C CASE STUDY

WUHAN | LEISHENSHAN HOSPITAL

Digital Solutions for Pandemic Response

To minimise cross-infections from ventilation systems, and reduce contagion between COVID and non-COVID patients in medical facilities, Dassault Systèmes partnered China's Central-South Architectural Design Institute to simulate and analyse virus dispersal systems in Wuhan's Leishenshan Hospital. The results have implications for hospital engineering, construction and operations.

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View of Wuhan skyline.
Image: sleepingpanda / Shutterstock.com

Hospitals in a pandemic create a particular challenge—the congregation of staff, visitors and patients means hospitals risk becoming places of contagion.

The Challenge

Wuhan, the capital of Hubei Province, is one of China's largest and most populous cities, with a population of over 11 million and a major transportation hub. In early 2020, Wuhan experienced a significant outbreak of the COVID-19 virus.

To provide medical care to thousands of COVID-19 patients and address the shortage of healthcare facilities, a makeshift, modular field hospital—Leishenshan Hospital—was built. Innovative digital and technological solutions using Building Information Modelling were employed to construct the hospital in a record 14 days.

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As the virus that causes COVID-19 is mainly transmitted through droplets from an infected person's coughs, sneezes or exhalations, a critical aspect of the hospitals' construction was ensuring that the ventilation systems would protect the safety of doctors and patients while the hospital was in operation.

To minimise the risk of contamination, an understanding of the airflow schemes within an existing or to-be-built facility was needed.

Aerial view of the Leishenshan Hospital in April 2020.
Image: Noel Celis / AFP via Getty Images

> The aim: to minimise cross-infection from the ventilation systems and mitigate the impact on the external environment.

The Solution

Dassault Systèmes worked with China's Central-South Architectural Design Institute (CSADI), which designed Leishenshan Hospital, to simulate and evaluate virus dispersal within the hospital. The aim: to minimise cross-infection from the ventilation systems and mitigate the impact on the external environment.

CSADI used Dassault Systèmes' SIMULIA XFlow software, a computational fluid dynamics software powered by the cloud-based 3DEXPERIENCE platform, to simulate indoor and outdoor dispersal of fluids and virus contamination within the hospital's ventilation systems.

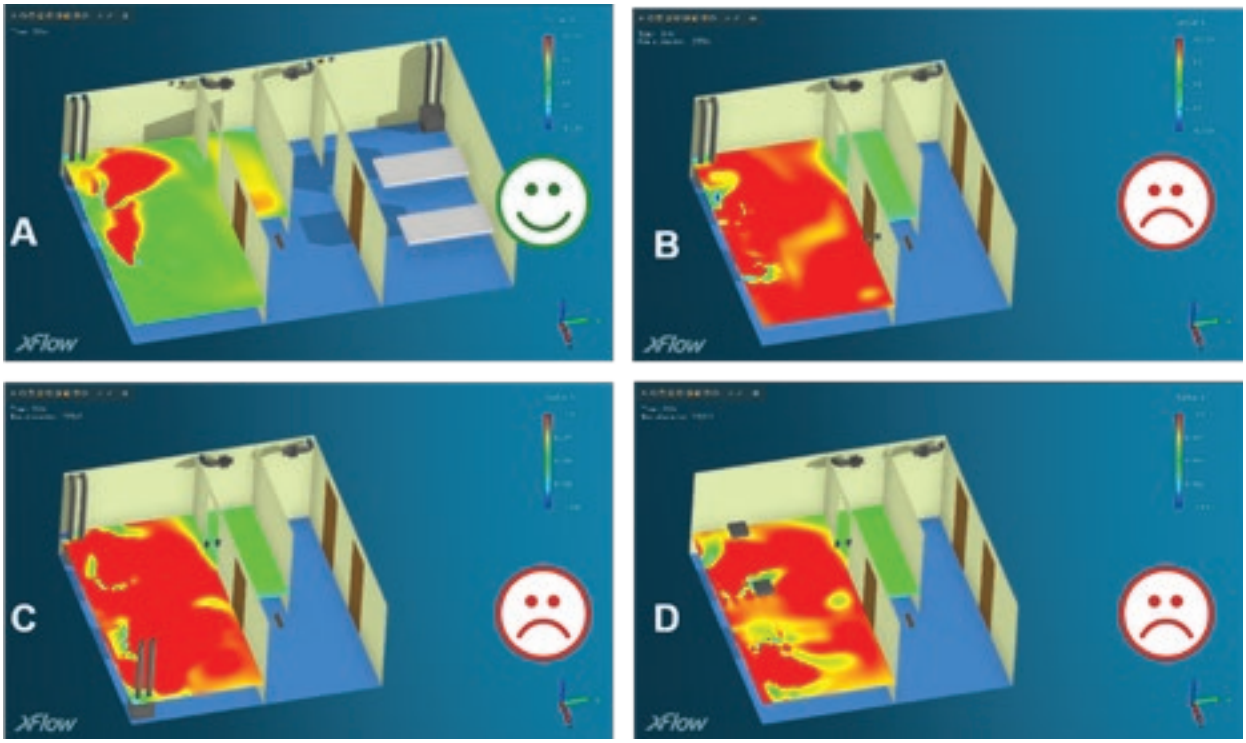
CSADI and Dassault Systèmes designed four ventilation layouts:

- Layout A: Incoming airflow from the lateral top and the ventilation outlet located in the same corner of the room
- Layout B: Incoming airflow from the ceiling lateral top and the ventilation outlet located in a corner on the other side of the room
- Layout C: Incoming airflow from the middle of the ceiling and the ventilation outlet located in two corners of the room
- Layout D: Incoming airflow from the middle of the ceiling and the ventilation outlet located above the patient's head

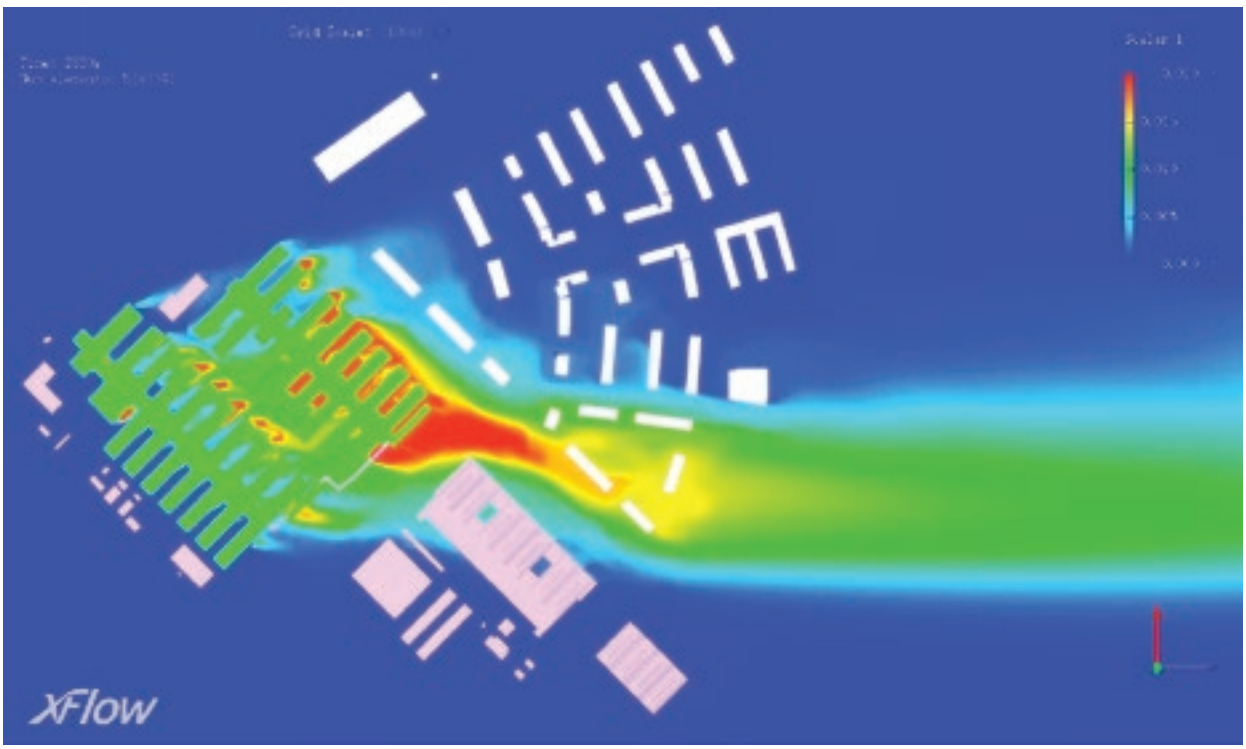
Workers at the construction site of Leishenshan hospital in February 2020.
Image: An Yuan / China News Service via Getty Images

Layout A's forced convection resulted in airflow going directly to the ventilation outlet, whereas the other layouts showed severe pollution dispersion throughout the entire room.

Proposed air supply and exhaust solutions for the isolation wards.
Image: Dassault Systèmes



Pollution concentration distributions for each of the proposed layouts.
Image: Dassault Systèmes



Simulation of external wind forces in the area surrounding the hospital.
Image: Dassault Systèmes

> The simulation results for Leishenshan Hospital helped Dassault Systèmes to improve the separation in other hospitals for floors occupied by COVID-19 and non-COVID-19 patients.

The indoor simulation was used to counteract negative effects from unplanned ventilation risks. After comparing the pollution concentrations for different ventilation layouts in hospital rooms, the simulation results identified Layout A as the best solution for suppressing pollution dispersion. Layout A's forced convection resulted in airflow going directly to the ventilation outlet, whereas the other layouts showed severe pollution dispersion throughout the entire room.

An outdoor simulation was also done to mitigate any impact on external communities, crowds and hospital surroundings. These simulations used basic environmental data such as wind direction and wind speed. The main buildings of the hospital, office areas and surrounding residences were modelled and included in the analysis.

This analysis highlighted areas that were more affected by the Northwest wind in winter, as well as areas with the highest concentration of virus pollutants. The analysis provided suggestions for better pollution discharge in isolation wards to protect medical personnel and optimise design solutions to meet pollutant dilution requirements.

The Outcome

The simulation results for Leishenshan Hospital helped Dassault Systèmes to improve the separation in other hospitals for floors occupied by COVID-19 and non-COVID-19 patients. Applying the same experience to the Marange Silvange Hospital in France, for example, minimised the risk to elderly patients sharing the same ventilation system as COVID patients.

The 3D cloud-based collaborative platform replaced an older, slower document-based approach. "Applied systematically to design, engineering and manufacturing, [the 3DEXPERIENCE platform] provides seamless remote collaboration at any time," said Ying Zhang, Managing Director, Greater China, Dassault Systèmes.

New hospital engineering, construction and operations processes that leverage the 3DEXPERIENCE platform can be developed. Dassault Systèmes and Aden Group, one of Asia's largest integrated facility management companies, are collaborating on the development of a turnkey, ready-to-use infectious disease hospital solution, Akila Care, for countries severely impacted by COVID-19. The solution relies on a virtual collaborative environment for the design, simulation and development of hospitals that can be built to be operational within 150 days.

"The 3DEXPERIENCE platform is the catalyst and enabler of such radical transformation," said Bernard Charlès, Vice Chairman and CEO, Dassault Systèmes. "Together we have already shown how simulating virus contamination and diffusion within the Leishenshan hospital's ventilation system can help to address urgent healthcare needs, and now we will work together to apply our knowledge and know-how to all aspects of the hospital lifecycle."

When used beyond healthcare planning, systems supported by the 3DEXPERIENCE platform will enable cities to track and plan thousands of parameters—ranging from existing buildings to information on soft mobility, urban heat island effect and pollution. Using this technology, cities can measure and anticipate major demographic, economic and environmental changes, enabling city leaders, policymakers and planners to deliver on sustainable goals and increase quality of life in the long term.