CONSIDERATIONS IN VERTIPAD DESIGN

Vertipads need to be integrated correctly into the urban realm to avoid costly design rework, operational limitations, negative public perceptions and most importantly, to ensure safety.

Vertipad designers must think holistically about how the use and function of a vertipad relates to the entire site in the context of the urban setting. This Insights article helps designers to understand key environmental issues that may need to be mitigated, how to evaluate mitigation options quantitatively and how to choose the right mix of solutions for a vertipad placement.

Vertipad Design Objectives

- Ensure safe operation of VTOLs (vertical take-off and landing aircraft)
- Minimize noise for VTOL passengers and urban neighbors
- Maximize VTOL use in all climatic conditions

RWDI Approach to Vertipad Design

RWDI analyzes proposed vertipad sites to obtain information about:

- prevailing wind climate (direction, speed, and frequency)
- wind microclimate at the vertipad site (influenced by building features and nearby structures)
- operational characteristics of VTOLs that will use the vertipad

With this information, RWDI tests probable solutions by modelling and/or physical testing in our wind tunnels. Our first goal is to ensure the safety of people using VTOLs and people nearby VTOLs and vertipads. There are many challenges when siting and designing vertipads. The proximity to existing urban infrastructure (buildings and critical systems) increases the risk to frequent and safe operation of VTOLs. There are however various options to mitigate potential problems and decrease risk. In this review, we'll look first at each source of difficulty and discuss mitigation options specific to that source. Then we'll discuss ways to think holistically about a vertipad design in the context of the urban environment.

Two major challenges in vertipad design: Wind and Noise

Wind effects on VTOLs may compromise safety

Our first goal is to avoid wind conditions that could impair a pilot's, or in the case of autonomous operations, the system's ability to maintain control. In an urban setting, the consequences of loss of control could be catastrophic. We want to minimize risk through good vertipad design processes, and we want to determine thresholds for limiting the operation of vertipads if necessary.

RWDI analysis: wind microclimate, CFD, wind tunnels

We start our analysis by determining the wind climate, and localized wind effects. We use an extensive library of meteorological data, advanced weather models and proprietary statistical methods to develop a customized profile of the typical winds at the proposed vertipad site. A key feature of this analysis is to

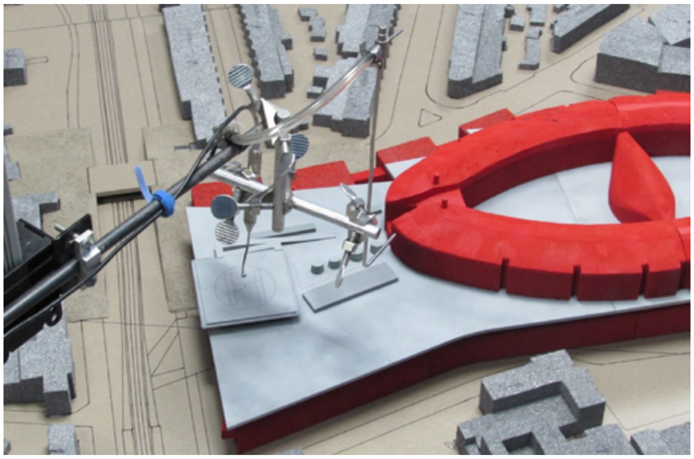

Figure 1: Model of New Children's Hospital Helipad, Dublin Ireland being tested in RWDI's wind tunnel. Model is instrumented with Cobra probes to establish turbulence conditions near the helipad.

Figure 2. Building structures nearby can create problematic turbulence at the vertipad. Here in an image from a wind tunnel test, the wind is coming from the left. While some of the airflow passes over the small structure on the right, most of it curls under to produce a region of turbulence directly over the vertipad which is not good.

determine the probable frequency of certain risky conditions that may impair VTOL operations. This wind profile is the basis for more detailed studies at the building level. We have two tools we use to determine the local wind environment: computational fluid dynamics (CFD) and wind tunnel testing.

Computational fluid dynamics (CFD) simulations are useful to visualize potential problems. CFD provides a qualitative understanding of large-scale effects. For example, CFD simulations may show that there is a possibility of large wake regions behind buildings. This may affect the usability of certain landing approaches to the vertipad.

To get a detailed picture of localized wind turbulence, which is highly sensitive to small details of the building envelope, a quantitative approach using wind tunnels is best. To do this we build instrumented physical models and test them in a wind tunnel (Figure 1). CFD studies cannot provide quantitative data of these complex effects - only wind tunnel studies can. When we do wind tunnel studies, we look for "red flag" conditions. These may include:

- Sudden changes in mean wind velocity with height (may be due to wind accelerating over and around a building)
- Large changes in gust velocity in the vertical direction

There may be other problematic wind-flow conditions identified as more information becomes available relative to specific VTOL designs and operation in the urban environment. This may require specific VTOL model testing in wind tunnels.

Problematic wind conditions can make control difficult for the pilot or the autonomous VTOL. Smoke tests in a wind tunnel help to pinpoint the locations of problematic flows (Figure 2). Wind tunnel test results can be combined with statistical weather data to quantify how often unfavorable conditions may occur.

Mitigation for airflow effects

Optimizing the vertipad location from the start avoids having to mitigate problematic airflow effects. At the design stage, RWDI's aerodynamic consulting experience can help to:

- adjust the siting of the vertipad (through comparison of potential options)
- select dimensions for an air gap below the vertipad to reduce turbulence
- select or refine the massing configuration of surrounding buildings
- understand the frequency of operational disruption

Ensuring VTOL safety during operations

When the vertipad is operational, the understanding of site-specific wind conditions based on wind tunnel testing can be combined with wind forecast information to:

- provide real-time information to advise pilots or the operating systems of difficult conditions
- restrict use when conditions reach an established threshold

Other sources of urban airflow turbulence

Wind is not the only source of turbulence in an urban environment. Rooftop exhaust sources such as cooling towers, cogeneration and diesel generation plants can emit plumes with enough heat and/or momentum

to create vertical turbulence. Depending on where this turbulence occurs in the VTOL approach path, it can disrupt a pilot's control during landing or takeoff. Solutions to solve these issues need to be proposed and evaluated. Possible solutions may include moving exhaust stacks, revising the VTOL approach path or making the approach path steeper to avoid plumes.

Noise may influence public acceptance of vertipad locations

For public acceptance of vertipad locations and the use of VTOLs, it is important to minimize the impact of noise on people. VTOL noise has two components: engine noise and rotor/ propeller noise. Engine noise is all around. Noise from the rotor/ propellers may be directed downwards or sideways, depending on the propeller configuration and mode of travel.

RWDI analysis of noise

Every VTOL type will have different characteristics that influence the volume and frequency of sound generated. For an accurate design analysis, it is necessary to know which type(s) of VTOLs will be using the vertipad and how frequently. Noise measurements of the actual VTOLs to be used at the site are ideal; however, at the time of writing of this article, there are some generic noise profiles available for a concept VTOL design, but not for any specific VTOLS. It is expected that this information will become available as part of the certification process of VTOLS. In the longer term, government certification bodies are expected to develop a database of noise data for use in VTOL noise modelling.

The most common noise-related complaints are in order of increasing severity: distraction, interference with speech and sleep disturbance. Numerous studies are available on annoyance due to aircraft noise (see references). Results are usually presented with increasing noise level on the x-axis and increasing annoyance on the y-axis. In general, as noise increases, the percentage of people annoyed will increase. Where specific noise limits are not defined by government regulations, these published curves can be used to guide good engineering practice and establish the acceptable criteria for vertipad design.

To determine propagation of VTOL noise, we examine the full range of available approach and takeoff paths around the vertipad. In addition to the stationary VTOL on (or above) the vertipad, we can model a flight path as a three-dimensional noise source, along with the geometry of the surrounding buildings. If the results of the noise modeling reveal that the criteria will be exceeded, then noise mitigation will be necessary.

Noise Mitigation

The first consideration in mitigation is location and proximity to sensitive uses. Rooftop landings result in longer noise exposures near penthouse suites or executive offices and thereby diminish their attractiveness and value. Rooftop landings also require skill to maneuver the VTOL close to buildings. Landing on the ground puts the greatest concentration of noise near occupied outdoor areas and takes up the valuable urban footprint. In either case, elements of the location can be used as a buffer to shield sensitive spaces. Thus, space planning that locates the more noise sensitive spaces farther away from the vertipad and flight path effects is beneficial.

Where location and space planning are not sufficient, the building envelope may be modified. This approach upgrades the façade with cladding that minimizes sound transmission. Such strategies are based on sound transmission class/outdoor–indoor transmission class (STC/OITC/Rw) ratings. However, modifying the façade is not enough by itself, because windows are always a weak spot for sound transmission.

Complementary operational measures are also likely to be required. One option is to revise the approach and takeoff paths; another is to use a steeper descent, known in helicopter operations as a "noise-abatement approach." These measures can be signaled to pilots by using visual glideslope indicators (VGSIs). It is expected that VTOLs will have even greater flexibility to accommodate steeper descents than helicopters.

Holistic Review of Solutions

The interrelationships among effects and mitigation solutions may be complex for vertipads. Table 1 lists the most significant considerations. We recommend taking time early in design to step back and look at how these strategies can work together holistically in the vertipad design. Not doing that may result in fixing one issue while creating another.

Table 1. Vertipad Design and Mitigation Options

Consideration	Mitigation Options
Location	Adjusting vertipad location Building layout Re-massing Space planning Site layout Setbacks Creating buffer zones
Building Envelope	Feasibility of operable windows (noise) Sound-transmission control
Mechanical Systems	Avoid nearby rooftop stacks
Operational	Visual glide slope indicators Limitations on operation schedule Closure during extreme wind events

The optimal solution may involve the use of several mitigation options. The goal is to find the right combination of mitigation measures to optimize the design—to reduce or offset as many issues as possible in the most cost-effective way.

Evaluation of potential issues early in the design phase is best

Ideas proposed to ensure safe and effective use of vertipads should be evaluated early in the design phase to result in the most cost-effective vertipad design. Proper

siting of the vertipad is most important. To optimize a vertipad location the following must be considered:

- building aerodynamics nearby the vertipad (to ensure safe VTOL operation)
- locating outdoor pedestrian spaces away from flight paths
- increasing the distance between vertipads and noise-sensitive receptors
- using setback/buffer zones for VTOL flight paths

Disclaimer – This document is intended to provide an overview of key issues affecting vertipad siting. There may be other issues such as rotor downwash and its impact on the building envelope, vibration effects etc. These issues will continue to be explored as more information becomes available on VTOL performance characteristics.

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