https://doi.org/10.26552/ pas.Z.2022.2.08

UNIVERSITY OF ŽILINA

CHINA AS A NEW COMPETITOR ON THE GLOBAL MARKET OF CIVIL AIRCRAFT

Tomáš Krajčo
Air Transport Department
University of Žilina
Univerzitná 8215/1
010 26 Žilina

Abstract

This paper deals with the Chinese aviation industry and its current state, and the main goal of this paper is to find out whether China, in terms of its position, can compete with the current Airbus-Boeing duopoly in the coming years on the large civil aircraft market, while it also aims to set possible scenarios of the development of the large civil aircraft market. The paper approaches the matter through the historical development and the current state of the large civil aircraft market to find out whether there is any perspective and chance for a new competitor to succeed, and the Chinese aviation industry, which allows a better understanding of the problems that China faces in the production of large civil aircraft. In the third chapter, a comparative method is used and its result is the determination of the competitiveness of large civil aircraft produced by China in comparison with those produced by European and American manufacturers, while it also points out their strengths, weaknesses and potential customers. In the last chapter of the paper, the "Compound Annual Growth Rate" method is used along with findings gained from pervious chapters in order to determine possible development scenarios of the large civil aircraft market regarding the position of China. While determining the scenarios, the current and possible future geopolitical situation, political relations of China and the resulting factors with the potential of affecting the Chinese aviation industry were taken into account. This paper also points out China's biggest problem, due to which, despite the enormous effort, it has not yet entered the market of large civil aircraft, with the problem being the dependence on foreign aviation technologies caused by the lack of expertise and experience stemming mainly from the historical development of the Chinese aviation industry. The paper also points out that, despite the slow development of the Chinese aviation industry, the entrance of China to the large civil aircraft market is only a matter of time. The results of paper about diploma thesis can be used to help to decide what threat China does pose to the Airbus-Boeing duopoly.

Keywords

China, Chinese aviation industry, COMAC, CRAIC, Large civil aircraft, Large civil aircraft market, Airbus, Boeing, The future state of the global aircraft fleet

1. INTRODUCTION

The global market of large civil aircraft is currently duopolistic and the only two competitive manufacturers are American company Boeing and European company Airbus. However, this market has historically not always been duopolistic and has gradually evolved into its current form. The development of the global market of large civil aircraft began in the late 1950s. Right after the Second World War, new technologies were used in the field of civil aviation industry too, which led to the development of the first civil jet airliner De Havilland DH-106 Comet by the United Kingdom [1]. This aircraft, however, had shortcomings, from which the manufacturers in the USA learned, and American company Boeing developed the first American civil jet aircraft Boeing B707, which completed its maiden flight in 1957 making it the world's first large civil aircraft, followed by Douglas DC-8 with its maiden flight in 1958 [1]. These two aircraft marked the beginning of a new era in civil aviation, the era of large civil aircraft.

At its beginnings, large civil aircraft market was dominated by American manufacturers McDonnell Douglas (created by merging McDonnell Aircraft and Douglas Aircraft in 1967), Lockheed Aircraft and mainly Boeing [1], [2]. European manufacturers were unable to compete with American ones mostly due to the competition among themselves in politically fragmented Europe, due to their decimated aviation industries and economies as a result of the Second World War. World War II also helped to kick up the aircraft production capacity of the US, which the US could use in the civil aviation industry. Author Burns [3] also came to this conclusion. Due to the inability of European civil aircraft manufacturers to compete with the US ones, some European governments decided to cooperate in order to produce a large civil aircraft capable of competing with Boeing and ensuring the survival of their own aircraft manufacturing industry, which led to the establishment of Airbus in 1970 [3]. The foundation of European manufacturer Airbus, which composed of several aircraft manufacturers with experience and was subsidized by governments, gradually led to changes in the competition on the large civil aircraft market. The market share of Airbus began to increase in 1980s and was driven by an increase in demand for air transport services in these years, to which American manufacturers were unable to respond promptly, and in combination with another innovations implemented by Airbus, like fly-by-wire and glass cockpit and the introduction of Airbus A320, American large civil aircraft manufacturers began to experience problems, which led to Lockheed leaving the large civil aircraft market in 1986, as it was not competitive enough [1-4]. McDonnell Douglas, however, could not design a competitive aircraft anymore and kept losing its market share too [5]. Therefore, in order to get better competing position of American manufacturers against Airbus, a merger of Boeing and McDonnell Douglas happened and took place in 1997, which meant the beginning of the Airbus-Boeing duopoly [1]. This merger, however, did not come into fruition as expected since Boeing was unable to integrate McDonnell Douglas effectively at first, which led to dissatisfaction of their customers [3], [11]. In combination with airlines and aircraft leasing companies not wanting a monopoly this represented another chance for Airbus to increase its market share and so it

has come to pass in 2003 [5] regarding the number of deliveries. After that, in 2004, the US government accused European Union of breaking the 1992 EU-US Large Civil Aircraft Agreement through illegal subsidies provided to Airbus. European Union reacted respectfully and made the same accusation, which led to Airbus-Boeing dispute [4], [7]. This dispute lasted for 17 years and was settled in 2021 due to the threat of a new emerging competitor – Chinese COMAC, and CRAIC in cooperation with Russian Federation (Chinese COMAC and Russian UAC) [7].

This new competitor possesses all factors that are behind the Airbus' success – government subsidies, drive, and experience with aircraft production. Therefore, Chinese COMAC, and CRAIC also, could succeed in a similar way Airbus did, since according to market forecasts published by Airbus, Boeing and COMAC, there will be high demand for new large civil aircraft in the next 18 years, especially in China with the need of more than 8000 new aircraft [8-10]. This means a good perspective and a chance for a new competitor to succeed.

2. HISTORICAL DEVELOPMENT OF THE CHINESE AVIATION INDUSTRY

In order to be able to determine the extent to which China can compete with the current Airbus-Boeing duopoly, and to identify the problems Chinese aviation industry faces along with their causes, it was necessary to look at the historical development of the Chinese aviation industry. We approached the historical development of the Chinese aviation industry from two perspectives – the first perspective in terms of organizational development and the second perspective in terms of the development and production of Chinese domestic aircraft. All the conclusions and findings were based on the literature used to create the timeline in figure 1 and literature used in this chapter.

In the organizational development approach, based on the most important milestones we have identified, we have divided the development of the Chinese aviation industry into 3 stages, which are shown in the figure 1 above the timeline.

We consider year 1918 as the beginning of the Chinese aviation industry from the organizational point of view since it was the year when the "Office to make preparations for matters concerning aviation" was established. However, this is a different opinion from Jin et al. [14] who consider the year 1920 as the beginning of the Chinese aviation industry because of the first commercial flight between Beijing and Tianjin, with which we can't agree since it has nothing to do with the organizational development, nor the aircraft development and production. According to the small number of milestones in this first stage, we consider the development of the Chinese civil aviation industry slow in this period of time, which is also the opinion of Zhao and Wan [27]. The second stage lasted from 1949 until 1980 and the focus was given to Chinese military aviation, while the development of civil aviation was practically abandoned, for the aviation industry was wholly controlled by military part of Chinese government and later by combination of military and civil part of the government. We set the end of this stage to the year of 1980 because the CAAC came fully under the control of the civil part of Chinese government meaning the beginning of aviation deregulation in China, which also agrees with the opinion of Zhang and Round [15]. On the other hand, we do not agree with the opinion of Wang et. al [28] and Jin et al. [14], who consider year 1978 as the end of the strict regulation period and the beginning of the deregulation, since in 1978 economic reforms started in China, but we consider it to be only the cause of the aviation deregulation in China. However, we came to a conclusion that the civil aviation industry development was slow in this stage mostly because of China's focus on military aviation, which also agrees with opinions of all the authors mentioned above. The year 1980, in our opinion, marked the beginning of the Chinese aviation industry deregulation, which led to more effective and stronger Chinese aviation industry. Wang et al. [16] say the deregulation was partially successful, and they connect it with a fast growth of the demand for air transport, while they also say the deregulation wasn't effective enough to stop the dominance of "The Big Three". We agree, that the deregulation helped the demand for air transport in China, however, even though we describe Chinese aviation industry as partially deregulated as the CAAC (Civil Aviation Administration of China) retained control over the development of airports, airlines and controls the entry of airlines on certain flight routes, we can't say the deregulation wasn't effective enough to stop the dominance of "The Big Three" [29]. We think it was effective as Chinese government intended and that the consolidation helped "The Big Three" to keep their dominance, just like Chinese government intended.

In the approach in terms of the development and production of Chinese domestic aircraft, we have divided the development of the Chinese aviation industry into 4 stages based on the most important milestones. These stages and milestones are also shown in the figure 1 but below the timeline. Each of these stages has its own features but overall, we characterize Chinese aviation industry in terms of the development and production of Chinese domestic aircraft as slow and dependent. Slow because it always took China a long time to develop its own aircraft, besides the second stage where it had help from Soviet Union, and dependent because China has needed foreign help and has been dependent on foreign technology during every single stage of their aviation industry development.

In this approach, we consider year 1913 as the beginning of the development of the Chinese aviation industry in the aircraft development and production, and we also consider it as the beginning of the first stage we named "Stage of low production and import", which lasted until 1949. Niosi and Zhao [30] described Chinese aviation industry in terms of aircraft development and production basically as non-existing, since according to their findings China had no capabilities of designing, developing or producing any aircraft whatsoever and, therefore, had to import them. Author Fai [31] came to the same conclusion as she said that before 1949 China could not produce its own aircraft. However, that is not certainly true, since according to findings of Andersson (2008) [20], China was able to produce a small amount of aircraft and had to import the rest, and these aircraft were mostly for military purposes of warlords. The next stage started in 1949 when People's Republic of China and CAAC have been founded. We named this stage as a "Stage of Soviet technology", since the Soviet Union was the main ally of China with more sophisticated technology, which was being transferred to China thanks to this cooperation. China made many leaps in this stage, which lasted up to Sino-Soviet split in 1966, which led to the withdrawal of Soviet scientists from China and to the cessation of cooperation between China and the Soviet Union. According to aircraft China produced at this time [22] and according to the findings about how the Chinese

aviation industry was controlled at this time, we concluded that domestic aircraft development and production was focused mainly on military aircraft. However, China made many great leaps during this stage, even though practically all its designs were based on Soviet designs and technology. Niosi and Zhao [30] and Crane et al. [23] concluded the same regarding Soviet technology dependency and the focus on military aircraft. Even though this cooperation helped the Chinese aviation industry, it also marked its continuous downfall. The combination of Sino-soviet split in 1966, The Great Leap Forward and the Cultural Revolution slowed down the development of the Chinese aviation industry in terms of the development and production of aircraft, since they meant stoppage of technology transfer, decimation of China's economy and loss in the intellectual potential of China. The third stage we defined was "Stage of Reverse engineering and western technology", which lasted from 1966 up to 2002.

At the beginning of this stage, China led isolationistic policy and had no foreign technology feed, nor it had its own because of negative factors which affected its aviation industry and the low level of aviation industry before the World War II. Therefore, China had to turn to reverse engineering and in spite of all the negative factors named above, China tried to develop civil jet aircraft Shanghai Y-10. However, as China didn't have enough experience, expertise and technology, this project failed and was cancelled in 1983 because China could not make it work. Because reverse engineering did not bring the required result and Sino-Soviet relations were bad, China decided to cooperate with west in order to gain technology, expertise and experience needed to develop their own civil jet aircraft. This was also the goal of a "Three-Step Plan" China made in 1983, which was supposed to make China independent on foreign aviation technology and help, so it could develop domestic civil jet aircraft on its own by 2010. However, China did not manage to reach this goal set by the "Three-step plan", which can be seen in COMAC ARJ21 and C919 component suppliers. Therefore, we agree with the opinion of Fai (2013) [31] who said that the technology transfer wasn't as big as China expected it to be.

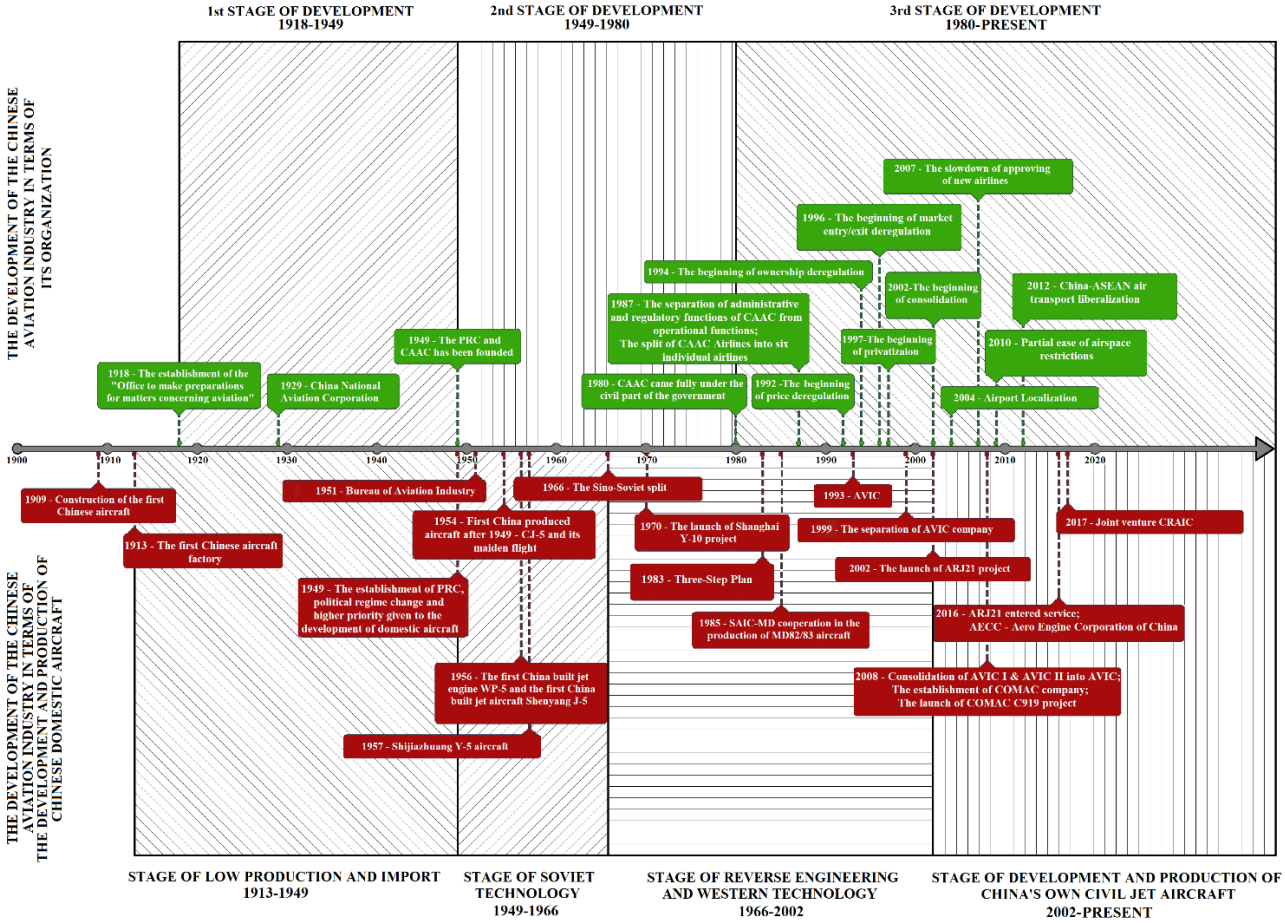

Fig. 1. The timeline of the development of the Chinese aviation industry. (Compiled by author, based on [5-12], [14], [21-24], [27], [30], [31], [33]. Full resolution may be provided by author on request.)

According to Wood et al. [24] the long-lasting problem of Chinese aviation industry, which is present even today, is the inability of developing its own aviation jet engine for civil aircraft. Despite the fact that China is still dependent on foreign technology, the plan led to the extension of cooperation between China and foreign countries in the field of aviation industry and aircraft production, thanks to which China managed to transfer technology and gain experience, which it subsequently began to use in the development of its own civil jet aircraft since 2002 when China started the development of the ARJ21. This is the last stage of the development of the Chinese aviation industry so far, which is still ongoing and its main domain is the development of the C919 aircraft and the CR929 aircraft. Already mentioned author Fai (2013) [31] also said, nine years ago, that Chinese aviation industry had enough experience to be successful thanks to the cooperation with

foreign firms. However, we can't agree with her opinion, since it is already 2022 and China can't build the whole large civil aircraft with all its components on its own, nor it does have its own aviation jet engine for this type of aircraft.

3. COMPARISON OF LARGE CIVIL AIRCRAFT PRODUCED BY THE USA, THE EU AND CHINA

China tried to enter the large civil aircraft market as early as 1970, when it launched the development of the Shanghai Y-10 civil jet aircraft. However, this project was unsuccessful and was cancelled in 1983. After that, China realized that it was unable to develop a competitive civil jet aircraft on its own and, therefore, it began to cooperate and to expand cooperation with foreign countries. Throughout this cooperation China gained experience in the assembly of aircraft, the aircraft production and the production of aircraft components, but thanks to this cooperation the foreign technology transfer to China took place too. The goal of China was to learn, gain the necessary experience, expertise and technology in order to be able to develop its own large civil aircraft. These experience and technologies are currently being applied in the development of Chinese large civil aircraft C919 and CR929, which are to get China to the large civil aircraft market. However, in order for these aircraft to enter the market successfully, not only good market perspective, gained technologies and experience, and state subsidies of the manufacturer are needed, but these aircraft must also be competitive with the products of the established Airbus-Boeing duopoly on the large civil aircraft market.

In order to determine the competitiveness of large civil aircraft produced by China (COMAC C919 and CRAIC CR929), this chapter uses comparative method and focuses on the technical, performance and economic attributes of aircraft, but also takes into account the dependence on component suppliers.

3.1. Comparison of COMAC C919, Airbus A320 and Boeing B737 aircraft

It is known that the aircraft C919 is supposed to compete with Airbus A320 and Boeing B737. The problem, however, is that these aircraft have been on the market for a longer period of time and entire families of these aircraft have been created, which, nowadays, include both older and newer types. However, the older types are gradually being replaced by newer ones. Therefore, in order for the comparison to be the least biased, we compared the C919 with the latest aircraft of these large families – the A320neo family and the B737 MAX family. As there are no extended and shortened version of the C919 yet, the comparison was made with the base aircraft of these families – the Airbus A320neo and the Boeing B787 MAX 8. The first among compared were technical specifications, which are listed in table 1.

TABLE I. TECHNICAL SPECIFICATIONS OF C919, C919(ER), A320NEO AND B737 MAX 8. (COMPILED BY AUTHOR [32-44])

	C919	C919 (ER)	A320neo	B737 MAX 8
Length [m]	38,9	38,9	37,57	39,52
Wingspan [t]	35,8	35,8	35,80	35,9
MTOW [t]	72,5	77,3	79	82,19
Payload [t]	20,4	20,4	20	20,88
Range [km]	4075	5555	6300	6570
Cruising speed [km/h]	834	834	828	839
Ceiling [m]	12100	12100	12100	12500
Take-off runway length [m]	2000	2200	1951	2500
Max. seating capacity	190	190	194	210
2-class seating capacity	158-168	158-168	150-180	162-178
Cabin width [m]	3,96	3,96	3,70	3,53
Cabin height [m]	2,25	2,25	2,24	2,19

According to the main technical specifications listed in table 1, all three compared aircraft are quite similar. However, the C919 aircraft has a slight advantage thanks to its cabin width, thanks to which it can provide higher seating comfort for passengers. There are, however, more disadvantages to this aircraft than advantages according to specifications. One of the main disadvantages is lower seating capacity, in both maximum seating configuration and 2-class seating configuration. Nonetheless, more severe disadvantage because of which C919 lags behind is its significantly shorter flight range compared to A320neo and B737 MAX 8, even in the C919(ER) extended range version. The competitive position of C919 and C919(ER) version is better described by the figure 2. We also used older aircraft of the A320 and B737 families to better illustrate C919's competitiveness. As the figure 2 shows, the C919 aircraft in its basic version does not compete even with older A320 and B737 aircraft regarding the range. The version with extended range C919(ER), even though it is competitive with older types regarding the range, it still lags behind the current competition, the A320neo and the B737 MAX 8 families.

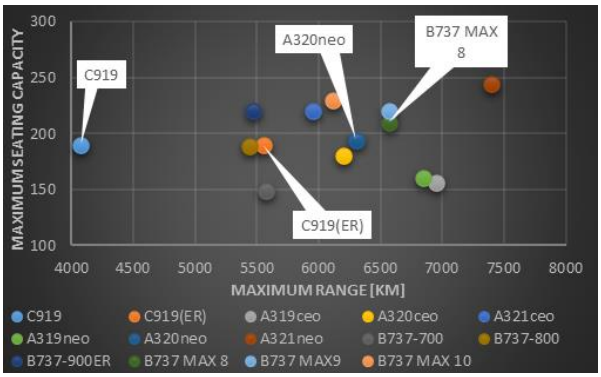

Fig. 2. The position of C919 and C919(ER) aircraft against the competition in terms of maximum capacity and range. (Compiled by author [32, 37, 44, 56-58]

However, this major disadvantage in the form of the C919's short flight range should be compensated by its economic advantage, which should be lower acquisition costs. The C919 aircraft should cost around $50 million and should be up to 55.3% cheaper than the A320neo aircraft and up to 60.8% cheaper than the B737 MAX 8 aircraft. An overview of aircraft prices is given in the table 2.

TABLE II. THE PRICE OF C919 AIRCRAFT, A320NEO AND B737 MAX AIRCRAFT FAMILIES (NOT INCLUDING B737 MAX 7). (COMPILED BY AUTHOR [45-47])

Aircraft	Price [mil. $]
A319neo	101,5
A320neo	110,6
A321neo	129,5
B737 MAX 8	121,6
B737 MAX 9	128,9
B737 MAX 10	134,9
C919	±50

The last compared attribute was the dependence of the aircraft on foreign technology. This is one of the biggest drawbacks of C919, since it is heavily dependent on foreign technology – mostly American. Even though B737 MAX and A320neo aircraft make use of components from all around the globe, suppliers of major components such as aircraft jet engines are from domestic countries of Airbus and Boeing [69]. China, on the other hand, can't provide COMAC with domestic suppliers of more complex aviation technologies, especially jet engines for civil aircraft, since China has problems developing them. The dependency of COMAC's C919 aircraft on foreign technology is shown in the figure 3.

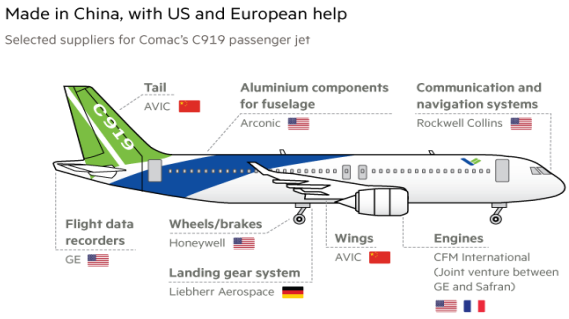

Fig. 3. C919's main component suppliers [48].

3.2. Comparison of CRAIC CR929, Airbus A350 and Boeing B787 aircraft

Another aircraft that China wants to finish developing and to produce is CRAIC CR929, which China develops in cooperation with Russia. Aircraft CR929 is a wide-body aircraft being developed by Russian company UAC and Chinese company COMAC in a joint venture CRAIC. According to the UAC president Yury Slyusar, CR929 is set to compete with Airbus A350 and Boeing B787 aircraft [66]. Several variants were produced from the Airbus A350 family and Boeing B787 family, but for the purpose of the comparison, we used those aircraft of these two families, that are closest to the basic version of the CR929 (also named CR929-600) regarding technical characteristics. Chosen aircraft were the Airbus A350-900 and the Boeing B787-9.

In comparison, we proceeded in the same way as with the C919 aircraft, and the first compared attributes were technical characteristics.

TABLE III. TECHNICAL SPECIFICATIONS OF CR929-600, A350-900 AND B787-9. (COMPILED BY AUTHOR [49-55])

	CR929-600	A350-900	B787-9
Length [m]	63,3	66,8	63
Wingspan [t]	63,9	64,75	60
MTOW [t]	245	280	254
Payload [t]	50,4	53,3	52
Range [km]	12000	15000	14010
Cruising speed [km/h]	908	903	903
Ceiling [m]	-------	13100	13100
Max. seating capacity	440	440	420
3-class seating capacity	280	300-350	280
Cabin width [m]	5,61	5,61	5,49

As the table 3 shows, CR929 lags behind its competition too. The CR929 has lower MTOW and a little bit lower payload, and even though the cruising speed of it is a tiny bit higher, the CR929's hour productivity is lower than the hour productivity of its competitors, which is one of the CR929's disadvantages. The hour productivity of CR929 reaches 45763.2 tonne-kilometres per hour, while A350-900 reaches 48129.9 tonne-kilometres per hour and B787-9 reaches 46956 tonne-kilometres per hour. Another and much more significant drawback of the CR929 aircraft is its short flight range, just like in the case of C919. Its lower seating capacity in 3-class seating compared to A350-900 is also a slight disadvantage, however, even B787-9 has just 280 seating capacity in this configuration and is successful on the large civil aircraft market. The competitive position of the CR929 aircraft compared to the potential wide-body aircraft competition is shown in the figure 4.

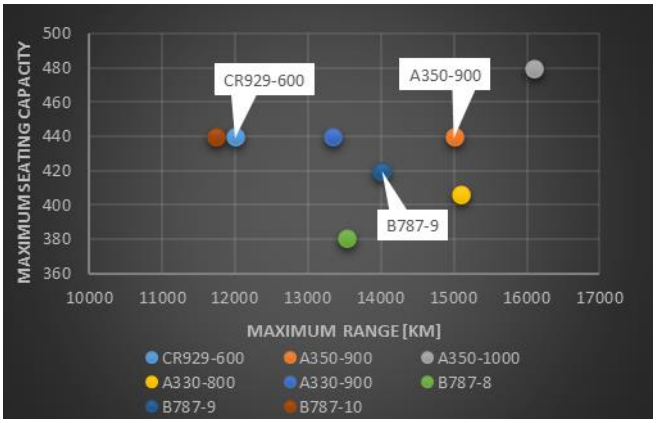

Fig. 4. The position of CR929 aircraft against the competition in terms of maximum capacity and range. (Compiled by author [49-55], [59])

In contrast with these disadvantages, mainly the disadvantage regarding shorter flight range, the CR929 aircraft provides interesting advantages too. These advantages are of economic nature, just like in the case of C919. The first advantage is predicted 15% lower operating costs compared to A350 and B787 [66], which could be rather interesting for every airline. And the second advantage is lower acquisition costs. The price of CR929 is yet to be set, but it is expected to cost $113.5-117.8 million, while B787-9 costs $292.5 million and A350-900 costs $317.4 million [46], [47], [65]. This makes CR929 59.7-61.2% cheaper compared to B787-9 and 62.9-64.2% cheaper than A350-900.

The last compared attribute is the dependency on foreign technology suppliers. While COMAC C919 was dependent mostly on American and European technology, CR929 is different. Although CR929 is still dependent on foreign technology, it is not dependent on American and European technology suppliers as much as C919 is, and that is only thanks to the cooperation with Russia. However, there are still some western technologies used and one of them are jet engines, which are, in this case, most important since nor China, nor Russia have engines for this type of aircraft at their disposal yet. Therefore, the first aircraft are to be fitted with American General Electric GEnx-1B76 engines or British Rolls-Royce Trent 1000 engines. These engines should be replaced by Russian PD-35 engine, which is currently under certification process, or by Chinese engine CJ-2000, which is expected to enter into service around the year 2030 [64]. Up until the moment of successful certification and entry into service of Russian or Chinese engine, the CR929 aircraft will stay heavily dependent on foreign technology. According to Airframer [69], Airbus A350 and Boeing B787 aircraft are more "international" products, since they have a lot of suppliers. Nevertheless, compared to the CR929 aircraft, they are less dependent because the main component suppliers of Airbus and Boeing are from domestic countries of these manufacturers or from politically friendly countries, while engine suppliers of CR929 are from countries Russia and China have bad relations with.

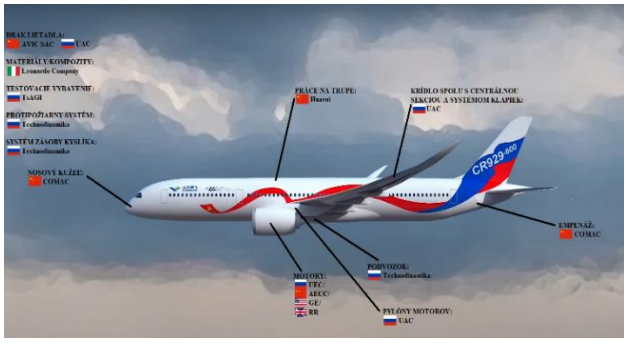

Fig. 5. Main component suppliers of the CR929 aircraft. (Compiled by author [60-64])

To sum it up, C919 and CR929 are rather interesting aircraft, which may become serious competition for Airbus and Boeing despite their main disadvantage – shorter flight range. There is also another disadvantage, the dependency on foreign technology, mostly American and European. This second disadvantage may cause lower competitiveness of these two aircraft and lower rate of production because of possible aviation technology tightening rules that may be applied in relation with bad and worsening political relation between Russia, China and USA, EU. If China will overcome problems regarding the dependency on western technology, the chances of its large civil aircraft will be much higher. However, even then COMAC and CRAIC will have to deal with another problems – certification (according to foreign countries' standards too), maintenance organization network and training organization network. If COMAC and CRAIC will be able to overcome these problems, thanks to the low price of C919 and CR929 compared to its competitors, it may succeed mostly on developing aviation markets where many new airlines will emerge, or in economically developing countries where possible customers are more price sensitive and will welcome a cheaper alternative to Airbus and Boeing aircraft. Another potential customers are low-cost airlines such as Ryanair or easyJet, which operate their flights mostly on shorter routes and, therefore, would not mind the shorter flight range.

4. SETTING MARKET TRENDS AND POSSIBLE DEVELOPMENT SCENARIOS OF THE GLOBAL MARKET OF LARGE CIVIL AIRCRAFT IN TERMS OF THE POSITION OF CHINA

In the last part of this paper, we focused on possible development scenarios of the global market of large civil aircraft considering current China's position and the current state of its aviation industry. In the previous parts of this paper, we have identified several factors that may significantly affect the development of this market and the China's large civil aircraft production capacity. In particular, these factors are the dependence of the Chinese aviation industry on foreign technology, since China is unable to develop more complex technologies e.g. civil aviation jet engines due to lack of experience and expertise, another factor is the settlement of Airbus-Boeing dispute in order to eliminate potential threat of a new competitor entering the market of large civil aircraft, China-US and China-EU political relations, China's commitment to enter this market and the fact that Chinese government owns majority share of Chinese largest airlines.

In setting possible development scenarios, we focused mainly on the Chinese domestic market of large civil aircraft for three reasons:

- Because we consider it a lucrative market, since according to Airbus, Boeing and COMAC market forecasts China will become the largest air transport market by 2040 and up to this year, it will need the largest number of new large civil aircraft with the estimation of 8230 units.
- The second reason is that the largest increase in air traffic volume and the largest increase on the global market of large civil aircraft is expected in China and Southeast Asia. This would mean the emergence of many new airlines for which cheaper Chinese aircraft could be a great substitute product for Airbus and Boeing aircraft in these developing countries. Therefore, we assume that the development of the world market, because of its growth predictions, will follow the development of the Chinese domestic market.
- The last reason is that the success of large civil aircraft produced by China on the global market will depend on their success on the Chinese domestic market, and whether these aircraft will meet the certification standards of other countries.

We set several possible scenarios of the development of the large civil aircraft market in China and we anticipate that the development of the global market of large civil aircraft will follow the same or very similar trend, mainly due to the fact that the largest increase in air traffic and on the market of large civil aircraft up to year 2040 is expected to take place in China and in Southeast Asia, where more cost-effective substitute to Airbus and Boeing could succeed. In setting these scenarios, we focused on the market share that China could gain and the volume of its large civil aircraft production, which China would have to meet in order to achieve the desired market share, while we also took into account various factors that could affect this. As a basic value of market share China plans to achieve, we used

10% of market share its joint venture CRAIC plans to achieve by year 2040 [66] and we applied It to large civil aircraft as a whole. To set the needed production volume, we used CAGR method and every single scenario is based on the assumption that China will have managed to certify and deliver the first three planned units of its C919 aircraft by the end of 2022.

The first scenario we set is based on China's goal of achieving at least a 10% market share on its own market of large civil aircraft by 2040. Based on this premise and by the use of the CAGR method, we determined what production of large civil aircraft China would have to meet in order to achieve this 10% share of its domestic market. This scenario is neutral, influenced only by factors currently affecting Chinese aviation industry, and is illustrated in figure 6. In order to achieve 10% market share on its domestic market, China would have to ramp up its large civil aircraft production capacity 25.025% each year reaching the annual production of 167 aircraft in 2040. This way, China would produce 823 units of large civil aircraft by 2040, which represents 10% of 8230 units this market will need.

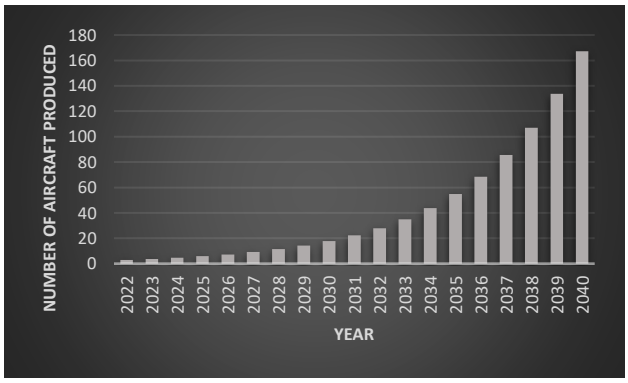

Fig. 6. The neutral scenario of the development of chinese large civil aircraft production.

Even though neutral scenario is possible, there are various factors that can affect every aviation industry in a positive or negative way and can have an effect on subjects competing on the large civil aircraft market. Only two giants Airbus and Boeing has been competing on this market since 1997 and their market share was roughly equal for a longer period of time until two Boeing B737 MAX accidents in 2018 and 2019. As a consequence of these accidents, Boeing's number of deliveries decreased by 52.85% between 2018 and 2019. Since then, there has been a big distrust towards Boeing's technology especially in China, where another Boeing aircraft B737-800 crashed in march 2022. When negative events like these happen, it damages the name of the manufacturer and it may provide room for another competitor to get his own market share. Therefore, our first positive scenario is based on one of the most serious factors that may affect large civil aircraft market share in the future and may positively affect the market share of aircraft produced by China, which is these negative events represented by accidents of competing aircraft. Our first positive scenario is based on the assumption that such tragic events may happen in the future and on the finding that Boeing's annual deliveries have dropped by 52.85% [68] as a result of the B737 MAX accidents, and we therefore assume that aircraft from China's production could reach a 52.85% higher market share than in the neutral scenario and thus 15.29%. Using the CAGR method, we found out that to achieve this market share, China would have to increase its production capacity by 28.744% year-on-year, which would lead to reaching annual production of 283 aircraft in 2040 and the total number of aircraft produced in 2022-2040 would be 1258 units.

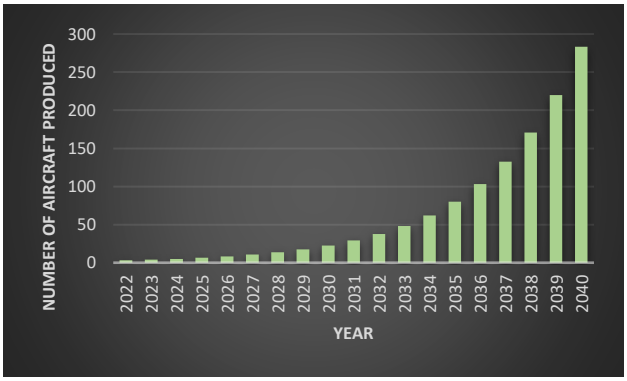

Fig. 7. The positive scenario no. 1 of the development of chinese large civil aircraft production.

The second positive scenario is based on a combination of various factors. The first of the factors is the assumption that China will manage to get its own aircraft into service as soon as possible – C919 in 2022 and CR929 in 2025. That would give China more time until 2040 to tune its supply chain and, therefore, reach higher rate of production. The second factor is the reduction of the dependency on foreign technology, mainly western one, since even now there are aviation technology export rules from US to China due to which China could not certify C919 in 2021 because it lacked spare parts [67]. Therefore, if China managed to find alternative suppliers or develop its own technology (mainly engines), China would reduce the foreign technology dependency and increase the production of its own large civil aircraft. The other possibility is an improvement of China-US and China-EU political relations. The other factors that could cause a more positive development on market for Chinese produced large civil aircraft are higher demand for domestic aircraft caused by national pride in terms of preference of domestically produced aircraft by passengers, which would force Chinese airlines to buy these aircraft, possible government pressure on airlines to buy domestic aircraft, and an effective use of experience gained from the production of regional jet ARJ21 and from participating in Airbus and Boeing aircraft production. We expect that this way China could reach 17%-20% share on domestic market. However, in order to achieve this, China would have to increase the domestic large civil aircraft production rate by 29.675% every year to reach 17% market share) or by 31.103% each year to reach 20% market share, and produce at least 1399 or 1646 aircraft respectfully by 2040. Reaching this high scale of production depends on whether China can reduce its dependency on foreign technology suppliers and optimise its supply chain and production process.

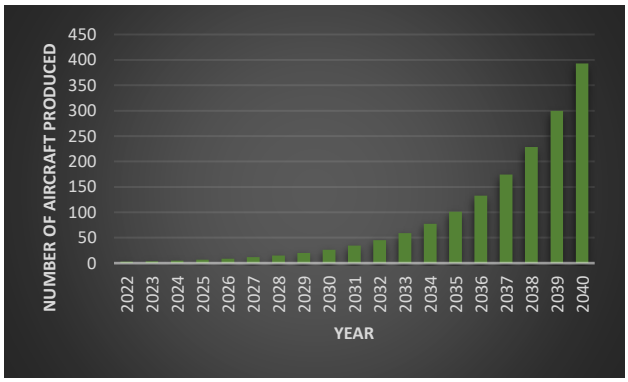

Fig. 8. The positive scenario no. 2 of the development of chinese large civil aircraft production needed to achieve 20% market share.

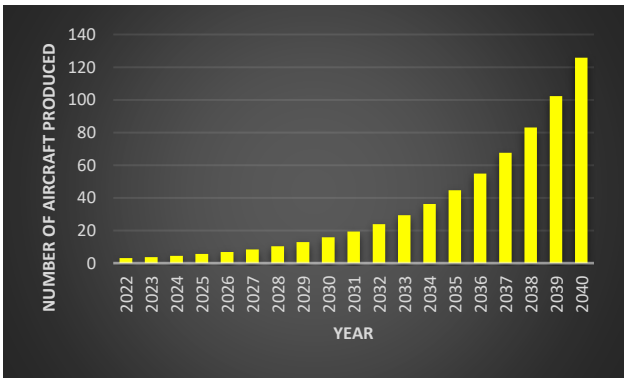

Fig. 9. The negative scenario no. 1 of the development of chinese large civil aircraft production.

However, negative scenarios are possible too and they represent lower volume of Chinese domestic large civil aircraft production and thus lower share on the Chinese domestic market and subsequently on the global market of large civil aircraft. The negative scenarios we set are based on the Chinese aviation industry dependency on foreign technology, settlement of Airbus versus Boeing case between US and EU so they could better face the challenge represented by COMAC and CRAIC, and the scenarios are also based on China-US and China EU political relations. We did set three negative and one catastrophic scenarios, which are based on number of factors that could lead to lower production capacity of Chinese large civil aircraft and to lower market share than 10%. Since China does not possess own jet engine for large civil aircraft and is dependent on foreign technologies, especially American, we deem these negative scenarios more likely to happen than positive ones. In any case, we expect a larger increase in production of Chinese large civil aircraft around 2030, because Chinese CJ-1000 engine should have been completed by then.

The first and the least serious negative scenario we set assumes that there will be no reduction in Chinese domestic aircraft production by further restricting aviation technology exports to China, but nevertheless China will achieve only 8% market share delivering a total of 658 aircraft by 2040. In order to achieve this number of deliveries, China would have to increase production capacity by 23.07% year-on-year. This negative scenario is based on US-EU common approach to a new potentially strong competitor represented by China, which is also the main reason why the Airbus versus Boeing dispute was settled so that this duopoly would not lose its market share to COMAC and possibly CRAIC. A prerequisite for this scenario is an adjustment of the bilateral agreement between the US Government and EU concerning the trade in large civil aircraft in order to allow greater government subsidies in order to reduce the prices of Airbus and Boeing aircraft, which would lead to a reduction of the competitiveness of large civil aircraft produced in China, but even then we do not expect them to match prices of Chinese aircraft. However, we also considered the possibility that Chinese aircraft will not have as sophisticated technical equipment as Airbus and Boeing, while also being less cost-effective. In this case, China could gain 8% market share thanks to still lower acquisition costs of their aircraft making them more suitable for start-up airlines, and possible Chinese government pressure on airlines to buy domestic aircraft, even if the government itself would prefer foreign aircraft more for reasons of operational efficiency.

The second negative scenario, in which China would be able to achieve only a 5% share of the domestic market of large civil aircraft is based on the assumption that measures on aviation technology export to China will be tightened, leading to a slowdown in the production rate growth and consequently lower market share of Chinese large civil aircraft on the domestic market, as well as on the global market later on. It's because Chinese large civil aircraft are dependent on foreign technology and China does not have any substitute for some of them, such as engines. Tightening aviation technology exports to China may be one of the measures the United States and the European Union may take in order to slow down the production of China's domestic large civil aircraft, thereby reducing China's competitiveness. If China would not be able to find suitable alternative suppliers and would have to develop its own technologies, a more significant increase in production could occur around 2030, when Chinese engines for large civil aircraft are expected to have been developed. In this case, China would have to produce a total of 412 aircraft during the 2022-2040 period to achieve 5% market share. The year-on-year increase in production China would have to achieve is 18.94%.

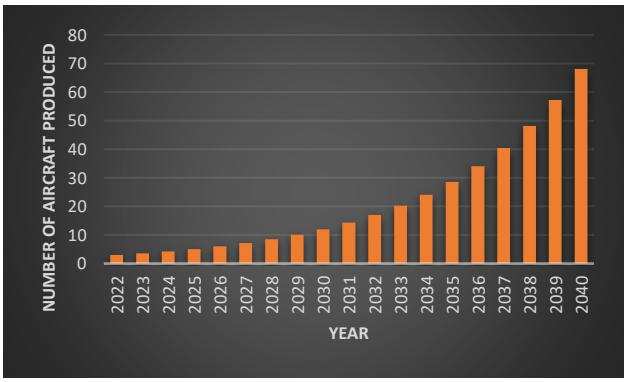

Fig. 10. The negative scenario no. 2 of the development of chinese large civil aircraft production.

The third negative development scenario for China's large civil aircraft, which we set, assumes that China will be significantly unsuccessful and will reach only 3.33% of its market by 2040, which would mean that out of the target number of 823 aircraft produced, China would achieve only the number of 274 domestic large civil aircraft produced. This negative scenario is based on the Chinese aviation industry's dependence on foreign technologies, but also on political relations and possible geopolitical situations that would affect China's production

capacity of large civil aircraft. China's relation with the West are strained, especially with the United States, and if they'll strain even more, which could be caused by the war between China and Taiwan, the United States and even European Union could react in a similar way they reacted to the conflict between Russia and Ukraine and completely cease to supply aviation technologies to China. In this case, the production of Chinese large civil aircraft would be severely limited and China would be forced to look for alternative suppliers or develop the technology itself. Initially, China could still use components and systems that had already been supplied or apply some military technology in the civil aviation. However, provided China could not find suppliers, especially suppliers of engines, the production of large civil aircraft would practically start after China developed its own engines and that should be around 2030. One of the options for China would be Russian engines and technologies, but given the current situation, Russian suppliers will more likely supply their domestic Irkut MS-21 aircraft, and therefore we expect that if this scenario was to occur, China could achieve only 3.33% share of its domestic market by 2040, and that would mean that during 2022-2040 period China would supply only 274 aircraft. In average, China would have to increase its production by 15.32% each year to reach 3.33% on its own market. The possibility of a ban on US and EU aircraft imports to China could be a counter-argument to this scenario, but it's needed to take into account a fact that due to the lucrativeness of Chinese aviation market such option would not be in the interest of any of the manufacturers, nor China, since China would not be able to achieve sufficient production capacity of its own large civil aircraft to meet the rapidly growing air transport market and the resulting demand for aircraft. The rapid growth could be slowed down by the conflict, but not stopped.

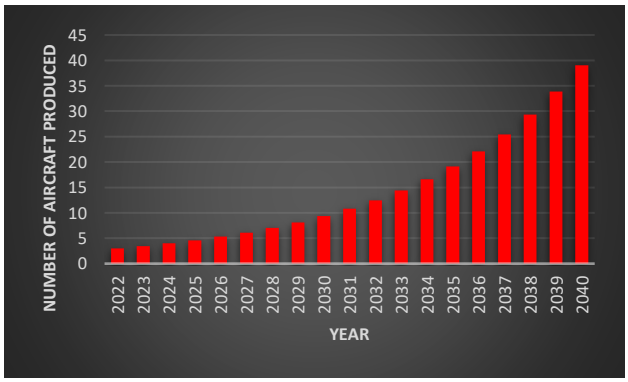

Fig. 11. The negative scenario no. 3 of the development of chinese large civil aircraft production.

The last scenario we considered would be catastrophic. This scenario is based on the possibility of absolute failure of large civil aircraft produced by China due to technical problems and tragic accidents of Chinese aircraft. In this case, the worst possible influence on the development on the market would be caused by C919 aircraft accidents shortly after their introduction into operation, as this would lead into a wave of mistrust and criticism towards a new manufacturer to the large civil aircraft market, whose name would be heavily damaged from his beginnings. Should such a development occur, we also expect only a little interest in the CR929 aircraft and thus, practically speaking, zero share on the Chia's domestic and global market of large civil aircraft.

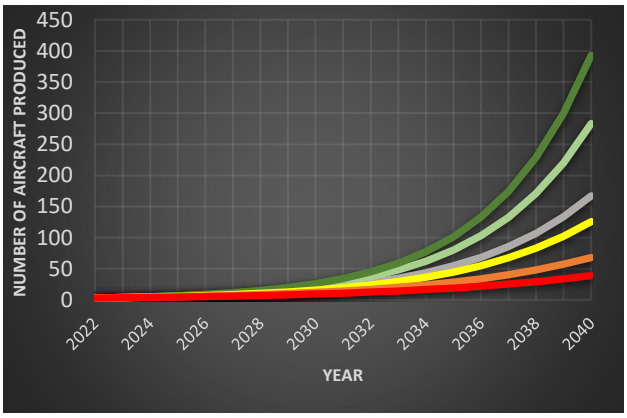

Fig. 12. Graphic comparison of all scenarios mentioned. Grey line – neutral scenario; Light green – the first positive scenario; Dark green – the second positive scenario; Yellow – The first negative scenario; Orange - the second negative scenario; Red – the third negative scenario.

5. CONCLUSION

All of the scenarios we set are possible, however, we consider The Neutral Scenario and The First Negative scenario as the most probable, since we do not expect that the US or EU would like to impose more restriction on supplying China with aviation technology in order to protect their own aviation component manufacturers. We also expect that large civil aircraft produced in China will not be as effective as those from the production of the US or EU, which could lower the prices of their aircraft through commonly agreed government subsidies provided to their manufacturers of large civil aircraft. The second positive scenario is really unlikely, since it takes China a long time to develop something in the area of aviation and that is why we do not expect it to develop engines before 2030. We don't even expect China-US and China-EU relations to get any better in the near future so we do not expect any ease of export measures imposed on aviation technology from US to China. The only possible alternative for engines and technology, if China-US and China-EU relations got worse, is Russia, which is most likely to supply its own domestic aircraft Irkut MS-21 because of its current geopolitical situation.

Nevertheless, the success of Chinese large civil aircraft on the global market will depend on their success on the domestic market. If these aircraft will be safe to fly, cost-effective and China will manage to certify them according to foreign countries' standards, they will definitely pose a threat to Airbus and Boeing. However, China will have to overcome problems regarding the dependency on western technology if it wants to reach full scale production as soon as possible, since this dependency in combination with political relations represent the greatest danger for reaching large-scale production of Chinese large civil aircraft. Besides, China will also have to build maintenance and training organization network.

We do not expect China to pose a big threat to Airbus-Boeing duopoly in the near future, but nor Airbus, nor Boeing can overlook China and its efforts to enter the large civil aircraft market through COMAC and joint venture CRAIC in the long term. Even though China will not be a significant competitor in the coming years with high probability, if its aircraft will be safe, effective and China will manage to overcome barriers in terms of the foreign technology dependency, the certification

according to foreign countries' standards and the creation of maintenance and training organizations network, the large civil aircraft market will no longer be duopolistic but "triopolistic." However, everything depends on whether Chinese aircraft will prove themselves in operations and on the production capacity China will be able to achieve. In any case, Chinese ability to penetrate markets can't be underestimated.

REFERENCES

[1] BRITANNICA. Aerospace Industry. [online]. Available on the internet: <https://www.britannica.com/technology/aerospace-industry>. [cit. 2022-03-12]

[2] BUGOS, G. E. 2001. History of the Aerospace Industry. In EH.Net Encyclopedia. [online]. 2001. [cit. 2022-03-12]. Available on the internet: <https://eh.net/encyclopedia/the-history-of-the-aerospace-industry/>.

[3] BURNS, W. A. 2007. How Airbus Surpassed Boeing: A Tale of Two Competitors: Master's Thesis. Knoxville: University of Tennessee, 2007. 74 s. [online]. [cit. 2022-03-12]. Available on the internet: <https://trace.tennessee.edu/cgi/viewcontent.cgi?article=1284&context=utk_gradthes>.

[4] PETRESCU, R. V. et al. 2017. Home at Airbus. In Journal of Aircraft and Spacecraft Technology. [online]. 2017, vol. 1, no. 2. [cit. 2022-03-12]. Available on the internet: <https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3073999>. Online ISSN: 2523-1197.

[5] SZEPAN, M. 2012. Changing the rules of the game: The commercial aircraft industry in China. In Harvard Asia Quarterly. [online]. 2012, vol. 14, no. 1 & 2. [cit. 2022-03-13]. Available on the internet: <http://www.andrewerickson.com/wp-content/uploads/2012/08/Szepan_Changing-the-Rules-of-the-Game_HAQ_2012.pdf>. ISSN: 1522-4147

[6] MORRISON, J. et al. 2011. Game Theory Analysis of Aircraft Manufacturer Innovation Strategies in the Face of Increasing Airline Fuel Costs. [online]. [cit. 2022-03-13]. Available on the internet: <https://www.researchgate.net/publication/265867776_Game_Theory_Analysis_of_Aircraft_Manufacturer_Innovation_Strategies_in_the_Face_of_Increasing_Airline_Fuel_Costs>.

[7] REUTERS. 2021. Highlights of the 17-year Airbus, Boeing trade war. [online]. Available on the internet: <https://www.reuters.com/world/highlights-17-year-airbus-boeing-trade-war-2021-06-15/>. [cit. 2022-03-15]

[8] BOEING. 2021. Commercial Market Outlook 2021-2040. [online]. Available on the internet: <https://www.boeing.com/commercial/market/commercial-market-outlook/>. [cit. 2022-03-23]

[9] AIRBUS. 2021. Airbus Global Market Forecast 2021-2040. [online]. Available on the internet: <https://www.airbus.com/sites/g/files/jlcbta136/files/2021-11/Airbus-Global-Market-Forecast-2021-2040.pdf>. [cit. 2022-03-23]

[10] COMAC. 2021. COMAC releases Market Forecast Report (2021-2040). [online]. Available on the internet: <http://english.comac.cc/news/latest/202111/01/t20211101_7330736.shtml>. [cit. 2022-03-23]

[11] ANDERSEN, P. A. 1998. The Changing Structure of the Global Large Civil Aircraft Industry and Market: Implications for the Competitiveness of the U.S. Industry: výskumná správa. Washington, DC: U.S. International Trade Commission, 1998. 228 s. [online]. [cit. 2022-03-12]. Available on the internet: <https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1452731>.

[12] BRAZELTON, , M. A. 2021. Aviation infrastructures in the Republic of China, 1920-1937. In History of Science. [online]. 2021 [cit. 2022-02-18]. Available on the internet: <https://journals.sagepub.com/doi/pdf/10.1177/0073275321995638>. Online ISSN: 1753-8564.

[13] SAN FRANCISCO AIRPORT COMMISSION – AVIATION MUSEUM & LIBRARY. 2015. The Legend of CNAC: China National Aviation Corporation, 1929-1949. [online]. Available on the internet: <https://www.sfomuseum.org/exhibitions/legend-cnac-china-national-aviation-corporation-1929-1949>. [cit. 2022-02-20]

[14] JIN, , F. et al. 2004. Geographic Patterns of Air Passenger Transport in China 1980-1998: Imprints of Economic Growth, Regional Inequality, and Network Development. In The Professional Geographer. [online]. 2004, vol. 56, no. 4. [cit. 2022-02-20]. Available on the internet: <https://www.researchgate.net/publication/253039480_Geographic_Patterns_of_Air_Passenger_Transport_in_China_1980-1998_Imprints_of_Economic_Growth_Regional_Inequality_and_Network_Development >. ISSN: 1467-9272.

[15] ZHANG, Y. – ROUND, D. K. 2008. China's airline deregulation since 1997 and the driving forces behind the 2002 airline consolidations. In Journal of Air Transport Management. [online]. 2008, vol. 14, no. 3. [cit. 2022-02-20]. Available on the internet: <https://eprints.usq.edu.au/5683/1/Zhang_Round_JATM_v14n3_SV.pdf>. ISSN: 0969-6997.

[16] WANG, J. et al. 2015. Air deregulation in China and its impact on airline competition 1994-2012. In Journal of Transport Geography. [online]. 2016, vol. 50. [cit. 2022-02-20]. Available on the internet: <https://www.sciencedirect.com/science/article/pii/S0966692315000472>. ISSN: 0966-6923.

[17] LEI, Z. – O'CONNELL, J. F. 2010. The evolving landscape of Chinese aviation policies and impact of a deregulating environment on Chinese carriers. In Journal of Transport Geography. [online]. 2011, vol. 19, no. 4. [cit. 2022-02-21]. Available on the internet: <https://www.sciencedirect.com/science/article/pii/S0966692310001687?casa_token=spaD1Bm3r34AAAAA:yE7BhY7rri7yMqW-

v_R6S7YR9nfBImjkOjBmTXUhTiiY9Fk18lSCLnpDvzs55k4J7UOju0sgfkM>. ISSN: 0966-6923.

[18] KOLIOUSIS, I. 2019. China's airline industry deregulation: assessing the impact on the operational performance of dominant carriers. In International Journal of Aviation Management. [online]. 2019, vol. 4, no. 3. [cit. 2022-02-21]. Available on the internet: <https://pure.coventry.ac.uk/ws/portalfiles/portal/22533866/Binder2.pdf>. ISSN: 1755-9901.

[19] JIN, Y. et al. 2019. Study on Structural Characteristics of China's Passenger Airline Network Based on Network Motifs Analysis. In Sustainability. [online]. 2019, vol. 11, no. 9. [cit. 2022-02-21]. Available on the internet: <https://www.mdpi.com/2071-1050/11/9/2484/htm>. ISSN: 2071-1050.

[20] ANDERSSON, L. 2008. A History of CHINESE AVIATION. Encyclopedia of Aircraft and Aviation in China until 1949. ROC, Taiwan, Taipei: Ko-lo Color Printing Co/Chu-men Co, 2008. 322 p. [cit. 2022-02-21]. Available on the internet: <https://www.pdfdrive.com/a-history-of-chinese-aviation-encyclopedia-of-aircraft-and-aviation-in-china-until-1949-e184744155.html>. ISBN: 978-957-28533-3-7.

[21] MAKSEL, R. 2008. The Father of Chinese Aviation. [online]. Available on the internet: <https://www.smithsonianmag.com/air-space-magazine/the-father-of-chinese-aviation-7979767/>. [cit. 2022-02-23]

[22] AVIC. History. [online]. Available on the internet: <https://en.avic.com/en/aboutus/history/>. [cit. 2022-02-26]

[23] CRANE, K. et al. 2014. The Effectiveness of China's Industrial Policies in Commercial Aviation Manufacturing. [online]. California, Santa Monica: RAND Corporation, 2014. 114 p. [cit. 2022-02-27]. Available on the internet: <https://www.rand.org/content/dam/rand/pubs/research_reports/RR200/RR245/RAND_RR245.pdf>.

[24] WOOD, P. et al. 2019. China's Aviation Industry: Lumbering Forward. [online]. United States of America: China Aerospace Studies Institute, 2019. 112 p. [cit. 2022-02-27]. Available on the internet: <https://www.airuniversity.af.edu/Portals/10/CASI/documents/Research/Infrastructure/CASI_Aeroengines%20041520.pdf?ver=2020-04-22-133912-480>. ISBN: 9781082740404.

[25] AIRWAYSMAG. First Flight COMAC ARJ21. [online]. Available on the internet: <https://airwaysmag.com/today-in-aviation/first-flight-comac-arj21/>. [cit. 2022-02-27]

[26] GOH, B. 2017. China, Russia set up wide-body jet firm in new challenge to Boeing, Airbus. [online]. Available on the internet: <https://www.reuters.com/article/us-china-comac-russia-idUSKBN18I0KZ>. [cit. 2022-02-27]

[27] ZHAO, Y. – WAN, J. 2019. Analysis of development and evolution rules of civil aviation in China based on life cycle theory. In Plos One. [online]. 2019, vol. 14, no. 2. [cit. 2022-02-22]. Available on the internet: <https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0212338#sec002>. ISSN: 1932-6203.

[28] WANG, J. et al. 2019. The Evolution of China's International Aviation Markets from a Policy Perspective on Air Passenger Flows. In Sustainability. [online]. 2019, vol. 11, no. 13. [cit. 2022-02-22]. Available on the internet: <https://www.mdpi.com/2071-1050/11/13/3566/htm>. ISSN: 2071-1050.

[29] DONG, X. – RYERSON, M. S. 2019. Increasing civil aviation capacity in China requires harmonizing the physical and human components of capacity: A review and investigation. In Transportation Research Interdisciplinary Perspectives. [online]. 2019, vol. 1. [cit. 2022-02-23] Available on the internet: <https://www.sciencedirect.com/science/article/pii/S2590198219300053>. ISSN: 2590-1982.

[30] NIOSI, J. – ZHAO, J. Y. 2013. China's catching up in aerospace. In International Journal of Technology and Globalisation. [online]. 2013, vol. 7, no. 1/2. [cit. 2022-02-26]. Available on the internet: <https://www.inderscienceonline.com/doi/pdf/10.1504/IJTG.2013.052032>. ISSN online: 1741-8194.

[31] FAI, F. 2013. Sectoral Systems of Learning in Late Industrialising Nations – A study of the Chinese Civil Aviation Industry. In the 35th DRUID Celebration Conference. [online]. 2013. [cit. 2022-02-26]. Available on the internet: <https://conference.druid.dk/acc_papers/uat5ak153sd3n29pj66tnun7kuht.pdf>.

[32] COMAC. C919. [online]. Available on the internet: <http://english.comac.cc/products/ca/>. [cit. 2022-03-25]

[33] AIRLINES INFORM. COMAC C919. [online]. Available on the internet: <https://www.airlines-inform.com/commercial-aircraft/comac-c919.html>. [cit. 2022-03-25]

[34] PERRETT, B. 2020. COMAC C919 Testing Exceeds Cruise Speed, Reaches Ceiling. In Aviation Week. [online]. Available on the internet: <https://aviationweek.com/aerospace/comac-c919-testing-exceeds-cruise-speed-reaches-ceiling>. [cit. 2022-03-25]

[35] MODERN AIRLINERS. COMAC C919. [online]. Available on the internet: <https://modernairliners.com/comac-c919/>. [cit. 2022-03-25]

[36] AEROSPACE TECHNOLOGY. COMAC C919 Passenger Aircraft. [online]. Available on the internet: <https://www.aerospace-technology.com/projects/comac-c919-aircraft-china/>. [cit. 2022-03-25]

[37] BOEING. 737 MAX. [online]. Available on the internet: <https://www.boeing.com/commercial/737max/>. [cit. 2022-03-26]

[38] TAGLIAFERRI, D. – CAPSONI, C. 2016. SNIR predictions for on-aircraft VLC systems. In 2016 International Conference on Broadband Communications for Next Generation

Networks and Multimedia Applications (CoBCom). 2016. [cit. 2022-03-26]. Available on the internet: <https://www.researchgate.net/figure/Section-of-the-Boeing-737-fuselage-cabin-with-the-main-dimensions-20_fig2_309327917>.

[39] MODERN AIRLINERS. Boeing 737 Specifications. [online]. Available on the internet: <https://modernairliners.com/boeing-737/boeing-737-specifications/>. [cit. 2022-03-26]

[40] AEROCORNER. Boeing 737 MAX 8. [online]. Available on the internet: <https://aerocorner.com/aircraft/boeing-737-max-8/>. [cit. 2022-03-26]

[41] AIRBUS. A320neo. [online]. Available on the internet: <https://aircraft.airbus.com/en/aircraft/a320/a320neo>. [cit. 2022-03-26]

[42] AEROCORNER. Airbus A320neo. [online]. Available on the internet: <https://aerocorner.com/aircraft/airbus-a320neo/>. [cit. 2022-03-26]

[43] MODERN AIRLINERS. Airbus A320 Specs – What is behind one of the most popular short-haul airliners?. [online]. Available on the internet: <https://modernairliners.com/airbus-a320-introduction/airbus-a320-specs/>. [cit. 2022-03-26]

[44] PANDE, P. 2021. What to Expect From The COMAC C919. [online]. Available on the internet: <https://simpleflying.com/what-to-expect-from-the-comac-c919/>. [cit. 2022-03-26]

[45] RAINS, T. 2022. Meet the Comac C919, the first mainline airliner made by a Chinese company that could begin deliveries this year. In Business Insider. [online]. Available on the internet: <https://www.businessinsider.com/comac-c919-chinese-commercial-jet-built-rival-boeing-and-airbus-2022-2>. [cit. 2022-03-27]

[46] SALAS, E. B. 2021. Boeing aircraft prices 2021. [online]. Available on the internet: <https://www.statista.com/statistics/273941/prices-of-boeing-aircraft-by-type/>. [cit. 2022-03-27]

[47] AHLGREN, L. 2021. How Much Do Airbus Aircraft Cost?. [online]. Available on the internet: <https://simpleflying.com/how-much-do-airbus-aircraft-cost/>. [cit. 2022-03-28]

[48] PFEIFER, S. – RIORDAN, P. 2021. China's rival to Boeing and Airbus set to join battle for the skies. [online]. Available on the internet: <https://www.ft.com/content/09024b14-6829-4e4e-84a9-3310afc5151b>. [cit. 2022-03-27]

[49] UNITED AIRCRAFT CORPORATION (UAC). CR929. [online]. Available on the internet: <https://www.uacrussia.ru/en/aircraft/lineup/civil/cr929/>. [cit. 2022-03-27]

[50] AIRLINES INFORM. CR929. [online]. Available on the internet: <https://www.airlines-inform.com/commercial-aircraft/cr929.html>. [cit. 2022-03-27]

[51] AIRBUS. A350-900. [online]. Available on the internet: <https://aircraft.airbus.com/en/aircraft/a350/a350-900>. [cit. 2022-03-27]

[52] BOEING. Boeing 787 Dreamliner. [online]. Available on the internet: <https://www.boeing.com/commercial/787/>. [cit. 2022-03-28]

[53] EUROPEAN UNION AVIATION SAFETY AGENCY (EASA). 2021. EASA Type-Certificate Data Sheet No.: EASA.IM.A.115 for Boeing 787. [online]. Available on the internet: <https://www.easa.europa.eu/sites/default/files/dfu/TCDS%20EASA%20IM%20A%20115%20B787%20Issue%2026.pdf>. [cit. 2022-03-28]

[54] MODERN AIRLINERS. What are the Boeing 787 Dreamliner Specs?. [online]. Available on the internet: <https://modernairliners.com/boeing-787-dreamliner/boeing-787-dreamliner-specs/>. [cit. 2022-03-28]

[55] AIRLINES INFORM. Boeing 787-9. [online]. Available on the internet: https://www.airlines-inform.com/commercial-aircraft/boeing-787-9.html>. [cit. 2022-03-28]

[56] AIRBUS. A320 Family. [online]. Available on the internet: <https://www.airbus.com/en/products-services/commercial-aircraft/passenger-aircraft/a320-family>. [cit. 2022-03-26]

[57] BOEING. Boeing Next-Generation 737. [online]. Available on the internet: <https://www.boeing.com/commercial/737ng/>. [cit. 2022-03-26]

[58] BOEING. 737 MAX By Design: 737 MAX Flies Farther Than the Next-Generation 737. [online]. Available on the internet: <https://www.boeing.com/commercial/737max/by-design/#/flies-farthest>. [cit. 2022-03-26]

[59] AIRBUS. A350-1000. [online]. Available on the internet: <https://aircraft.airbus.com/en/aircraft/a350/a350-1000>. [cit. 2022-03-28]

[60] AIRFRAMER. CRAIC CR929. [online]. Available on the internet: <https://www.airframer.com/aircraft_detail.html?model=CR_929>. [cit. 2022-03-28]

[61] HUARUI AEROSPACE MANUFACTURING. 2021. COMAC Announces Huarui as the Primary Supplier for CR929 Mid-Fuselage. [online]. Available on the internet: <http://www.huaruiaero.com/news_show.aspx?id=52>. [cit. 2022-03-28]

[62] ROSTEC. 2018. Rostec Develops Components for Russian-Chinese CR929 Aircraft. [online]. Available on the internet: <https://rostec.ru/en/news/rostec-develops-components-for-russian-chinese-cr929-aircraft/>. [cit. 2022-03-28]

[63] UNITED AIRCRAFT CORPORATION (UAC). Russia-China Project is nearing the stage of choosing system suppliers for the new widebody CR929. [online]. Available on the

internet: <https://uacrussia.ru/upload/CR929.pdf>. [cit. 2022-03-28]

[64] KARNOZOV, V. 2019. Sino-Russian CR929 Has Room for High-tech Input from the West. [online]. Available on the internet: <https://www.ainonline.com/aviation-news/air-transport/2019-06-14/sino-russian-cr929-has-room-high-tech-input-west>. [cit. 2022-03-28]

[65] ВЕЛИЧКО, А. 2017. Кто будет играть первую скрипку в проекте ШФДМС. [online]. Available on the internet: <http://aviation21.ru/kto-budet-igrat-pervuyu-skripku-v-proekte-shfdms/>. [cit. 2022-03-28]

[66] GOH, B. 2017. China, Russia set up wide-body jet firm in new challenge to Boeing, Airbus. [online]. Available on the internet: <https://www.reuters.com/article/us-china-comac-russia-idUSKBN18I0KZ>. [cit. 2022-02-27; 2022-03-27]

[67] REUTERS. 2021. China's home-grown C919 aircraft hit by tough US export controls, limiting threat to Airbus and Boeing. In South China Morning Post. [online]. 2021. Available on the internet: <https://www.scmp.com/economy/china-economy/article/3150240/chinas-home-grown-c919-aircraft-hit-tough-us-export-controls>. [cit. 2022-03-09]

[68] BOEING. 2020. The Boeing Company 2019 Annual Report. [online]. Available on the internet: <https://s2.q4cdn.com/661678649/files/doc_financials/2019/ar/2019_Boeing_Annual_Report.pdf>. [cit. 2022-03-18]

[69] AIRFRAMER. Aircraft program directory. [online]. Available on the internet: https://www.airframer.com/aircraft_front.html#tabs

[70] BADÁNIK, B., ČERVINKA, M. 2015. Marketing leteckých spoločností a letísk. 1. vyd. Bratislava : DOLIS, 2015. 152 s. ISBN 978-80-8181-024-4.