Grant Deliverables and Reporting Requirements for UTC Grants

UTC Project Information	
Project Title	Sustainable and Healthy Communities through Integrating Mobility Simulations in the Urban Design Process
University	Cornell University
Principal Investigator	Timur Dogan, Samitha Samaranayake
PI Contact Information	tkd9@cornell.edu 857-207-9669 ss3496@cornell.edu 607-255-5785
Funding Source(s) and Amounts Provided (by each agency or organization)	USDOT: $80,663 Cornell: $40,000
Total Project Cost	$120,663
Agency ID or Contract Number	Sponsor Source: Federal Government CFDA #: 20.701 Agreement ID: 69A3551747119
Start and End Dates	Start date: 10/01/2019 End date: 12/31/2020
Brief Description of Research Project	**PREVIOUS WORK:** With previous CTECH funding, the PIs were able to implement a proof-of-concept software tool called Urbano.io (Figure 1). Urbano automates the gathering of simulation inputs such as urban form, amenities, and population density from GIS and OpenStreetMaps and hence allows users to create complete mobility networks with a few clicks. Based on these networks, Urbano computes simple active mobility metrics such as Walkscore and Streetscore using shortest path routing (Figure 2). This work was published at SimAUD2018 [1] and generated great interest in the design community and started an in-depth collaboration with designers from Kohn Pedersen Fox Architects (KPF), a leading design firm that works on high profile national and international urban projects. Together we rigorously tested the early prototype software in a project associated with Sidewalks Labs that aims to re-develop the Toronto Waterfront. In parallel, we made significant advances with spatial outdoor comfort simulations. Figure 3 shows novel meshing techniques that accelerate annual wind simulations [2] [3]. A preliminary

validation study shows (Figure 4) how this is leveraged to compute perceived temperatures (Universal Thermal Climate Index [4]) that can be mapped spatially [5].
In general, a fast and easy to use multimodal mobility simulator is required to enable holistic mobility enabled urban design. While Urbano has been successfully used to optimize walkability in KPF projects, a number of limitations of the prototype were revealed. The most important need identified was to incorporate other travel models (such as biking, transit, and shared mobility) and a choice model to determine which modes would be used for different mobility needs. In addition, further research is needed to link the outdoor thermal microclimate with mobility simulations by adapting statistical and behavioral models from the transportation literature to incorporate street quality and comfort-aware active mobility mode choices over others. A recent study showed strong correlations between public space usage and pleasant outdoor conditions[6]. It is hence believed that thermal stress impacts active mobility mode choices as well as associated health risks during heat waves. Coupling of simulated outdoor comfort and potential heat and cold stress (exposure to pollution levels will be added later) around urban canyons with individual routing (street A over street B) and system-wide mode selection (active transportation or not) to estimate the impact of "healthy" city planning on urban energy demand as well as public health improvements.

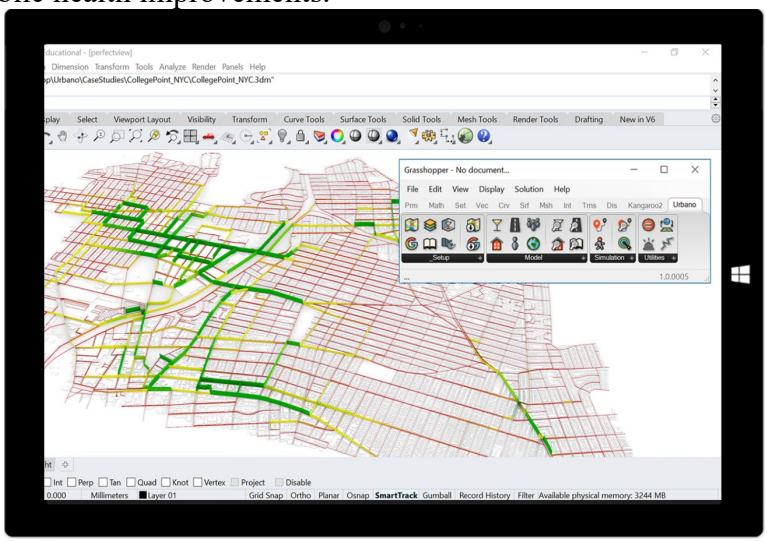


Figure 1: Proof-of-concept tool called Urbano.io

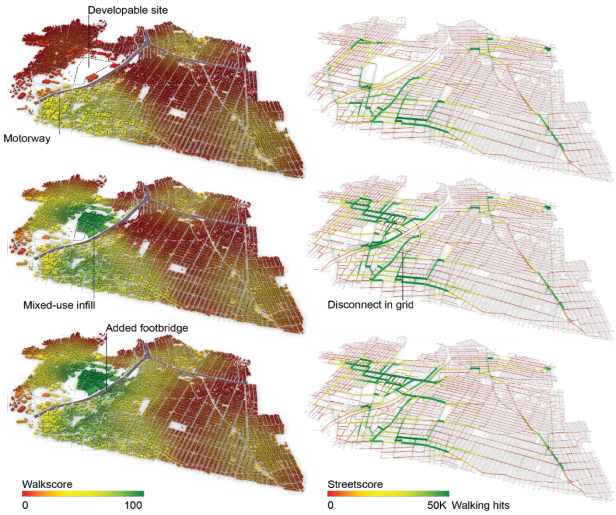


Figure 2: Walkscore and Streetscore

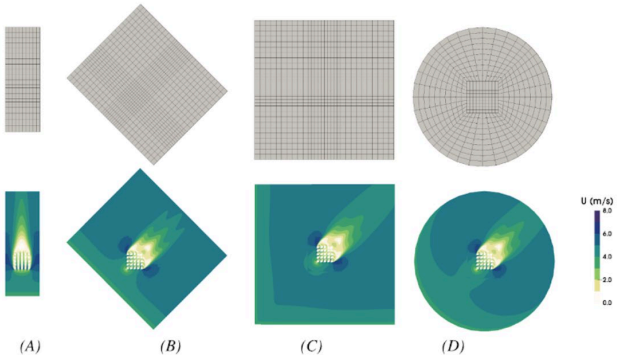


Figure 3: Cylindrical simulation domain (D) is compared against conventional meshing approaches (A-C) in an annual simulation with multiple wind directions.

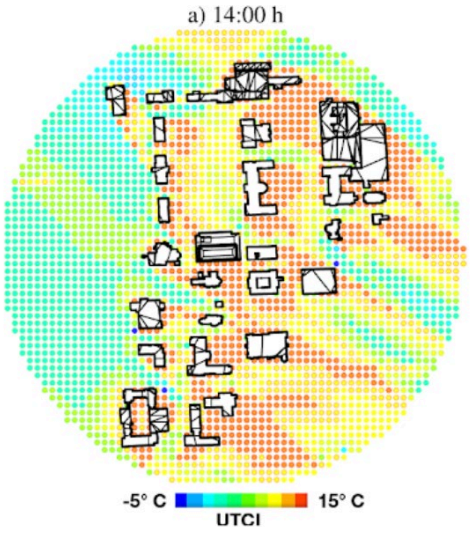


Figure 4: Simulated UTCI temperature distribution for 1h

PROPOSED RESEARCH

We aim to further develop Urbano to address the following high-level questions: How does a specific design choice influence active mobility and transit use, and what kind of health and sustainability impacts will stem from that? We identify four major novel contributions that are needed to provide actionable feedback to the designer towards creating healthier and more sustainable urban neighborhoods (e.g. designs that promote active transportation and reduce personal vehicle trips):

1. Integration of different mobility modes including bikes, on-demand services, transit, taxi. (WIP).
2. Validation of outdoor comfort simulations using field measurements in Ithaca[5] (WIP) and NYC (New).
3. Adapting statistical and behavioral models from the transportation literature to incorporate street quality and comfort-aware active mobility mode choices over others (New).
4. Validation and training of the above models using existing mode choice models, NYC open data, historic weather in conjunction (New).
5. Development of high-level metrics that predict mobility related public health, economic, environmental, and energy parameters for urban design proposals: Mobility (Vehicle miles, walkability), public health (daily activity), economic (amenity utilization), environmental (energy and carbon footprint) and social (street segment, park and public space utilization). The details of the metric system will be developed in close collaboration with urban designers at KPF and the NYC Department of City Planning to capture the insight of major stakeholders in urban design projects (New).

ANTICIPATED IMPACT

The proposed research will make the following contributions:
Facilitate the design of healthy and sustainable cities: This research will significantly advance our understanding of the mobility systems during the urban design process through user-friendly computational modeling, visualization interfaces that can cope with spatial and temporal data sets. Implementation in Rhino3D provides increased accessibility to optimization and machine learning workflows for designers. Given the enormous construction and planning efforts needed in light of urbanization and population growth, the potential impact of the proposed tool that facilitates the design of better urban environments is significant if widely adopted.

	Improved STEM Education: This research will grow the scientific workforce capable of studying and managing mobility systems as it lowers the barrier of entry to complex simulations. Urbano is used in classes taught at AAP. **Collaboration with design practitioners:** This research aims to yield directly applicable results and hence closely collaborates with design practitioners to solicit their feedback and to test research outcomes on real-world projects and problems. The KPF and Cornell collaboration lead to several implementations of Urban in design and a joint project conducted with Sidewalk Labs in Toronto. We aim to expand collaborations with others after our public release of the software this summer. **METRICS OF SUCCESS** **Research publications:** We expect to make important contributions to the literature by developing a new design framework that can incorporate public health and environmental impact factors related to mobility into the urban design process. We expect to publish these results in Journals such as TAD the Journal of Technology, Architecture, and Design, Building Research Information and the Journal of Urban Design. **Education:** The project tools will also be incorporated into a design studio course at Cornell to teach and engage students in such design co-optimization frameworks to obtain feedback regarding ease of use and applicability in design. Impact on the new UrbanTECH hub in NYC is anticipated. **Industry adoption / Tech Transfer:** The PIs believe that a very important metric for success in this particular project is the adoption of the tools by urban designers. Thus, a key objective is to showcase the applicability by incorporating our tools into a design project with KPF as a proof of concept. The direct application in "real-world" projects with a leading industry partner represents a unique opportunity to create precedents that others may follow. We anticipate reaching 500-1000 users in leading architectural and urban design practices, engineering and consulting firms as well as students from other universities where Urbano will be leveraged as a teaching tool until the end of the project within a year after the public release of the software. **Product Development / Commercialization:** If successful, the project will develop a new design toolkit that will enable a more efficient and effective design process, while taking into account urban mobility. Thus, this toolkit presents the opportunity for a new IP that may be commercialized. Dogan already has a track record of commercializing previous research (Solemma.com).

REFERENCES

1. Dogan T, Samaranayake S, Saraf N. Urbano: A new tool to promote mobility-aware urban design, active transportation modeling and access analysis for amenities and public transport. Delft, Netherlands, 2018.
2. Kastner P, Dogan T. Optimization of meshing methodologies for annual urban CFD simulations. In: ESIM Canada 2018. Montreal, Canada: IBPSA Canada, 2018.
3. Kastner P, Dogan T. A Cylindrical Meshing Methodology for Annual Urban Computational Fluid Dynamics Simulations for the Built Environment. Journal of Building Performance Simulation.
4. Jendritzky G, de Dear R, Havenith G. UTCI—Why another thermal index? International Journal of Biometeorology 2012; 56: 421–428.
5. Kastner P, Dogan T. Towards High-Resolution Annual Outdoor Thermal Comfort Mapping In Urban Design. Rome, Italy, 2019.
6. Reinhart CF, Dhariwal J, Gero K. Biometeorological indices explain outside dwelling patterns based on Wi-Fi data in support of sustainable urban planning. Building and Environment 2017; 126: 422–430.

Describe Implementation of Research Outcomes (or why not implemented)

Place Any Photos Here

We finalized our simulation models for outdoor thermal comfort and developed a new algorithm that allows us to scale these simulations to urban scale applications. We further validated these simulation algorithms using four microclimate data loggers that we installed in four locations on campus [Figure 1].

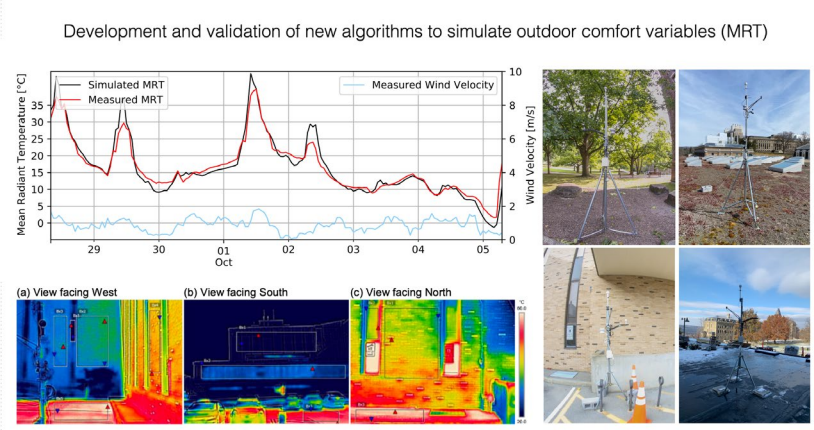
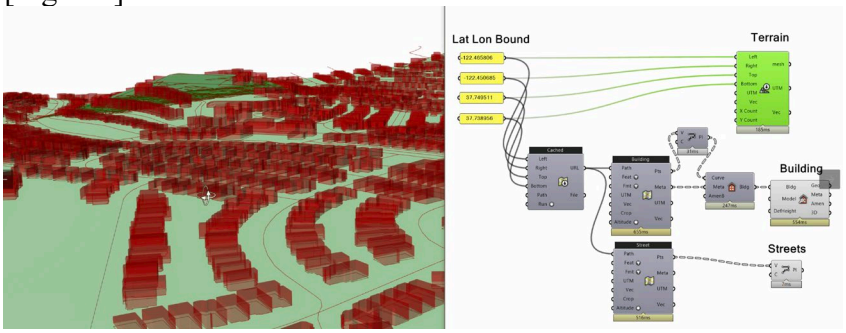


Figure 1: Measured and simulated mean radiant temperature and wind velocity for the use in the Universal Thermal Comfort Index (UTCI) model.

	We further development high-level metrics that predict mobility related public health, economic, environmental, and energy parameters for urban design proposals: Mobility (Vehicle miles, walkability), public health (daily activity), economic (amenity utilization), environmental (energy and carbon footprint) and social (street segment, park and public space utilization). These metrics can be computed with the latest version of Urbano [Figure2].  *Figure 2: Screenshot of Urbano 1.3. showing how to load OSM and terrain data for walkability analysis.*
Impacts/Benefits of Implementation (actual, not anticipated)	Urbano.io version 1.3.2 has been released publicly on Food4Rhino.com and www.Urbano.io and has been downloaded over 4000 times. Urbano users are affiliated with leading Architecture, Engineering and Construction (AEC) industry such as AECOM, KPF, Miller Hull, Ramboll, Buro Happold, Henning Larsen, Transsolar, Perkins+Will, Graphisoft, SOM, HKS, LINK, and AS+P. Further, Urbano is being used in leading academic institutions for research and teaching including Cornell, MIT, Harvard GSD, Carnegie Mellon, Columbia, TU Delft, TU Berlin, Technion, University of New South Wales, Polytechnico Milano and many more. Recently also planners that are affiliated with municipalities joined user group such as City of Calgary, NYC Department of Transportation. KPF leveraged Urbano.io in a COVID-19 web tool for sidewalk crowding prediction. https://medium.com/@kpfui/sidewalk-crowding-in-the-age-of-covid-19-3ca9d20039a7 In the light of the current COVID-19 crisis, Prof. Nathaniel Hupert from Weill Cornell Medicine and I initiated a new funded collaboration at the nexus of urban mobility design and epidemiology. This study leverages Urbano.io to investigate how urban design attributes like density, housing typology, demographic and programmatic mix, mobility infrastructure, walkability, and bike-ability relate to epidemics.

Web Links • Reports • Project website	https://urbano.io/ https://medium.com/@kpfui/sidewalk-crowding-in-the-age-of-covid-19-3ca9d20039a7 http://ctech.cee.cornell.edu/final-project-reports/