HOW ASSESSING WIND INFORMS VERTIPORT DESIGN AND VTOL OPERATIONS

By Sharon Schajnoha, RWDI, Strategic Director – Principal

The siting, design, and operations of vertiports in cities require close consideration of wind flows in the built environment. The introduction of vertical takeoff and landing (VTOL) and electric vertical takeoff and landing (eVTOL) aircraft into cities is new. However, wind features in cities are well understood. Wind features are commonly assessed in wind engineering following well-established and codified practices.

This wind expertise is vital to inform many elements of design. Examples include the structural and cladding design of tall buildings; wind comfort and safety on city streets; and the design of mechanical ventilation systems. It also plays a major role in the safe design and operations of heliports. Finally, it is a critical part of vertiport design and VTOL/eVTOL operations.

Here are the details on why you need to assess the wind in cities to inform safe vertiport design and safe VTOL/eVTOL operations.

What are the Design Guidelines for Vertiports?

Several international aviation authorities have published design guidelines for their safe design, including:

- United States Federal Aviation Authority's Engineering Brief No 105,
- European Union Aviation Safety Agency Vertiports specifications, and
- Australian Government Civil Aviation Safety Authority's Advisory Circular AC 139.V-01 v1.0 Guidelines for Vertiport Design.

These documents call for assessments of turbulence above the final approach and takeoff area (FATO). However, they don't specify how to conduct the assessment. They also don't outline the design or performance criteria to guide the extent to which mitigation or operational restrictions are required.

Despite the limited guidance, vertiports are being planned and designed around the world as test beds. The intent of these test beds is to provide proof of concept for the advanced air mobility (AAM) sector's technical and economic viability. Therefore, there is an immediate need for reliable wind assessment methods to support vertiport design.

Why Does Wind in Cities Matter to Vertiport Design?

The smaller size of eVTOL/VTOLs relative to traditional aircraft makes them more susceptible to wind features that are unique to the urban environment. These unique wind features include:

- changes in wind speed,
- changes in wind direction,
- shear,
- turbulence, and
- vorticity.

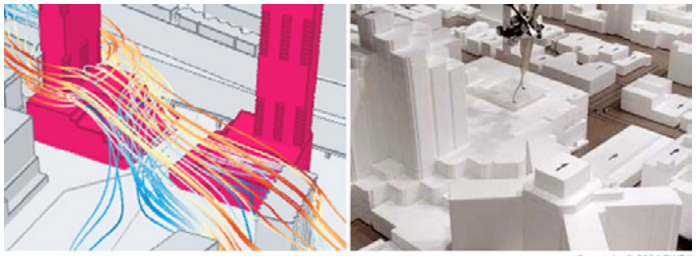
These features may compromise the stability of the aircraft. On the other hand, if the aircraft can remain stable in these wind conditions using gust rejection systems or other advanced control mechanisms, operating their control mechanisms will result in increased power consumption.

The wind effects may also adversely impact the quality of the ride for the passengers. Using an advanced control system of the multi-rotors could likely improve the ride. However, it would be at the cost of extra power consumption.

How To Assess Wind in Cities

There are many tools in a wind engineer's toolbox to assess wind in cities, including:

- AI-based software tools,
- numerical simulations using computational fluid dynamics (CFD) models, and
- physical modeling in wind tunnels.



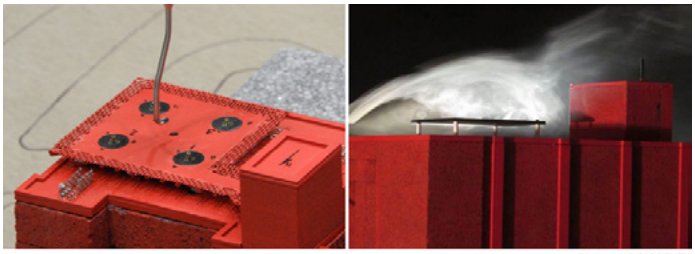
CFD and physical models

Each of these tools offers a different level of fidelity and is useful for different purposes. Where human safety is of concern, physical modeling in wind tunnels remains the gold standard. This is certainly the case for the design of infrastructure like vertiports.

Wind Tunnel Modeling

Wind tunnel modeling is a proven method of accurately analyzing wind conditions and wind features in cities. Wind tunnel modeling quantifies wind conditions by instrumenting a physical model and testing it in a boundary layer wind tunnel. The physical model consists of:

- the vertiport,
- approach/departure paths, and
- the surroundings.



Wind pressure sensors and wind flow visualization on physical models

"Red flag" or problematic wind conditions are identified and measured and compared to design criterion based on the performance envelope of the eVTOL/VTOL. The wind tunnel measurements are combined with long-term meteorological conditions representative of the site to determine whether vertiport design changes or wind-based operational restrictions are required.

Moving Forward with Informed Vertiport Design and VTOL/ eVTOL Operations

Vertiports are being designed and developed around the world to enable VTOL/eVTOL operations and the evolution of the AAM sector. However, eVTOLs/VTOLs are quite small in size when compared to traditional aircraft. As a result, they are more susceptible to the wind flow features unique to cities. Thus, carefully considering wind in cities is essential to ensure safe vertiport design and VTOL/eVTOL operations.

Where human safety is of concern, physical modeling in wind tunnels remains the gold standard in the design of infrastructure, including vertiports. Wind tunnel modeling results inform the need for siting and design changes. They inform the need for weather-based restrictions to operations. Finally, they also inform passenger comfort and energy management.