

Second Destination Earth User eXchange

CityNexus

A DestinE use case for Assessing Air Quality Impacts of Road Network, Mobility and Urban Interventions

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What is CityNexus

CityNexus is an innovative urban digital twin designed to assess the environmental, social, and economic impacts of changes in road networks, mobility, and urban spaces. It aims to evaluate baseline conditions for human mobility, including key indicators like air quality, population distribution, public health, and service accessibility.

Using advanced Artificial Intelligence and machine learning, CityNexus enables users to explore interactive 'what-if' scenarios and assess real-time impacts of interventions, such as road redesign and low-emission vehicle usage. The solution leverages explainable AI (XAI) to ensure transparency and foster policy adoption.

CityNexus leverages the DESP/DestinE system to model the impacts of interventions in road networks, mobility, and urban fabric.



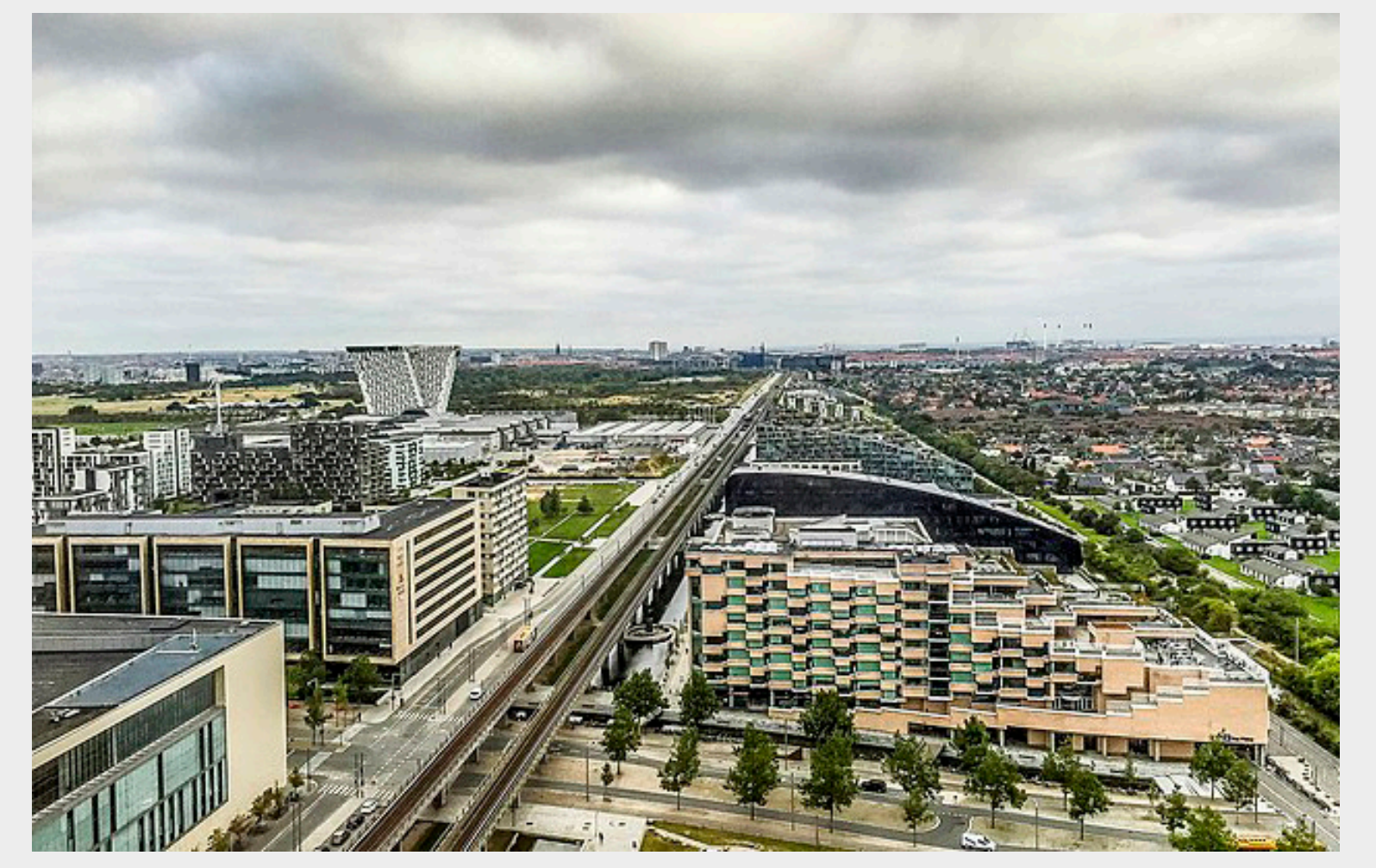
Our use case: Copenhagen and Amager Vest District

With an emphasis on environmental sustainability and urban quality of life, the City of Copenhagen aims to reduce traffic congestion and foster sustainable transportation. One initiative involves transforming high-speed thoroughfares in areas like the Amager Vest district to enhance air quality and living conditions.

CityNexus is tailored for Copenhagen but transferable to other Danish cities and aims to:

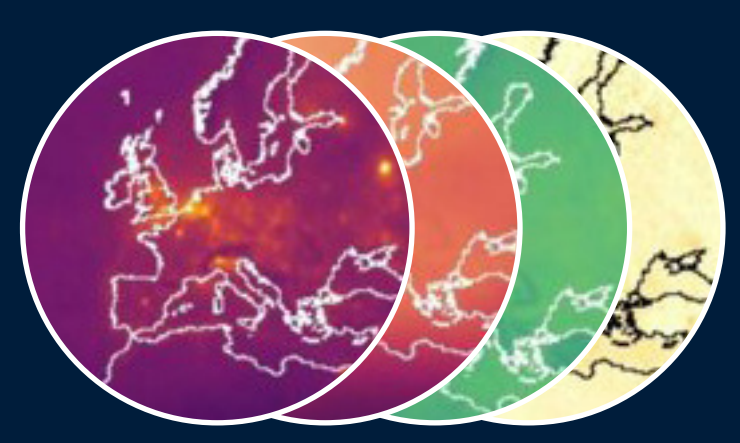
- Evaluate baseline conditions for human mobility and other key performance indicators (KPIs) such as air quality and public health.
- Provide an interactive system for assessing the impact of infrastructural changes through 'what-if' scenario simulations.

By assessing the impacts of transformation scenarios, CityNexus aspires to be a valuable tool for data-driven urban planning, promoting sustainable urban development solutions and improving quality of life for all.



INPUT DATA

DestinE Data Portfolio



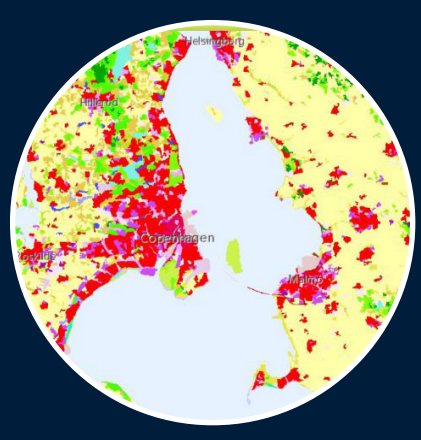
Sentinel-5P TROPOMI Level2 daily tropospheric NO₂, SO₂, CO, O₃ vertical column densities



Copernicus Digital Elevation Model of Europe available at 10m resolution



ECMWF ERA5 hourly estimates for different meteorological variables



CORINE Land Cover map available from the Copernicus Land Monitoring Service at 100m.

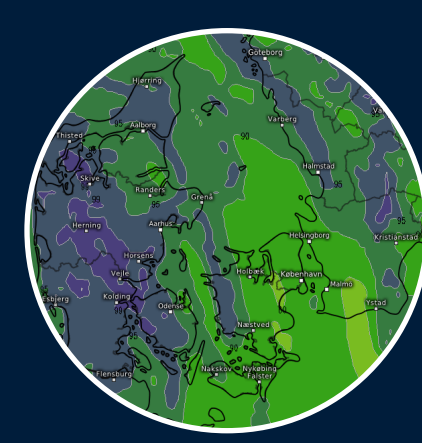
Open data



OpenStreetMap road network



Public transportation schedule



Meteorological data from ground monitoring stations



Air pollution data from ground monitoring stations



Copenhagen Air View (CAV) via Google's Environmental Insights Explorer (EIE)



Copenhagen urban trees



TNO/MACC-III regional European emission inventor



World Settlement Footprint suite (WSF)

Commercial data



High Frequency Location Based mobility data

In CityNexus, diverse datasets are curated for simulating urban scenarios. This includes data from the DestinE Data Portfolio, publicly available datasets, OpenStreetMap data, authoritative datasets and commercial human mobility patterns.

These datasets, spanning from air quality to urban infrastructure, aim to comprehensively analyze and simulate various what-if scenarios in urban planning.

The CityNexus platform



The CityNexus platform will be designed to support evidence-based decision-making at the municipality level, with a primary focus on the Copenhagen Greater Metropolitan Area.

It targets a set of KPIs addressing five different thematic areas:

- 1. Mobility patterns:** providing insights into commuting patterns, travel behavior, traffic flows, congestion rates, peak traffic hours, and overall mobility dynamics.
- 2. Air quality:** evaluating concentration of various pollutants at ground level [e.g., nitrogen dioxide (NO₂), sulfur dioxide (SO₂), carbon monoxide (CO), ozone (O₃), black carbon particles, ultra-fine particles] derived either by exploiting data gathered from mobile mapping campaigns and in-situ stations, as well as by downscaling Sentinel-5P data to 100m spatial resolution by means of a cutting-edge approach leveraging recent advances in artificial intelligence.
- 3. Dynamic population distribution:** describing the patterns of human presence over time;
- 4. Public environmental health:** assessing environmental exposure of population to air pollution and the incidence of diseases associated with exposure to different pollutants;
- 5. Service accessibility:** assessing the availability, accessibility and equity of various key urban services, such as transportation, healthcare, education, workplaces, commercial and recreational facilities.

Live 'what-if' scenario modeling



CityNexus offers dedicated functionalities for generating "what if" simulations based on four complementary transformation scenarios. Here users are given the possibility to assess the effects of different interventions on targeted KPIs and explore their compound effects in a risk-free virtual environment before real/world implementation, facilitating a coordinated approach to decision-making. These are:

- 1. High-speed Road Redesign:** this scenario allows simulating the tunneling of any existing road segment, while repurposing the reclaimed space above ground for other urban uses; this scenario reflects ongoing discussions in Amager Vest and the Copenhagen regarding the potential transformation of urban high-speed roads.
- 2. Electric, Low-Emission Vehicles and Active Mobility:** this scenario enables users to customize the proportion of these vehicles and modes within the overall traffic fleet. This scenario responds to the City of Copenhagen's efforts to promote the adoption of electric and low-emission vehicles and of active mobility options.
- 3. Low Emission Zones Creation:** this scenario will allow users to convert specific census units, neighborhoods or manually defined areas to LEZ, where motorized circulation is prohibited or limited to specific classes of vehicles. This scenario aligns with the City of Copenhagen's exploration of implementing low emission zones (LEZ).
- 4. Road Speed Adjustment:** this scenario enables adjustments to speed limits for specific road segments or entire categories of roads and reflects the concerns of Amager Vest Local Council on the impact of high traffic speed on air quality and environmental pollution.

Engaging users to shape sustainable futures

The CityNexus platform and its integrated what-if scenario capabilities will be designed responding to actual needs of the Local Council of Amager Vest and the City of Copenhagen. It offers policymakers a collaborative environment to experiment with different strategies and solutions, simultaneously consider heterogeneous factors and variables which are key to successful and sustainable urban interventions.

The creation of "what-if" scenarios as part of the digital twin model in CityNexus is a powerful tool for collaboratively envisioning and planning a sustainable urban future. By allowing users to simulate and analyze the potential impacts of different decisions and interventions in a virtual environment, it brings an interactive and participatory element to urban planning.

Beyond the immediate user community in Copenhagen, the Consortium is committed to expanding the reach of CityNexus, fostering partnerships with other local councils, municipalities, and organizations promoting sustainability.

The engagement does not stop at regional boundaries; efforts are being made to establish connections with cities involved in the EU's 100 Climate-Neutral and Smart Cities by 2030 initiative.

This multi-tiered strategy seeks to contribute to the local sustainable goals of Copenhagen and to catalyze a broader change, encouraging cities worldwide to join hands in their pursuit of sustainable urban development.



CityNexus/DESP system integration

The DESP platform aims to serve as a comprehensive hub, facilitating access to and navigation of data generated by projects, conducting simulations as requested, and effectively sharing and disseminating results. It employs an integration approach aligned with the OGC Best Practice for Earth Observation (EO) Application Packages.

The communication between clients and the platform, as well as the underlying computing infrastructure, is managed through the OGC API Processes.

The applications are packaged within containers, allowing them to be executed seamlessly across various cloud environments. These containers can be invoked using the Common Workflow Language (CWL), an open standard designed to describe analytical workflows and tools in a manner that ensures their portability and scalability across diverse software and hardware setups, ranging from individual workstations to clusters, cloud platforms, and high-performance computing (HPC) environments.

In this scenario, the DESP platform is entrusted with delivering the following services:

- Validating and accepting requests for application deployment or execution.
- Initiating the process execution on the designated processing cluster.
- Monitoring the ongoing process execution and retrieving the results.

