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ABOVE-BUILDING PARKING AREA AND URBAN PLAN ARRANGEMENT PROPOSAL FOR CIVIL AIRCRAFT: THE CASE OF TÜRKIYE

Fahri BİRİNCİ [1], Mehmet Fatih YILMAZ [1], Emre ALPASLAN [1], Erdem Emin MARAŞ [2], Metin Mutlu AYDIN [1]✉

[1]*Faculty of Engineering, Ondokuz Mayıs University, Samsun, Türkiye*
[2]*School of Civil Aviation, Samsun University, Samsun, Türkiye*

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Abstract. This study examines the feasibility of integrating vertical take-off and landing (VTOL) civil aircraft into urban environments in Türkiye, with a focus on adapting existing building structures and urban planning regulations. The research investigates the structural, legislative, and urban design modifications needed to support the safe operation of personal and family-use VTOL vehicles. Case studies from Istanbul, Ankara, Izmir, Diyarbakır, and Samsun highlight the challenges and opportunities posed by both old, unplanned urban areas and newer, systematically developed regions. The findings reveal the need for significant legal reforms, including updates to civil aviation regulations, and structural adjustments such as rooftop reinforcements to support VTOL operations. The study emphasizes that incorporating aircraft-friendly infrastructure in new urban developments is more cost-effective than retrofitting existing buildings. It also highlights the importance of creating dedicated take-off, landing, and parking areas within urban spaces to accommodate the growing demand for urban air mobility. The research concludes that proactive urban planning, legislative changes, and technological innovation are critical for fostering sustainable urban air mobility, enhancing transportation efficiency, and ensuring safety in Türkiye's evolving urban landscapes.

Keywords: urban planning, civil aircraft, flying car, drone taxi, flying taxi.

✉Corresponding author. E-mail: *metinmutlu.aydin@omu.edu.tr*

1. Introduction

Humankind has always had a passion for flying, starting from the earliest times. It is known that the first flying person by creating wings in the form of cloth-covered bird wings was Abbas Ibn Firnas (in 810–820 years) in Spain-Andalusia-Cebel-i Arus (Fikriyat, 2019). Hezârfen Ahmed Çelebi's flight from Istanbul-Galata Tower in 1632 with a bird-wing-like vehicle in the same form, crossed the Bosphorus and landed in Üsküdar-Doğancılar, 3558 m away (Kansu et al., 1971; Korul & Küçükönal, 2003), shows that people's interest in flying has always been kept alive. The world's first general-purpose powered aircraft was flown by the Wright Brothers on December 17, 1903. In the nine years following this date (in 1912), Türkiye (Ottoman Empire) showed the importance it attaches to aviation with an airport built in Istanbul (Yeşilköy, Atatürk), two aircraft it bought, and two hangars allocated. Today, different ways and means of flying are sought.

Studies are carried out on manned and unmanned aerial vehicles in many countries such as America, Russia, China, India, Japan, Slovakia, Netherlands, France, Malaysia, Canada, Germany, and Türkiye (Yeşilay & Macit, 2020; Eker et al., 2022). Finn and Wright (2012) studied how privacy and other civil liberties were impacted by the use of unmanned aircraft systems (UAS) for surveillance in civil applications. In order to demonstrate the advantages and disadvantages of the technology, Christie et al. (2016) evaluated cases of UAS use to document wildlife abundance, behaviour, and habitat. The usage of UASs in the American construction sector was studied by Tatum and Liu in 2017. The dangers of deploying UASs on building sites, internal and external sources, and predictions about UAS applications in construction in the future are the main areas of focus. The possible uses, ramifications, and technical and non-technical challenges of integrating unmanned aircraft vehicles (UAV) into smart cities are examined by Mohamed et al. (2020). Choi et al. (2020) examined the problems related to current aviation legislation in their study. Ilić et al. (2022) carried out a study to determine the possible application of UAS for the smart city transformation of Belgrade, the capital of the Republic of Serbia, by taking into account the unique aspects of the city. Gaikwad et al. (2023) proposed a computer vision based autonomous system for the taxiing of an aircraft in the real world. The system integrated both lane detection and collision detection and avoidance models. The lane detection component employs a segmentation model consisting of two parallel architectures. An airport dataset is proposed, and the collision detection model is evaluated with it to avoid collision with any ground vehicle. In another study, Silkov and Delas (2015) examined the substantiation of the complex parameter that characterizes the technical level of an unmanned aerial vehicle (UAV). This parameter included the maximum lift-to-drag ratio, propeller efficiency, specific fuel consumption, and other components, on which the main flight characteristics, such as flight range and flight duration, depend. In his study Turza (2014), based on Federal Aviation Administration (FAA) data, predicted that the civilian drone market will reach 10.9 billion dollars in 2025. Json.tv (2018) states that 47% of the world drone market is civil, 24% is commercial and the remaining 19% is for different consumer purposes, and a price decrease of 7–27% can be expected with the increase in production. Thus, an increase in civilian use can be expected.

The societal acceptance and economic viability of flying taxis are also critical for their widespread adoption. Public perception plays a crucial role in the adoption of flying cars. Surveys indicate that while many people are excited about the potential benefits, concerns about safety, cost, and practicality remain significant barriers (Ahmed et al., 2020). The introduction of flying cars could create new markets and job opportunities in renewable energy, manufacturing, and transportation. However, ensuring equitable access and affordability will be critical for widespread adoption (Kashem et al., 2024). In their study Finn and Wright (2012) raised concerns about privacy and civil liberties, particularly in surveillance-related applications of unmanned aircraft systems. In another study, Tatum and Liu (2017) emphasized the risks associated with deploying unmanned aerial systems in construction, which parallel the operational hazards in UAM contexts. Additionally, the forecast by Turza (2014) on the civilian drone market growth underscores the commercial potential and necessitates proactive policy-making to support sustainable development. Additionally, Rajendran and Srinivas (2020) examined the economic feasibility of flying taxis, identifying key cost factors and market entry barriers. Brown and Harris (2020) explored public perceptions of urban air mobility, emphasizing the importance of safety and environmental concerns in shaping public acceptance. Naveen et al. (2024) conducted a comprehensive study on the integration of UAM into existing transport systems, highlighting the need for multi-modal connectivity and efficient air traffic management.

The integration of flying cars into existing airspace requires robust regulatory frameworks. The Federal Aviation Administration (FAA) is expected to play a key role in establishing standards for air traffic control, pilot certification, and vehicle safety (Ahmed et al., 2020). Flying cars powered by renewable energy sources, such as hydrogen fuel cells or solar power, have the potential to significantly reduce greenhouse gas emissions compared to traditional combustion engines (Shen et al., 2024). Flying cars represent a transformative technology with the potential to revolutionize urban mobility. While significant progress has been made in addressing technological, regulatory, and environmental challenges, many new studies is needed to ensure safe, sustainable, and equitable deployment.

The forms of flying and landing are important for civilian use. Vehicles that can travel both on land and in the air and the sea, on land and in the air (flying car types), and both in the sea and the air, based on the accelerating flying principle, can be named as species according to the way they fly. Vehicles suitable for commercial and personal use aiming at transportation between points can be counted as helicopter-type aircraft with vertical take-off-landing, horizontal take-off-landing vehicles based on acceleration and flying, and vertical take-off-landing drone-type vehicles. Today, there are models such as Ehang, Volocopter, UberAir, Vahana, Joby, Lilium Jet, and SureFly, which have completed the prototype stage or are in the production phase. The three selected countries and their sample productions are summarized below.

- United States of America: Flying car (Pioneer PAL-V, 3-wheel and 2 passenger capacity, 230 horsepower, 599 thousand dollars, 600 kg weight, 164 m × 30 m runway required, 10 minutes conversion time, 8 seconds to ascend to 100 m).
- China: Ehang 216 electric, autonomous system (2 passenger capacity, drone type aircraft height: 1.77 m, aircraft width: 5.61 m, max payload: 220 kg, range with max payload: 35 km, max speed: 160 km/h).
- Türkiye: Cezeri, electric, autonomous, multi-purpose, drone type-prototype (cruise speed: 100 km/h, Maximum flight altitude: 2000 m, Airtime: approximately 1 hour, Takeoff/landing: Vertical take-off-landing, Maximum Takeoff Weight: 241 kg, Range: 70–80 km, Full charge time of batteries: 1 hour) (Alemdar, 2020).

According to the existing building stock of the cities, the building features are not suitable for systems other than vertical take-off and landing. For this, it is thought that it will be easier to create a large number of areas close to the settlement areas of the cities but outside the city. For this purpose, the 164 m × 30 m runway (take-off-landing area) proposed for Pioneer PAL-V above can be considered as multiple longitudinal and transverse. As an example, the creation of 300 m x 40 m longitudinally and transversely arranged areas with an exit to the parking area perpendicular to the take-off-landing direction from each special runway end was emphasized. The principle of using the upper slabs of existing buildings or new buildings as both take-off-landing and parking areas has been adopted for vertical take-off-landing systems. Below, the current situation and what needs to be done for this adopted system are discussed, considering the legislative information.

2. Materials and methods

2.1. Plan and structures of cities

When city plans and building status are examined around the world, it is seen that most residential buildings have roofs. Building heights next to each other in city centers are not at the same level. In non-central settlements of cities, for example, in Europe, building heights are closer to each other and have fewer floors. However, the use of roof voids and the fact that they are quite steep and high due to meteorological events prevent the thought of removing the roofs (Figure 1).

Figure 1. Example street view form Hilversum, Nederlands

In Türkiye, it is seen that there is unplanned construction in the old settlements outside the city center or that the plans made are not followed, the number of floors and building heights are quite different. In new settlements, this problem is at a lower level. In both cases, removing the roofs are less of a problem due to not using the roof cavities and the small roof heights (Figure 2). It is clear that special and new arrangements should be made for the use of the building's upper slab, which forms the core of this study, for take-off-landing and parking purposes. If arrangements are made for this purpose in planning new urban areas, the solution will be much easier and more economical. New structural arrangements will also become mandatory to make existing buildings usable for the take-off and landing of aircraft. As a solution, certain mandatory regulations were examined by bringing out the upper slab roofless and taking advantage of the requirements of the civil aviation regulations. For the sampling for Türkiye, old or unplanned and new or planned areas were selected from the central districts of Istanbul, Ankara, Izmir, Diyarbakir, and Samsun. The structuring conditions in the selected provinces and districts are demonstrated in Figure 2 and their schematic representations are represented in Figure 3.

When the urban texture is examined, it is seen that the buildings before 2000 (after the 1950s) or in the

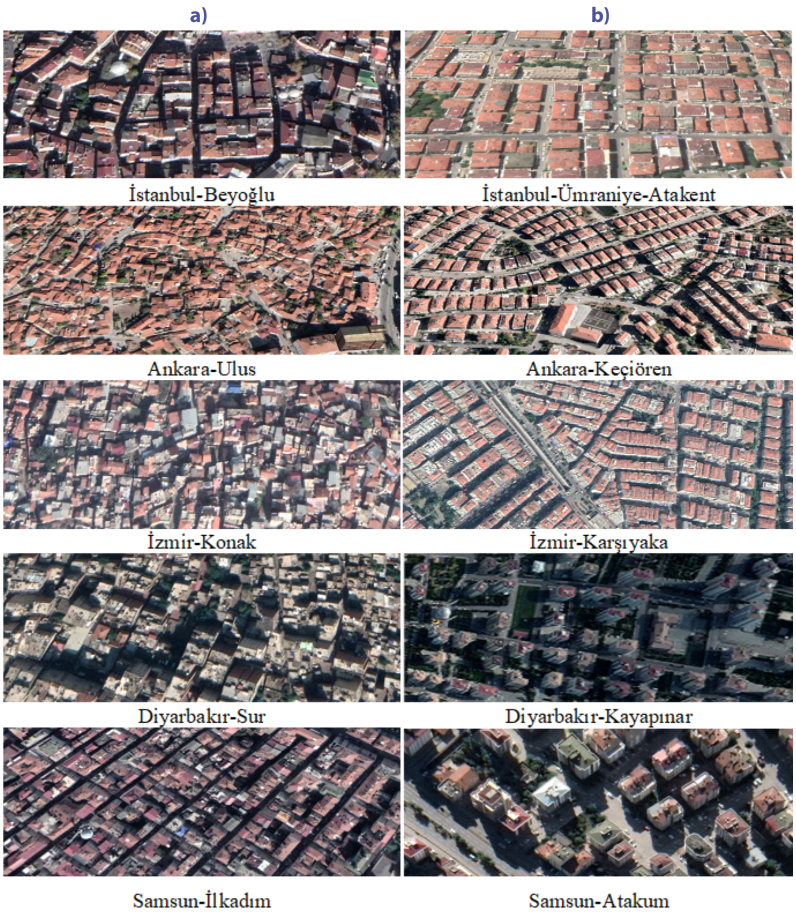
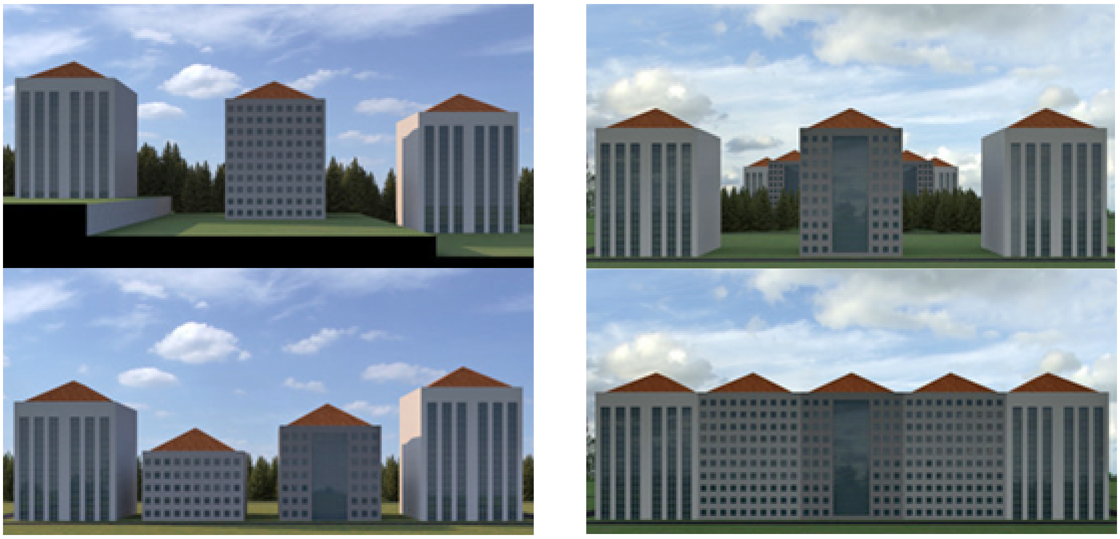


Figure 2. Selected five cities and settlements: a) city and old/irregular residential areas, b) city and new/regular settlements



a) b)

Figure 3. Construction on sloping or flat land in Türkiye (schematic): a) old/unplanned, b) new/planned

economically lower-income population areas of the city were constructed more frequently, the current legislation and standards were not followed when they were built, and the number of floors differs on the block basis (Figure 2a old/unplanned/ irregular settlements). On the other hand, it is seen that the legislation and standards are more complied with in the regions where people with a newer settlement or higher economic status live, and the difference in floor heights is less in adjacent buildings (Figure 2b new/planned/regular settlements). The difference in the height or number of floors of the buildings is related to the fact that the facade is determined according to the width of the road, the level difference, and the number of floors specified in the zoning plans. For this reason, it is clear that the solution will be much more difficult in old areas for vertical take-off-landing aircraft. However, it is easier to make a new urban planning regulation with the thought that the buildings in these regions are old, that their economic life has come to an end, and that urban renewal (urban transformation) is necessary.

In areas where new buildings (after 2000) are located, it may be possible to remove only the existing roofs and use the building roof slab as take-off-landing and parking areas with partial interventions. Arrangement of the upper slab elevations formed due to the natural topographic condition of the city area and what needs to be done on the buildings or the proposed solutions are given in the sub-title of "Study and Sampling for Türkiye".

2.2. Current civil aviation rules

After the Wright Brothers used the first motorized aircraft in 1903, the Ottoman Empire made the necessary preparations between 1909–1912 and bought two airplanes in 1912, and started its history of aviation. A grassed runway and two hangars were built in Yeşilköy for these two civil aircraft (TUSAŞ MAG, 2021). It is accepted that civil aviation in the world started with the first flight in 1903 and was in the Formative Period until 1938. The first civil aviation institution in Türkiye is the Turkish Aircraft Society, which was founded in 1925. The first civil air transport institution was established under the name of "Turkish Air Mail" with a small fleet of 5 aircraft, established in 1933 by the Government Airline Administration Management (under the Ministry of National Defense) (Directorate General of Civil Aviation [DGCA], 2021b). Established in 1954, the Civil Aviation Administration has been the General Directorate of Civil Aviation (DGCA) since 1987. It has become a financially autonomous organization within the scope of Law No. 5431, which entered into force in 2005 (Zincirkıran, 2016). Türkiye is a member of various international organizations due to the importance it attaches to the developments in aviation, which it always follows closely. It became a party to the "International Civil Aviation Agreement (Chicago Convention)", which forms the basis of International Civil Aviation, in 1945 and was among the founding members of the International Civil Aviation Organization (ICAO). Türkiye, as one of the 19 founding members of the European Civil Aviation Conference-ECAC established in 1955 (European Civil Aviation Conference, 2021), participated as a member of the 41-member European Organization for the Safety of Air Navigation-EUROCONTROL headquartered in Brussels (EuroControl, 2021). Apart from these, Türkiye, which is a member of various organizations at the regional level, continues its aviation activities in accordance with national and international legislation (DGCA, 2021).

Aviation is one of the important industries developed worldwide. After the use of aircraft as weapons in the 1st World War for military purposes, aviation activities were divided into two groups civil aviation and military aviation activities, and civil aviation began to develop. Civil aviation includes all non-military (private, sporting, commercial) aviation activities (Oyman, 1998). Since the 1980s, the establishment of private airline companies and the use of personal aircraft have been legally permitted. Turkish Airlines, a public institution, is among the largest airline companies in the world. There are airports serving all cities in Türkiye. However, the need for legislative arrangements that will allow the free and easy use of newly developed civil aircraft suitable for personal and family use, which has gained momentum since the beginning of the 2000s, has not yet been met. The rules existing in international civil aviation organizations to which Türkiye is a party ensure the safety of life and property of aircraft, users, beneficiaries, service, and technical support services without taking any risk (with strict rules). It is clear that there is a need for adaptation studies for various newly developed aircraft without compromising on issues related to life and property safety. Because the existing rules require that commercial aircraft and vehicles for personal use should be built in the same physical areas and according to the same rules. For example, issues such as the use of residential roofs as take-off-landing and parking areas or making new area arrangements are not possible according to the existing rules. Therefore, there is a need to make new regulations without departing from the basic principles.

An aircraft is defined as any vehicle capable of taking off and navigating in the air, and no obstacles are allowed in the take-off-landing areas (Presidency Legislation Information System, 1983). According to Directorate General of Civil Aviation (2021b), the airline business is defined as commercial activity operating with "aircraft with a seating capacity of more than 20", air taxi enterprise is expressed as "transportation with aircraft with a maximum seat capacity of 19", and commercial aircraft is specified as "registered vehicle engaged in commercial air transport". There are also restrictions on the heights to be flown; approximately and in AGL, passenger planes are at 30–35 thousand feet, helicopters are at 20,000 feet, and drones are at 400 feet. Classification of all aircraft is also carried out in the determination of the rules. One of the vehicles that have been emphasized in recent years is the pilotless unmanned aerial vehicle (UAV), which is automatically operated and controlled from the ground. UAV aircraft are classified according to criteria such as weight, fuel/energy, wing structure, automatic or remote control, and intended use. With similar features, the FAA limits vehicle weight to less than 25 kg for Unmanned Aircraft/Aerial Systems (UAS). If these vehicles are automatic, their use is prohibited in almost all of the world, including EU countries, and such vehicles are excluded from the scope of drones (Kahveci & Can, 2017). In countries where legal regulations are made, limitations have been established on user characteristics (age, whether he will receive training, whether he will have a document) and vehicle characteristics (weight, where and how it can be used, weather conditions, distance and height of the vehicle to the point where it was flown).

In case of a large number of vehicles to be used for civil purposes, which are drones (take-off-landing vertical, no taxiway) or helicopters (horizontal distance and taxiway required for take-off-landing), it will not be possible to use the existing airports due to their distance from air traffic and living areas. Existing or ongoing civil aviation rules will also not be appropriate. For these reasons, it will be necessary to create new areas for take-off and landing and to make the legislation appropriate and sustainable.

3. Results

3.1. Application and case studies in Türkiye

SHY 6A-ÇH (Directorate General of Civil Aviation, 2017) defines very light aircraft in two groups. Fixed wing: fixed-wing aircraft with a maximum take-off weight of 750 kg and less, equipped with engines, rotary wing: rotary-wing aircraft with a maximum take-off weight of 600 kg and less, equipped with engines. According to the SHT-OPS (Directorate General of Civil Aviation, 2020b), the standard passenger weights for aircraft with 19 or fewer passenger seats (for a 1–5-person capacity) defines as males: 104 kg, females: 86 kg, children: 35 kg (including infants to parents), and luggage weights 11–15 kg. It is imperative to consider the fuel weight in the total weight limitation. Total take-off weight of "vehicle+fuel+360 (disposable load) kg" can be envisaged for two adults, three children of different ages, and five luggage (13 kg on average). In this case, it means that the vehicle weight can be "240 kg-fuel" according to the 600 kg, which is the upper weight limit of the vehicles in the rotary wing group. According to current knowledge and technological possibilities, it is still very difficult to think of an aircraft carrying a family of five people, weighing 240 kg with its fuel. Here, it is necessary to take into account the assumption that at least one of the family members is a trained and certified pilot. If the vehicle is considered for two people, it would be "vehicle+fuel+216 kg" and the vehicle weight could be "383 kg-fuel" for the upper limit of 600 kg. For a single-seater vehicle, it becomes "vehicle+fuel+117 kg" and the vehicle weight becomes "483 kg-fuel". It emerges as a valid option according to current limitations and technological possibilities. From this, it is understood that the weight that the aircraft should carry is certain and the main issue is knotted in the weight of the aircraft itself. The value of 220–600 kg, given as the maximum take-off weight of the vehicles under development, is not yet in a position to carry the above-mentioned family human load (evaluated according to vertical take-off-landing drone-type vehicles). Although helicopter-type aircraft seem to be superior in terms of carrying capacity, it is not suitable for the idea of using the buildings examined in this study.

By examining the "Heliport Handbook (DGCA, 2024)" which is the Turkish translation of SHY-14A (Directorate General of Civil Aviation, 2016), SHY-14B (Directorate General of Civil Aviation, 2017a), SHT-HELİPORT (Directorate General of Civil Aviation, 2018), SHT-MANIA PLAN

(Directorate General of Civil Aviation, 2020a) and ICAO-Heliport Manual Doc 9261-AN/903 (International Civil Aviation Organization, 2021), SHT-UAV (Directorate General of Civil Aviation, 2019), SHT-OPS (Directorate General of Civil Aviation, 2020b), SHY-6A (Directorate General of Civil Aviation, 2021a) and SHY-6A-ÇH (Directorate General of Civil Aviation, 2017b), the determinations regarding the use of the upper slab of the buildings can be listed as follows:

- While there are definitions and rules based on the commercial nature of all aircraft in the documents, the vehicles under development can be both commercial and personal, and private.
- It should be taken into account that those with personal and family means of transport will occur to a greater extent. Otherwise, continuous expenses due to parking and ground services will prevent personal or family-type uses and indirectly the development of production.
- Having received training to operate the aircraft, the conditions of use listed according to commercial uses will need to be renewed for private use.
- Although it is expected that there will be less problems for autonomous vehicles, it is important due to uncertainties.
- It is important because of the uncertainties, although it is expected that there will be fewer problems for autonomous vehicles.
- In a solution to be controlled from a center, major problems may not be expected unless the number of vehicles and users is large.

A study of a heliport design with a steel-bearing system done by Haydaroğlu et al. (2009) was performed by the International Civil Aviation Organization (ICAO) documents and designed according to the American Institute of Steel Construction-Load and Resistance Factor Design (AISC-LRFD) regulations, benefitted from various Turkish Standards and suitability conditions was satisfied. From this, it can be concluded that there is a standard infrastructure suitable for all calculations required for buildings in Türkiye. Calculations of the vehicles that can be used according to the loads that will occur due to crashes and falls from a height are excluded from the scope of this study. However, if required, the Turkish Standards infrastructure is sufficient. Saatcı (2010) examined the design of the structure against impact and explosion loads, and Toplu and Kırtel (2018) examined the performance of seismic isolated reinforced concrete structures under the effect of blast loads and explained how the buildings should be controlled under such effects.

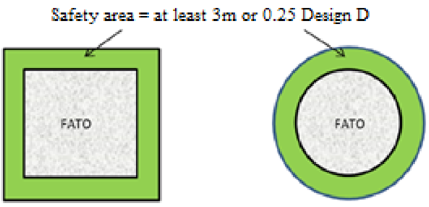


Figure 4. FATO and associated safety area (International Civil Aviation Organization, 2020)

The usage of helicopter-type aircraft (with the help of both ground-level heliports and elevated heliports) does not seem possible except in very special circumstances, due to needs providing some physical requirements such as the use of buildings, the safety area, helicopter stand, helicopter taxi route, helicopter ground taxiway, touchdown, and lift-off area (TLOF). It is also stated that the provisions of the relevant regulation are based on the design assumption that there will not be more than one helicopter in the final approach and take-off area (FATO) at the same time. However, the physical conditions such as the FATO surface being a static load-bearing surface and the requirement for at least one dynamic load-bearing TLOF in each heliport can be met.

The requirement that take-off, landing, ground motion (taxi), and parking areas be free of obstacles, which is one of the important conditions that must be met for any aircraft, is also necessary for buildings. The regulations and requirements, which are called obstacles and contain the rules to be followed for all flight activity, cover both the active area and the entire flight-related area outside this area. Even possible discontinuities on the ground due to gaps, cracks, etc. in the area should be added.

It is understood that for FATO+safety, helicopter-type vehicles with vertical take-off and landing techniques (drone-type vehicles can also be considered the same type in this respect) will need a square with a side measuring 1.5–2 times its longest dimension or a circular area with this diameter (Figure 4 and Figure 5). A variety of FATO/Safety Areas/Side slope layouts are shown in Figure 6 and

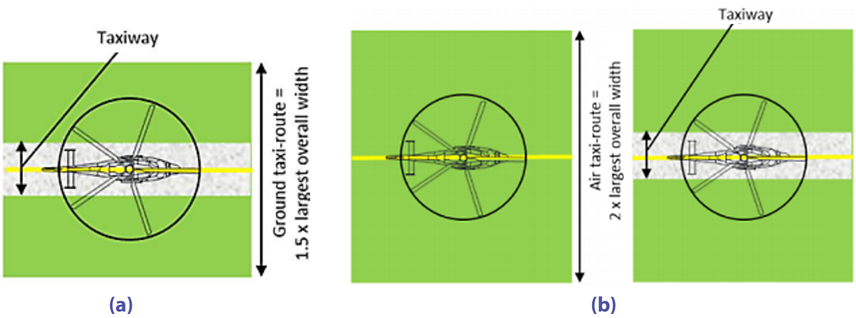
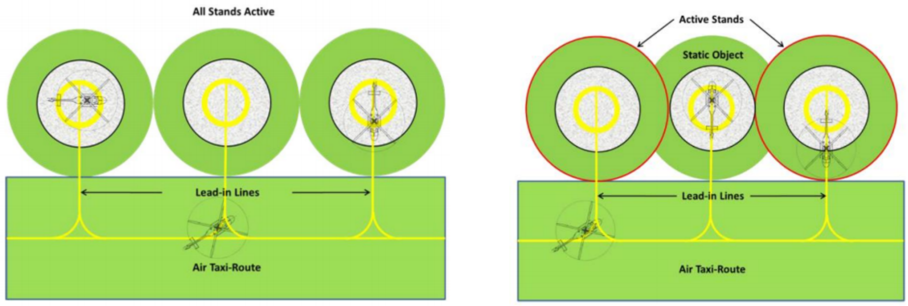


Figure 5. Helicopter take-off-landing area dimensions a) Helicopter ground taxi-route, b) Helicopter air taxi-route and combined air taxi-route/taxiway (International Civil Aviation Organization, 2020)



(a) (b)

Figure 6. Turning stands (with air taxi-routes: a) simultaneous use, b) non-simultaneous use-outer stands active (International Civil Aviation Organization, 2020)

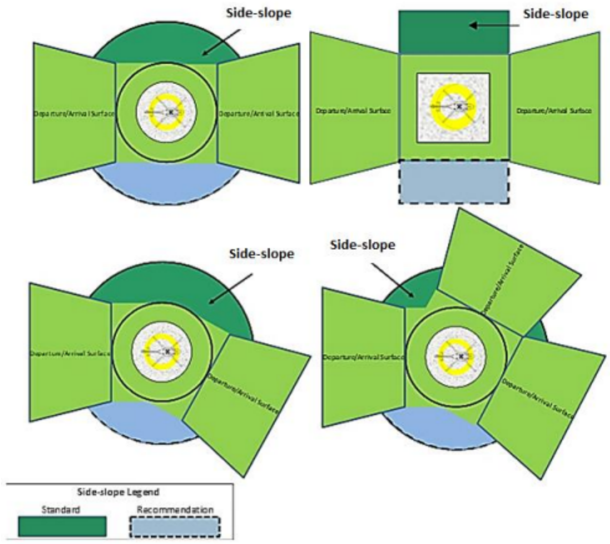


Figure 7. FATO simple/complex safety area and side slope protection (International Civil Aviation Organization, 2020)

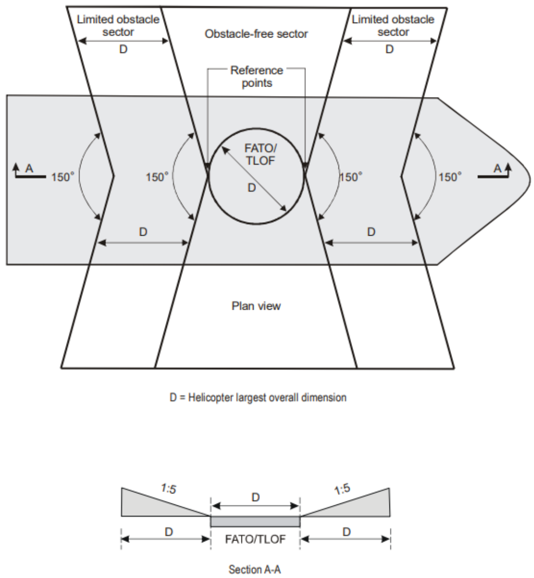


Figure 8. Amidship's location-shipboard heliport obstacle limitation surfaces (International Civil Aviation Organization, 2020)

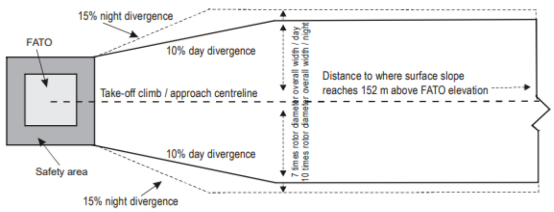


Figure 9. Take-off climb/approach surface width (International Civil Aviation Organization, 2020)

Figure 7. Appropriate provisions are required to ensure that there are no obstacles between the FATO and/or safety area and the arrival/departure surfaces for more complicated arrival/departure arrangements that include two surfaces that are not opposed, more than two surfaces, or a large obstacle-free sector (OFS) that abuts directly to the FATO.

In addition to these parking areas, the volume bounded by adjacent areas with a slope of 1:5 and as long as "D" in the largest dimension of the aircraft "D" (Figure 9), must be unobstructed (Figure 8 and Figure 9). For buildings on sloping land or for buildings located as shown in Figure 2, if there is an intermediate distance of 15 m, the height difference will mean 3 m (approximately one-floor height). In this case, it is understood that the floor difference for side-by-side buildings built on the same plane can be at most one floor or the difference between the upper slab of the buildings at different levels can be at most 3 m. For larger openings, the problem can be solved more easily, while for smaller clearances, the solution will be more difficult due to obstacle conditions. In case the building's upper slab has heliports, it is envisaged to use safety nets or grid systems for the safety of people on the roof edges where all obstacles are removed (Figure 10a, 10b, 10c).

(a) (b) (c)

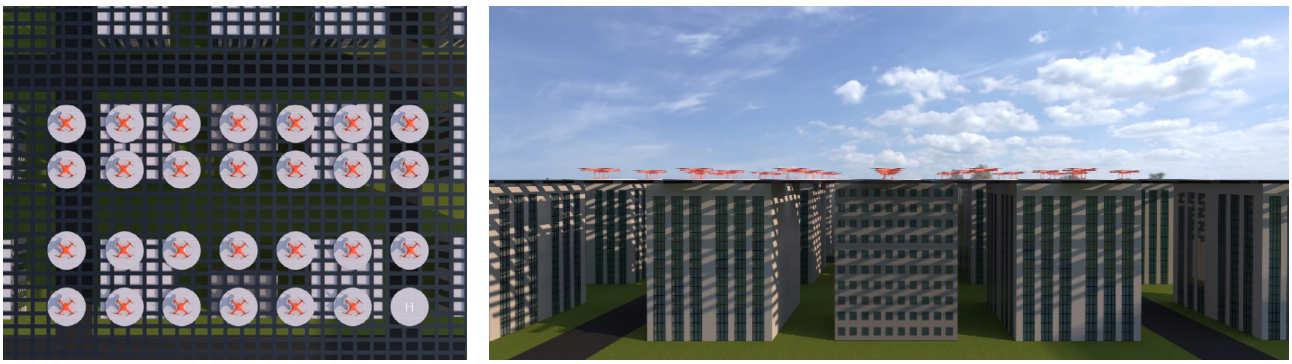
Figure 10. Design examples for the flying vehicle heliports: a) helicopters, b) flying vehicles and, c) drones

3.2. Building configuration-suitability assessment and suggestions

Existing plans and construction situations are naturally far from providing suitable conditions for a necessary and sufficient infrastructure for aircraft. In only some parts of the cities, areas for take-off landing and parking can be created in buildings that meet the necessary static-dynamic calculation requirements. However, when the buildings are taken into account individually, providing the necessary area of use for aircraft is at a level that allows for a very limited capacity. For example, the dimensions given for Cezeri are width × height × height: 3730 × 4070 × 1875 mm. In this case, the safe area will be a square (66.26 m^2) with 2 × 4.07 m (8.14 m) sides or a circle of the same size. For the simultaneous and singular implementation to this extent, the joint use of the security area given in Figure 6 has not been considered.

As stated above, if there is sufficient distance between the buildings and the upper slabs are at the same level, all the upper slabs of the buildings in the area surrounded by the streets (zoning block) can be arranged to be used as a single area. It is recommended that the surfaces of all buildings be made flat so that there are no protrusions (with the bearing capacity of the buildings provided) and that the spaces between the buildings should be closed in such a way as to allow as much light and rain as possible. In case there is less than a one-floor level difference between the upper slabs, additional fabrications may be required to reach the lower-level ones to the elevations of the adjacent buildings. In any case, it will be necessary to decide that the bearing capacities of the buildings are appropriate. For this purpose, a perforated or grid system should be considered for connecting the upper slab of the building with fixed or movable steel belts along the block sides, using suitable metal and transparent materials on the tops of the gaps, and rain permeability (Figure 11a and Figure 11b). If there is a chimney in the existing buildings, it will have to be arranged on the side walls instead of the roof so that the upper level does not exceed the roof level. It is recommended to use windbreakers so that the chimneys taken to the outer wall are not affected by the lateral wind. It seems possible to arrange a horizontal sliding system that can be opened and closed automatically at the junction of the ladder with the roof, or the ladder can be arranged by taking it out from the middle of the last floor height (last landing).

The buildings selected for sampling have an area of 10 × 15 m (6 buildings in total for a zoning block), the required safe FATO area is 8 x 8 m and only one or two take-off-landing areas can be created (6–12 in total). In the proposed solution, 21 safe areas can be created on the 64 m × 49 m area including narrow streets on the block where the buildings are located (2394 m^2), (57 m × 42 m without including the neighboring block). Assuming that each vehicle has an additional load effect of 10 kN, there will be a total of 210 kN of additional load. This load creates a load much smaller than the 100 kN/m^2 value used as the roof design load. In addition, considering the removed roof slab, it can be assumed that the additional



(a) (b)

Figure 11. Use of suitable building roofs for aircraft: a) plan b) side view-perspective

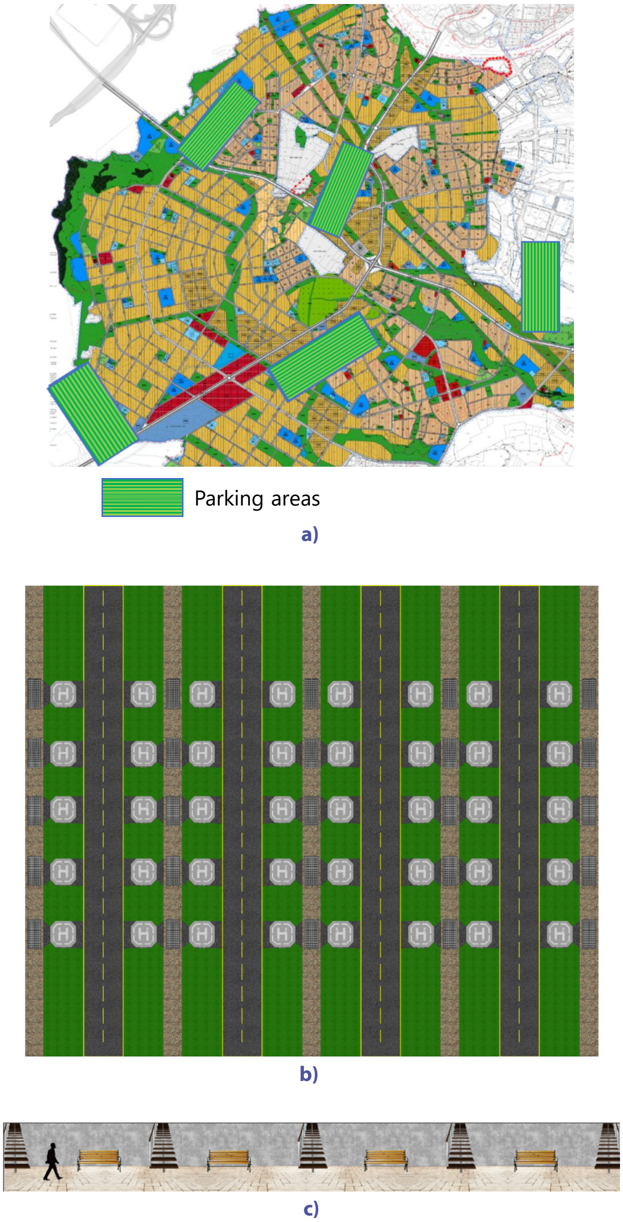


Figure 12. The suggestion of horizontal take-off and landing areas in cities: a) urban planning, b) park plan, c) park section (service area)

loads arising from the additional operations to be performed for waterproofing and positioning of the aircraft will be balanced by the removal of the roof loads. Additional dynamic loads that will occur in the structure as a result of the vehicles falling from a certain height should be evaluated separately.

For all aircraft except vertical take-off-landing aircraft (only drones), it will be necessary to create new areas only for this purpose by making a plan arrangement at the closest distance to the city or within the city, if any except for airports (Figure 12a). In the proposed areas, the same area will be used for landing, parking, and take-off, and it was deemed necessary to have a floor under the parking area to prevent human mobility (Figure 12b and Figure 12c).

3.3. Static evaluation of proposed changes on roofs of buildings

There will be limited changes in the loads that will affect the building roof caused by aircraft. The distributed load per m^2 originating from the aircraft has been calculated as very small. It is seen that this load value is also quite small compared to the average snow load and roof live load values in Türkiye according to TS 698. The snow load that will affect the roof will create difficulties in the landing, take-off, and parking operations of aircraft and will also bring additional loads to the structure. Preventing snow accumulation and reducing additional loads on the structure should be considered as an alternative to the heating systems to be built. To increase the parking areas of the aircraft, it is recommended to increase the usage area and capacity by placing mobile and fixed systems between the buildings on the same block (on the gaps and small side roads). In this case, it is important to establish a system that allows building movements with one side fixed and the other side moving, to prevent additional loads from coming to the buildings under horizontal loads such as earthquakes and winds. In this case, the largest displacements of the buildings should be considered and the rolling supports should be sized to accommodate these displacements. If fixed systems that do not allow deformation at both ends are used, the effects of these systems on the building performance should be carefully examined, and the loads on the connection areas and elements should be calculated in detail. If there are attic floors used on the upper slab, a new horizontal space arrangement above the highest level of the roof can be considered as a solution, with the roofs remaining the same.

4. Conclusions and suggestions

In conclusion, the study highlights the growing importance of adapting urban planning and building infrastructure to accommodate the anticipated widespread use of vertical take-off and landing (VTOL) civil aircraft in the near future. The research emphasizes that the current urban layouts and building structures in Türkiye, especially in older, unplanned areas, are not suitable for the integration of such aircraft without significant modifications. Key findings indicate the necessity for legal reforms and structural adjustments, including the removal and redesign of building roofs to support the weight and operational requirements of VTOL aircraft.

The analysis of various Turkish cities, including Istanbul, Ankara, Izmir, Diyarbakır, and Samsun, reveals that new, planned urban areas offer more potential for adaptation due to their more uniform building heights and adherence to modern construction standards. Conversely, older urban areas will require extensive urban transformation initiatives to become compatible with VTOL operations. The study suggests that integrating aircraft-friendly features into new urban developments will be more cost-effective and efficient compared to retrofitting existing structures.

Furthermore, the current civil aviation regulations in Türkiye are inadequate for governing the safe and efficient use of VTOL aircraft within urban environments. The study recommends the development of new legislation tailored to the unique operational characteristics of these aircraft, focusing on safety, accessibility, and integration with existing urban infrastructure. The research concludes that proactive urban planning and legislative changes are essential to support the emerging trend of personal and family-use civil aircraft. By addressing these challenges, Türkiye can foster an environment that supports technological innovation, enhances urban mobility, and promotes sustainable development in line with future transportation needs. Finally, it can be suggested that it will be beneficial to create special areas of use in the central regions of the cities or the adjacent areas and make the roofs flat and usable for take-off and landing because potentially vertical take-off-landing aircraft (drone type) will come to the fore.

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