



International Civil Aviation Organization

## WORKING PAPER

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### ASSEMBLY — 42ND SESSION

#### TECHNICAL COMMISSION

#### Agenda Item 25: Other issues to be considered by the Technical Commission

#### STRATEGIC PLANNING AND OPTIMIZATION OF IRAN'S AIRPORT NETWORK: DEMAND FORECASTING, COST MODELLING, AND SCENARIO-BASED PLANNING

(Presented by Iran (Islamic Republic of))

#### EXECUTIVE SUMMARY

To ensure sustainable and economically efficient airport network planning for each state, strategic, data-driven analysis is essential. This paper outlines a methodology for creating a comprehensive National Airport Network Master Plan for Iran, with a focus on sustainable aviation sector growth. It integrates national transportation policies and provides strategic guidance for airport development and management. Using a modelling framework that factors in projected travel demand, fleet capacity, and route-specific costs, the study solves an optimization problem to determine the ideal number and configuration of airports. Forecasts identify future traffic volumes and hub airports.

|                                |                                                                                                                                                                                                         |
|--------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <i>Strategic Goals:</i>        | This working paper relates to <i>Every Flight is Safe and Secure</i> and <i>the Economic Development of Air Transport Assures the Delivery of Economic Prosperity and Societal Well-being for all</i> . |
| <i>Financial implications:</i> |                                                                                                                                                                                                         |
| <i>References:</i>             | Doc 9184, <i>Airport Planning Manual</i> , Part I — <i>Master Planning</i><br>Doc 9626, <i>Manual on the Regulation of International Air Transport</i>                                                  |

## 1. INTRODUCTION

1.1 The strategic development of a national air transportation network is a critical component of broader economic and infrastructural planning, particularly in countries experiencing rapid population growth, urbanization, and increasing mobility demands. Achieving a sustainable and economically efficient airport network requires an integrated, data-driven approach that accounts for projected demand, operational costs, and evolving policy frameworks. This study presents a comprehensive methodology for the strategic planning and optimization of Iran's airport network, incorporating forecasting techniques, cost modelling, and scenario-based analysis.

1.2 Through this approach, the paper offers insights into the long-term planning of Iran's aviation infrastructure, highlighting strategic priorities such as hub designation, fleet composition, and route expansion. The findings contribute to the broader field of transport planning by demonstrating the utility of integrated modeling and optimization techniques in supporting sustainable aviation policy.

## 2. RESEARCH METHODOLOGY

2.1 In the first step, the air transport modal split demand in comparison with other modes of transportation was forecasted. To achieve this, two scenarios has been defined:

- a) *Baseline scenario*. This scenario assumes that the current trend of demand growth continues. The supply is met solely by the existing fleet, with no changes in fleet size or composition. It reflects the prevailing conditions, including ongoing sanctions, which constrain both the qualitative and quantitative enhancement of the fleet. As a result, there is no scope for fleet expansion or modernization under this scenario.
- b) *Optimistic scenario*. This scenario anticipates a higher rate of demand growth, driven by accelerated economic or sectoral expansion. On the supply side, it assumes that capacity will scale in line with rising demand, supported by unrestricted access to a more modern and adequate fleet. In this case, there are no barriers to fleet expansion or improvement, enabling full alignment between supply capabilities and market needs.

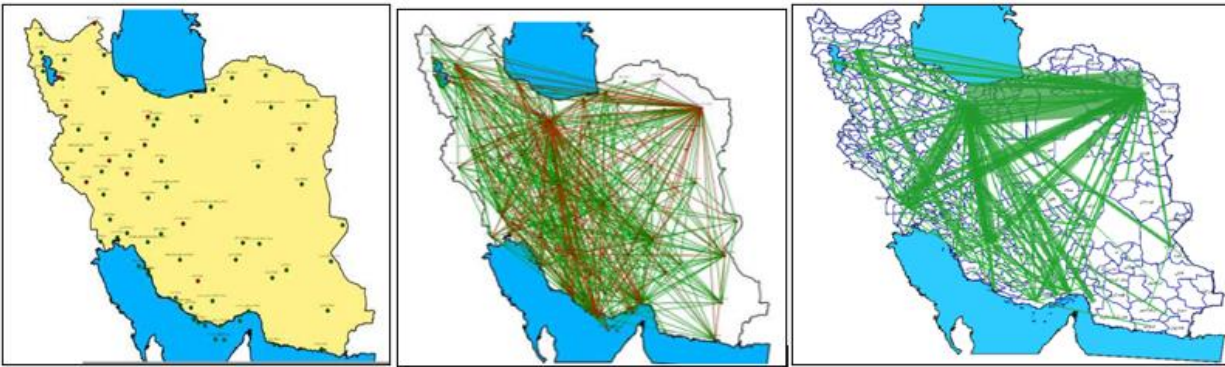
2.2 Based on these scenarios, the Four-Step Travel Demand Model was applied, consisting of traffic generation, traffic distribution, mode split, and traffic assignment. Through these steps, the air transport network was modelled. Table 1 summarizes the key assumptions underlying each scenario used in the modelling process.

**Table 1. Summary of baseline and optimistic scenarios**

| Scenario No. | Demand Scenario     | Supply Scenario                                          | Overall Travel Demand Forecast (millions of passengers) | Overall Flight Demand Forecast (millions of passengers) | Overall Operational Cost Of Internal Flight Network (million USD) |
|--------------|---------------------|----------------------------------------------------------|---------------------------------------------------------|---------------------------------------------------------|-------------------------------------------------------------------|
| 1            | Baseline Scenario   | Existing fleet will be maintained without additions.     | 2 784                                                   | 35.48                                                   | 1 845                                                             |
| 2            | optimistic scenario | New fleet additions will be made based on demand growth. | 3 540                                                   | 44.99                                                   | 2 340                                                             |

2.3 The volume of trips generated within the country and forecasts of future travel demand have been determined based on the National Comprehensive Transport Masterplan. This masterplan, as a high-level policy of transportation of the country, covers generated trip for all modes of transportation. This information has been developed using travel generation and distribution models, based on previous trends in passenger mobility, as well as the influence of demographic variables such as population, employment rates, gross domestic product (GPD), travel growth, and etc., utilizing data from the past 15 years.

2.4 In the next step, the air transport modal split was estimated in comparison with road and rail transport. This share was then allocated across various domestic and international airports. Determination of the Air transport modal split was carried out using the Four-Step Travel demand model, which includes trip generation, trip distribution, mode split, and traffic assignment. Accordingly, future airport traffic was also projected. Separate travel demand models were developed for three categories: domestic passengers, international passengers, and freight volume. The current airport layout, existing and planned air routes, as well as the current traffic between various airports within the country (Figure 1) were incorporated into the passenger traffic distribution across the airport network.



**Figure 1. Existing airports (left), origin–destination pairs of travel routes (middle), and projected traffic demand between airports (right)**

### 3. COST FUNCTIONS

3.1 To account for air transport costs, a cost function comprising both airline costs and airport costs was defined. The airline cost function was estimated based on the distance travelled and fixed maintenance costs according to aircraft capacity, categorized into five classes. The cost function considered is presented in Table (2). In addition to the costs accounted for active airports, a fixed cost of \$700 000 is added to the aforementioned expenses to incorporate inactive small airports into the operational cycle. Table (3). Cost functions for estimation of airlines travel cost.

**Table 2. Airline cost function based on travel distance**

| No.                                                          | Aircraft Capacity | Average Seats | Cost per Passenger (USD)                         |
|--------------------------------------------------------------|-------------------|---------------|--------------------------------------------------|
| 1                                                            | AC<50             | 20            | $0.02748 \times L + 17.4852$                     |
| 2                                                            | $50 < AC < 80$    | 60            | $0.0229 \times L + 14.571$                       |
| 3                                                            | $80 < AC < 120$   | 100           | $-0.00001 \times L^2 + 0.0361 \times L + 9.8353$ |
| 4                                                            | $120 < AC < 180$  | 150           | $0.00001 \times L^2 + 0.0315 \times L + 12.929$  |
| 5                                                            | $AC > 180$        | 260           | $-0.000001 \times L^2 + 0.017 \times L + 21.26$  |
| L: Distance between origin and destination (travel distance) |                   |               |                                                  |

**Table 3. Cost functions for aerodrome operations**

| No. | Aerodrome Size    | Annual Number of Passengers (ANP)       | Cost per Passenger (USD) |
|-----|-------------------|-----------------------------------------|--------------------------|
| 1   | Large Aerodrome   | $ANP > 5 \times 10^6$                   | 3.14                     |
| 2   | Average Aerodrome | $1.5 \times 10^6 < ANP < 5 \times 10^6$ | 5.92                     |
| 3   | Small Aerodrome   | $ANP < 1.5 \times 10^6$                 | 14.18                    |

#### 4. OPTIMIZATION USING ANT COLONY OPTIMIZATION(ACO) METHODS:

4.1 Considering the existing airports (both active and inactive), current routes, new routes, research assumptions, and associated costs, the optimization problem was formulated to optimize the objective function. Artificial intelligence algorithms and the Ant Colony Optimization method were employed to achieve convergence towards the optimal solution. Given the variable number of airports and air routes, approximately 30 000 scenarios were analysed, and the optimal solution was determined under the optimistic scenario.

#### 5. CONCLUSION

5.1 In this study, an optimized design for Iran's air transport network was developed according to existing airports. The work involved determining the passenger air network for both domestic and international routes, forecasting demand, estimating the number and type of aircraft required for each route under different supply and demand scenarios. The results including calculating passenger costs within the network and across routes, identifying eligible hub airports, and assessing demand for new or currently inactive airports has been provided.

5.2 All findings presented in this study are based on the outcomes of the developed network modelling software and the integrated optimization system. Given the vast number of possible permutations and configurations within the national air transport network, a wide range of supply and demand scenarios has been analysed. As a result, the model provides detailed estimates of passenger volumes at the airport level, optimized air route assignments, and appropriate aircraft type selection for each flight under varying conditions.

5.3 Some key quantitative results of the analysis are:

- a) a total of 77 existing airports are sufficient to serve the national air transport network;
- b) seven airports qualify as domestic hubs; and
- c) under current demand levels, a fleet upgrade is necessary—the optimistic scenario requires 188 active passenger aircraft to meet travel demand.

5.4 At present, there are 120 distinct domestic origin–destination routes. To support network and fleet expansion, this must increase to 400 routes.

5.5 These results used in prioritization of airport capacity expansions, the development of new airports, the reactivation and utilization of inactive facilities, and the planning of future fleet requirements to ensure sustainable growth of the aviation industry.