FORECASTING METHODS AND ICAO'S VISION OF 2011-2030 GLOBAL AIR TRAFFIC

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ABSTRACT

Forecasting has been a key factor in the planning and development of civil aviation. This paper surveys current techniques in air traffic forecasting. The advantages and disadvantages of the techniques, as well as the criteria for selecting of a particular technique are discussed. Then, the forecasting work of the International Civil Aviation Organization (ICAO) is comprehensively introduced, i.e. the traffic data, the methodological framework, and the major models. It involves ICAO's practices under this subject in the last two decades. ICAO's forecasting has long been a reliable reference for its 191 member states. In this paper, main results of ICAO's up-to-date forecasts of 2011-2030 global air traffic, both passengers and cargos, are conveyed.

Keywords: forecast, method, ICAO, air traffic, data, long-term

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1. INTRODUCTION

Reliable forecasts of civil aviation activity play a critical role in the planning process of states, airports, airlines, engine and airframe manufacturers, suppliers, air navigation service providers and other relevant organizations. In the civil aviation field, forecasts generally are used to:

- assist states in facilitating the orderly development of civil aviation and to assist all levels of government in the planning of airspace and airport infrastructure such as air traffic control, terminal facilities, access roads, runways, taxiways and aprons;
- assist airlines in the long-term planning of equipment and route structures; and
- assist aircraft manufacturers in planning future types of aircraft (in terms of size and range) and when to develop them.

The International Civil Aviation Organization (ICAO) is a specialized agency of the United Nations (ICAO, 2006). It stands for the safe and orderly development of civil aviation throughout the world, sets standards and regulations in all necessary fields, and serves as the global forum for the cooperation of its 191 Member States. Over 20 years, its Air Transport Bureau (ATB) has been conducting and publishing worldwide, regional, and route group air traffic forecasts.

Besides ICAO, there exist other deliverers of air traffic forecasting. Airbus (2011), as well as Boeing (2011), delivers its 20 years' market outlook timely, always aiming at the demand of aircrafts. The International Air Transport Association (IATA), which represents 230 airlines registered in 118 countries, provides five-year traffic forecasts for individual country-pairs (IATA, 2011), plus aggregate results at region and global level. Airports Council International (ACI) provides passenger forecasts over the next 20 years, based on over 300 member airports worldwide and on the latest traffic statistics (ACI, 2011). Some other companies, i.e. EMBRAER and Rolls-Royce, also publish their market forecasts with specific emphases.

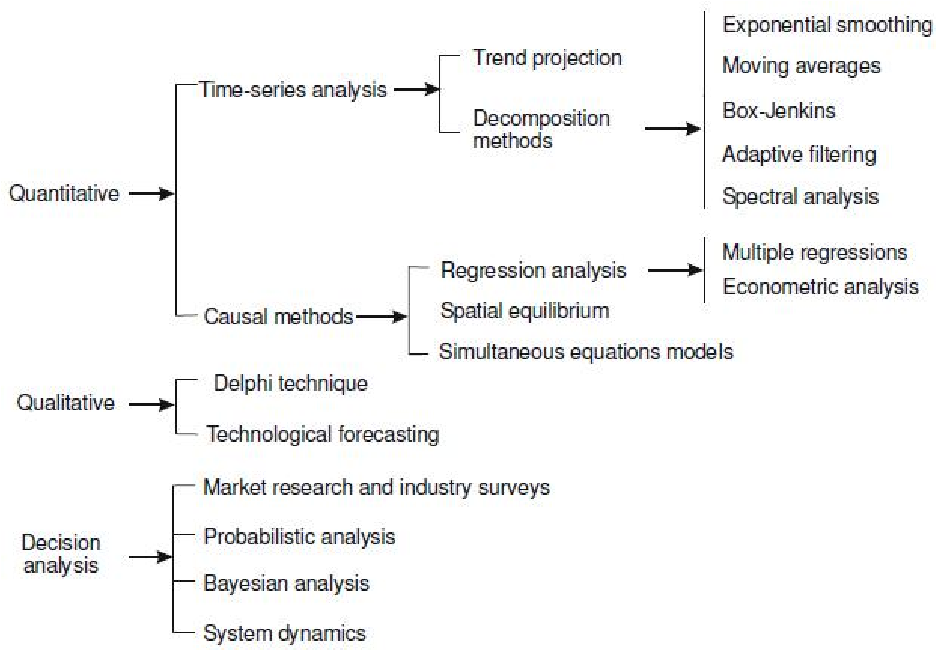
These forecasters differ in long-term or short-term, passenger or freight, world, regional or country level. Among all the forecasters, ICAO covers all the categories. For ICAO, forecasting serves as a global planning guideline for all member states, especially those countries that try to maintain sustainable growth in civil aviation. The reputation of the ICAO's forecasting is related to its duty as an inter-government non-profit organization.

In the following section, this paper surveys major forecasting techniques and the proper circumstances for their applications. Then the forecasting system of ICAO is introduced in Section III. The main results of ICAO's forecasts, i.e. ICAO's vision of 2011-2030 global air traffic, are presented in Section IV. The conclusions are addressed in Section V.

2. FORECASTING TECHNIQUES

Forecasting methods in air traffic can be divided into three categories: quantitative, qualitative/judgmental, and decision analysis. Forecasting techniques that start with historical data and develop a model based on a set of rules fall into quantitative methods.

Figure 1: Categories of Forecasting Techniques in Air Transport



2.1 Quantitative Methods

Quantitative forecasting methods can be classified into two subcategories: time-series analysis and causal methods.

2.1.1 Time-Series Analysis

A first step in quantitative forecasting is usually to study the historical air traffic data (time series) and the trend in traffic development. The time-series analysis methods are largely based on the assumption that historical patterns will continue, and they rely heavily on the availability of historical data (Chèze et al., 2010).

Trend projection applies mathematical techniques in determining the best fit line through the data. In the context of medium-term or long-term forecasting, the appropriateness of trend projection depends heavily on stability in past developments and the confidence of projecting trends into the particular future environment.

Decomposition methods involve the dissection of the problem into various components. These methods are particularly relevant when strong seasonality or cyclical patterns exist in the historical data. They are useful to identify three aspects of the underlying pattern of the data: the trend factor, the seasonal factor and any cyclical factor that may exist.

A general forecasting technique that attempts to deal with the fluctuations in a time series (trend, seasonality and cyclical factors) is smoothing (Aragon and Gnassou, 2008), i.e. moving average or exponential smoothing. The exponential smoothing emphasizes on the most recent data, to increase their influence on the forecast. So it is important to recognize the seasonality inherent in the data if monthly or quarterly forecasts are considered. A smoothing factor would determine how much weight is to be placed on, for example, various months of the year. The moving average differs from exponential smoothing in that each observation is weighted equally. Compared to exponential smoothing, the advantage of moving average is its simplicity, with a disadvantage that a longer data series is necessary.

Besides, there exist Box-Jenkins, Adaptive filtering, and Spectral analysis as members of the decomposition method. The method of Box-Jenkins handles complex time-series data (Andreoni and Postorino, 2006), where a variety of patterns exists such as a combination of a trend, a seasonal factor and a cyclical factor. The method allows for much flexibility, while also calling for much subjectivity. Adaptive filtering (Li et al., 2010) is another approach for determining the appropriate set of weights for each of the time periods. The process is repeated by adjusting the weights to reduce the error, where the final weights are to minimize the mean squared error. Spectral analysis can be used to study the cyclical variation over time. The data can be decomposed into a series of sine waves of different frequencies and magnitudes (Welch and Ahmed, 2003). This demands prior knowledge that such a form could be adapted in the forecasting process.

2.1.2 Causal Methods

Causal methods infer a cause-and-effect relationship, hence the name. They offer an alternative to time-series analysis by taking into account how economic, social and operational conditions affect the development of traffic. This process is actually a testing procedure, which is designed to evaluate whether the relationship of the dependent variable (as expressed in the causal model) to the independent (explanatory) variables is significantly related to the movements of these variables.

Regression analysis is by far the most popular method in civil aviation forecasting (Airport Authority Hong Kong, 2011; Taneja, 1978). The econometric model attempts to explain the demand for air travel as being caused by the changes in the explanatory variables. The use of multiple regression analysis with a price-income structure is generally referred to as econometric analysis or econometric modelling. Dependent variables, in general, are historical traffic data measured in terms of passengers or revenue passenger-kilometres (RPK) and tonnes of freight or freight-tonne kilometres (FTK). The explanatory (or independent) variables are those variables which would have an influence on the demand for air travel.

Spatial equilibrium models (Bröcker et al., 2003) establish a relationship for the movement of traffic between any two traffic centres or regions. In the basic form of this relationship, the traffic between each two points is directly proportional to some characteristic of the size of the region and inversely proportional to the distance between regions.

In a simultaneous equations model (Lu et al., 2003), the variables simultaneously satisfy all the equations. The model addresses the issue of supply-demand interactions. An advantage of the model is that it provides the values of several explanatory variables from within the model itself. However, estimation of the parameters of the equations involves more complex issues than those encountered in a single equation model.

2.2 Qualitative Methods

Qualitative forecasting methods are used when a number of historical observations are sparse or not available and where experience and judgment have to be used.

These methods can also be used in an assessment of how new technological or other developments would affect the forecast. They are largely intuitive and rely heavily on the judgment of experts and may be used to predict a significant change in historical patterns or, due to lack of sufficient historical data, for a quantitative analysis.

2.2.1 Delphi Technique

The technique has two steps. A selected group of experts are first presented with a questionnaire so that each expert indicates a most probable course of development in the activity being forecasted. The initial returns are then consolidated and the composite response returned to all contributors, giving them the opportunity to revise their original assessments in light of prevailing opinions among other experts. This technique is a practical means moving towards a consensus among experts.

2.2.2 Technological Forecasting

Technological forecasting method attempts to generate new information about future performance of systems. This information can be either explanatory or speculative in terms of what new developments will take place in certain areas and is used to obtain a better understanding of future expectations. Technological forecasting can be classified into two categories: explorative and normative.

2.3 Decision Analysis

Decision analysis should be considered as a combination of both quantitative and qualitative analysis methods. In decision analysis, the analyst's judgment is used in preparing forecasts for a particular area of expertise in combination with some statistical or mathematical techniques including subjective inputs of probabilities. Decision analysis is helpful in the assessment of uncertainty and in risk analysis.

2.3.1 Market Research and Industry Surveys

Traffic forecasting through market research surveys aims at analyzing the characteristics of the air transport market in order to examine empirically how the use of air transport varies between different sectors of the population and different industries. Such results, in combination with forecasts of socio-economic changes, may indicate the likely future development of air transport.

2.3.2 Probabilistic Analysis

There is uncertainty associated with the forecasted value. When the amount of uncertainty is large, it would be desirable to assign probabilities to the outcome of a variable or the forecast itself. Having a distribution of possible outcomes for a variable, and the range of the forecast can be assessed based on subjective probabilities.

2.3.3 Bayesian Analysis

Bayesian analysis is a procedure to improve a prior estimate using new data or using conditional regression, a method to refine prior estimates of the regression coefficients by using objective data. Coefficients of one of the explanatory variables can be assigned and the coefficients of the other variables can then be re-estimated. This process can be repeated until all relationships have been estimated.

2.3.4 System Dynamics

System dynamics techniques use large-scale computer models of integrated mathematical formulas and algorithms. Such methods can be used to simulate the behaviour of the system concerned in response to certain variables. The models may be used to evaluate alternative policy scenarios and their impact on aviation activity.

2.4 Forecasting Time Horizon

The length of forecasting time horizon may vary for the particular type of application concerned. It is actually a key criterion for matching a specific forecasting situation with the appropriate methodology. For the aviation industry, the following time horizons are generally used:

- Short-term: up to 1 year;
- Medium-term: 1 to 5 years;
- Long-term: more than 5 years.

Short-term forecasts generally involve some form of scheduling, which may include for example the seasons of the year, for planning purposes. The cyclical and seasonal factors are more important in these situations. Medium-term forecasts are generally prepared for planning, scheduling, budgeting and resource requirement purposes. The trend factor as well as the cyclical component plays a key role in the medium-term forecast because the year-to-year variations in traffic growth are an important element in the planning process. Long-term forecasts are used mostly in connection with strategic planning to determine the level and direction of capital expenditures and to decide on ways in which goals can be accomplished. The trend element generally dominates long-term situations. As the forecast horizon is long, it is also important that forecasts are calibrated and revised at periodic intervals. The methods generally found to be most appropriate in long-term situations are econometric analysis and life-cycle analysis.

3. ICAO'S FORECASTING SYSTEM

In the analysis of the real world, data collecting is the first step. ICAO has its own data reporting system by which each of the Member State contributes, monthly, quarterly, and yearly, to the air traffic data of ICAO. The Member States of ICAO also submit extensive data, such as On-Flight Origin and Destination and Traffic by Flight Stage provided historical passenger data by major route.

3.1 Data

Usually, the information that ICAO collects from its Contracting States is compiled into multiple data series. The data are updated in real time and change, often daily. These data series forms the base of the traffic database of ICAO. The database is now publicly accessible through the website of ICAOData (ICAO, 2013). It offers a user-friendly interface allowing for easy pick-up and analysis of the ICAO statistical data on the air transport industry.

3.1.1 Data Source

Data from traditional sources such as the Official Airline Guide, the airframe manufacturers and government data agencies provide additional depth. For the verification purpose of the reported data, ICAO keeps a continuously contact with other data collectors, such as IATA, OAG, and ACI. Besides the air traffic data, ICAO also purchased the econometric data package from Global Inside. These efforts make it possible for ICAO to conduct the analysis and the forecast of the air traffic.

3.1.2 Data Structure

As to the statistics of air traffic, the base data is the operation of a flight. It tells everything of the flight, such as original and destination airport, available and revenue seats, flight distance, flight hours, revue and total load, flight number, market type (international or domestic), etc. It could be a performed flight or a scheduled flight that has not yet been performed. Note that for a single flight, some data are calculated out upon some others. For example, the available seat kilometre (ASK) is the multiply of available seat number and flight distance. The revenue passenger-kilometre (RPK) is the multiple of revenue passenger and flight distance in kilometre. The revenue tonne-kilometre (RTK) is the multiple of revenue load in tonne and flight distance in kilometre. The load factor (LF) is the ratio of RPK versus ASK, representing the revenue level of a flight. Such type of data is named as city-pair data in the industry.

For a specified city-pair market, the data can be aggregated by time, by airline, by direction, etc. Different city-pair data can also be aggregated by origin/destination city, by country, or by region. For the forecasting purpose, ICAO defines 9 regions as the composition of the world, as shown in Figure 2. Then all the city-pair data are aggregated by its origin/destination region.

Figure 2: ICAO's Definition of 9 Forecasting Regions

Therefore, the traffic data fall into three categories: international traffic between regions, intra traffic between countries within a given region, and domestic traffic within a country of the region. Now that the world is divided into 9 geographical regions, forecasts will be developed for 53 route groups (36 inter-regions, 8 intra within region and 9 domestic within regions).

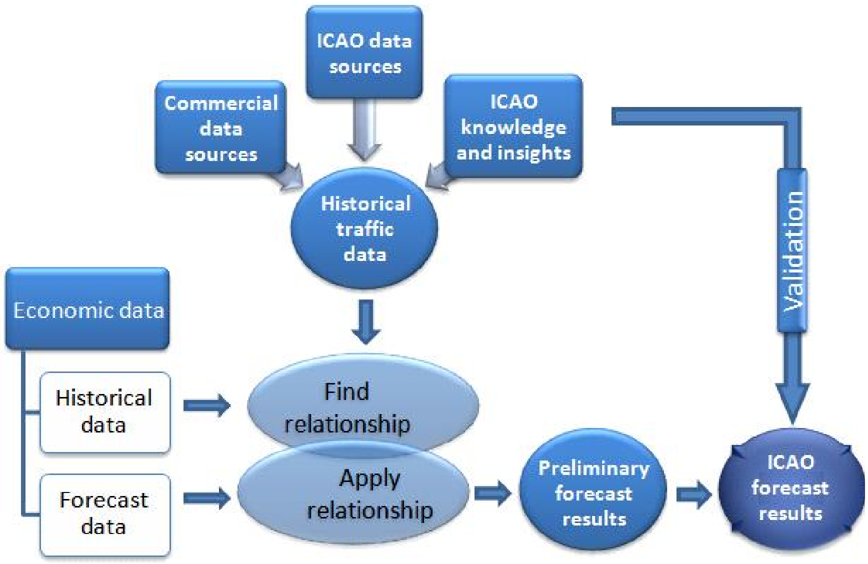
3.2 Methodology

In brief, the technique of linear regression has been used for the forecasts of RPK and FTK. Then the forecasts of aircraft movements are derived from these results, in addition to some assumptions on future passenger load factors, average aircraft seating capacity and average stage length by route group.

3.2.1 Framework

ICAO produces 20 year forecasts of air traffic to support aviation planning throughout the world. Figure 3 shows a simplified schematic diagram of the process.

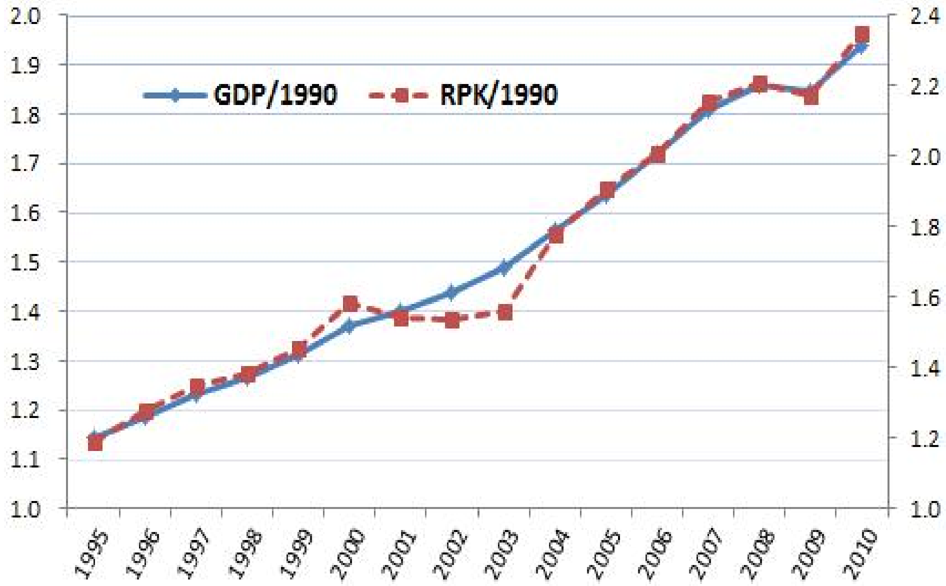
Figure 3: Forecasting Framework of ICAO



ICAO forecasters examined many non-aviation variables to find variables whose past history bears a strong relationship to air traffic. They apply mathematical methods to express historic air traffic in terms of these variables. ICAO has found that a region's Gross Domestic Product (GDP) tracks its air traffic consistently well. A relationship that expresses traffic in terms of GDP closely replicates the historical traffic. Fig. 4 shows the long-term relation between the growth of world GDP and the growth of world RPK.

GDP contains a very broad range of economic activity, and therefore has a minimal sensitivity to industry-specific fluctuations. It is a widely accepted index of economic prosperity. As GDP had a close relationship to air traffic in the past, it should maintain this relationship in the future. By "plugging in" the historical relationship into the future, the model should generate good forecasts of future air traffic.

Figure 4: Relation between World GDP and World RPK



3.2.2 Models for RPK and for FTK

ICAO forecasts revenue passenger-kilometres (RPK), freight tonne-kilometres (FTK), and aircraft movements for the major region-pairs and regions. The two former metrics reflect both the number of passengers and freight carried and the distances that they travel. It is presented hereby the detailed algebraic discussions of the estimation process. The basic model form assumed is:

$$y = a \cdot x_1^{b1} \cdot x_2^{b2} \qquad (1)$$

where, for the model of passenger traffic, y represents the RPK, x_1 is the GDP, and x_2 could be revenue per passenger-kilometre or a dummy variable; for the model of freight traffic, y represents the FTK, x_1 is world exports, and x_2 is freight revenue per freight tonne-kilometre or a dummy variable. The parameter a, b_1 and b_2 are constant coefficients whose values were obtained by statistical estimation, using econometric analysis. The b_1 and b_2 are equal to the elasticity of demand with respect to the corresponding x_1 and x_2.

The forecasts use the technique of linear regression. This involves examining one variable, in this case air traffic, against other variables from outside aviation. The goal is to find one or more variables which change over time, and whose changes are associated with changes in the air traffic variable. Annual data were used in the estimations, covering a period of 30 years for the model. A dummy variable could be introduced to take into account the special years where traffic and prices grew in the same direction.

3.2.3 Model for Aircraft Movement

Passenger traffic forecasts, expressed in terms of RPK, can be converted into forecasts of aircraft movements by using assumptions on future average load factor, average aircraft seating capacities and average distance stage length for each selected route group. It is described below the technical details concerning the methodology for forecasting aircraft movements.

The relationship between aircraft-kilometres, load factors and aircraft size (seats per aircraft) was developed for passenger aircraft as follows:

$$p = \frac{RPK}{\frac{RPK}{ASK} \cdot \frac{ASK}{p}} = \frac{RPK}{LF \times aircraft\ size} \qquad (2)$$

where p stands for aircraft kilometres.

Forecasts of aircraft movements incorporate assumptions about future passenger load factors, average aircraft seating capacity and average stage length by route group. Load factors on all route groups are expected to increase over time but would not exceed 85%. At this level, air carriers are assumed to switch to larger aircraft or to add frequencies. The trend of average aircraft seating capacity depends on the route groups. For mature and highly competitive markets, such as Domestic North America, where frequency is a major determinant of market share, aircraft seating capacity is projected to decrease, whereas for developing long haul markets, such as Europe-Middle East and all routes between Middle East and Asia/Pacific, aircraft seating capacity is projected to increase. Average stage length is expected to increase on the majority of route groups.

The average growth rate of aircraft kilometres in the history was then used to calculate the forecast number of aircraft kilometres for all scheduled services, including all freight as well as combined passenger and freight services. Then the relation between aircraft departures, aircraft kilometres and aircraft stage length for passenger and all freight aircraft combined is derived as follows:

$$q = \frac{p}{p / aircraft\ movements} = \frac{p}{stage\ length} \qquad (3)$$

where q represents the aircraft movements. The forecast for aircraft movements in the future was generated by substituting into this expression the forecast for aircraft kilometres and the assumption for the growth of average stage length in the future.

4. ICAO'S VISION OF 2011-2030 GLOBAL AIR TRAFFIC

By 2011, some regions and region-pairs had attained maturity, with large per-capita aviation use, price-sensitive customers and a stable industry structure. Others were relatively undeveloped, hence performing sustained growth. These different conditions have led to apparent different growth rates for commercial aviation around the world.

4.1 Global Passenger Traffic

Recent historical and future traffic are hence derived for all world air routes. By 2030, an average annual growth rate (AAGR) of 4.5% for world total passenger traffic will result in 2.3 times of RPKs of the 2011 level. Growth during the 2020-2030 will fall slightly as markets mature. Domestic traffic will grow slightly slower than international travel volumes. Improved surface transportation, particularly high speed rail, will absorb part of the demand for air transport.

4.1.1 Passenger Traffic at a World Level

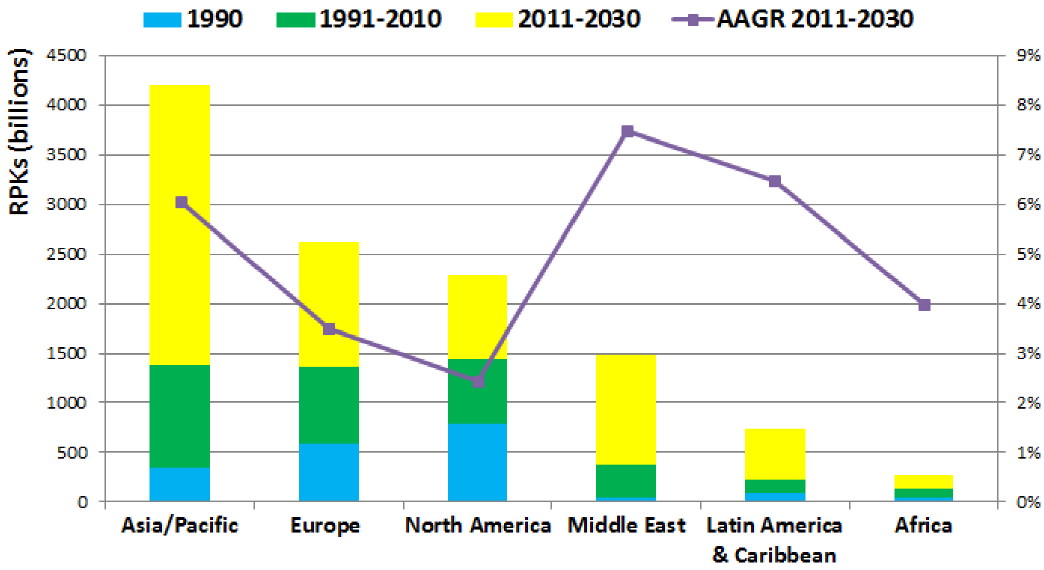
Economic processes are hard to forecast, and some regions will deviate from the most likely assumptions. ICAO therefore prepared two further sets of forecasts, the high (optimistic) and a low (pessimistic) to measure the consequences of our uncertainty about the future. Over the period 2011-2030, the high forecast for global passenger calls for an average annual growth rate of 5.1% per year. A rate of 3.6% annually would result from the assumptions in the low scenario.

Table 1: Summary of Passenger RPK Forecasts
by Region of Airline Registration

Region	Growth Rate (%)		Share of World Total (%)		
	1990-2010	2011-2030	1990	2010	2030
Africa	5.5	4.0	2.2	2.6	2.3
Asia/Pacific	6.8	6.1	18.2	27.4	36.2
Europe	4.1	3.5	31.2	27.9	22.6
Middle East	10.5	7.5	2.5	7.4	12.8
North America	3.0	2.4	41.4	30.1	19.7
Latin America & Caribbean	4.5	6.5	4.6	4.5	6.4
WORLD	4.6	4.6	100	100	100

The forecasts of by region of airline registration may differ from the forecasts by route group. Since most countries reserve domestic traffic exclusively for their own registered airlines, the domestic route group will be served by regionally domiciled carriers. A route group's trans-border traffic will be served primarily by regionally based carriers, although airlines from other regions may hold international traffic rights within that region.

Figure 5: Passenger RPK Forecasts by Region of Airline Registration



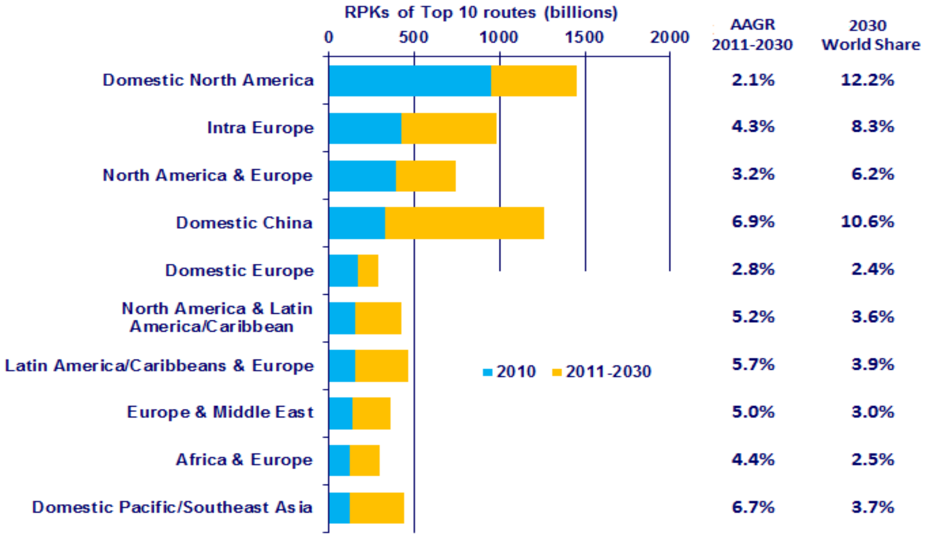
The airlines of two separate regions will share the inter-regional traffic. Bilateral agreements, negotiated on the balance of benefits principle, would lead in theory to equal traffic shares. In practice, the airlines of one region might substantially out-carry those of the other. Carriers based outside either of the two regions may also capture a share of the traffic. For example, Delta Air Lines and United Airlines both carry local traffic between Tokyo and Singapore.

Unlike the route group forecasts summarized previously, the "Asia-Pacific" route in this part includes China, North Asia, Pacific/South East Asia and Southwest Asia. The sustainable growth of the Asia/Pacific region is significant. Its strong economic growth will have propelled it, from the sixth largest market in 1990 to the largest in 2030 in terms of passengers. North America will have the lowest growth, and its world rank will fall from the first to the third. The North American carriers' declining share results from low population growth, stodgy growth in the GDP, and the already extensive use of commercial aviation in 2011. North American markets have the longest post-liberalization experience, and the stimulus was already reflected in the historical volumes.

4.1.2 Passenger Traffic Forecasts of Major Routes

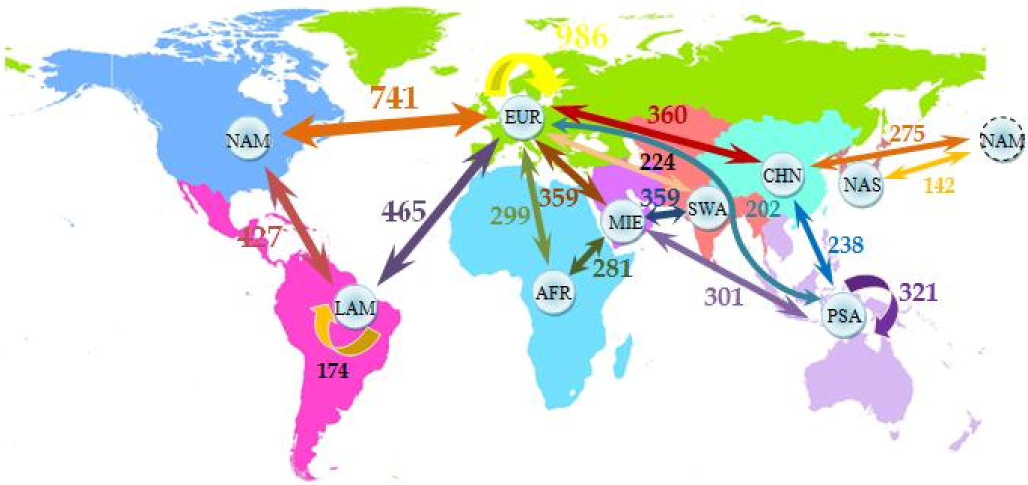
For the next two decades, the AAGR of route group RPKs is range from 1.0% for Domestic Northeast Asia to 9.1% for Middle East - Africa.

Figure 6: Top Ten Passenger Traffic Routes in 2011 and Growth 2011-30



The Intra Europe route will remain the largest international route by 2030. Europe stays the major motor of international passenger traffic in 2030, see Figure 7 below.

Figure 7: Major Routes of International Passenger Traffic in 2030



Still, the air network of Middle East will be reinforced as the region rises up as the hub between Europe, Asia, and Africa.

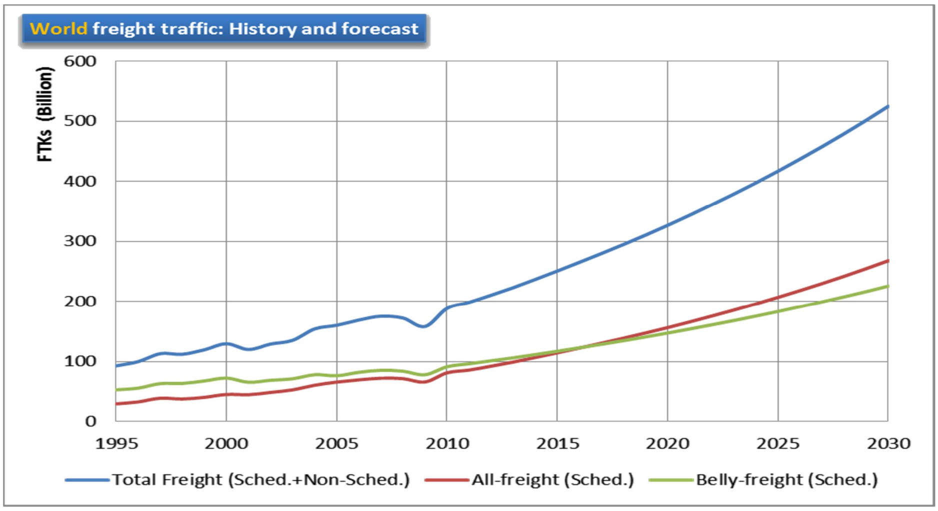
4.2 Global Cargo Traffic

By 2030, the 5.3% annual growth in total freight traffic (Scheduled and non scheduled flights) will result in an increase of 2.7 times the 2010 level. Domestic traffic will grow at the same pace with international travel volumes.

Table 2: Summary of FTKs Forecasts by Region of Airline Registration

Region	FTKs (million)			AAGR (%)		World Share (%)		
	1990	2010	2030	1990-2010	2011-2030	2000	2010	2030
Africa	1126	2284	4638	3.6	3.5	1.8	1.3	0.9
International	1035	2198	4536	3.8	3.6	2.0	1.5	1.1
Domestic	91	86	102	-0.3	0.8	0.5	0.3	0.1
Asia/Pacific	16340	62812	212157	7.0	6.2	33.9	36.3	43.0
International	14832	55537	186443	6.8	6.2	36.1	38.0	44.7
Domestic	1508	7275	25714	8.2	6.5	20.3	27.4	33.7
Europe	20008	44576	89646	4.1	3.6	29.5	25.8	18.2
International	17413	43832	87900	4.7	3.6	33.5	30.0	21.1
Domestic	2595	744	1746	-6.1	4.4	5.0	2.8	2.3
Middle East	2440	16191	72118	9.9	7.4	3.9	9.4	14.6
International	2351	16095	72000	10.1	7.4	4.4	11.0	17.3
Domestic	89	96	118	0.4	1.1	0.6	0.4	0.2
North America	16176	40938	92140	4.8	4.3	27.1	23.7	18.7
International	8533	24671	50866	5.5	3.9	20.2	16.9	12.2
Domestic	7643	16267	41274	3.8	4.8	69.3	61.3	54.1
Latin America & Caribbean	2736	6022	22870	4.0	7.5	3.8	3.5	4.6
International	2183	3943	15500	3.0	8.0	3.7	2.7	3.7
Domestic	553	2079	7370	6.8	6.5	4.3	7.8	9.7
WORLD	58826	172823	493569	5.5	5.4	*100*	*100*	*100*
International	46347	146276	417245	5.9	5.4	*100*	*100*	*100*
Domestic	12479	26547	76324	3.8	5.4	*100*	*100*	*100*

Figure 8: Forecasting of World Air Freight



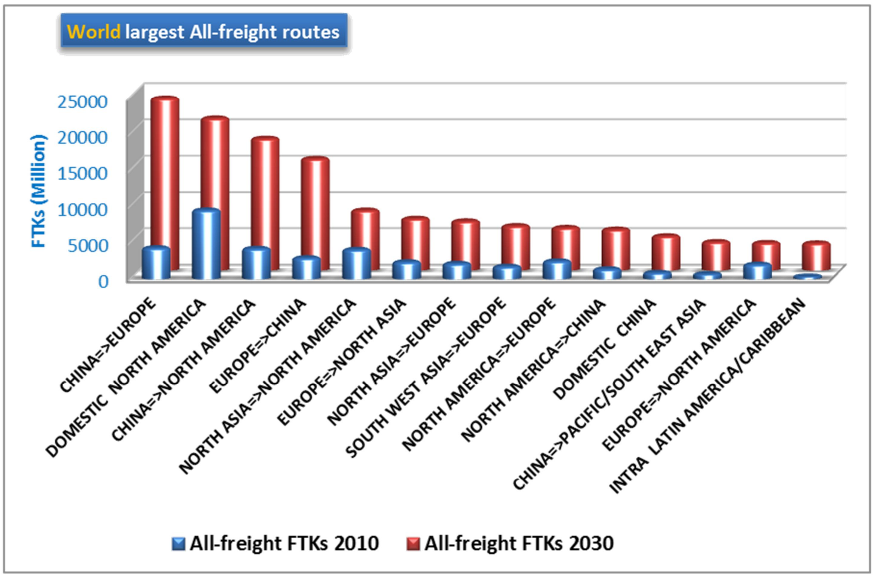
All-dedicated freight traffic will grow faster than Belly-freight traffic. In 2010, the freight carried by Freighter represents 47% of the total freight traffic. In 2017, that all-dedicated freight traffic will cross the symbolic market share of 50% to reach in 2030 a 54% market share.

4.2.1 All-Freight Global Results

According to ICAO's forecasts, all-freight traffic will grow at 6.2% per year for the next 2 decades.

All-freight traffic from China to Europe will grow much faster than the Domestic North America all-freight market. Further, Domestic North America all-freight traffic will become the second largest route in 2030 as measured by Freight tonnes-kilometres carried, the China to Europe route traffic coming to the first rank.

Figure 9: 2030 Rankings for All-Freight Traffic



International routes will represent 89% of the world all-freight traffic. International all-freight traffic will be dominated by China to Europe, followed by China to North America, which will account together for 18% of the traffic. Domestic all-freight traffic will be dominated by North America, followed by China, which will account together for 90% of the world domestic traffic.

4.2.2 Belly-Freight Global Results

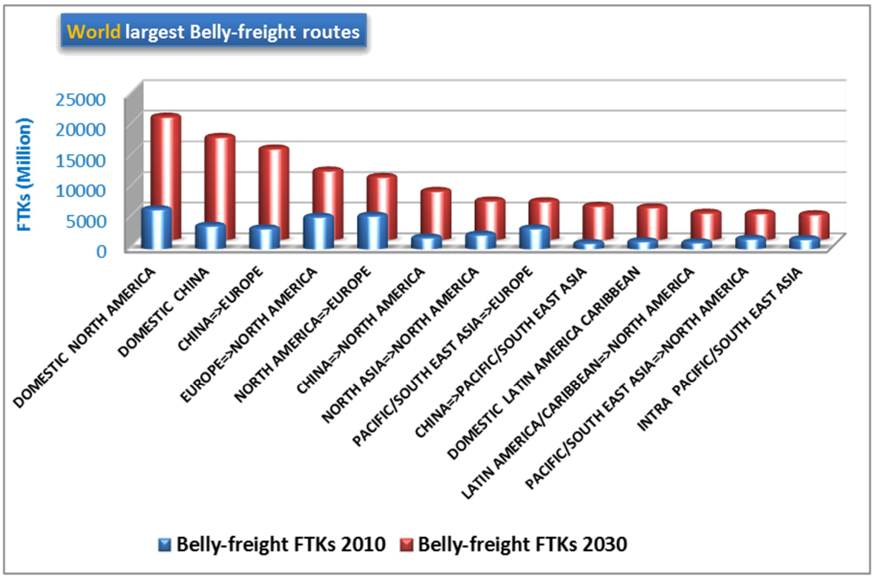
International routes will represent 79% of the total belly-freight traffic in 2030, a 5% decrease from the 2010 market share. Therefore, domestic traffic is going to increase faster than international traffic. International Belly-freight traffic will be dominated by China to Europe, followed by Europe to North America, then North

America to Europe, and only in fourth position China to North America. According to ICAO's forecasts, belly-freight traffic will grow at 4.6% per year for the next 2 decades. Domestic North America belly-freight traffic will remain the largest market as measured by freight tonnes-kilometres (FTK) carried in 2030. Domestic belly-freight traffic will be dominated by North America, followed by China, which will account together for 78% of the traffic in 2030.

4.3 Global Aircraft Movements

Along with the RPKs forecasting, the aircraft movement is very important for airport planning. The forecasts help airports determine the number of runways they need and the total land that they will require. It is also an important factor in the need for ATC facilities and for the development of new international routes.

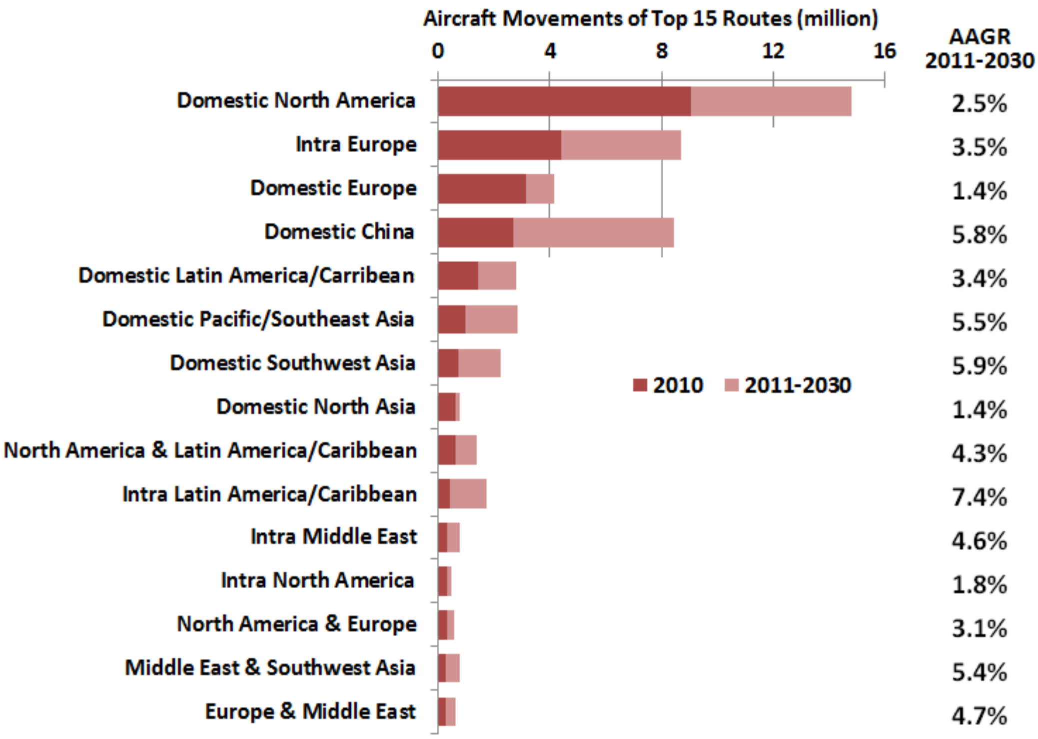
Figure 10: 2030 Rankings for Belly-Freight Traffic



Factors such as the technology available, how airlines manage the available capacity, the types of aircraft used and the structure of airline networks are of crucial importance in defining the number of flight operations. Pricing concerns are also important, since premium business passengers tend to require high frequencies. Very high load factors tend to correspond to low average fares.

The forecasts of aircraft movements closely parallel the forecasts of RPKs. North America, North Asia and Europe are all large and mature regions. They will grow relatively slowly to 2030. China, Southwest Asia, and the Pacific/Southeast Asia regions will experience rapid growth. Other regions, including the Middle East, Africa and Latin America will also see robust growth.

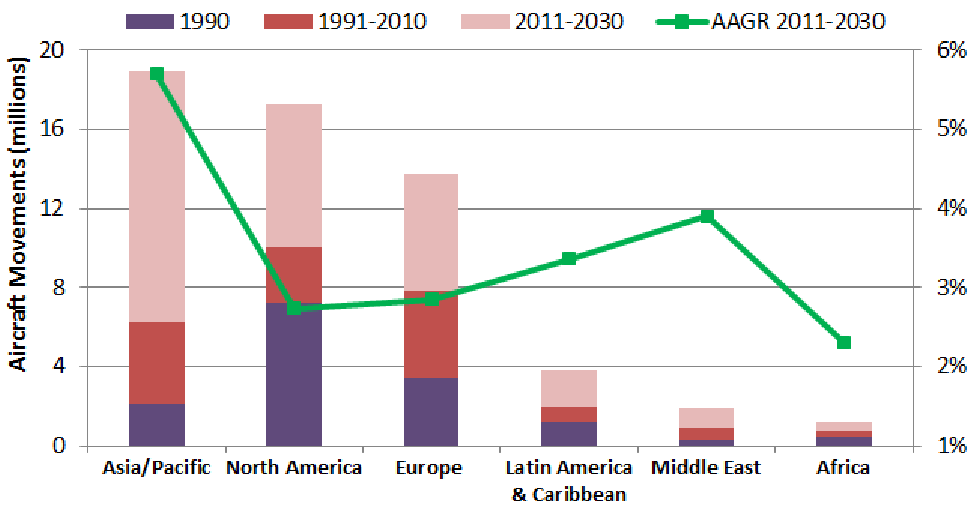
Figure 11: Forecasts of top 15 Routes of Aircraft Movements



4.3.1 Forecasts of Passenger Aircraft Movements by Regions

The growth of air travel has been particularly beneficial to developing countries. Airlines of Southeast Asia, Latin America and Africa are capturing a growing share of total traffic.

Figure 12: Forecasts of Aircraft Movements by Region of Airline Registration



Global aircraft movements (excluding all freight movements) are forecast to grow at the average annual rate of 3.6% over the period 2011-2030, compared to 3.2% for 1990-2010. The main reasons for this difference are the projected improvements in load factors and overall increases in average aircraft seating capacity and in range. Asia/Pacific airlines, including those of China and Southwest Asia, will experience particularly rapid growth. Only they will exceed the world average, and only they will increase their share of the total world aircraft movements.

4.4 Global Pilot Demand

During the last decades, strong growth of commercial air transport has led to many new commercial air transport operators and the highest number of aircraft orders ever registered. Over the next 20 years, the demand for qualified aviation personnel, such as pilots, aircraft maintainers, and air traffic controllers will need to be correlated to aircraft delivery plans. Using its breadth of civil aviation expertise, ICAO estimated current and future requirements for civil aviation personnel and training capacity in each region (ICAO, 2011). The table below summarizes the forecast on pilot demand and training capacity in 2030.

Table 3: Summary of Pilot Forecasts by Region of Airline Registration

Region	Pilot Demand	Training Capacity	Assessment
Europe	15532	7955	SHORTAGE
Asia/Pacific	13983	4935	SHORTAGE
North America	10449	27655	SURPLUS
Latin America	6250	1945	SHORTAGE
Africa	3814	1010	SHORTAGE
Middle East	2458	860	SHORTAGE
World Total	52506	44360	SHORTAGE

5. CONCLUSIONS

This paper has surveyed current techniques in air traffic forecasting. Besides, the forecasting work of ICAO is comprehensively introduced. The main results of ICAO's forecasts of 2011-2030 global air traffic have been presented, serving as a reliable reference for its 191 member states.

In the aviation industry, the forecasts rely heavily on the historical data. Traffic by Flight Stage (TFS) information and On-flight Origin/Destination statistics for air carriers are different from the traffic data for airports. It is rare that one could get all data from a single data provider. The situation often gets complicated as the provider has only part of the historical data. For example, some of the member states have been reporting to ICAO the traffic data from 1950, while many other states have only provided the data in the recent 30 or even 20 years.

It is interesting to compare the results from different forecasters. It is not easy, however, to achieve the comparison, in view of their differences in data sources, in ways of aggregating data, and in forecasting techniques. Different forecasting techniques may apply to best fit the application situation. For example, aircraft manufacturers such as Boeing and Airbus, conduct their forecasts of RPK/FTK, as well as of the global/regional fleet that depends on the airplanes in service, airplanes removed from service, and the new airplane deliveries. Nevertheless, it is remarkable to note, for a comparative study, that the definition of global regions by ICAO (see Fig.2) is different from both that of Boeing and from that of Airbus.

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