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IMPACT OF OUT-OF-THE-BOX APPROACH ON THE FUTURE AIR TRANSPORTATION SYSTEM

The goal of this paper is to present the impact of the so-called out-of-the-box thinking on the future development of the air transportation system. It (i) shortly explains the approach based on out-of-the-box thinking (or thinking outside the box), (ii) introduces some of the most appealing original solutions and (iii) shows a systematic out-of-the-box approach to problem solving on a selected innovative operational concept (addressing the radical reduction of the environmental impact related to the take-off and landing processes). Finally, the paper defines the methodology related to the development and evaluation of original solutions.

Keywords: *out-of-the-box thinking, disruptive technology, future air transportation, aircraft take-off and landing*

INTRODUCTION

The stakeholders of the aeronautical industry defined challenging visions and future targets (e.g. NASA Blue Print [1], European Aeronautics: A vision 2020 [2], Flightpath 2050 [3], ACARE Strategic Research and Innovation Agenda [4]), to (i) better fulfill customer requirements, (ii) cope with the present problems of air transportation, and (iii) ensure that the future air transportation will be sustainable, greener, safer, more secure, efficient, and time/cost effective. These documents underline, that aviation passed through two major S-curve developments (Fig. 1), basically known from the innovation diffusion theory [5]. The first is related to the pioneering era, while the second to the introduction of the gas turbines and the development of the commercial aviation after World War II.

These major S-curves could be also decomposed to smaller S-curves related to „smaller" innovative technologies within the given period, as shown more detailed in the representation of the second period of aviation history in the Fig. 2.

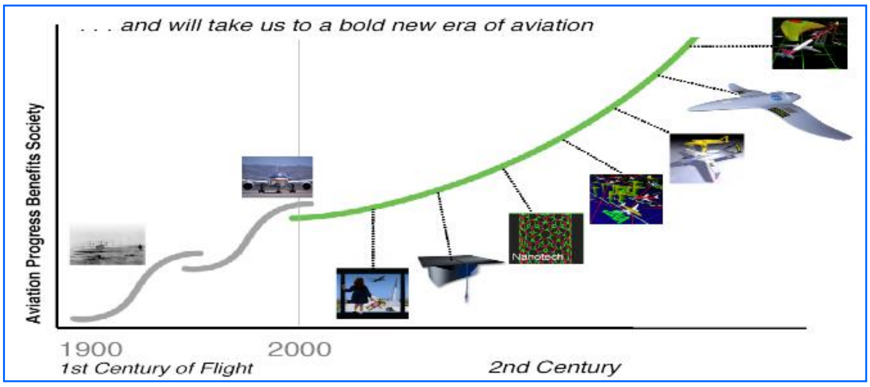


Fig. 1. Areas having strong influences on the future aviation [1]

S-curves are initiated due to different approaches in technology development. Technology developments could be classified into the so-called (i) innovative and (ii) disruptive technologies

[7][8][9]. While the first maintains and continuously improve the available existing technologies, the second rather aims to broader and develop new markets and provide new functionality, which, in turn, may disrupt the existing market and rebuilt it on the other, higher level (Fig. 3).

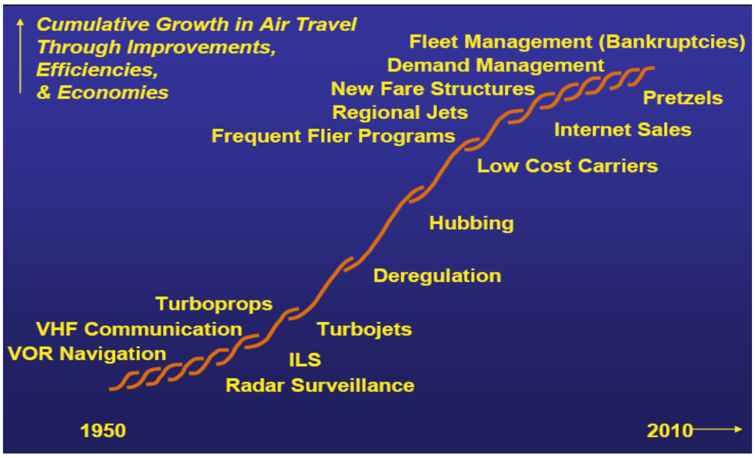


Fig. 2. More detailed description of the second `S curve` of aviation [6]

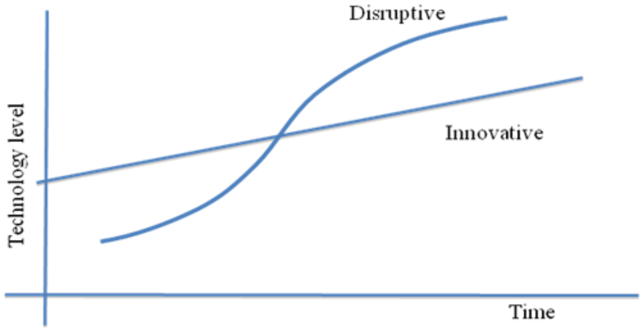


Fig. 3. Different technology developments [9]

Therefore, at the end section of an S-curve, new major technologies and advanced innovative solutions based on disruptive solutions (revolutionary new technologies) are favorable to initiate a new S-Curve, and thus ensure a proper technological development.

According to the NASA (Fig. 1), the third S-curve should be launched, since the challenging aviation targets require outstanding results based on innovative solutions, instead of implementing marginal modifications leading to marginal gains. However, the visions and SRIAs cannot define exactly the guiding (technological) principles, but the development direction (Fig. 1) and general goals [1][2][3][4] to be reached (like reduction of the aircraft emissions by 50–80%). It is thus clear that innovative solutions and the disruptive technology development require an original way of thinking, unconventional approaches in problem solving, which is usually called out-of-the-box thinking.

1. THINKING OUT-OF-THE-BOKSZ

According to the Oxford Dictionary[1], thinking out-of-the-box (or thinking outside the box, or out-

[1] http://www.oxforddictionaries.com/definition/english/think-outside-or-out-of-the-box

of-the-box thinking) means an approach in which thinking is original or creative. Others[2] gives an analogical definition: thinking outside the box is a metaphor that means to think differently, unconventionally, or from a new perspective, that often refers to novel or creative thinking.

It seems that the most known original solution of the intractable problems is cutting the Gordian knot by Alexander Great. Another good example is the story about the egg of Columbus published by the Italian historian Girolamo Benzoni in 1565 [10][11]. From these, at least two important conclusions might be derived:

- original (out-of-the-box thinking) solution is a new solution that has never used before and unknown for the other, however
- after initiating and accepting the new original solution, it is often seen as easy, repeatable and „not remarkably new" anymore.

While the first known unconventional, very original solutions appeared many hundred years ago, the term out-of-the-box dates back to the 1970s, only.

Generally, out-of-the-box thinking, as creativity can be learned and trained from the early children's, even baby's years. The society and education system however, play a crucial role in the development and use of such competence. This is due to the fact that the society in general has no time to evaluate and accept the original solutions, and rather prefers people thinking on the „traditional way". As a consequence, the education system is pressing the students „in the box".

In addition, we may also forget that the original solutions are often simple solutions. For example, the eye of the fruit fly is roughly equivalent to a 26×26 pixel array covering one visual hemi field [12], which is ridiculously low compared to state-of-the-art artificial vision, and about 150 000 times „worse" than human eye retina [12][13]. This means, we would be able to find significantly better solutions for vision control, where the biological concept-based control could be established on simplified basis. However, it is a problem to return to the development of simple solutions, since too much new and applicable technologies are to born, and we are far from using all the possibilities.

Thinking out-of-the-box and more particularly its importance on the technological development was also outlined by NASA administrator, Daniel S. Goldin, in the lecture titled „Aviation Daydreaming" presented on the SAE World Aviation Congress in 1999 [14]. He called up our attention for a nice citation. As T.E. Lawrence[3] wrote ... *„Those who dream by night in the dusty recesses of their minds, wake in the day to find that it was vanity: but the dreamers of the day are dangerous men, for they may act on their dreams with open eyes, to make it possible."* ... and as Mr. Goldin finished his speech: „So become daydreamers". It seems that this is the right approach, let thus permit the young generation to dream with open eyes.

[2] Wikipedia The Free Encyclopedia: Thinking outside the boksz, e-doc. (online), url: https://en.wikipedia.org/wiki/Thinking_outside_the_box

[3] Lawrence, T. E. Seven Pillars of Wisdom, Wordsworth Editions Limited, Ware, 1997 p. 7.

2. SOME POSSIBLE ORIGINAL SOLUTIONS

As specified above, NASA defined [1] the beginning of the second S-curve in the history of aviation with the development of the gas turbines. The scientific development and inventory process of gas turbine took long time. The first steam - powered turbine engine was created by the Greek mathematicians Hero of Alexandria. His turbine, called aeolipile, consisted of a hollow sphere and four canted nozzles[4]. The sphere was rotating freely on two feed tubes that carried steam from the boiler. 2,000 years later, the Hungarian Aladár Zselyi investigated the analogical stream machine [15]. (By the way, in 1912, Aladar Zselyi and Tibor Melczer designed a new large 34 seat aircraft called „Airbus”. - Unfortunately they did not make a trademark for this name). Another Hungarian Jendrassik designed and built a small 100 horsepower gas turbine for research purposes. One year later, he developed a larger turbine that would become the CS-1, the world's first working turboprop engine [16][17].

The invention of the gas turbine demonstrates that even the disruptive technologies, the radically new ideas are to born over long development processes. Such processes need common (state and European) support, because the profit oriented companies cannot spend their funds on radically new ideas, which only generate profit on the longer term. Therefore, the co-called breakthrough innovation must be initiated by universities and small innovative, creative companies, SMEs (Fig. 4.).

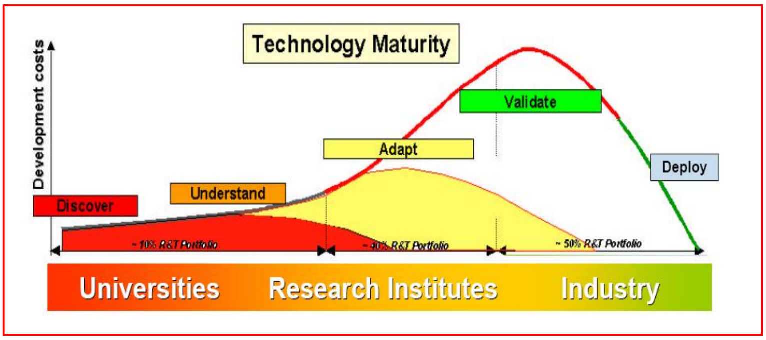


Fig. 4. Vision of Airbus [18] on technology development process

Seeing this, it is not a coincidence that in Europe, the first idea on the cruiser-feeder concept was published [19] about 25 years earlier, than the Commission started to fund such ideas. [20][21]. The original idea [19] was to use the same type of numerous smaller aircraft, which in-flight could be connected together into one large flying object to continuously circulate at cruising altitude (Fig. 5). In the vicinity of the arrival airport, a smaller part of the large aircraft could be disconnected to bring passengers down.

The relevant EU projects dealing with slightly different solutions. For example, the RECREATE project [20] develop feeders with cabin container (Fig. 6.a.) while the MAAT [21] consortia creates an original solution based on aerostats (Fig. 6.b.).

[4] see for example in „Fireman - Navy firefighter, Fireman training manual”, http://firecontrolman.tpub.com/14104/ (accessed at Nov. 20, 2015)

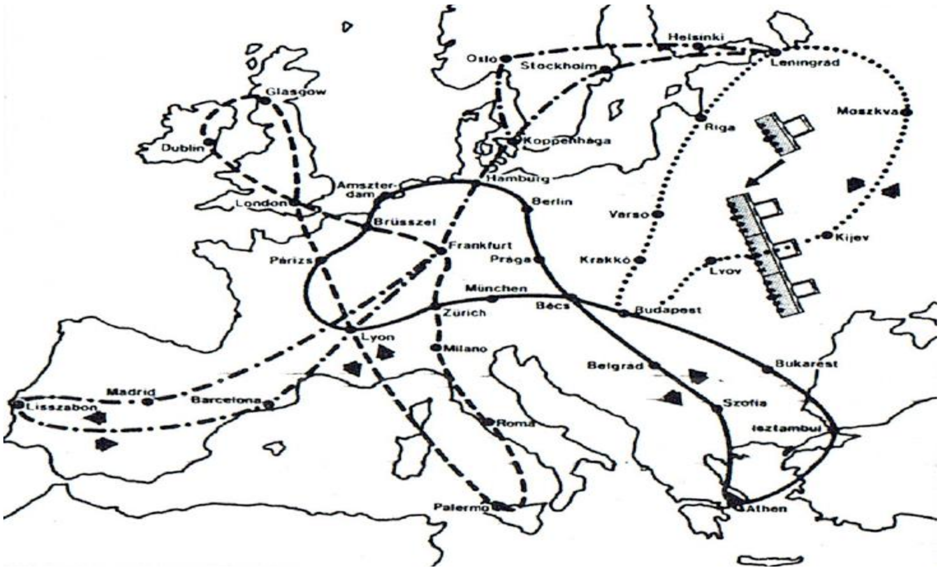


Fig. 5. A cruiser - feeder concept (using the flying object) that continuously circulates at cruising altitude [19]

a.)  b.) 

Fig. 6. The cruiser - feeder concept of the RECREATE [20] anad the MAAT projects [21]

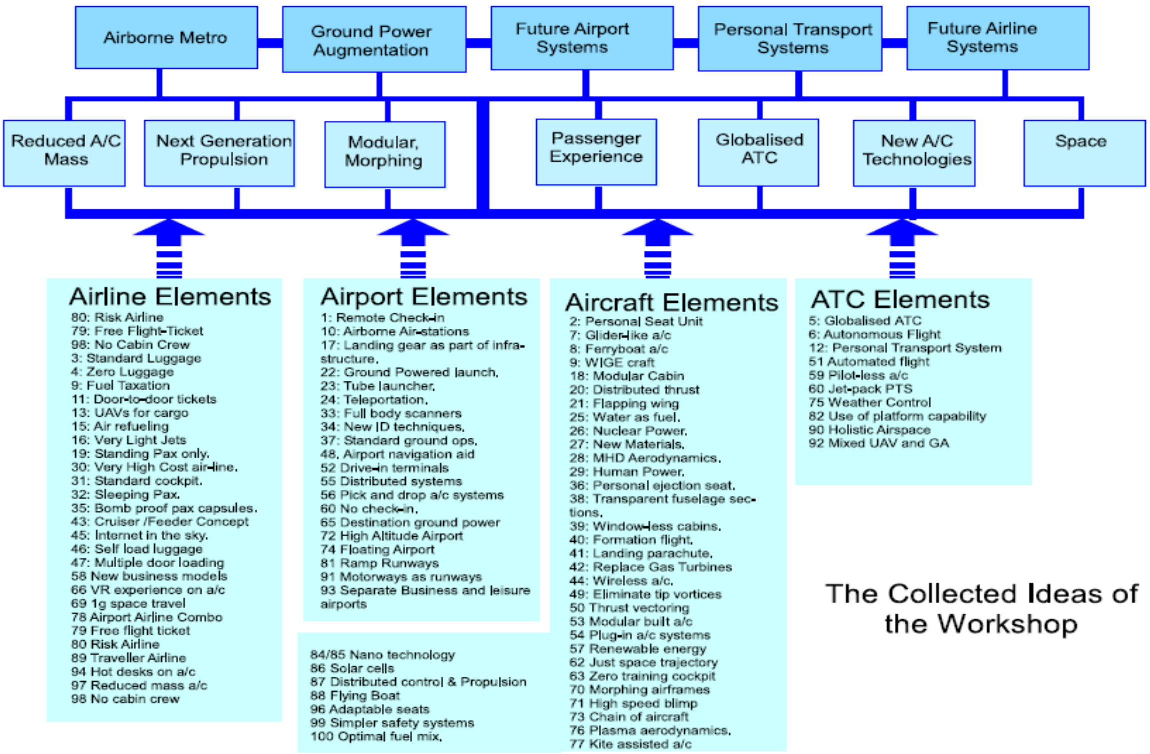


Fig. 7 The results of „Out-of-the-box" project [22]: list of collected ideas passed the first level evaluation

The leaders of the World economy (US, Japan, Russia, EU) use the same out-of-the-box philosophy and preliminary define the possible future development (of aviation [1][2][3][4]) by supporting breakthrough innovation.

Following to this idea, at first, the Commission initiated and supported a project titled „Out-of-the-box" [22]. The participants of the project defined several really new ideas, new solutions to cope with the present problems of aviation. On the first workshop, several hundred ideas were analysed, and finally, the experts named the top 100 most appealing ideas (Fig. 7.).

The potential project ideas included ideas, which z

- already deployed or soon deployable (as internet on-board, development of very light jets, personal aircraft (Fig. 8)),
- might be applied after a relatively short-term development (like pilot-less aircraft, thrust vectoring including the thrust unit control, box-wing aircraft (Fig. 9.a.),

Fig. 8. Different solution for personal air transport [22]

- need considerable research and development (for example refuelling the aircraft (Fig. 9.b),
- might require significant investments (as floating airport (Fig. 9.c)),
- could be introduced into operation after a long-term research and development phase (as the cruiser-feeder concept or use of ground powered assisted take-off and landing - see next point), and
- might not be accepted by the society (like the transport of sleeping passengers (Fig. 9.d).

a.)  b.) 

c.) 

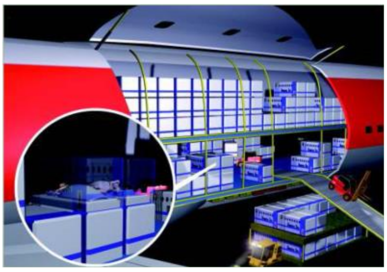
d.) 

Fig. 9. Box-wing (a), refuellin (b), floting airport (c) and sleping passenger concepts [22]

As numerous ideas proposed in the „Out-of-the-box" project [22] addressed radically green take-off and landing processes, these are addressed more in detail in the following chapter (Fig. 10).

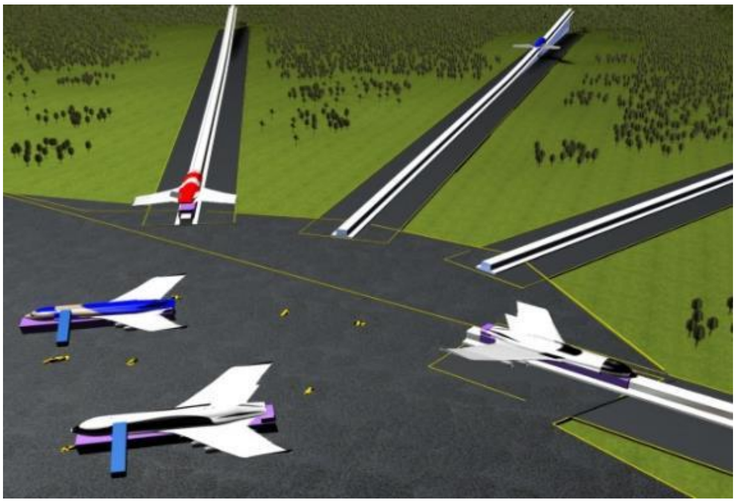


Fig. 10. The use of magnetic levitation technology to to assist the aircraft take-off and landing [22]

3. RADICALLY NEW GREEN SOLUTIONS FOR THE TAKE-OFF AND LANDING PROCESSES

Numerous innovative concepts seeking radically new solutions to cut the environmental problems at the airport vicinities. Recognizing the importance of the domain, this paragraphs outlines some of the most appealing concepts [23][24].

A. Take-off with limited fuel and fuelling at high altitude

This is the less radical concept (due to the existing refueling technology at military aircraft), which is also relatively easy to adapt. Once fuelling at high flight altitude (Fig. 9.b), the take-off weight could be reduced by 15–25 %, and the take-off velocity by 7–12 %. Naturally, the required fuel for take-off would be also decreased by 25–40 %, while the rate of climb could be augmented. Unfortunately, the large fuel tankers require almost 92–93 % of the energy required for the take-off procedures of all served aircraft. However, the large aircraft can be operated from airport far from the cities and therefore the solution might reduce the noise and chemical emissions at the airport regions used by commercial air transport.

B. Ground assisted lift generation

The concept is based on the use of vertical micro jets built in the runway to increase the aircraft lift (Fig. 11.a). The concept requires significant amount of investments and a special pneumatic control system.

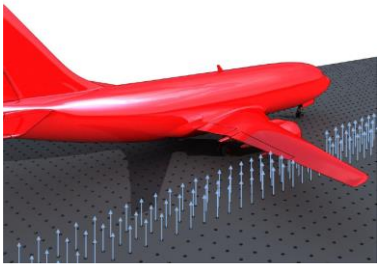
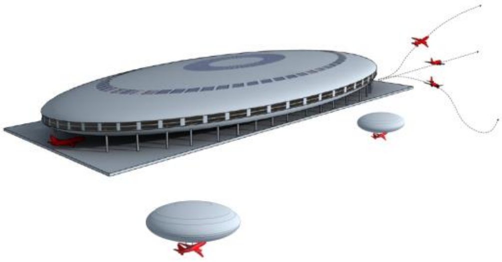
a.)  b.) 

Fig. 11. "ground assiting lift generation (a) and aircraft lifting (b) [23][24]

C. Lifting up - down the aircraft by aerostatic ships

The idea is to lift up the aircraft before take-off to the altitude of 1,500–1,800 meters by a special aircraft carrier aerostatic balloons or ships (Fig. 11.b). The aircraft will be accelerated on the short distance (about 500 m) on a special rigid runway hanged under a large airship and finally will reach the stable horizontal flight or further climb after acceleration in descent.

D. Airport in the sky

It is already foreseen that the technology „will be soon" available to develop and build an airport at high altitude, approximately 10 km above the sea level. As shown in the Fig. 12, such airport could be based on the top of several large airships being connected to the land with flexible cables. The passengers and cargo could be transferred to the airport platform by lifts moving on the holding cables.

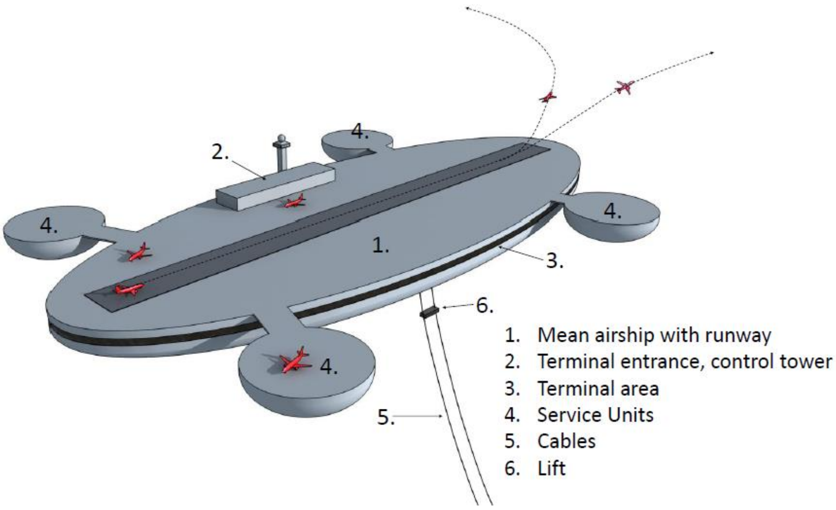


Fig. 12. Airport in the sky [24]

E. Airport above the city

The society problems, emission and noise at the airport vicinities could be solved, once the airport would be lifted to about 450–600 m above the city (Fig. 13) [25]. That is less than the 300 meters of altitude, where the emission and noise might generate society problems. The airport construction could be shielded to further limit the noise propagation towards the urban areas.

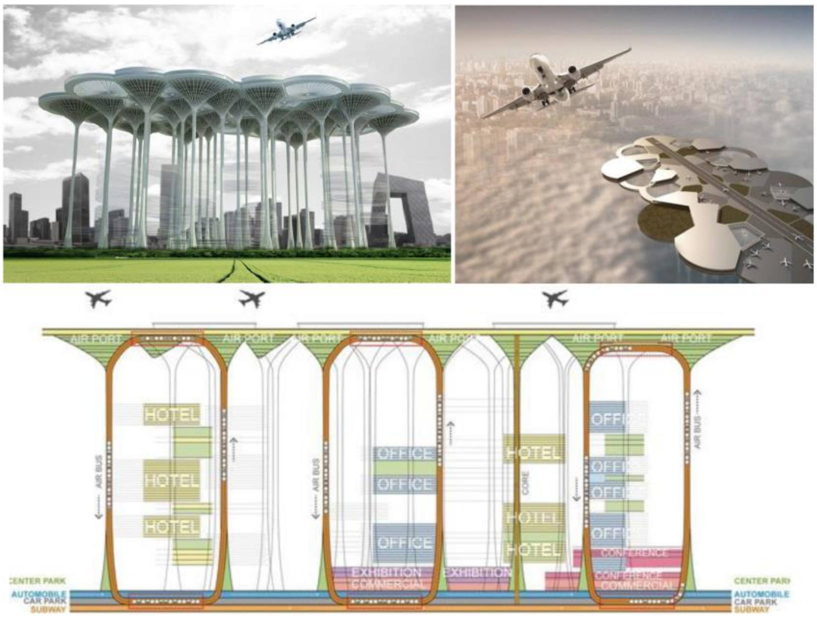


Fig. 13. Airport above the city [25]

The project MAAT develops a resembling concept, as shown in the Figure 14.

F. Underground airport

To cut emissions related to holdings and increase airport capacity, an innovative investigation performed at EUROCONTROL [26] proposed the multi-level runway concept (Fig. 15). The upper is simply placed above the lower runway, and built on concrete pylons. Naturally, this leads to numerous safety and other problems, such as wake vortex or air ventilation.

Fig. 14. The idea developed by the MAAT project [21]

Fig. 15. Possible implementation of the two level runway to Heathrow Airport [26]

G. Cruiser - feeder concept

In the cruiser - feeder concept (Fig. 6), a series of large cruiser airplanes are envisioned to fly continuously on fixed routes (in a cost effective cruise flight phase) over the major cities, to serve relatively small feeder aircraft connecting the cruiser to the airports on the ground. The feeders could be designed for a short range of flight from the airport to the rendezvous points with the cruisers, therefore their take-off weight could be reduced by approximately 25–35% relatively to the presently operated aircraft. In addition, this concept also permits to cut the number of take-off and landings by about 25–40%, due to the elimination of transit flights at the airport level.

H. Ground based energy supply - microwave energy supply

The project idea uses the new microwave energy transfer technology that was tested in practice [27]. The transferred energy could be used directly by the engines or the thrust could be generated by the distributed electric driven ventilators.

I. Electric engine accelerators

In the electric engine accelerator concept, the take-off process is assisted by extra electric engines (Fig. 16), which after take-off and climb (to about 400 meters) will be detached from the aircraft and returned to the airport as a small UAVs, to be later connected to another aircraft to assist their landing. The energy can be supplied from accumulators (carried by the electric UAVs) or (especially on and near to ground) served by microwave energy transfer [24].

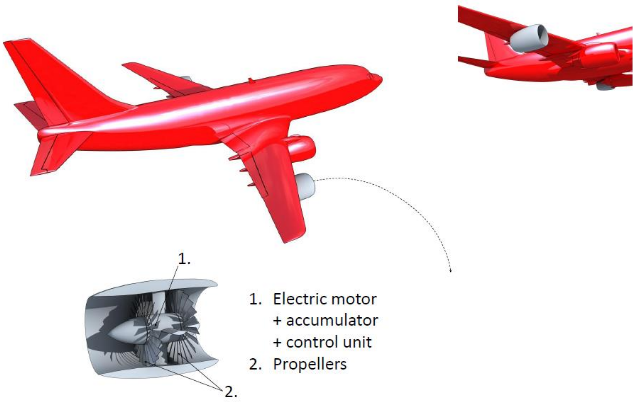
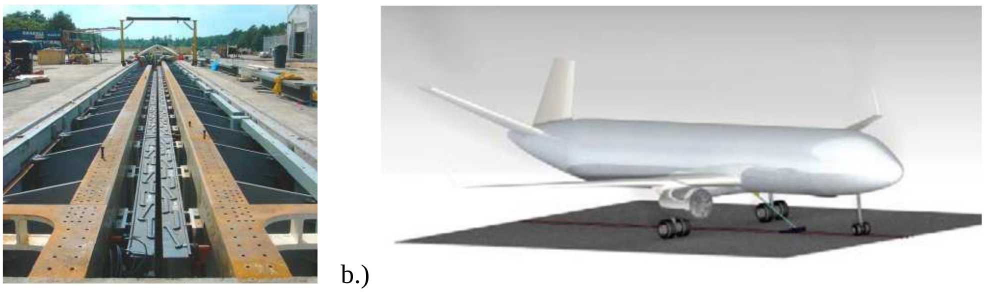


Figure 16: Use of electric engine - UAV for take-off and landing

J. Electromagnetic aircraft launch system (EMALS)

The Electromagnetic aircraft launch system [27][28] is investigated by the US Navy, as it is predicted that the proposed system may generate about 30% greater energy capability (Fig. 17.a). Such system can be applied to assist the take-off of the conventional aircraft (Fig. 17.b.). The use of EMALS to assist the conventional aircraft take-off could be based on existing systems without any extra problems, but the noise and the emitted emission reduction, would only be marginal.



a.) b.)

Fig. 17. EMALS applications: a.) built for full-scale test [28] at the Naval Air Engineering Station in Lakehurst, b.) and the concept investigated by TU Delft [29]

K. Use of magnetic levitation technology

One of the most promising ideas – aiming to radically cut the environmental impact over the TOL – is related to the concept of flying without an undercarriage and use magnetic levitation as a ground-based power to assist the aircraft take-off and landing processes. Once the aircraft is levitated above a maglev track over the TOL, this unique solution is expected to considerably reduce the aircraft weight (as no undercarriage is needed), and less fuel would be required to carry on-board. In addition, if maglev power is applied to accelerate and decelerate the aircraft on the ground, then the engine power could be reduced, resulting in less engine weight, less drag and further fuel consumption reduction. Using ground power could also cut CO_2 and NO_x emissions at airports whilst noise levels could be substantially reduced since only airframe (and engine with reduced power) noise will be produced during take-off. Moreover, less weight decreases the wake vortex that affects the airport capacity issues, whilst the production of aircraft having a smaller weight leads to savings on material costs.

The application of magnetic levitation is already extensively researched, developed and deployed in rail transportation. It has numerous operational, commercial systems, for example at (i) the Shanghai International Airport Transrapid system since 2004, (ii) the Nagoya Linimo system since 2005, (iii) the Daejon Rotem system since 2008. In addition, various maglev tracks/projects are under development, such as the Chuo Maglev Shinkansen track.

Being motivated by the promising results in rail transportation application, magnetic levitation opportunities were also explored in air transportation. At first, The US Naval Air Test Center started to investigate the domain and address electric catapult system, as early as 1946. The Navy [30] was very optimistic about their idea, and even envisioned that the catapult would be used in small, conveniently placed airports. Since then, the technology was improved considerably. In 2000, the US Naval Air Systems Command (NAVAIR) awarded General Atomic a prime contract for the design and manufacture of a prototype Electromagnetic Aircraft Launch

System (EMALS), to replace the C-13 steam catapults used on the aircraft carriers. The EMALS launch mechanism – as planned to be installed on aircraft carriers – was successfully tested with numerous military aircraft [30] between 2010 and 2011.

The NASA Marshall Space Flight Center in Huntsville was also looking for the potential in magnetic levitation technology. The idea was to use maglev as a ground-based power (Fig. 18.) to support launches of space aircraft [31]. Preliminary investigations suggested that maglev could significantly cut the costs of getting into the space, by saving 30–40% of the fuel required to perform the launch [32]. The further investigate the idea, numerous test tracks were made, including a 50 feet long outdoor system.

Fig. 18. NASA concept demonstration at Marshall Space Flight Center

The Russians were working on the possible use of magnetic levitation in the hypersonic cosmic airplane MIG-ACS domain [33][34].

In Europe, the EU funded GABRIEL[5] consortia [23] developed a special out-of-the-box project that targeted maglev technology to assist the aircraft take-off and landing processes. In short, this project assessed whether the use of maglev is to support the TOL is technologically feasible, safe, and cost-effective. The project defined the operational concept, evaluated the deployable maglev technologies, define the system elements, assessed the impact (in terms of aircraft weight, noise, emission, cost-benefit), and validated the concept on a small-scale maglev track. In addition, Airbus also mentions the option to launch aircraft with Maglev systems [35] very much in line with the Out-of-the-box project idea (Fig. 19.). Supported by regional funding in Hamburg, the German Airport 2030 project looked into the feasibility to create a launching facility. The launch system uses MAGLEV technology and looks for the launch of heavy aircraft like the A380. Total system cost is estimated at 500 million Euro per runway [36].

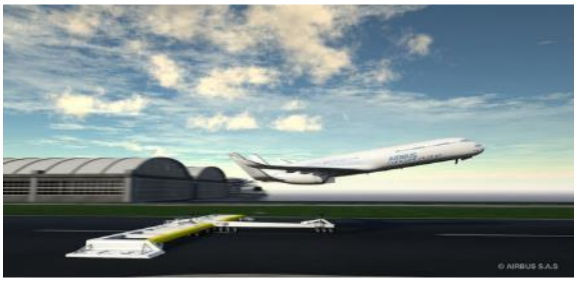


Fig. 19**.** The Airbus future concept [35]

[5] GABRIEL (Integrated Ground and on-Board system for Support of the Aircraft Safe Take-off and Landing – EU FP7 L1 project [23]

Recognizing the benefits of the concept, the Technology Roadmap 2013 [37] developed by the International Air Transport Association envisions the option of flying without an undercarriage to be in operation by 2032.

4. METHODOLOGY TO DEVELOP RADICALLY NEW CONCEPTS

Numerous recommendations and rules are proposed in the literature to use out-of-the-box thinking. One lists only five steps[6], another defines 11 ways[7]. The recommendations include even "ask the children" type of methods. Generally, creativity and ability to think out-of-the-box are the twin brothers [38], but creativity is more known and investigated.

The general philosophy of developing the originally new technologies and products is shown in the Figure 20.

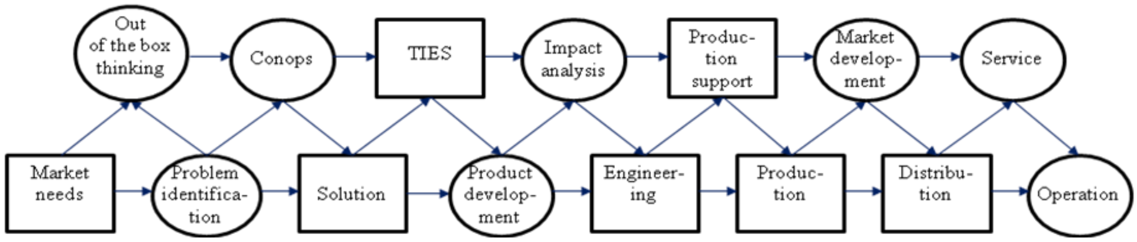


Fig. 20. general process of developing the product with out-of-the-box thinking (the circles show the difference beetwen the conventional and unconventional out-of-the-box thinking applied in the product development).

The process starts with the identification or foreknowledge of the market, and thus the society needs. Due to thinking out-of-the-box, the market and / or society needs can be identified as a problem to be solved. The most important step is to generate the concept of operations (CoNOps) from which the solution can be derived. The concept of operations or operational concept is a „document" defining the characteristics of a proposed or developing system from the user point of view. It thus describes how to develop, implement and use of the proposed product by highly involving the user.

When the solution is developed, the required technologies (for the realization) must be chosen from the enabling and emerging technologies. This process is rather complicated and called as technology identification, evaluation and selection (TIES) [39]. That deals with simulation technique, compatibility and impact analyses, decision support methods, and uses e.g. the morphological, or technology impact matrices.

The solution itself is not a product, and thus the product should be developed, which might require new original ways of preliminary designs.

The selected technologies and preliminary determined performance of the product allows to perform the impact analysis, e.g. prediction and analysis of the environmental impact, safety and security aspects, cost benefit calculation, society acceptation. This analysis also includes the concept validation and verification.

[6] 5 steps to thinking outside of the box, http://www.inc.com/matthew-swyers/5-steps-to-thinking-outside-of-the-box.html
[7] 11 ways to think outside the box, http://www.lifehack.org/articles/featured/11-ways-to-think-outside-the-box.html

The engineering is the detailed design of the product. It is a process of design the structural solutions, use of mufti-goal, multi-disciplinary optimization, determination of the load and operational envelops, analysis of the structural integrity, fabrication of the required prototypes, and certification tests.

The production support and production process development might require to use unconventional solutions as well, as the developed radically new product is probably based on revolutionary new technologies.

For the new product, especially for the radically new technologies and products, the market should be also developed. So, such new product needs new type of market, service (maintenance, repairing technologies and methods), and new way of operation.

The EU funded out-of-the-box GABRIEL [23] project (which intended to use magnetic levitation as a ground-based power to assist and take-off and landing processes and flying without an undercarriage), is a good example to demonstrate, how to use creative, unconventional, and original out-of-the-box thinking in problem solving.

At first, the society needs were defined, such as air transportation demand, or environmental impact reduction. After the investigation of the potential solutions, the MagLev assisted take-off and landing was identified as the most effective technology. The consortia [23][24][40] developed a series of operational concepts including the possible solutions for transition periods, and several airport layout scenarios.

The possible solutions were analyzed according to their effect on e.g. the required aircraft modification, potential cut in the aircraft weight, influences on the passengers terminal flows, and the envisaged impact on the take-off and landing procedures, turnaround time, safety, emitted emission, noise, and security aspects [42]. Finally, the detailed analysis suggested to choose a principle based on a *cart-sledge system* (Fig. 21.). As the aircraft has no undercarriage, the cart is primarily supposed to carry the aircraft while ground-born and perform the ground movements, while the sledge includes the necessary magnetic levitation systems, while also permitting to yaw and pitch the cart, and thus facilitate the positioning over the TOL processes (Fig. 21).

Fig. 21. Aircraft landing on the cart-sledge system in general situation

After the concept development, the team (i) defined the core system elements (including the required aircraft modifications, the ground-based system and airport elements, and the dedicated control systems), (ii) analyzed in detail the impact on the aircraft weight, fuel consumption, emitted emission [41], noise, safety and security aspects. Investigations also covered a mature cost-benefit analysis. Regarding for example safety, it was found that landing on the cart-sledge system, as well as emergency landing on airports not being equipped with the dedicated maglev system require further attention. Accordingly, a special focus was devoted to emergency landings, with numerous alternative solutions investigated and proposed, as showed in the Figure 22.

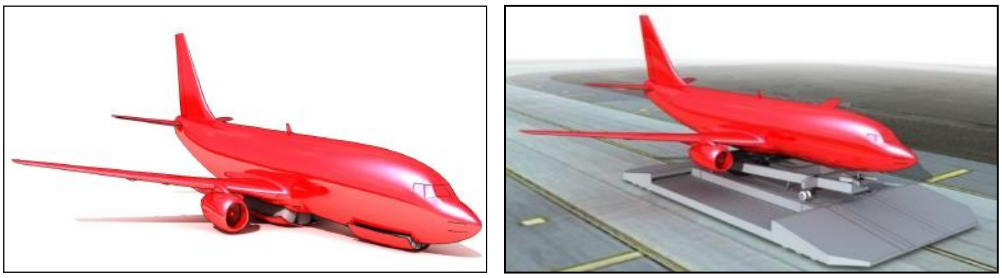


Fig. 22. An example of the investigated emergency landing solutions: lightweight skids (left) and emergency cart (right).

Regarding the landings on the cart-sledge system, a dedicated highly accurate so-called rendezvous control system was designed and developed, which permit autnous landing at the required landing accuracy [42].

Finally, the proposed concept was validated (Fig. 23). For the validation of the technical feasibility of the maglev track under the developed operational concept, a special small-scaled magnetic levitation track was designed and built with a length of almost 6 meters [43]. For the validation of the rendezvous control system, a small scale validation system composed of a validation aircraft, a validation rendezvous control system and two types of validation ground systems (one consisting of a small conventional electric cart, and another of a small scaled validation maglev track [44]) were used. The first system was intended to analyze the practical feasibility of the developed control concept, while the second to validate the overall concept and analyze the landings on the developed small-scaled maglev track.

The validation results showed that the concept is (i) technologically feasible, and (ii) the developed GABRIEL rendezvous control concept permits landings – on the rendezvous platform being moved and levitated by the maglev track –at the required accuracy.

Fig. 23. The validation experiments of the rendezvous control system on the electric cart (left) and on the validation maglev track (right).

Altogether, investigations of the concept found that:

- the envisioned maglev assisted TOL processes are technologically feasible (as demonstrated with the experiments), while also meeting the requirements (e.g. in accuracy),
- the deployment of the concept is safe and secure,

- the concept brings substantial benefits:
  - reduction of aircraft weight and fuel consumption up to 9.3 and 18.1% respectively (in case of mid-size passenger aircraft),
  - reduction of noise during the take-off (up to −64%) and the landing phases (up to 19%) depending on the SEL,
  - reduction of the emitted emissions over all phases of flight, but especially over the take-off by 38–58% depending on the take-off scenario implemented,
  - positive cost-benefit ratio, or cost savings up to € 1,467.26 per flight (on a typical European flight with a mid-size passenger aircraft).

CONCLUSIONS

This paper was dealing with the basis of out-of-the-box thinking. It analyzed the importance of innovation, radically new ideas and out-of-the-box thinking, which contain unconventional, even radically new, so-called disruptive technologies and solutions.

The paper shortly explained the term and the method of out-of-the-box thinking (or thinking outside the box) metaphor.

Recognizing the importance of environmental load reduction at the airport surroundings, the paper outlined some of the most appealing out-of-the-box concepts related to the domain, to clearly demonstrate the potential, the level of maturity and the innovation capability related to out-of-the-box thinking.

Finally, the paper gave the basic methodology to develop out-of-the-box concepts, and showed the major steps over the example of the GABRIEL project.

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AZ OUT-OF-THE-BOX GONDOLKODÁSMÓD HATÁSA A LEGIKÖZLEKEDÉSI RENDSZER JÖVŐJÉRE

A cikk az úgynevezett out-of-the-box gondolkodásmód légiközlekedésre gyakorolt hatásával foglalkozik. Összefoglalja az out-of-the-box megközelítés lényegét, betekintést ad néhány kiemelkedő out-of-the-box megoldásba, szisztematikusan bemutatja az out-of-the-box megközelítés problémamegoldó jellegét egy választott területen (a fel- és leszállási folyamatokhoz köthető környezetkárosító hatások radikális csökkentése), majd meghatározza az innovatív megoldások definiálásához, és fejlesztéséhez használható alapvető metódust.

Keywords: *out-of-the-box gondolkodásmód, légi közlekedés jövője, repülő eszközök fel- és leszállása*

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