Abstract: With the developing of global economic and extensive trade cooperation, the transport demand volume increases quickly both passenger and freight traffic in China. It is much higher frequently that China connect with other country in trade and people commuting, which makes much more the need of transport. The civil aviation is played important role in the integration of multi-modal traffic and transportation network. Here we discuss the function, topology of airport planning and its coordination with diversified region solid economic pattern in order to make fast and convenient multi-layer traffic network to fit our economic development. And we study China civil aviation three relationship of (1) airport and flight course network topology, which is a free-scale complex network, from the point of systematic theory view; (2) the airport network with the region attract and origin activity, and (3) the airport group layout and regional economy forming an traffic economic belt space effect. Sum up the study content and give some suggest for China airport planning.

Key words: airport network, free-scale network, airport group

1. THE ANALYSIS OF CURRENT AIRPORT LAYOUT

After several decades construction of China's aviation industry, a combined civilian airport system has initially formed and plays much more important role in the integrated transport system. It can provide air transportation services basically to every city with populations over 200,000.

Now, China's aviation has 145 civil airports, and 1279 scheduled routes, basically formed a domestic route network connecting the main provinces, municipalities, autonomous regions and major cities and an international airline network connecting the world's mostly region and countries which makes Beijing, Shanghai and Guangzhou as its cores airport. By the end of 2005, the layout of national aviation system shows east dense and west sparse, in other words, the eastern area makes about 0.54 airports per sq.km; western area about 0.25 airports per sq.km; and in the middle 0.28 per sq.km; and in northeast area about 0.14 per sq.km.

21st century regional economic development with the new features of multi-level and highly-efficient with the wider use of knowledge-based economy and the high technology, the layout plan of China's civil aviation airport should fully consider the characteristics of regional development, such as the geographical dispersion of knowledge-based industries Space, High-tech industry movable and conglomeration in region select and regional direction. By the theory of the regional financial center, geographical location and traffic
network, structure, demand, we study our airport layout in region analysis and try to solve these problems: (1) The coordination of relations between the airport and the city; (2) The combined use of airport to military and civilian; (3) the coordination between the airport and the route network; (4) The efficiency of the airport connect with other transport means; (5) The coordination problems of the air volume polarization and airport layout equilibrium.

2. THE TRENDS OF REGIONAL SPATIAL DISTRIBUTION AND THE TRAFFIC ECONOMIC BELT CHARACTERISTICS

The layout of the airport is closely related to the characteristics of the region, thus, when designing the layout of the airport, the regional location, spatial extent and attractive, strength should be considered.

2.1 THE VARIOUS REGIONAL FEATURE IN THE ECONOMIC DEVELOPMENT

China's regional economic conditions, geographical location, natural resources, social factors, regional infrastructure, regional ecological environment, and other regional advantages displaying a variety of regional pattern. These regions constitute closely related to the pattern of the urban and regional characteristics, also urban and regional ties. The interaction between the urban and regional shows a way of polarization and the pervasion. The polarization refers to the concentration of regional material and energy to the key cities, which promotes the expansion of our center city; the pervasion is the materials, energy and regional functions of city feeds back to the regional area. There are several methods for the performance of the functions of city pervasion. The first one is neighbors pervasion, from urban centers to the neighboring areas; another is grades pervasion, over a certain distance, with some radiating rules but not continuous in space.

The features are:
(1). Metropolitan Area. The metropolitan area gradually formed and promote the interaction between city and region. Periphery of the city to create a new regional center
(2). Core Cities. The spread trend of city guides the evacuation of urban industries and population, some industry removes in the city out side. Thus, some new manufacture centers appear in the outside of the city. As a result, the functional structure of city has been purified, more evident show the city leading role to the regionas, urban and regional integration trend more clarity.
(3). Small town with a single center. Normally, city with the role of external radiation can constitute a single center town.
(4). The phenomenon of peri-urbanization. The development and economic exchanges of different regions, change the original relationship and dependent factors between urban and rural areas.

In short, the region develops from the traditional system to a network form, making up a model of multi-center, multi-level and grouping regional-development modes.
2.2 AIRPORT NETWORK ACCELERATE THE FORMATION OF ECONOMIC BELT

The mutualism and accessibility between the city and region area are multi-aspects, and all transactions and information flow link one city with other cities in many ways at the same time like the movement of physical heat transfer way, material and intangible. Economists J-R. Boudeville considers that economic space includes not only structural relationship between economic variables associated with the certain geographical area, but also the geographical structure relations of economic phenomenon. These relations can conclude as follow: (1) Homogeneous region. In this kind of space, each component or geographic region has similar characteristics as possible. (2) Polarization region. The polarization refers to the growth "pole" role, or it can be considered as the process of economic attraction. The different parts of the polarization region are interrelated or interdependent through the growth “pole”. (3) Planning region. Generally refers to the actual existence region governed by plans and policies or with political means and to coordinate the region planning and polarization region.

The development of transport makes the above region development as possible. The airport layouts accelerate the scale and economy network distribution. It also promotes the geographical advantages and international trade. The formation of the airport: (1) Arteries connecting the provincial capitals with large and medium-sized cities, enlarging the small and medium-sized cities connection, and making up a multi-level air route structure. (2) An excellent transportation network close to the international and domestic airport, harbor, and the capital. (3) Promoting the rationalization of passenger, cargo flow and develop the tourism resources of the latercomer advantage factors. At present Beijing, Shanghai and Guangzhou are the positive examples of Chinese three-metropolitan areas economic Zone.

2.3 THE DEMONSTRATION OF YANGTZE RIVER DELTA ECONOMIC BELT

The Yangtze River Delta, with Shanghai as its core areas of economic zone. In the system of The Yangtze River Delta, Cities with well inner traffic capacity and these cities makes the points, and the transport infrastructure makes the lines, regional support industry is the surfaces. Christelle’s the hexagon region-cities space network with proper and effect center status of the central city in network system of different levels determines city role like mount up pole in the region's geographical and radiation and forms different Region--cities space network systems. Of these three elements in the region, the points and the lines are in core role. Because almost all industries are focus in those points and linked By transport infrastructure lines, it expands urban areas and the functions space that railways, highways and waterways, shipping and other traffic modes play the core functions in the region area. The expacibility and specificaion of the china airport routes distribution makes the interactions between the city and region coming into multi-effect. And it promotes the formation of the four-level geographical circle region. The inner center circle is by the Shanghai metropolitan areas and suburban areas. The next circle is formed by the core of the Shanghai, Shuzhou, Wuxi cities region. The third layer extrapolation to Nanjing and
Hangzhou, it is abdominal region. The outer ring is the Golden Triangle leading the entire Yangtze River Delta megalopolis. And it even can spill over to the scope of the Wuhu, Anhui and Ma An Shan the outlying cities in the Yangtze River Delta.

Under the dual role of globalization and local multi-center diversity, china’s region becoming more diversified and the metropolitan area emerging as a hub status as figure 1 shown.

Figure 1: The forming of metropolitan as hub status

3 THE AIRPORT LAYOUT COMPLEXITY ANALYSIS

China's civil aviation airport layout is the basis of the development strategy of large and powerful china airport and route network. The level and function, and the coordination of development strategy is much related with the regional economy. Due to the multi-factors, the layout of the airport presents some complexity.

3.1 THE COMPLEXITY OF AIRPORT LAYOUT NETWORK

The topological structure, function and hierarchical structure, transport system level and the route linking network of the airport layout determine it complex network features. Take the weight of freight-route and degree distribution as example (figure 2). We can analysis the main plan of airport layout through the different perspectives of network, structure and needs of airports shown in table 1.

Table 1. Airport layout contents

<table>
<thead>
<tr>
<th>Field</th>
<th>Key Part</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>The topology of airport network</td>
<td>The current airport network topology structure</td>
<td>Connectivity</td>
</tr>
<tr>
<td>airport network hiberarchy</td>
<td>network efficiency, flow control and routing</td>
<td>Effectiveness</td>
</tr>
<tr>
<td></td>
<td>management</td>
<td></td>
</tr>
<tr>
<td>airport network operation function and structure</td>
<td>the coordination rules of airport network environment and function on the sustainable civil aviation system</td>
<td>Availability</td>
</tr>
<tr>
<td>integrating of airport transport system</td>
<td>the time and the overlay extension of the passenger and freight transport flow of the airport network</td>
<td>Tri-dimensional network</td>
</tr>
</tbody>
</table>
3.1.1 the airport topology network the airport routes determine the level evolutionary

(1) In fig 4 shows the present airport routes forms which determine the level evolutionary of our airport topology network. There are two types of routes in china’s airport net, city to city routes and hub routes (fig 4 shown), according to the complex networks and the type characteristics of Cayley tree, the distribution of airport describe as (2) and (3) in fig4 with the characteristics of scale-free networks.

As a scale-free network, deciding the airport network distribution should choose the important nodes which are of small number but optimal controlled. These nodes greatly impact on the coordination of the entire network nodes and the growth capacity of nodes. Otherwise, the entire network will be blocked at the airport hub and cause ability attenuation. In the scale-free networks of airport, there are numbers of core nodes with a large number of links, such as the international hub airport and the regional hub airport and lots of “peripheral Node” with few links. The network of airport distribution is uneven or non-homogeneous, which we can see from the continuously decreasing of the link distribution curve. The functional diversification of international hub airport makes the airport route perfect (figure3).

The node’s importance degree definition

\[ I_i = \frac{k_i}{\sum_{i=1}^{N} k_i} \]  (1)

Where \( I_i \)—the importance degree of node

\( N \)—the number of nodes

\( k_i \)—the degree of node \( i \)

If there are few numbers of “core nodes” and lots of “peripheral Node” in network and the nodes with different important degrees, this network is called “in order”.

The entropy of the network structure defined as:

\[ E = -\sum_{i=1}^{N} I_i \ln I_i \]  (2)
where \( N \) is the number of nodes in network. If the network is completely homogeneous, which means \( I_i = 1/N \), \( E \) achieving the maximum; if in network all the nodes connect with a center node, which means the network is most uneven, the entropy of the network structure reaches the minimum. To exclude the influence of the number of nodes required for network entropy normalized, The standard entropy of the network structure defined as:

\[
\bar{E} = \frac{E - E_{\text{min}}}{E_{\text{max}} - E_{\text{min}}} = \frac{-2 \sum_{i=1}^{N} I_i \ln I_i - \ln 4(N-I)}{\ln N^2 - \ln 4(N-I)}
\]

(3)

By analyzing the index of the airport network, we can find an airport topology which is relatively stable, dynamic and adjustable.

3.1.2 The hub airport function and airport group formation

"core nodes" is an important concept in the airport network scale-free networks, using the technical and economic indicators, the routes level and size, indicators of the airport’s effectiveness measure the level of the airports and define which is the gateway airport or regional aviation hub or the core hub airport of china. Developing and perfecting these "core nodes" to improve the reliability of the entire airport network, to prevent the airport jams and to reduce its impact on the efficiency of the entire aviation network. Using the method of nodes contraction in complicated network, we can construct airport group of multi-level. Connecting the ki nodes to the node \( v_i \) forming a new node \( v'_i \) via ability and function to replace the \( k_i+1 \) scattered nodes. The nodes associated with the original node are now associated with the new node. It not only ensures the existing aviation demand, but also adapt to the increased volume. Node \( v_i \) condensed the other \( k_i \) nodes into a new node, which becomes a new important core point, as well as called airport group. Thus the contraction of the entire network are integrated together better. The process can be seen in figure 5.

![Core airport form](image1)

The airports in crucial position which many other routes will go through form an airport group. This airport group will greatly reduce the average distance of route network and ease the contradictions between the idle capacity and excessive traffic flow. It also forms a joint and convenient regional route network, which can reach a larger integration and more advantages. The efficiency of the airport group network could be measured by many indexes, such as airport reliability, maintainability, security, safety, effectiveness, convenience, and
strategic adaptability, capacity of network, and congestion control measures, and assessing connectivity so on. The main point is the stability under the random function, for example, we must reduce the damage and failure of the airport and the route function caused by the random breakdown of the air traffic control or route conflicts. Under emergency incident, the Airport Network must be complementary and stability.

3.2 THE ANALYSIS OF LAYOUT LEVEL OF THE AIRPORT GROUP

According to the geographic characteristics of region and the distribution of current airport, and route structure of spoke network, the direction of airport's passenger flow, and the flow differences, the spatial and temporal distribution of routes resources, the regional development patterns, we formed the grade of airport-group.

The distribution of the airport-group shows the reasonable distribution of Airport system, the market-oriented, the balance of geographical distribution, the uniformity of west-east geographic. The distribution of airport-group will enhance the role of traffic economic belt. It is shown mainly as follows:

- The distribution of traffic demand has these characteristics: extensive international flow and intensive inter-district flow and the latter with combining of dispersion season and huge radiation field.
- The trend of passenger and cargo flow distribution, the geo-traditional culture, industry-oriented, consumption structure.

The hierarchy and the size of airport group was identified according to the factors as follow:

(1) The formation and development of the regional civil aviation advantage, and the comparative advantages to attract the flows from international market or within the region.
(2) The airport layout related to the urban traffic flow and the capacity of regional economic, and geographic conditions as well, for the grade and scale of the airport rely on the level of region areas’ traffic condition and the connectivity of inter-city or regional passenger and the size or scale of the airport's cargo transit.
(3) A reasonable division of each airport group and strong accessibility and connectivity by the airport line with other regions.
(4) The capacity density, the scale and route network structure of future airport and the coordination of the airport group system and coordinate connection of the auto, rail, and air as cubic modal choice, or three-dimensional transport network.
(5) Highlighting the key airport-group, forming resources advantages, improving the airport functions and forming airport groups based on the market.

Based on the airport distribution planning above, it can determine the program of the layout of airport-group, and on the existing hub airport’s routes network, it should form the international passenger and cargo demand, the five regional airport groups are as follows, including: Beijing-Tianjin-Hebei region airport-group, Shanghai-Nanjing-Hangzhou Region airport-group, the Pearl River Delta Regional airport-group (echoed to Hong Kong Airport), Chengdu-Chongqing-Kunming region airports group and Urumqi region airports group. The divisions of the airport-group stressed the complementary nature of the scope of services and the radiation covering areas. The formation of the core nodes is shown in Figure 6. Thus it not only realizes a convenient and quick transfer between the airport and the city transportation,
but also extends a smooth transport system which connects the regional cities and towns outside the cities.

4. CONCLUSION

According to the demand of China’s national airport planning, the layout and the construction of the airport will be divided into two phases: short-term and long-term. The short-term planning is mainly to improve and perfect the existing facility utilization, route capacity and function, according to policy of the state civil aviation development, the regional development needing, and the regional economic scale. The long-term planning is mainly to enhance the airport division and degree of expansion linking with other ways of transportation. Furthermore, according to the require of factors of security, the distribution of the industry and resources, the level and scale of the economic development and the stratagem of the region development, and scale of de traffic demand in different term, we arrange the build order of the airport. The development of the airport network should embody the “three priorities and two salient” principle. The first priority is to build the airport which contributes more to the entire network efficient. It can alleviate the problem of traffic bottlenecks in supply and demand caused by the poor transport infrastructure. The second priority is to build the airport which will promote the form of industry and the regional or international Tourist Flow. And the last one is to build the airport which will promote the new economic growth. Airport network serve to the inter-city and regional areas by its faster connectivity lines and convenient linking with inner city traffic modes.

REFERENCE

A. Barrat, M. Barthélemy, and A. Vespignani (2004), Phys. Rev. Lett. 92, 228701
Yu xiaochun(2002),the research of china hub airport construction. (Ph.D)beihang university.