Fundamental Aspects and Analysis of Circular Runway

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Abstract- *This paper presents an innovative and radical new concept for future airport operations, consisting of an airport with one circular circumventing runway, called The Endless Runway. This runway is used for take-off and landing in any direction from any point on the circle and offers through this the unique characteristic a sustainable capacity in all wind conditions through the possibility for an aircraft to operate with headwind during the take-off and landing phase. By placing airport facilities inside the circle, the airport will be more compact, runway crossings can be avoided and taxiing aircraft will be able to shorten their global trajectory through optimized arrival and departure routes. The project, the Endless Runway, is partly funded under EC FP7.[1]*

I. INTRODUCTION

The Endless Runway project aims at building a concept of runway of circular shape that enables aircraft to always operate with headwind at landing and take-off. The runway is called "endless", as runway overruns cannot occur since the runway has no end. The airport terminals with all aircraft, passenger, baggage, and cargo facilities are located within the circle, making the airport more compact than a conventional airport of equal dimensions.

Wind direction, wind speed, and visibility conditions are the major factors in the decision of air traffic control to use a certain runway configuration. Tailwind and crosswind components determine whether runways can be used or not, and low visibility limits the use of dependent runways. Imposed direction of the runways results in a dependency to the wind direction, and to the fact that aircraft have to use the same approach path, resulting in the need for wake turbulence separation. The Endless Runway operates a concept consisting of a circular runway that will allow take-off in any direction and landing from any direction, thus making the airport operations independent of wind direction and speed. [2]

In this document, elements concerned with the design and operation of the Endless Runway are explored.

Modern runways and their disadvantages Modern runways have number of operational disadvantages. The most important of which is the wear resistance of the covering, be it asphalt, concrete or asphalt-concrete. The main question of the operational longevity of these coverings is not in the hardness of the materials, but in the applied load on the runway. As a consequence, repair of such runway requires its complete closure for the time of removal of the problem. The next important disadvantage of the modern runways is the dependence on the constant approach course. To date, the solution to this problem is to increase the number of runways with different magnetic courses, but because of the lack of the territory and the inconvenient location of airports, it is appeared to be unlikely. Also, increasing the number of runways is a solution to the problem of crosswinds. Also an important aspect of the operational period of an aircraft is the limited runway length and the solution to this problem will increase safety during take-off and landing and will extend the operational period of the aircraft's life. [3]

II. CIRCULAR RUNWAY'S ANALYSIS

The lack of capacity at airports is the major constraint to growth in air transport. Current technology projects optimize the use of the available airport capacity, but unless a structural new approach is followed, the expected three-fold increase in air traffic is not realistic to achieve. Physical constraints on runway operations, like wake vortex separation minima and cross- and tailwind limits, make it hard to improve performance of conventional airport configurations further. The circular runway is a radical and novel airport concept. This type of runway can generate a breakthrough in sustainable airport capacity by avoiding the physical constraints of conventional runways through shifting the lift-off and touchdown points of individual aircraft. The main feature of the circular runway is that it will become possible to let an aircraft operate always at landing and take-off with headwind. Whatever its strength and direction, circular runway becomes independent of the wind. When allowing limited crosswind, airspace users can shorten the global trajectory of the flights through optimized departure and arrival routes(figure 1). The circular runway is a radical and

novel airport concept. This type of runway can generate a breakthrough in sustainable airport capacity by avoiding the physical constraints of conventional runways through shifting the lift-off and touchdown points of individual aircraft.[3]

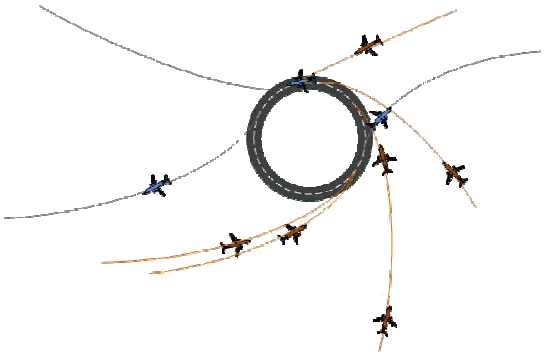

Figure 1:"The principle of circular runway's work" [3]

III. OPERATING OF CIRCULAR RUNWAY

Wind direction, wind speed, and visibility conditions are the major factors in the decision of air traffic control to use a certain runway configuration. Limits on tailwind and crosswind components determine whether runways can be used or not and low visibility limits the use of dependent runways. Direction of the runways results in a dependency to the wind direction and that aircraft have the use the same approach path, resulting in the need for wake turbulence separation. The circular runway operates a concept consisting of a circular runway that will allow take-off in any direction and landing from any direction. The fundamental principle of the circular runway is that the aircraft take-off and land on a large circular structure. This will allow for the unique characteristic that the runway can be used in any wind direction, thus making the runway independent of the direction of the wind and therefore also the airport capacity independent of the wind direction. Three different situations can be identified for aircraft landing on the circular runway: strong wind, low wind, and changing wind directions.

a) In strong wind conditions, the aircraft will fly in sequence towards the circular runway to allow for landing at the touchdown point where dependency from the wind is at a minimum (exactly headwind). This is no difference from today, with the exception that an optimum touchdown point always exists where for a conventional runway a certain crosswind will need to be accepted; hence the circular runway reaches a sustainable maximum capacity under every wind condition with every wind direction.

b) In low wind conditions, no meteorological restrictions exist for the aircraft to land towards any direction, enabling the possibility of shorter landing intervals. The aircraft can be sequenced such that consecutive aircraft originate from different directions and do not have to be spaced according to wake turbulence categories.

c) With changing wind, the aircraft sequence can gradually "move" with the wind direction. No break in the sequence occurs which is the case with conventional runway configurations. No costly operations for tactical runway changes or changing runway directions during operations will be necessary.

From a capacity point of view, the circular runway seems to be advantageous compared with a classical runway system. The circular runway project will assess capacity of the newly proposed runway, but also take into consideration the additional developments it involves (ATC new tools and procedures), and the trade-offs (from an environmental standpoint, etc.). The main feature of the circular runway is that it will become possible to let an aircraft operate always at landing and take-off with headwind. Whatever its strength and direction, circular runway becomes independent of the wind. When allowing limited crosswind, airspace users can shorten the global trajectory of the flights through optimized departure and arrival routes.

The circle of the runway, whose diameter is set to 3 kilometers, is large enough to provide sufficient room for infrastructure preferably inside the circle, even for a hub airport. This makes the airport compact, while allowing current-day aircraft to use the circle without significant structural modifications.

IV. U.S. NAVY CONCEPT (1960-1965)

In 1960, Navy Pilot Lt. Cmdr. James R. Conrey from the U.S. Navy seriously thought of the circular runway, having in mind the ability to land in any wind condition. After his death in a plane accident, a project dedicated to the circular runway was launched by the U.S. Navy. The airport design (see Figure 2) consists of a main runway in the form of a banked track constituting the perimeter of the airport. At the centre of the circle is the control tower (N) housing radar and navigation aids. It is surrounded by an open parking and gardens (M), themselves encircled by a ring-shaped passenger terminal building (L). The entire outer wall of the terminal faces the runway. It provides a maximum of parking and loading positions for planes (K). The parking and loading area is connected with the runway by taxiways for departing aircraft (I) and high speed turn-off ramps for arriving aircraft (H), 24.4 meters wide and arranged like spokes on a wheel. Finally, a roadway (J) passes under the airport for passengers' access to the terminal building. The circular runway, to

accommodate aircraft with broad speed ranges (e.g. up to 151 km), would need to be 98 meters wide. It would be about 9,400 meters long, which corresponds to a diameter of about 3,000 meters. In operation, three or more aircraft could take off simultaneously, which would leave more than 3,050 meters separation between each plane. In low wind conditions, aircraft could then depart in three different directions.

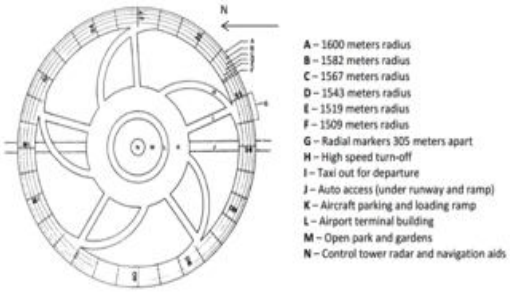

Figure 2:" Circular runway airport design, US Navy report."[3]

Actually, the wheel-shaped airport was foreseen for both civilian and military use, with a diameter ranging from 1,200 to 6,100 meters for the largest international airports. The dilution of the cross-wind problem, the gain in land use compared to a comparable conventional airport (one-third saved space), and the unlimited runway available for take-off and landing were already known from previous circular runway designers. From the safety side, one can mention the inherent stable tracking feature, the maximum runway access for the crash crews and the possibility to make flameout and dead-stick. [3]

V. ADVANTAGES OF A CIRCULAR RUNWAY

- Unlimited runway available for both takeoff and landing;
- Design allows unlimited flexibility in planning approach and departure corridors;
- Dilution of the cross-wind problem;
- provides an inherent stable tracking feature;
- affords minimum required taxi distance and maximum runway access for the crash crews; affords optimum control tower placement;
- allows optimum placement of navigation aids;
- requires a smaller total area than a comparable conventional airport;
- TheCentre building complex allows optimum passenger access to and departure from aircraft;
- Rapid aircraft departures and arrivals possible;
- Affords optimum low visibility procedures;
- Compactness derived in the building complex;
- Design contributes to noise abatement. [4]

VI. FUTURE SCOPE

Many aspects will have to be considered when constructing an airport with a*Circular Runway*. The motivation for a location will be different, as aircraft will fly in any direction and more noise near the airport can be expected.

The technological challenges that will have to be solved for operating an *Endless Runway* are actually mostly already under way. Increased automation in the aircraft and on-ground will aid in planning the runway segments to be used and in determining exactly what take-off or touch-down point will be optimal. To exactly follow the plan, automation will also help. Research performed in *the Endless Runway* can benefit current developments in for example the application of Adaptive Runway Aiming Points (A-RAP).

Regulations, standards and certification will need to be adapted to *the Endless Runway*. As far as possible, current regulations and standards have been followed within the project, but the new runway shape will certainly require changes. The main issues will be the circular shape and the bank angle of the runway and the complexity of the TMA operations. [2]

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