SkyDrive: Aircraft Design Philosophy Material

The Advantage of Low Disk Loading Architecture

The eVTOL Safety Dilemma in Congested Urban Environments

SkyDrive is a Japanese compact eVTOL company aiming “to take the lead in the once-in-a-century mobility revolution”. Under its future vision for urban transportation, flying in eVTOLs will become a regular part of city life. SkyDrive has been working with civil aviation authorities in Japan and the US to obtain certification for “SKYDRIVE”, with the aim of launching the aircraft into service in 2028.

1. Our Dream: Enjoy the City from Above - A New Perspective of Excitement

The future SkyDrive envision is not a luxury or a temporary attraction; it is the establishment of a next-generation social infrastructure seamlessly integrated into daily life.
Imagine waking up in the morning and deciding on your commute: "Should I take the train, drive my car, hail a taxi—or fly?" A world where anyone can utilize the sky for their daily travels as a natural, ordinary option. By transcending the physical limitations of two-dimensional roads, we are transforming the sky into a new space for daily transportation. Our goal is not to create a passing trend, but to upgrade human mobility—making daily life richer and more free—and establish a new global standard for tomorrow's lifestyle. This is the future SkyDrive is dedicated to delivering to the world.

2. The Aircraft: Embodying Our Philosophy

We do not merely build aircraft; we unlock a new dimension of mobility by transforming the sky into an exclusive, high-value business field grounded in rigorous engineering. While utilizing eVTOLs will be a premium choice compared to traditional ground transportation, our mission is to ensure that every flight delivers an exceptional and special experience. While fixed-wing configurations inherently offer distinct smoothness during forward cruise, our low disk loading architecture is meticulously optimized for the premium comfort required during takeoff, landing and hovering within dense urban spaces. By eliminating complex tilting mechanisms, we bypass the jarring transitions between flight modes, delivering a remarkably stable, serene, and well-controlled ride where it matters most for urban missions. This document introduces SkyDrive’s next-generation mobility.

In the following sections, we disclose how our world-class safety, quality, and innovative fixed-rotor technology will not just move people, but deliver the ultimate excitement of enjoying the city from a breathtaking new perspective.

3. The Advantage of Low Disk Loading Architecture

[Global Urban Situation]

Distance-Based Mobility Selection Criteria and SkyDrive's Market Opportunity

According to the research by regional organizations and researchers (*1), when choosing a mode of transportation, individuals unconsciously weigh "time," "cost," and "effort (comfort)" against the distance of their trip. This behavioral psychology is well-documented and systematized in transportation engineering.

① Under 1 km (Ultra-Short Distance: Walking Zone)

- Primary Mode: Walking
- User Psychology & Behavior: This is the threshold where users decide that "walking for 10–15 minutes is less hassle than waiting for or boarding a vehicle." Factoring in the time lost at traffic lights or finding parking, walking is perceived as the most time-efficient option.

② 1 km to 5 km (Short Distance: Urban Mobility Zone)

- Primary Modes: Bicycles, e-scooters, buses, taxis, ride-sharing (Uber, Lyft, etc.)
- User Psychology & Behavior: This zone is defined by the mindset: "Too far to walk, but not far enough to take a train." The vast majority of urban taxi and ride-sharing trips are concentrated within this distance (*2).
    - The Bottleneck: In megacity centers, traveling this 5 km stretch routinely takes over 30 minutes due to gridlock, making it the zone with the worst time efficiency.

③ 5 km to 50 km (Medium Distance: Urban & Intercity Commute)

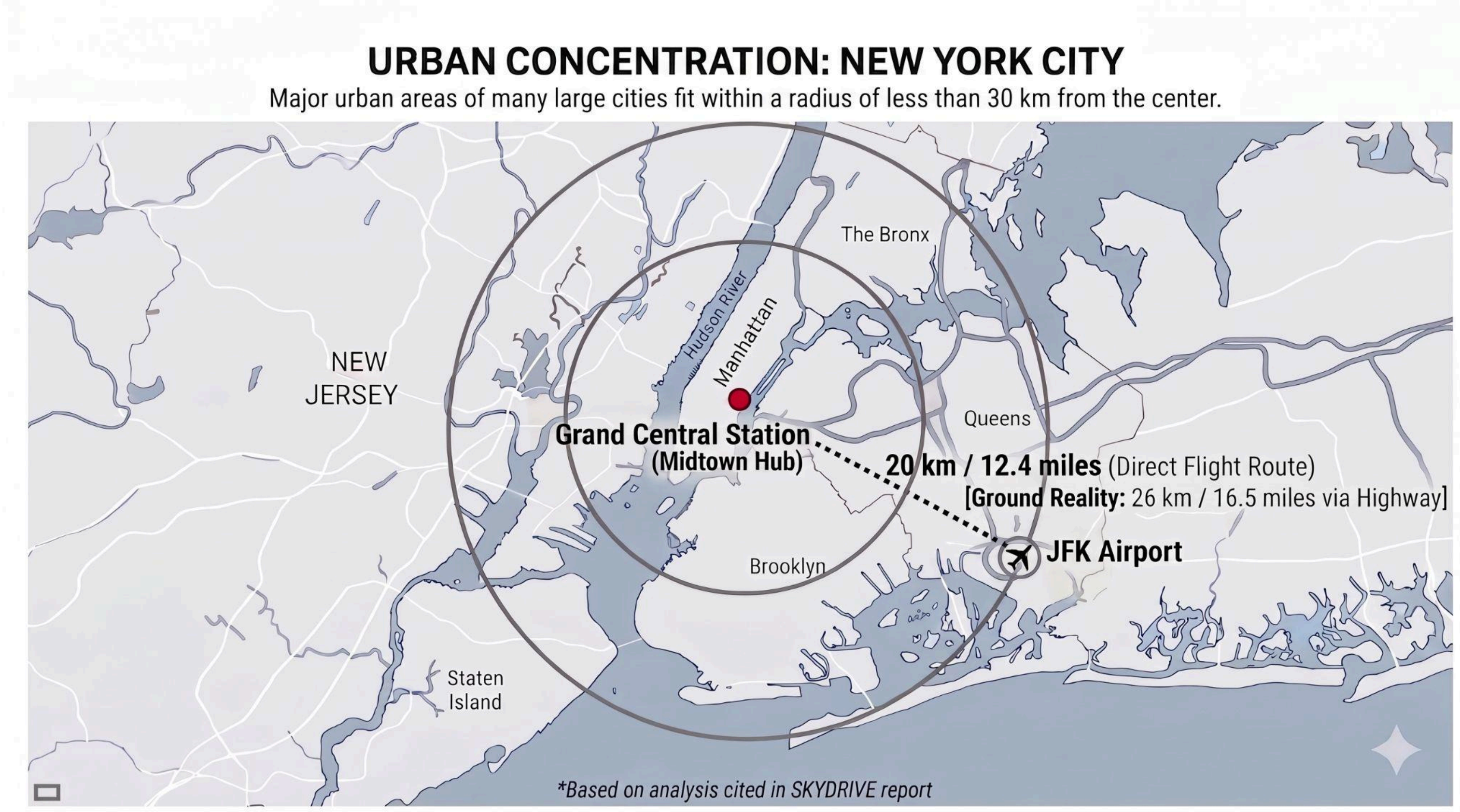
- Primary Modes: Urban railways (subways, commuter trains), personal automobiles (highways)
- User Psychology & Behavior: Walking or cycling are completely ruled out; users become 100% dependent on public transit or cars. Travel times stretch to between 30 minutes and 1.5 hours, crossing the threshold where users acutely experience transit-related fatigue and stress.
    - The Bottleneck: Geographical barriers such as rivers, bays, and mountains (e.g., Tokyo Bay, the Hudson River, the Thames) force massive detours. Coupled with rush-hour gridlock, user frustration peaks due to the disproportionate amount of time required relative to the actual distance.

④ 50 km to 500 km (Long Distance: Regional Travel)

- Primary Modes: High-speed rail (Shinkansen, express trains), highways (automobiles)
- User Psychology & Behavior: Travel in this zone is categorized as a "day trip" or "business trip." For drivers, driving for more than 2 hours enters the fatigue zone where rest stops are required, driving a strong preference toward high-speed rail for its punctuality and comfort.

⑤ Over 500 km (Ultra-Long Distance: Interregional & International Travel)

- Primary Modes: Commercial aviation, high-speed rail
- User Psychology & Behavior: A distinct psychological threshold known as the "4-Hour Wall" exists here. Once total travel time exceeds 4 hours, user preference shifts dramatically from rail to aviation (e.g., Tokyo to Osaka [~2.5 hours] is dominated by Shinkansen, whereas Tokyo to Fukuoka [~5 hours] is dominated by flights).



Currently, 75% of the world's population lives in urban areas, and this number continues to grow. According to the United Nations' *World Urbanization Prospects (2018 Revision)* (*3), it is predicted that more than 60% of the world's population will reside in urban areas by 2030. While many cities already experience morning and evening traffic congestion and commuting rushes, as even more people reside in cities, the limits of existing transportation infrastructure are becoming apparent.

Analysis shows that because the major urban areas of many large cities fit within a radius of less than 30 km (18.6 miles) from the center, high demand and business potential lie in "intra-city air taxi missions"—a vital solution to bypass the severe ground transit bottleneck known as the "4km (2.5miles) Wall" (see Appendix).

In regions where ground infrastructure is limited or congested due to geographical obstacles such as tall buildings, mountains, and rivers, eVTOLs can seamlessly connect the movement from when passengers disembark from trains or airplanes to their final destinations, such as hotels or offices.

In the coming era, an innovative way to connect "one point" to "another point" in a city is to "fly over the skies". Born in Japan, a country with high-density cities such as Tokyo and Osaka, the compact-sized SkyDrive does not require large-scale land development. By deploying a minimal package that sets the "aircraft and port" together, it provides a vehicle that allows people to feel secure and casually enjoy aerial mobility while solving current social issues.

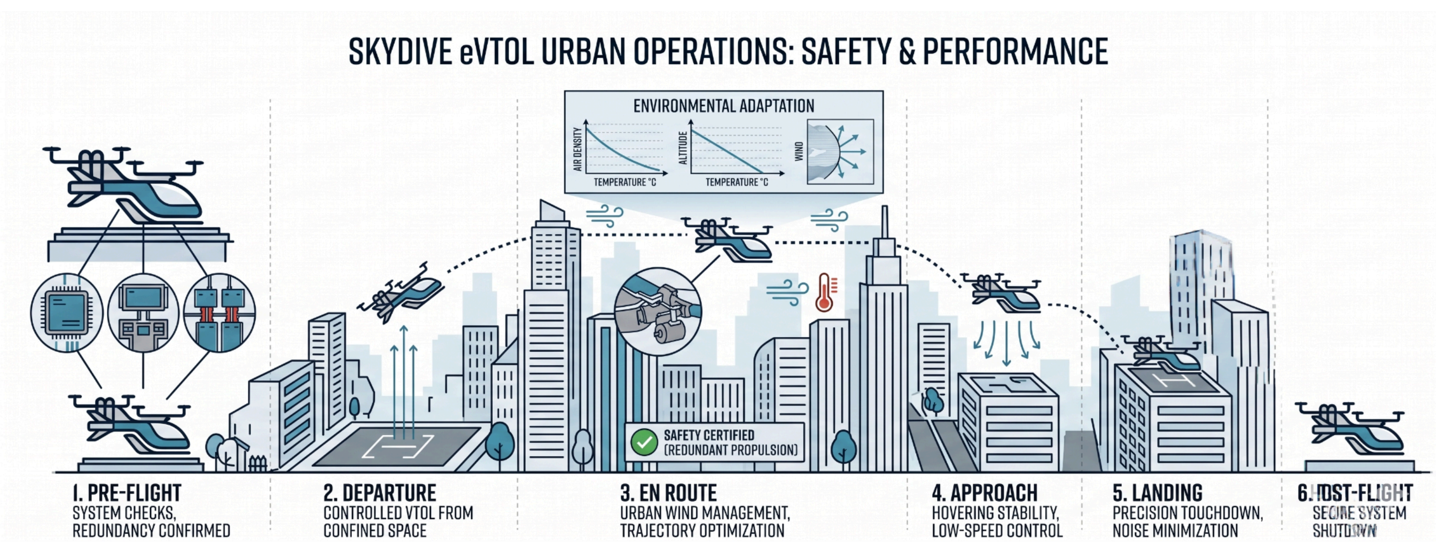
[Challenges in Urban Areas]

When operating an eVTOL in a congested city, there are challenges that differ from operations in standard locations. Crucially, to provide services in congested areas, "Vertical Take-Off and Landing (VTOL)" is required. Furthermore, this operation must be proven safe within limited spaces or specified areas.

Safe operation in dense urban areas is directly linked to the limitations of battery power density and the safety redundancy (backup function) required for the propulsion system. The ability to take off and land in congested areas is directly linked to the aircraft's "handling characteristics at low speeds and during hovering," which are determined by the aircraft's rotor disk loading, power density limits, and the redundancy (backup function) of the batteries and motors.

In addition, the unique environment of urban areas lined with buildings and recent abnormal weather pose major hurdles for flying cars. There is a battle against strong winds to prevent losing control, as well as against air that becomes thinner in places where "the temperature is higher and the altitude is higher". When the air is thin, the propellers' ability to grip the air weakens, and power decreases. Therefore, the dimensions of the motors and propellers are calculated based on the worst-case scenario—"the hottest and highest-altitude day" (size-determining factor)—to ensure that the aircraft can still lift off safely. High disk loading architectures (such as tilt-rotors) inherently require higher power output during hover, which necessitates larger propulsion systems to meet peak takeoff demands. In contrast, SkyDrive's design focuses on a low disk loading architecture. This allows us to fulfill the critical hover phase with a lighter powertrain, optimizing weight allocation directly for payload efficiency in short-range urban missions.

What is Disk Loading?
Disk loading measures how much aircraft weight is supported relative to its total propeller area. A larger propeller area per weight (= lower disk loading) allows the aircraft to hover efficiently using less power. This creates a critical "power margin" that ensures safe hovering and landing, even in contingency situations.



[Aircraft Design & Rotor Dome Advantages]

Based on these points, SkyDrive is designing the SKYDRIVE (Model SD-05) based on a Low Disk Loading Architecture.

Optimized Payload-to-MTOW Ratio for Urban Missions

While tilt-rotor aircraft are highly effective for high-speed, long-range cruise, their higher disk loading requires larger power systems specifically sized for takeoff and landing. For short-range urban hops (under 30 km), where forward cruise is brief, carrying additional propulsion mass offers diminished returns. By adopting a low disk loading approach, SkyDrive optimizes the powertrain for hover and transition phases, reducing overall propulsion system weight and maximizing the Payload-to-MTOW ratio, enabling a compact aircraft that delivers optimal passenger capacity and practical utility.

<u>When compared with fixed-wing eVTOLs</u>

Ports require an operating area 1.5 times the diameter of the aircraft. Because SKYDRIVE is compact, the required port size is also smaller.

The "Rotor Dome Design," which is a unique design feature of SKYDRIVE, offers the following advantages:

- Controllability: Because the rotors are tilted (angled), the aircraft can be turned more efficiently.
- Safety: Even in the unlikely event that a rotor fails or a bird strike occurs, causing rotor fragments to scatter, the aircraft architecture is engineered to isolate the damage. The spatial and structural layout ensures that liberated fragments do not impact adjacent critical systems. This design explicitly prevents a cascade effect - a phenomenon where an isolated failure chains into a catastrophic accident.)

Why Helicopters Have Difficulty Utilizing Rooftop Ports

There are several reasons why it is difficult to routinely utilize the "H mark" and "R mark" ports on building rooftops, but one of the major reasons is "noise". Helicopter noise ranges from 80 to 100 dB, making it difficult for society to accept and resulting in operational regulations. Furthermore, because the aircraft is heavy, the floor strength of the buildings where it takes off and lands becomes an issue. Additionally, helicopters face critical safety constraints on rooftops. Even in modern twin-engine models, if one engine fails, the remaining engine requires a lag time to "spool up" and deliver the missing torque. This forces the aircraft to either drastically reduce its payload or perform a diving maneuver to recover airspeed - options that cramped rooftop environments cannot accommodate. In contrast, SkyDrive's distributed fixed-rotor architecture leverages the instantaneous torque response of electric motors. If a motor fails, the remaining units compensate immediately without any lag. Eliminating the need for diving maneuvers or severe payload penalties, our aircraft safety maintains its vertical flight path to land securely on confined rooftop ports.

Additionally, unlike our distributed fixed-rotor design, helicopters basically depend on a single main rotor, which means flight routes are restricted to ensure safety, which is another reason why utilizing rooftop ports is difficult.

[High Controllability & Design Philosophy]

SkyDrive's aircraft are designed in accordance with the safety concepts of large aircraft. For example, it adopts a "dissimilar redundant (doubled or tripled by combining different mechanisms to prepare for unforeseen failures) flight control system". The development process itself also follows standard aircraft design procedures actually used in the aerospace industry.

SkyDrive's aircraft is designed to achieve high controllability.

- Electric engine:
  - High redundancy is achieved by independently controlling 12 electric propellers. Even in the unlikely event that an anomaly occurs in a part of the propulsion system, the remaining systems instantly compensate to maintain stable flight. The distributed propulsion system eliminates single points of failure, ensuring safety and reliability at a high level.
- Flight Control:
  - A "3+1 configuration" featuring a triple-system flight control system plus an independent backup system is adopted. Even if an anomaly occurs in the main systems, it immediately switches to the backup to continue flight control. The multiplexed control system achieves a high level of safety and fault tolerance.
- Battery:
  - Power supply redundancy is secured through a battery system divided into 4 systems. Even if a malfunction occurs in some of the batteries, the other systems continue power supply to maintain flight safety. Power management via multiple systems achieves a stable energy supply and high reliability.
- Range Confidence & Battery Evolution
  - Through the integration of next-generation battery cells - which currently deliver a 20% performance increase over our earlier demo aircraft, with the clear technological potential to reach up to 40% - SkyDrive ensures the practical mission ranges required for urban transportation and premium touristic flights.
- Simplicity
  - SKYDRIVE pursues simplicity through a fixed-rotor architecture, eliminating complex tilting mechanisms and minimizing moving parts to enhance maintainability and reliability. This bypasses the need to certify flight-mode transitions, making our certification pathway significantly simpler, faster, and more predictable.

[Seamless Integration with Ground Infrastructure]

SkyDrive is not designed to replace existing transportation methods. By partnering with robust ground infrastructure, such as railways and highways, we aim to build an integrated multimodal network—a system where various modes of transportation connect seamlessly—fundamentally revolutionizing the urban mobility experience.

1. Business: The Last Mile from Major Terminals, Bypassing the "4km Wall"
    a. Example: Passengers transition to SkyDrive at major railway stations (such as high-speed rail hubs) or highway interchanges, flying directly to downtown office buildings or convention centers.
    b. Benefit: Travelers can utilize mass transit (railways and highways) to travel swiftly to urban hubs within the 30 km radius, and then leap over the heavily congested "4km Wall" in the city center by air, dramatically slashing travel times for executives and business professionals.
2. Airport Access: Direct Transit from International Airports to Urban Hubs
    a. Example: Flying directly from international airports (e.g., JFK or Haneda) to major downtown hubs like Grand Central Station or Tokyo Station, or to waterfront hotels.
    b. Benefit: It frees fatigued business travelers and VIPs from complex ground transfers and chronic traffic congestion after their flights, connecting them seamlessly to their final destinations.
3. Tourism & Resorts: A Premium Travel Experience Completely Evading Traffic
    a. Example: Direct flights to tourist destinations far from railway stations, or to mountainous and coastal resort facilities.
    b. Benefit: Even in locations where geographical obstacles make ground infrastructure development difficult, taking to the air enables access via the shortest route, transforming the travel experience itself into premium, extraordinary entertainment.

Sources:

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