and user operations in various formats, such as PDF.

16) The system should be able to perform Multi-User Collaboration:

   a. Implement user authentication and authorization features to allow multiple users (agency team members) to collaborate on the same dashboard.
   b. Add user roles (e.g., admin, editor, viewer) with different levels of access to the data and functionalities.
   c. All user information, including usernames, passwords, and permission levels, should be stored in the database

17) The system should be able to provide clear error messages for any operations (e.g. logging

failure, invalid action, etc.) to aid in troubleshooting

5. OPTIONAL EXTENSIONS

Some additional features, which could be implemented if you have some time left over:

1) A Map view with the runway overlaid over real-world images.

2) The ability to zoom and pan the views.

3) A 3D visualisation of the airfield.

4) Provide API support for the use of assistive technologies, such as screen readers.

5) Provide alternative colour schemes for your program, which allow colour-blind users to view it.

6) Be able to print out the results of the currently viewed situation in a textual format.

7) Any other useful extensions that you can think of. These must be clearly stated and explained in your final report.

BIBLIOGRAPHY

[1] Civil Aviation Authority. CAP 168: Licensing of Aerodromes.