



Physics-Based Digital Twin Comfort Insights for Airport Terminal Operations

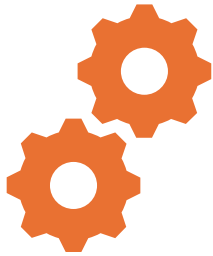
Giulia Barbano, R&I Operations Manager
Integrated Environmental Solutions Ltd

Sustainable Places 2025

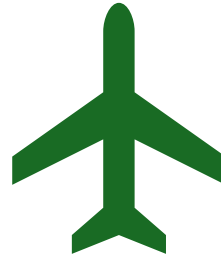
10 October 2025



Introduction



Digital Twins for
Building Operations

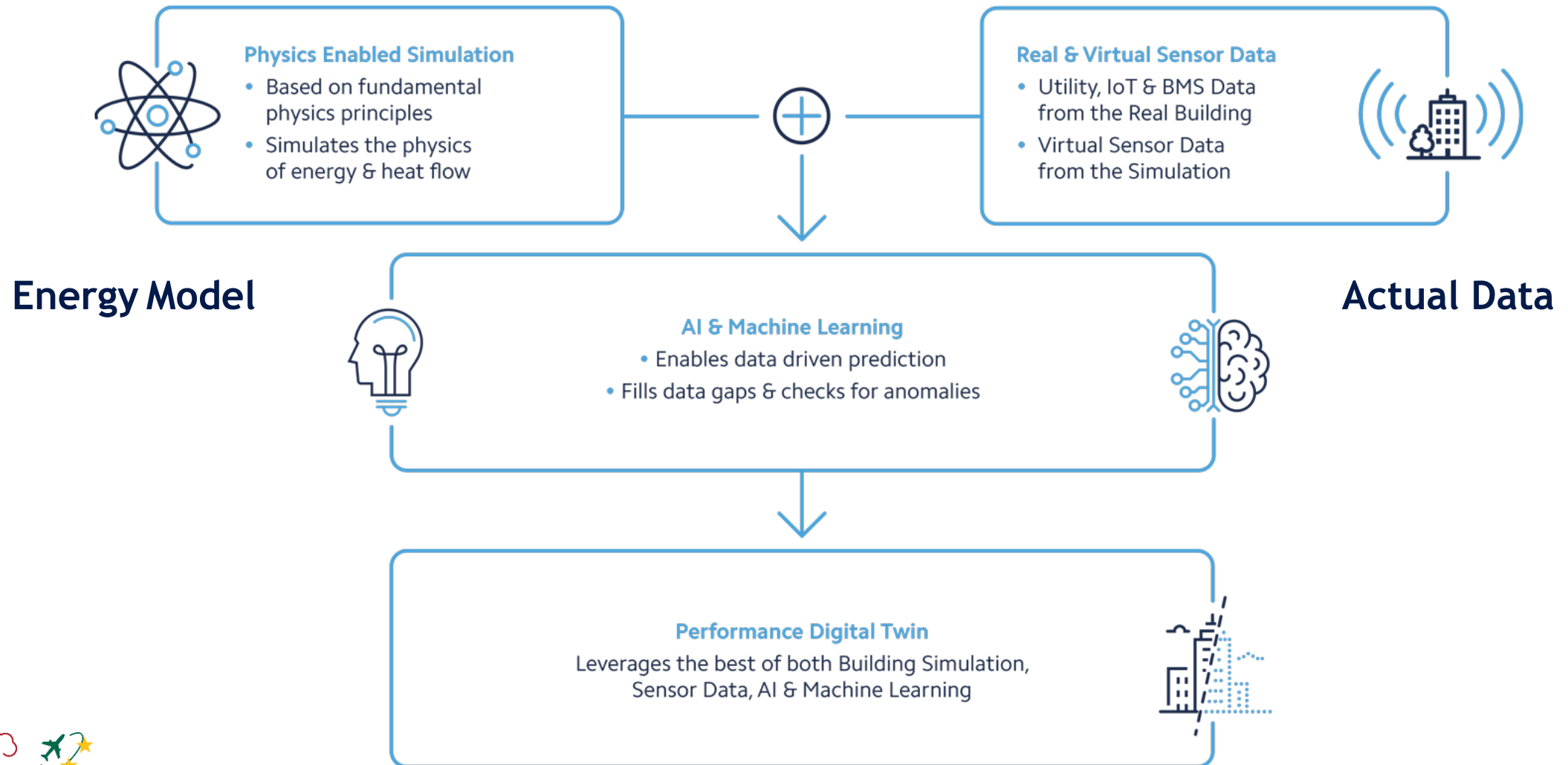


The specific case of
Airport Terminals



The STARGATE Project
Context

DT for Building Operations



Airport Terminal Context

EU airports set ambitious pledges to reduce the emissions under their control towards net zero

Need to maintain high levels of service to their passengers

Must provide comfortable conditions during their stay in the airport premises

The Technical Problem

- highly variable nature of occupancy and transient activity in airport terminals
 - complexity of the buildings and their HVAC systems
- insights on the short-term forecast of building operations can only be served by dynamic, physics-based analyses

Intelligent Terminal Command Centre

- Operate lighting, heating, ventilation, and air conditioning optimally via an Intelligent Terminal Command Centre,
- by understanding the core needs of the facilities managers
- and supporting their work with augmented intelligence techniques

The Setup

Creating the DT
Forecasting Indoor
Comfort

Designing User
Interaction

Fit-For-Purpose DT



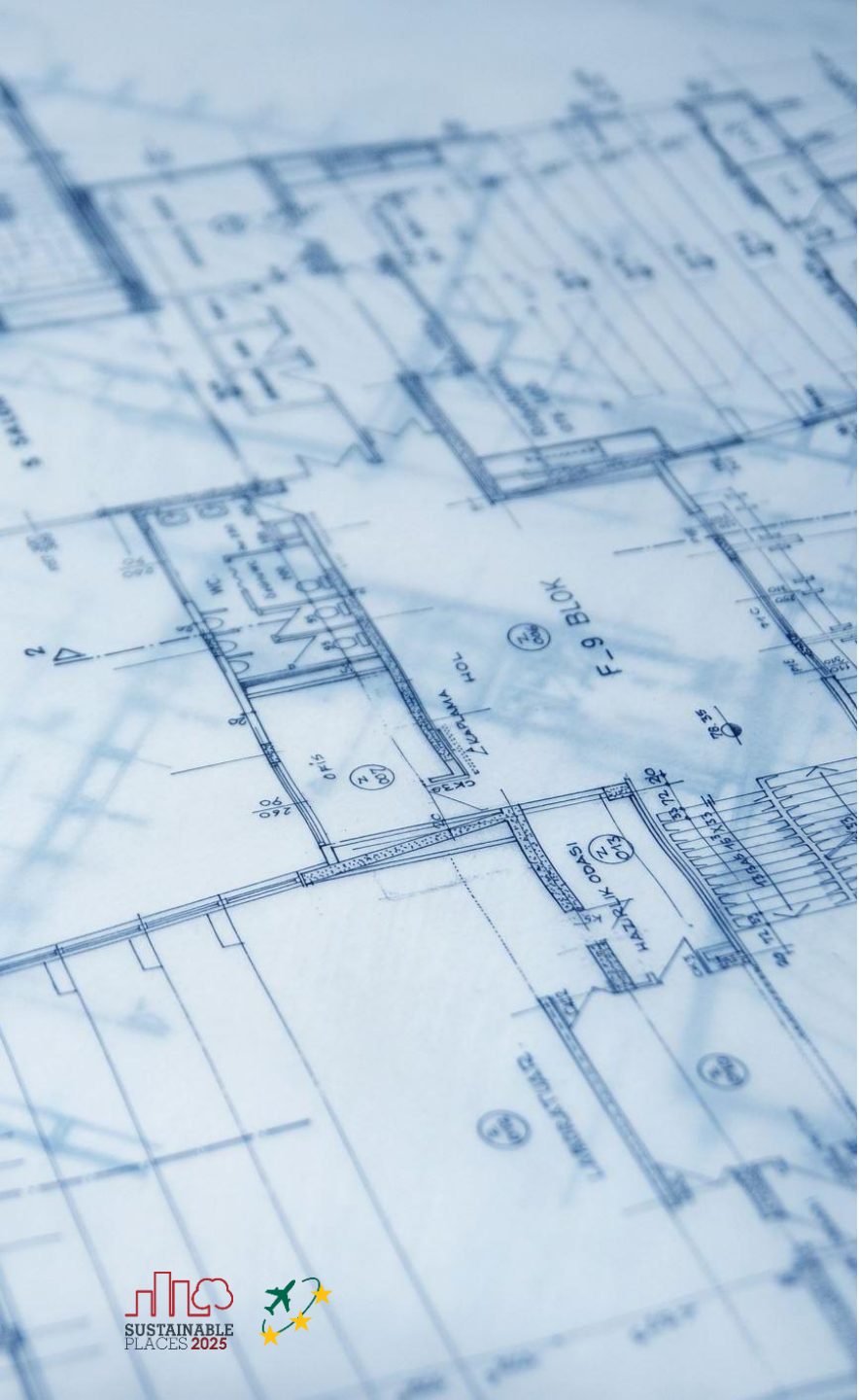
Data Collection



DT Creation



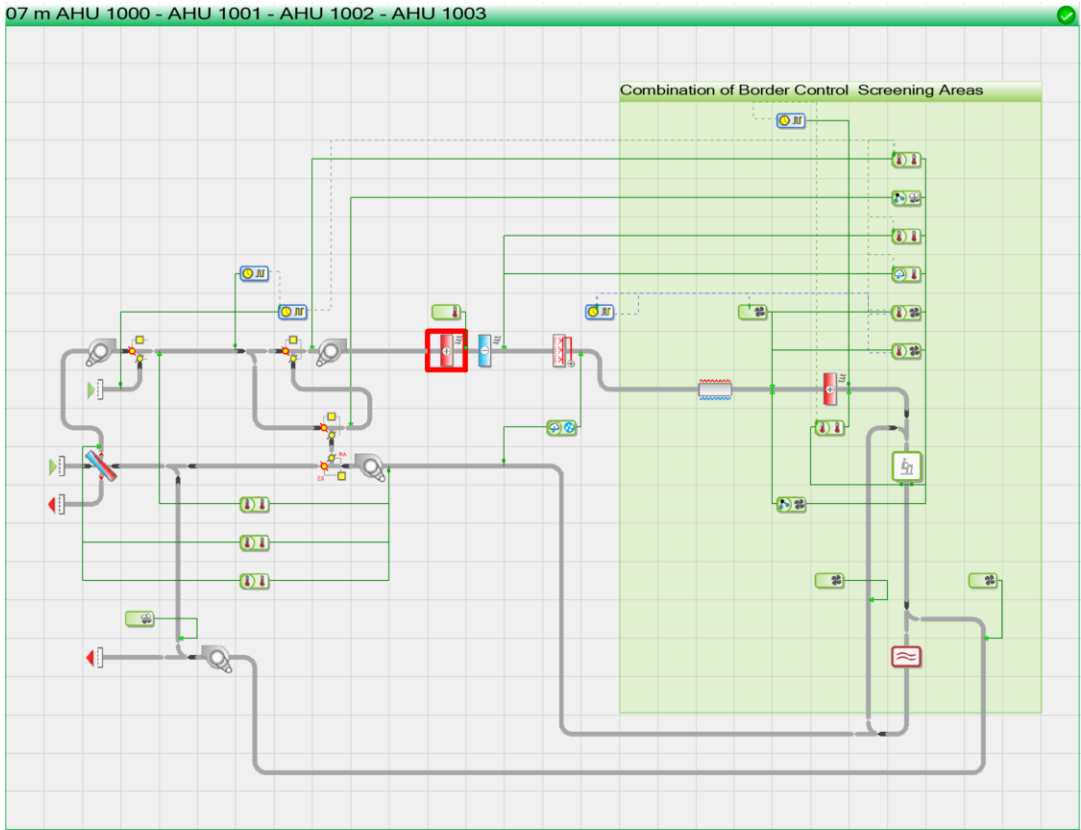
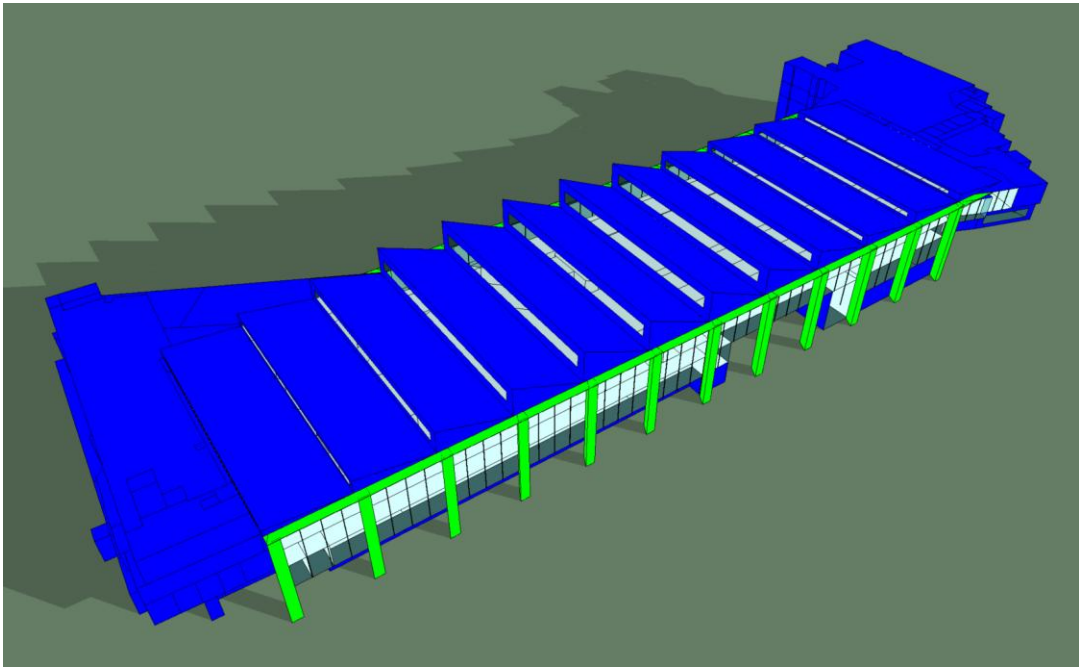
DT Validation



Data Acquisition

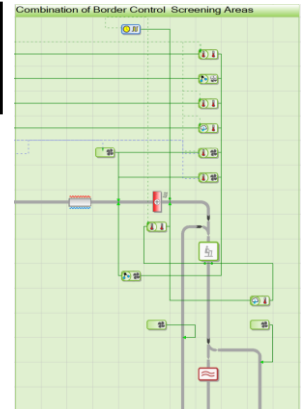
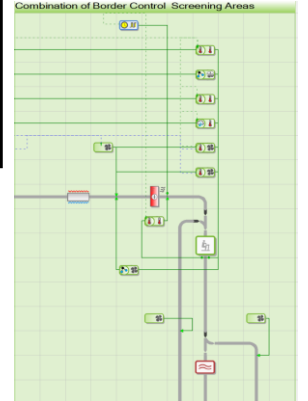
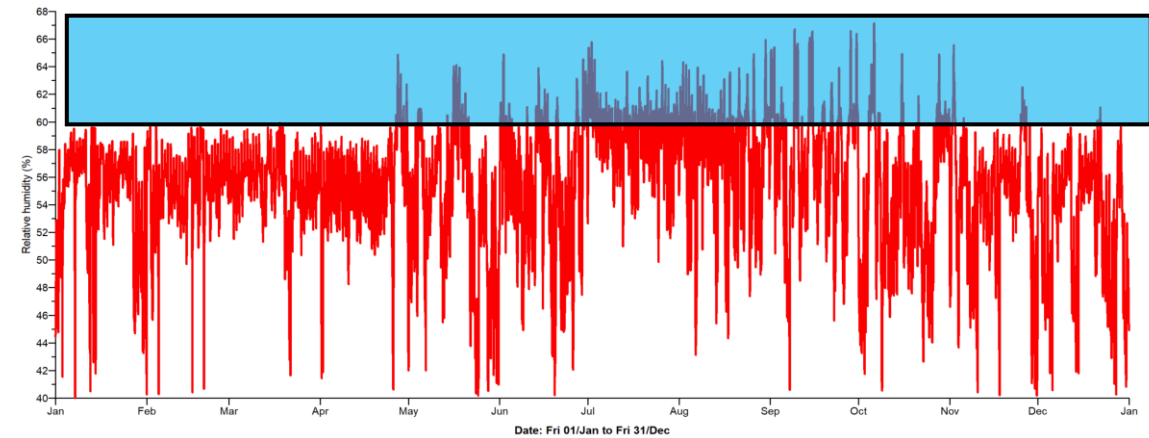
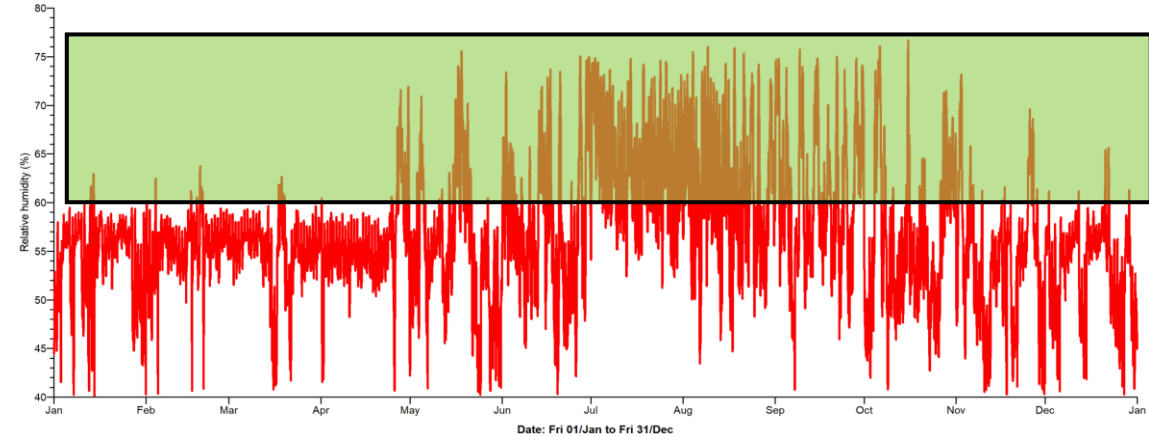
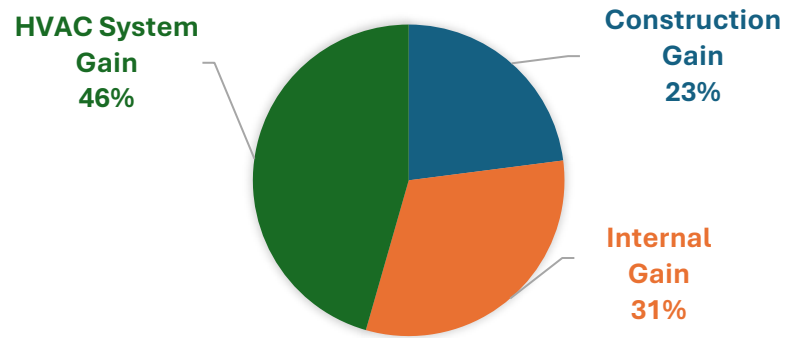
- Detailed plans
- HVAC schematics and specs
- Onsite visits
- Occupancy measurements
- Focus: Security Screening Area (high density)

DT Creation



DT Validation

COOLING LOAD DISTRIBUTION



- Potential summer peaks of RH%
- HVAC demand heavily driven by occupancy load

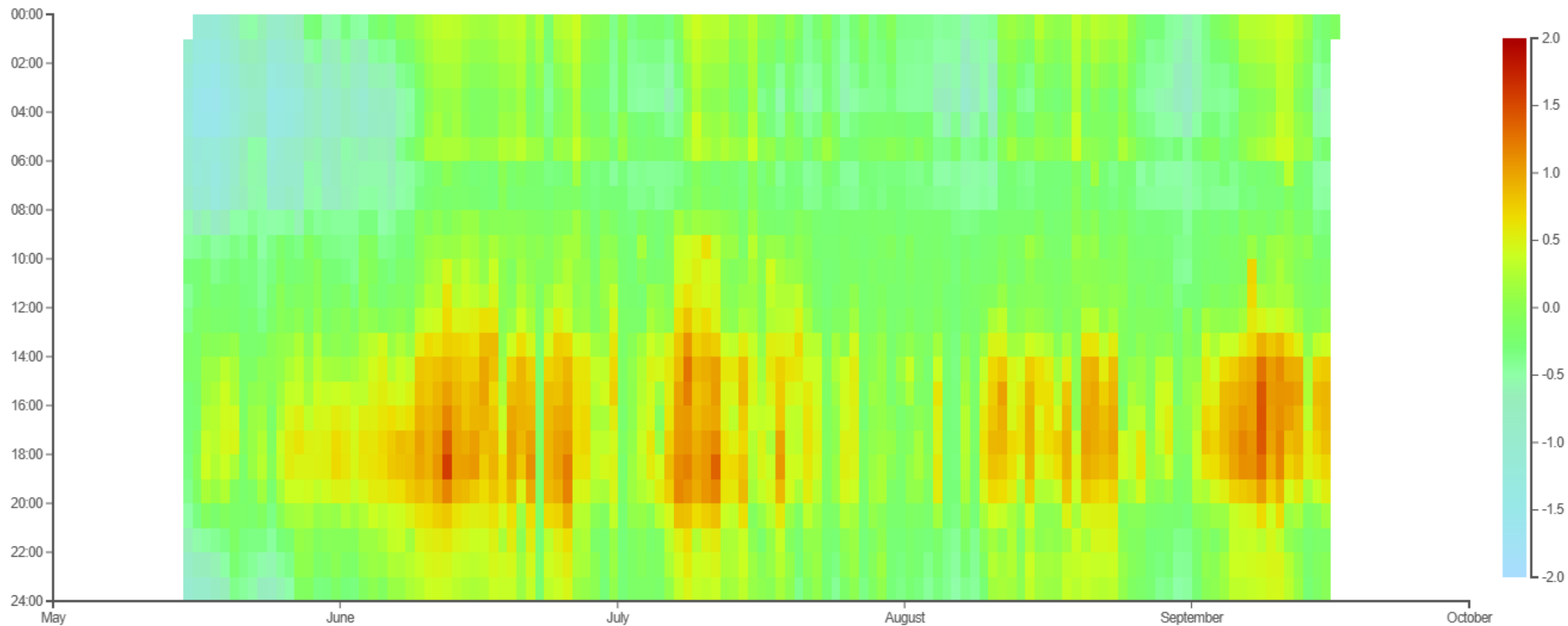
Short-Term Comfort Forecasting

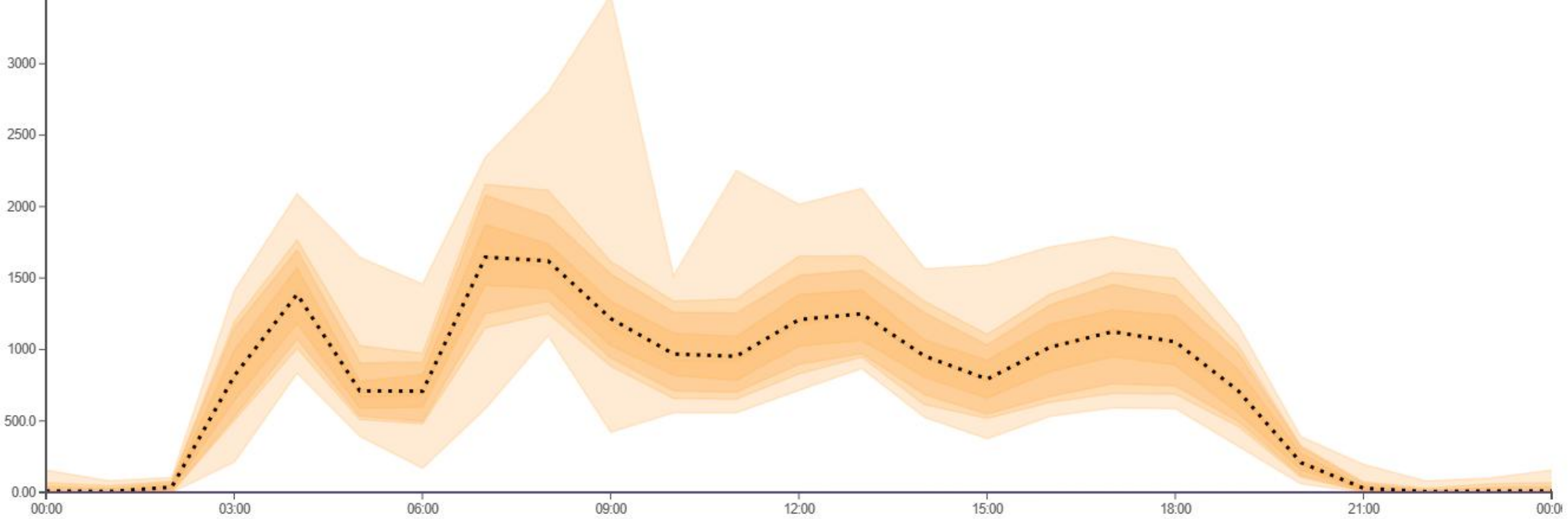
PMV Evaluation (Retroactive Validation)

Daily Simulations (from 2024)

Automated Recurring Analysis

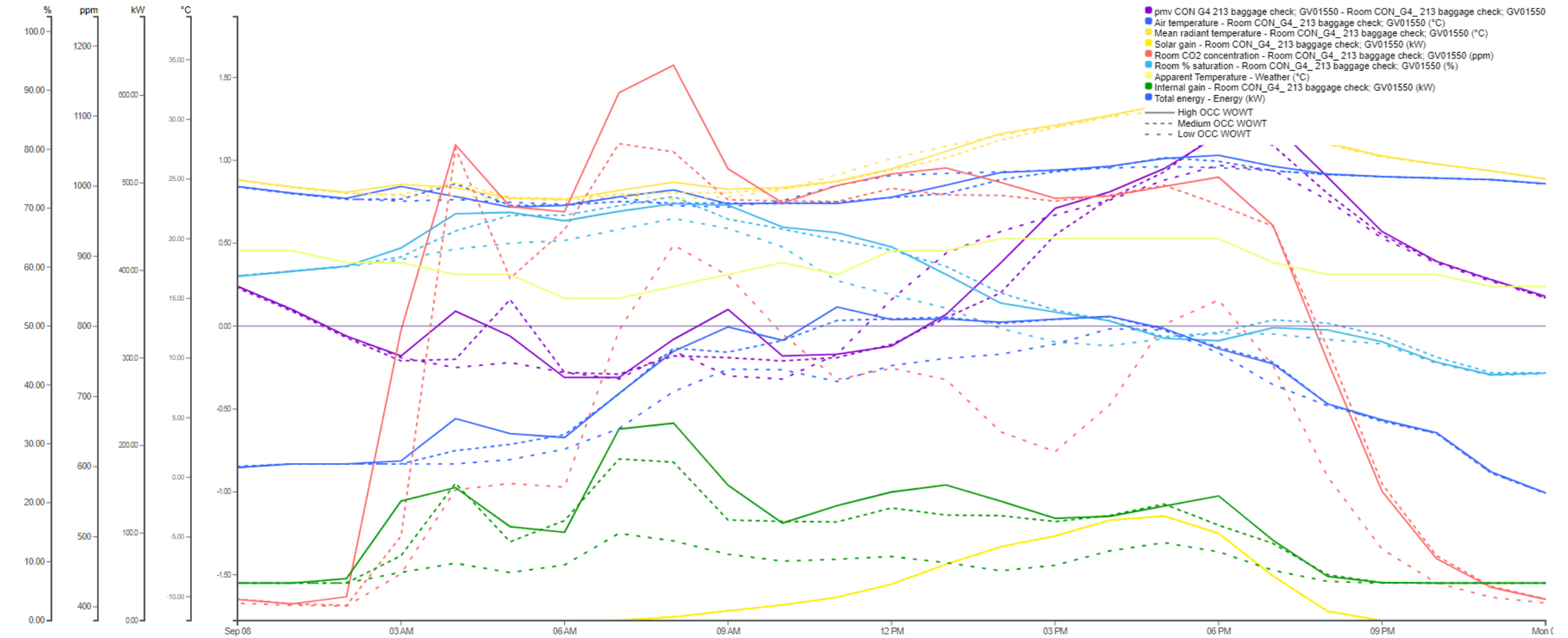
PMV Evaluation (2023 summer)





Daily Simulation

- DT runs every day using forecast weather of the next 3 days
- Output: hourly forecast indoor thermal conditions, PMV
- Three scenarios: high, med, low occupancy (based on max, avg and min of full summer of occupancy data)



Recurring Automated PMV Analysis



User Interaction

User Research

Problem Definition and Validation (the “Job to Be Done”)

Human-in-the-Loop Approach

User Experience Design

User Research

- **UX Goals**

- Understand airport staff needs regarding thermal comfort monitoring
- Design an intuitive interface to communicate comfort and related alerts
- Provide actionable insights through a dashboard and notification system

- **UX Activities**

- User Interviews & Research
- Ideation & Conceptualisation
- Design & Prototyping
- Iterative Feedback Loop with Users



The BMS Team's “Job to Be Done”

- “When I **anticipate** high occupancy loads, I want to **predict** times when occupants of my building might experience discomfort, so that I can **proactively** ensure passenger comfort.”

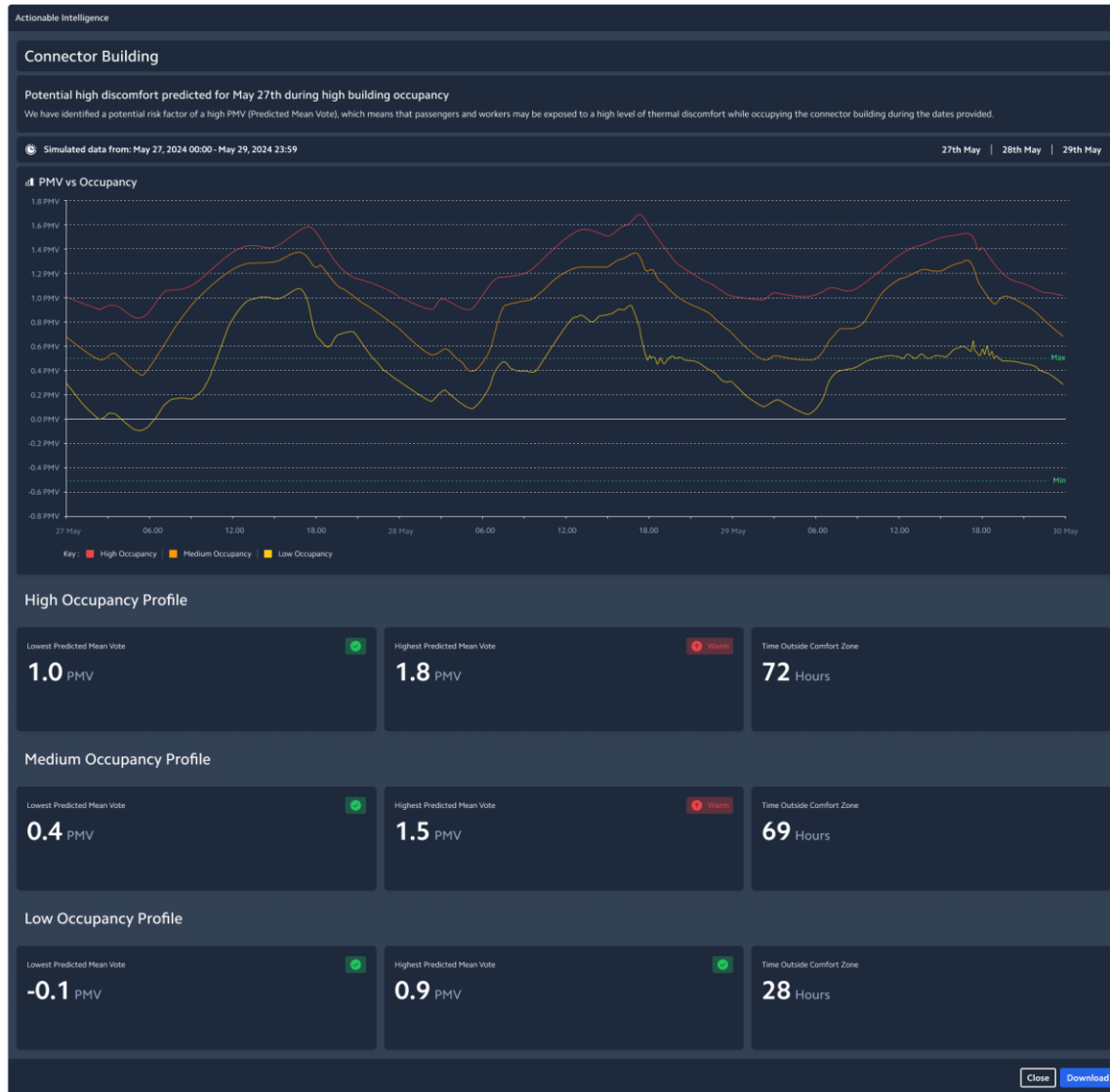
Human-in-the-Loop Approach

- A cost-effective strategy
- BMS team can be proactive



UI Design - first prototype

- How can we help the BMS Team?
 - visually represent discomfort peaks
 - analyse different occupancy scenarios
 - translate data to insights
 - provide actionable suggestions



Results

Insights and Actionable Feedback (2024 test run)

User Notification

Next Steps

Forecast Insights



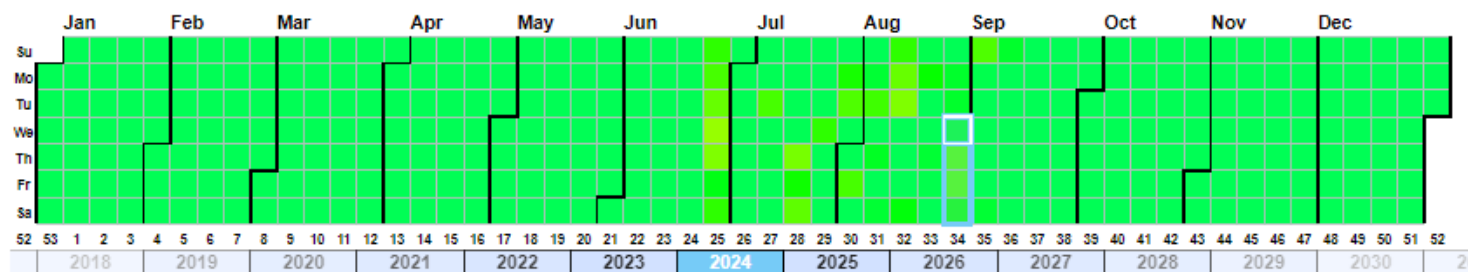
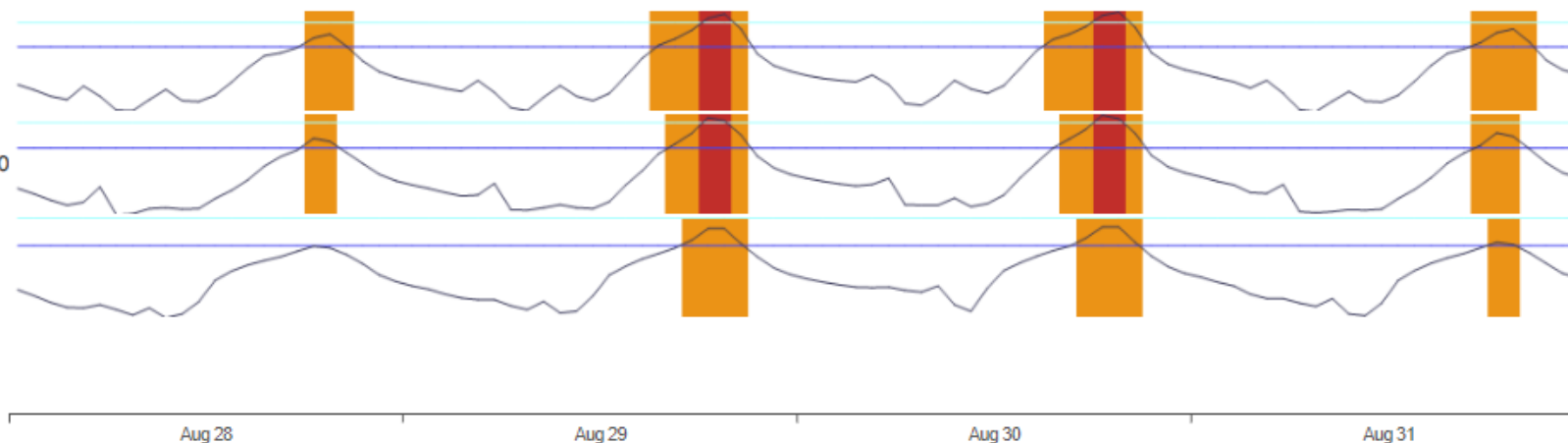
iSCAN Research Insights - Connector WOWT

Project ▾ Building ▾ Data ▾ Investigate ▾ Reports ▾

Sce_PMV_HighOcc - CON_G4_213 baggage check; GV01550

Sce_PMV_MediumOcc - CON_G4_213 baggage check; GV01550

Sce_PMV_LowOcc - CON_G4_213 baggage check; GV01550



IES

Powered
by IES Digital Twin

Projects

STARGATE

Brussels Airport

IEQ Performance

0
of 0
0%
CO2

0
of 0
0%
Temperature

0
of 0
0%
Humidity

Sensors

NO DATA

Actionable Intelligence

Potential Discomfort - Occupancy scenarios

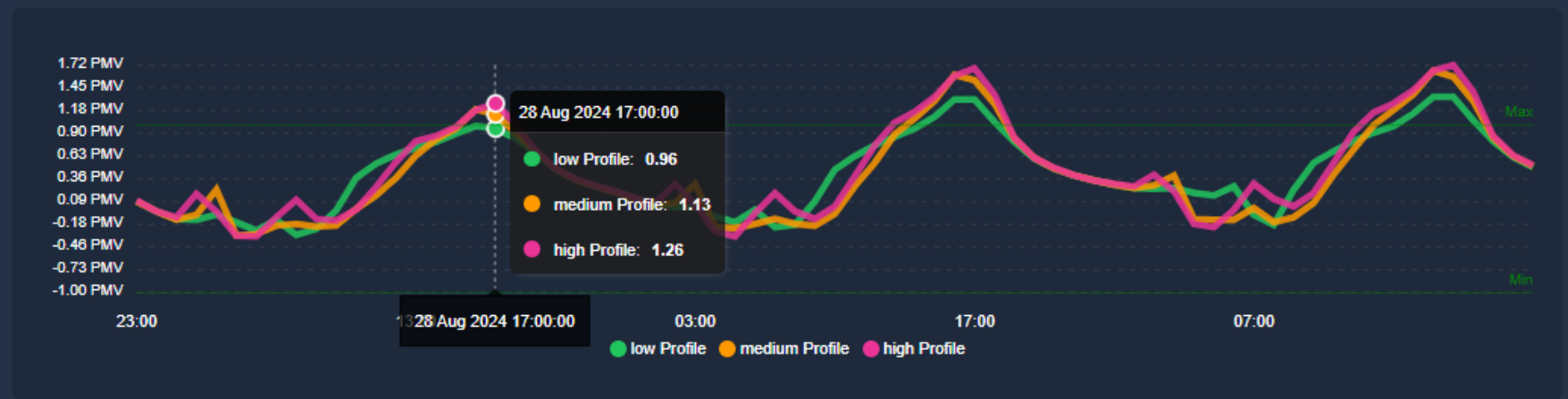
Connector Building



Potential Discomfort - Occupancy scenarios

Connector Building

We have identified potential thermal discomfort risks indicated by Predicted Mean Vote (PMV) values. These deviations from optimal PMV values suggest that the thermal environment within the Connector Building may not meet comfort standards for passengers and staff during the specified dates. We have evaluated three scenarios including high, medium and low occupancy profiles.



Action Items

- Proactive HVAC Adjustment**
Adjust HVAC settings in advance based on PMV alerts.

High Occupancy Profile

Lowest Predicted Mean Vote	-0.33 PMV	Highest Predicted Mean Vote	1.72 PMV	Time Outside Comfort Zone	15 Hours
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Medium Occupancy Profile

Lowest Predicted Mean Vote	-0.33 PMV	Highest Predicted Mean Vote	1.13 PMV	Time Outside Comfort Zone	12 Hours
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Actionable Feedback

Predicted High PMV Levels in Connector Building



To
Cc  Giulia Barbano

  Reply  Reply All  Forward 

Wed 28/08/2024 14:34

[Suggested Meetings](#)

[+ Get more add-ins](#)

Dear

I hope this message finds you well. As part of our ongoing monitoring and simulation efforts, we have identified a potential issue regarding thermal comfort in the connector building at Brussels Airport.

Forecasted Period:

Wednesday, August 28th to Friday, August 30th

Occupancy Levels:

High

PMV Levels above +1:

From 14:00 – 20:00 on Thursday August 29th, and Friday August 30th

PMV Levels above +1.5:

From 17:00 – 19:00 on Thursday August 29th, and Friday August 30th

Potential Risks:

Increased risk of passenger discomfort and dissatisfaction

Heightened likelihood of heat-related incidents, especially among vulnerable individuals

Please feel free to contact us if you need any further information or support.

User Notification (manual, during 1st run)

Next Steps

- Ongoing testing, design and feedback loop
- Connect new data & expand to other spaces (border control area)
- Automate notifications



Stargate

About the project

Stargate: Accelerating Greener Aviation



22 Partners

3 Goals



Decarbonisation



Modal Shift



Local Environmental
Quality

2021-2026

**24,8
mio**

**Grant EU
Green Deal**



**30+
Projects**



**30% Funding by
Stargate Partners**



A strong and diverse European partnership



Advisory Board:

AIRBUS



Focus on 3 pillars

- The **mission** of the STARGATE consortium is to develop, test and deploy a set of innovative solutions aimed at making the airport ecosystem significantly more sustainable.
- Our **vision** is to build with STARGATE a sustainable eco-system benchmark and be source of inspiration to other airports in Europe and the world





We need you as Stargate ambassador!



Stargate - EU Green Deal



www.greendealstargate.eu

Stay tuned and
subscribe to
our newsletter!



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement GA101037053.

