A methodology for air route planning: the case NAP - NYC

Elpidio Romano

University on Naples “Federico II”, Department of Transportation Engineering “Luigi Tocchetti”

Vittorio De Riso di Carpinone

University on Naples “Federico II”, Department of Transportation Engineering “Luigi Tocchetti”

Andrea Tocchetti

University on Naples “Federico II”, Department of Transportation Engineering “Luigi Tocchetti”

The entrance in service of wide body aircraft at the beginning of the 70’s and the effect of the air transport liberalization are probably the main reasons for the increase of air traffic. The interest of airlines and airport management came up in this context with the aim of planning new air routes. The analysis of the demand of the existing flights, through the use of mathematical models, represents the initial stage of a planning process. Many researches have been developed in this field.

In the present paper the convenience of direct air links, without intermediary landings between Naples and New York has been examined. The technique followed is that of simulating the choice behavior of the passengers through the use of a Logit Model. As to the qualifications characterizing each available alternative we have developed 3 different hypothesis. In the first we have considered: the time of transportation, the fare, the frequency and a variable concerning the quality of the service offered. In the second hypothesis the transportation time and the frequency only have been taken into account. Finally in the third, we have considered a change in the fourth variable, believing it to be necessary to simulate the probability that a passenger might not find seats available on an certain journey. The next phase concerned the model calibration on the existing situation of the air link between Naples and New York, determining the capacity of the mathematical model in reproducing the present situation. Then, we have assumed the existence of the direct link between Naples and New York through the alternative of a true journey and a hypothetical one, obtaining the flows on all the journeys of the network. It has been showed that the alternative of direct transportation without intermediary landings would be the most attended one. However, the profitability for the airline under determined fare and frequency hypotheses should be expected as from 2004.

The network definition is that of a “weighted graph”. In other words, each link is associated to a “cost function” which defines quantitative characteristics.

In the network which models the air link between Naples and New York, each node is an airport: Capodichino (NAP), Newark (EWR) and the Kennedy (JFK) are origin or destination airports, depending on the direction of the travel; Brussels (BRU), Milan (MXP), Rome (FCO), Munich (MUC), Paris (CDG or ORY) London (LGW or LHR) are hubs.

The air link between coupes of airports can be represented with oriented links. The next picture shows this.

stage, borders inside which the transport system is located must be defined and it is supposed that all effects can be absorbed therein.

In the present study, the area which has been considered is made by western Europe and USA.

- The second stage is the zoning. It is possible to specify two traffic macro areas in order to model the supply system between Naples and New York.
- The last stage is the “building of the network model”, which models the service supplied by the airport transportation system.

- The first one is the definition of the catchment area. In this each link of the network represents the travel time and all other outus sustained by the passengers while moving from
the origin airport to the destination one. The transportation cost for a link can be regarded as a variable which synthesizes all disutilities perceived by users.

Transportation costs are, in general, non-homogenous quantities i. e. the travel time, the lack of comfort and monetary cost. Now, it is necessary for practical reasons to reduce the whole cost to a scalar quantity through the use of homogeneity coefficients b whose value can be estimated with mathematical models.

Most part of the studies concerning the air transportation system networks, consider the following quantities for determining the generalized transportation cost:

a) the total travel time necessary for the flight;
b) the airline fare;
c) The flight frequency.

N. Ashford et al. in their studies and Alamari and Black consider another quantity named “Nation” which can assume “0” or “1” values. The “0” value can be associated to flag airlines and the “1” value to stranger airlines. We don’t agree with the utilization of the fourth quantity characterizing the airline nationality. In fact, Ashford study was developed in South Korea and Korean attitudes are different from Italian ones because Koreans have a fair knowledge of other languages.

Three different hypotheses have been developed in order to define the elements characterizing the generalized cost of air transport between NAP and NY airports. Each one of these has been shared both for tourist and business passengers.

In the first hypothesis we have considered the following elements as attributes of the generalized cost:

1) the total travel time in minutes, sum of three parts: the first is the time needed for traveling from NAP to the intermediate airport; the second is the time spent at the intermediate airport and the third is the travel time needed for the last part of the journey;
2) The fare in USD; we have determined the fare for each route choice with the help of important tour operators according to IATA recommendation.

About this, we want to remind that determining a fare is not easy as it depends on the period of the year, how long before flight the ticket is bought, open or not open ticket etc. We have chosen a reference period in July, which is the most crowded period for NAP and the fare is reported to a 30-day period. Of course, the fare has different weights for tourist or business passengers.

3) The frequency, i. e. the total flight number available during a week for each route alternative. The NAP-NY route had in 1999 12 different alternatives; two of these were not daily: the Alitalia-Continental and Air France.

It could happen that a certain route could have a limited seat capacity. We have modified flight frequency weighting it with appropriate coefficients. These coefficients are related to the load factor of each airline.

In fact, an airline could be more attracting for passengers than another due to different factors. This could determine a passenger overflow exceeding aircraft capacity. In order to keep this into account, airlines having lower seat availability have been made less readable than others with higher seat capacity. We report in the following draft the load factors declared by airlines in the year 1998.
4) The Airline characteristic is the fourth and the last attribute we have set for the generalized cost. We have considered some disutilities for the passenger in order to determine a value for this quantity, weighting each of them with a certain value included in an interval we have chosen:

a) Perception of the danger of flight: we have set the interval for this disutility between [-1, -1.5]; we have estimated the knowledge of the passenger about the accident number, which regarded a specific airline. We developed a survey on this and we found out the 100 worst aviation accidents; TWA appears 3 times, Continental and Delta 2, Air France 1 time and Alitalia 2;

b) Change of airport: we have set the interval for this disutility between [-1, -2]; the change of airport at the hub happens just in the Air France case: the aircraft arrives in ORY and departs from CDG. Of course this means time lost especially for business passengers;

c) The nationality of airline: this quantity is similar to those reported. We associate the 0 value to the flag airline, -1 to stranger airlines;

d) The number of intermediate stops: we have kept into account disutility perceived by passenger in the lost of time spent at the hub. Every route has 1 intermediate stop and we have evaluated this in a negative way.

In the following table we report values for the A,C attribute for each airline:

<table>
<thead>
<tr>
<th>Airline</th>
<th>Dangersomeness (1-10)</th>
<th>Airport change (1-9)</th>
<th>Nationality (1-9)</th>
<th>Interal stops (1-9)</th>
<th>Total (1-9)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALITALIA (ATR, ATZ)</td>
<td>-3</td>
<td>0</td>
<td>0</td>
<td>-1</td>
<td>-4</td>
</tr>
<tr>
<td>ALITALIA</td>
<td>-1</td>
<td>0</td>
<td>0</td>
<td>-1</td>
<td>-2</td>
</tr>
<tr>
<td>BRITISH AIRWAYS</td>
<td>-1</td>
<td>0</td>
<td>-1</td>
<td>-1</td>
<td>-3</td>
</tr>
<tr>
<td>AIR FRANCE</td>
<td>-2</td>
<td>-2</td>
<td>-1</td>
<td>-1</td>
<td>-6</td>
</tr>
<tr>
<td>SABENA</td>
<td>-1</td>
<td>0</td>
<td>-1</td>
<td>-1</td>
<td>-3</td>
</tr>
<tr>
<td>LUFTHANSA</td>
<td>-1</td>
<td>0</td>
<td>-1</td>
<td>-1</td>
<td>-3</td>
</tr>
<tr>
<td>TWA</td>
<td>-6</td>
<td>0</td>
<td>-1</td>
<td>-1</td>
<td>-8</td>
</tr>
<tr>
<td>CONTINENTAL AIRLINES</td>
<td>-4</td>
<td>0</td>
<td>-1</td>
<td>-1</td>
<td>-6</td>
</tr>
<tr>
<td>DELTA AIRLINES</td>
<td>-4</td>
<td>0</td>
<td>-1</td>
<td>-1</td>
<td>-6</td>
</tr>
</tbody>
</table>

In the second hypothesis travel time and fare only have been considered. But we want to underline that in none of the previous hypothesis there was any reference on the passenger flow tra

veling on the specific link. That's why we introduced in the third and last hypothesis another quantity: the seat availability on the aircraft. We named this quantity disp, with the following functional form:

\[
\text{disp}(l) = \text{Cap.} - f(l) \quad l = (1,...,13)
\] (1)

being f(l), the passenger flow traveling on the link NAP-NY and Cap the aircraft seat capacity. We developed one of them for each airline and aircraft used in the air service NAP-NY.

Analyses of the current moving demand

It is possible to define the "transportation demand" as the number of users (passengers) with certain characteristics utilizing the transportation system within a certain time interval.

Now, many of the mathematical models simulating transportation demand try to model human behavior, with different results. It is preferable for practical reasons, to express the global demand function by the product of interconnected sub models. Each sub model is related to choice limits.

It is possible to express the demand function in the following way:

\[
\phi_{\text{passenger}}(s,h,a,k) = n\cdot(n_{\text{passenger}} \cdot \alpha) \cdot p[NY_{s,h}] \cdot p[aff_{NY_{s,h}}] \cdot p[k_{NY,s,h,a}]
\] (2)

Each symbol has the following meaning:

- \( n \) (NAP)=n_{\text{passenger}} \cdot \alpha, is the total passenger number belonging to "i" tourist or business category, moving from the Naples catchment area; \( \alpha \) is the economy or business class percentage; it can be evaluated with the average value of assigne seats to economy or business over the total by the airlines;

- \( p[NY_{s,h}] \) is the fraction of passengers departing from Naples who for different reason (s) and in a defined time interval (h) decides to go to NY. This percentage can be determined with the help of traffic data;
- \( p[aff_{NY_{s,h}}] \) is the percentage of passengers moving from NAP to NY by air; in this case, its value is 1 because this is the only transportation mode available;
- \( p[k_{NY,s,h,a}] \) is the route choice model which indicates the percentage of passengers moving from NAP to NY in the time interval h for s reasons and choosing the k route among those available.

In this study we have simulated the route choice with a stochastic utility model. This kind of models has a basic hypothesis, which considers the rational user maximizing utilities concerning his choices.

The utility can be expressed by the addition between a medium value, variable for all users that have the same ambit of choice and "aleatory remainder", that is the uncertainty of the analyt to be able to interpret exactly the perception of the utility of each alternative:

\[
U_i = V_i + \varepsilon_i \quad \forall i \in I
\] (3)

So the choice probability of the alternative will depend on the
systematical utility values and the joint distribution law of
“aleatory remainders”. In relation to the functional shape of
the aleatory remainders different mathematical models are
defined. The most diffused in the applications of the transport
demand is “Logit Multinomial Model”. For this category of
models it is supposed that the aleatory remainders are distribu-
ted independently and identically according to a variable
“Gumbel” with null mean and opportune variance:

\[ E(e_i) = 0; \quad \text{Var}(e_i) = \bar{\xi} \cdot \theta \]

the expression of the probability function is given by:

\[ p(j) = \frac{\exp(V_j/\theta)}{\sum_{i} \exp(V_i/\theta)} \]

A last consideration is made about the shape of the systemat-
cal utility function that appears in the expression of the choice
probability. The most used mathematical relation is that con-
siders the utility like a linear function of the attributes, trough
some opportune coefficients “\(\beta\)”:  

\[ V_j = \sum_{i} \beta_i \cdot X_i \]

where \(n\) is the number of attributes important for the alterna-
tive “\(j\)”, \(X_i\) represents the generic attribute.

In the explicatio of the choice model of the journey between
NAP and NY, the systematical utility function presents a dif-
fert expression as to that said till now. In fact, it is usually
assumed that the variables that influences the choice of the
journey are some attributes of negative sign service level, that
is some costs like the travel time and the fare. For this reason,
different notation are used in the explicatio of the systemat-
cal utility and also in the choice probability of the journey:

\[ C_j = c_j + e_j \]

\[ p(j) = \frac{\exp(C_j/\theta)}{\sum_{i} \exp(C_i/\theta)} \]

In the paragraph concerning the description of the supply
model three possibilities about the determination of the attri-
butes important for the estimation of the generalised cost of
each journey have been defined. It is possible to render explic-
it the following systematic utility function in this phase for
each recalled hypothesis:

\[ C_j = \beta_1 \cdot TT_j + \beta_2 \cdot FARE + \beta_3 \cdot FREQ + \beta_4 \cdot AC_j \]  

being:

\[ TT_j = \text{travel time expressed in minutes} ; \quad \text{FARE} = \text{fare, expressed in USD} ; \quad \text{FREQ}_j = \text{frequency, expressed in number of flight/week} ; \quad \text{AC}_j = \text{airline characteristics} . \]

\[ I H \text{ hypothesis} \]

\[ C_j = \beta_1 \cdot TT_j + \beta_2 \cdot FARE + \beta_3 \cdot FREQ + \beta_4 \cdot AC_j \]  

\[ III \text{ hypothesis} \]

\[ C_j = \beta_1 \cdot TT_j + \beta_2 \cdot FARE + \beta_3 \cdot FREQ + \beta_4 \cdot DISP_j \]

being:

\[ DISP_j = \text{availability}, \text{ that assumes the value (} cap_j - f_j \text{) when} \]

\[ f_j = \text{number of users/day for the alternative } j ; \]

\[ \beta_1, \beta_2, \beta_3, \beta_4 = \text{coefficients to be estimated} . \]

\[ \text{Calibration and validation of the demand model} \]

The evaluation of the transport demand with the mathematical
models requires they to be specified, calibrated and validated.
The choice model of journey between NAP and NY can be
seen like a mathematical relation that provides the probability
that the person "i" chooses the alternative "j", in function of
the vector \(X\) of the attributes of all available alternatives and
the vectors of the parameters concerning the cost of journey
and the parameter of the Gumbel distribution (\(\theta\)).

In fact the choice probability of journey "i" is expressed in
function of the utility of each alternative that is linear function
of the vector of attributes \(X\) trough the parameters \(\beta\).

To calibrate a demand model means to obtain evaluations of the
coefficients \(\beta\) (cost of the journey) and the parameter \(\theta\) (stability
as to minimisation), on the basis of choices effects by the users.
The evaluation methods follow two different approaches: the
first called of "Maximum Likelihood" and the latter based on
the valuation of the coefficients of the choice model of jour-
ney, trough the survey of the traffic flows.

The evaluation method of the coefficient trough the flows rea-
olised on some journeys of the graph NAP – NY has been used in
the first hypotheses.

It has been seen how the vector of demand can be defined like
a function of the coefficients \(\beta\). However it is necessary in
this phase to verify how it is possible to use aggregated valu-
ations, concerning the traffic flows, to calibrate the choice
model of journey. Once defined the choice model of journey,
it will be possible to obtain the flows of passenger flow for
each alternative, multiplicand the function of probability for
the total number of users that move between NAP and NY.
Moreover, for the journeys served by foreign companies it
was possible to know the real number of users that used these
vectors. From the annual valuations of traffic disaggregated
for each airline, it has been obtained the daily number of pas-
sengers, trough these operations:
a) The multiplication of the annual passengers flow between
NAP and NY, for each company, for 0.14 that represents
the percentage of traffic developed in August; b) The division of the value so obtained for 31, number of days of August and following multiplication for 0.51 that constitutes the median percentage of daily passengers in a single direction (outward journey or return journey). For each of the five journeys between Naples and New York, served by foreign vectors, the number of daily passengers in economy class or bus service has been obtained with this procedure. The valuation methodology consists in minimizing the difference between the flows realised and those aforesaid through mathematical models. The objective function that must be minimised is represented by a weight quadratic margin:

$$O.F. = \sum \frac{(\varepsilon_i - \mu(\frac{k}{s.h.NYC,aff}) \cdot d_{3a,nc})^2}{\text{var}(\varepsilon_i)}$$ (12)

through the variance of \(\varepsilon_i\), the weight to associate at each addend of the function has been defined considering a link with the journey flow. In particular, it has been given more "confidence" at those addends of the function that present high values of passenger flow as to those with low value. The value used to minimise the objective function represented is called GLS (Generalised Least Squares). The classical valuation method of Maximum likelihood that provides the values of the uncertainty parameters that maximise the probability to observe the choices effected by the air passengers has been used in the calibration of the coefficients \(\beta\) that characterise the generalised cost functions of the journeys in the third hypothesis. The traffic valuations are the result of a simple sampling of the number of users that use each alternative. The probability or likelihood to observe the whole of the choices of the user sample is given by the product of the probability that each user, belonging at the sample, effects the choice \(j\), when \(j\) is the journey that the user "i" really used. Since the probability \(p^j\) depends on the vector of the coefficients \(\beta\), the function "L", product of probability, will depend on the same vector too:

$$L(\beta) = \prod_{i=1}^n p^j(j(i)) (\beta, \theta)$$ (13)

The valuation of maximum likelihood of the parameter vectors is obtained solving an algorithm of maximisation of the function "L".

Once specified and calibrated the choice model of the journey must be validate. The validation is articulated using different statistical test. The tests used are:
- the test of likelihood relation on the vectors of the coefficients;
- the test \(\rho^2\) on the good quality of the approach of the model at the reality.

The first verifies the so-called null hypothesis according to that all the coefficients are equal to zero or the model doesn’t provide any further information as to the hypothesis of equitable probability of the choice (with all null b) against the alternative hypothesis that it isn’t true. The test \(\rho^2\) is a normalised measure in the interval (0,1) of the model capacity to reproduce the observed choices:

$$\rho^2 = 1 - \frac{\log L(\beta)}{\log L(0)}.$$ (14)

The statistics \(\rho^2\) is equal to "0" if \(L(\beta)=L(0)\), it is equal "1" if the model provide a probability equal to "1" to observe the choice really done by each user of the sample. For each examined alternative of project the results of the calibration of the choice model of journey are reported and those of the mentioned statistical test:

<table>
<thead>
<tr>
<th>I hypothesis</th>
<th>Economy</th>
<th>Business</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\beta_1)</td>
<td>-0.00140</td>
<td>-0.008</td>
</tr>
<tr>
<td>(\beta_2)</td>
<td>-0.01792</td>
<td>0</td>
</tr>
<tr>
<td>(\beta_3)</td>
<td>0.180</td>
<td>1.685</td>
</tr>
<tr>
<td>(\beta_4)</td>
<td>-0.0025</td>
<td>-0.8971</td>
</tr>
<tr>
<td>II hypothesis</td>
<td>Economy</td>
<td>Business</td>
</tr>
<tr>
<td>(\beta_1)</td>
<td>-0.00123</td>
<td>-0.004</td>
</tr>
<tr>
<td>(\beta_2)</td>
<td>-0.01710</td>
<td>0</td>
</tr>
<tr>
<td>III hypothesis</td>
<td>Economy</td>
<td>Business</td>
</tr>
<tr>
<td>(\beta_1)</td>
<td>-0.00262</td>
<td>-0.00519</td>
</tr>
<tr>
<td>(\beta_2)</td>
<td>-0.02032</td>
<td>-0.000001</td>
</tr>
<tr>
<td>(\beta_3)</td>
<td>0.03552</td>
<td>0.57481</td>
</tr>
<tr>
<td>(\beta_4)</td>
<td>0.01043</td>
<td>0.17296</td>
</tr>
<tr>
<td>stat. (\rho^2)</td>
<td>0.40</td>
<td>0.30</td>
</tr>
<tr>
<td>stat. L.R.</td>
<td>30.00</td>
<td>25.00</td>
</tr>
</tbody>
</table>

Table 2: Statistical tests for each Hypotheses

If from a technical point of view the excellent result of the statistical test makes it possible to characterise the capacity of the demand model to simulate the working of the air transport system between NAP and NY, it is important to verify if the situation of the passenger flow for the different available alternatives of journey can be reproduced, assigning the demand of overall moving between the two cities at the air transport network (through opportune mathematical models). Different models of assignation can be classified in relation to the hypothesis about the cost functions, that express the dependence of the performances of the transport system on the flow that bind different elements. In particular, if we assume that there isn’t dependence between costs and journey flows (not congested networks), the models of assignation at constant costs or network loading are used. This makes possible to determine the flow on different air journey links by multiplying the overall demand between NAP and NY for the choice probability obtaining the number of daily passengers that use each alternative that links the two cities. Indeed if costs depend on the flow, we have models of assignation at congested networks: the determination of the shape of "stability" of the air transport system is more complicated; the circular dependence between demand cost and flow, render
necessary an iterative methodology for the determination of the journey flow. In relation to a different schematisation of the supply system of air transport between NAP and NY it has been made reference both to the case of not congested networks and the case of congested networks. In this work we assumed the case of not congested network (in the hypothesis II and I) and congested network in the hypothesis III.

The number of passengers, that daily move between the two cities choosing foreign companies is almost identical (in each of the three mentioned hypotheses) at those realised through statistical researchs. This result, together with the statistical test effected in the phase of validation of the choice model of journey, makes it possible to reaffirm the good quality of the methodology used in this work to simulate the present situation of the air link between NAP and NY.

Now it could be introduced between the alternative previously listed the direct journey with opportune costs, moving times and frequency of the service in order to evaluate the flow of passengers that frequent it, applying the model of assignation. However, before this, it is necessary to verify if the infrastructures of Naples airport (first of all, the runway length) are able to assure the operativness of the aircraft to execute long range routes.

Technical analysis

The airport of Naples-Capodichino is located in the north east of the city. In the course of the years the lack of planning policies caused an intense as to uncontrollable urbanisation of the area adjacent the airport. This situation is realised with the presence of numerous buildings and obstacles that make dangerous the manoeuvres of landing and take-off.

The airport is at a height of about 90 metres above sea level and has an annual average temperature of 19°C. The airfield is at single runway, RWY 06-24, inclined of 57° as to geographic north. It is 2650 metres long, 45 metres wide and 0,89% inclined. The runway has a threshold moved for the landing of 405 metres on the head 06 and 200 metres on the head 24, to provide the necessary distance on these obstacles. From the comparison between the declared distances of runway by the airport authorities and those demanded by each typology of aircraft that execute a medium – long ray link it is emerged that the aircraft that could execute a direct link, without intermediate landings between Naples and New York are: 767 – 300 ER and A300 – 600. Moreover by 2015 following the directives of the development Master - plan of Naples’ airport, it could be carried out the extension (for about 300 metres) of the runway, in this way, making it possible, the flight-operations for the above-said aircraft with more certainty.

The development provision of air traffic between Naples and New York

The analysis of the present air moving demand between NAP and NY let to the individuation of 42000 users who in the course of 1998 moved between the two cities. It must be added about 25000 passengers who chose one of the main cities of the USA like destination of own journey. So in all it can be asserted that the present demand between the catchment area of Capodichino airport and USA is of about 67000 unities. This specification is important because in the supposition of introduction of direct air link the passengers that reach the USA from NAP could find more convenient this alternative, arriving without intermediate stop in one of the two airports of New York and then to continue the journey for the final destination, instead to execute the journey with more than one intermediate landing.

The development provision of the air transport demand has been led making a reference to the study executed by ATAG through the application of an extrapolation methodology; it is based on the principle that the lines of the trend showed in law of demand in the past must be reflected in the next years too, without suffering particular changes; so it must be recognised the “trend” present in the historical data of traffic with a convenient statistical research and to deduce the forecast data from this.

It has been considered three different scenarios of the demand: basic scenery corresponding at a medium rate of growth of 4,4%, like stressed by the study of ATAG; maximum scenario
corresponding at a percentage change of the air traffic demand of 7% (maximum percentage change valued for the civil aviation), the average scenario corresponding at a growth rate obtained like mean of the two percentage values of the previous scenarios.

The simulation of the air link

In this phase of study the attention has been turned to the simulation of the air traffic flows between Naples and New York, for the years from 1998 to 2015. The determination of the passenger number for each available alternative has been reached using the whole of models, calibrated on the present situation. Precisely two possible scenarios have been supposed: the first called “not project”, where any change of the air transport network NAP – NY hasn’t been provided; the second called “project scenario”, where, instead, the presence of the direct air link between the present

Applying the model of assignation (SNL) at the air transport network between NAP and NY for the years 2000, 2004, 2010, we have obtained the following distribution of the passenger flows for each alternative of available moving.

The aim of this phase of study consist in determining the “optimum” fare and frequency, or a couple of values able to “take away” passengers at the other alternatives, so that the load factor of the aircraft, used in the direct link, isn’t less than 60% of its capacity. The research has been developed for the years 1998, 2000, 2004, 2010, determining the number of passengers on each alternative of journey, in particular on that direct link between NAP and NY, applying the model of assignation at congested networks (SNL). We have fixed the values for the two attributes: moving time and capacity (disp), we have changed the fare and the frequency of direct link. In particular some levels of fare have been fixed and for each of them the flows of journey have been

alternatives has been supposed.

With the help of forecast data of the air transport demand between NAP and USA for every year from 1998 has been possible to determine the distribution of air passengers between the available alternatives, applying the model of assignation for the two transport networks schematised in the two scenarios.

In the “not project” scenario the air transport network between NAP and NY has been considered constant in the time. It is formed by twelve alternatives of journey, each characterised by an intermediate landing in Italian airports Hub (Rome and Milan) or European (Munich, Paris, Brussels and London).

Figure 4: Passenger distribution on different alternative routes (year 2004)

determined according to change of the frequency in the interval (1 - 7):

- the first value of fare was of 577 $, This fare is the highest of those practised by the airline companies in the link NAP – NY;
- the second level of fare was of 556 $;
- the third of 514 $, corresponding at the fare practised by British Airways;
- the fourth of 472 $;
- the fifth of 430 $;
- at least the sixth level of fare was of 411 $, that represents the fare practised by Alitalia in September (off-season).
**Conclusions**

The realization of the connection without intermediate landings between Naples – Capodichino international airport and one of New York’s airports (EWR and JFK), modifies, probably, the choice behavior of the passengers. The variables that influence are:

- the time of transfer, reduced with regard to the existing alternatives for the lack of intermediate landings;
- the frequency;
- the air fare;
- the availability of seats on the airplane that executes the shift.
In this work a mathematical model reproducing the choice behavior whether the business passenger or the tourist has been developed. It has been possible to simulate the user choice not only in the current conditions in which the route alternatives between Naples and New York are known but also in hypothetical condition in which the connection without intermediate
landings is provided. We have demonstrated that direct connection between Naples and New York is possible with aircraft 767 – 300 ER and also with the A 300 – 600. New air routes, however, not only depend on the capacity of airport infrastructures, but also on a series of researches, of financial type, made by airline that wants to realize the new connection. This analysis characterizes the final phase of the feasibility study and it takes the name of “financial feasibility”: the variables from which depends are numerous and informations that concern it are largely not accessible. For this reason our attention has been turned to the determination of the fare and the frequency of direct link able to attract a considerable share of request. In cohesion with what asserted, a research of “excellent mix” of the fare and the frequency has been developed to warrant on forecasted direct flight a load factor not less than 60%. The interval of values in which the research of excellent fare has been developed is included between the lowest and the highest value of fare currently applied by airline companies. The final result is that now there is no convenience in the realization of direct air link between the two cities. In fact, it has been shown that even though reducing drastically the air fare and with a daily frequency, the maximum value of load factor is 47%; the direct flight would result the more frequented, with a value of the choice probability of 90% but the 47% load factor doesn’t guarantee the profitability for the airline. However it is reasonable to hypothesize that an alternative journey between Naples and New York without intermediate landings would make an expansion of the traffic basin that would probably result extended to the whole Southern Italy Supposing this new scenario in the travel demand between Southern Italy and the USA and with a provision of future growth equal to 5.7% we are arrived at the statement that the possible realization of the link without intermediate landings between Naples and New York begin to result advantage for the airline from 2004. In 2010 it could be exceeded the threshold of 60% load factor. Final results are synthesized in the table that follows:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>AIR FARE</td>
<td>577$</td>
<td>556$</td>
<td>514$</td>
<td>472$</td>
<td>430$</td>
<td>411$</td>
<td>472$</td>
<td>430$</td>
<td>411$</td>
<td>472$</td>
<td>430$</td>
<td>411$</td>
<td>472$</td>
</tr>
<tr>
<td>FREQUENCY</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>LOAD FACTOR (%)</td>
<td>41%</td>
<td>42%</td>
<td>42%</td>
<td>46%</td>
<td>46%</td>
<td>47%</td>
<td>46%</td>
<td>47%</td>
<td>48%</td>
<td>52%</td>
<td>52%</td>
<td>54%</td>
<td>54%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>YEAR</th>
<th>2000</th>
</tr>
</thead>
<tbody>
<tr>
<td>AIR FARE</td>
<td>577$</td>
</tr>
<tr>
<td>FREQUENCY</td>
<td>5</td>
</tr>
<tr>
<td>LOAD FACTOR (%)</td>
<td>28%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>YEAR</th>
<th>2004</th>
</tr>
</thead>
<tbody>
<tr>
<td>AIR FARE</td>
<td>577$</td>
</tr>
<tr>
<td>FREQUENCY</td>
<td>5</td>
</tr>
<tr>
<td>LOAD FACTOR (%)</td>
<td>30%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>YEAR</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>AIR FARE</td>
<td>577$</td>
</tr>
<tr>
<td>FREQUENCY</td>
<td>5</td>
</tr>
<tr>
<td>LOAD FACTOR (%)</td>
<td>38%</td>
</tr>
</tbody>
</table>
REFERENCES


