Chapter 2

Public Realm

Design an outdoor comfort system for all seasons

Even when the conditions are right to promote a vibrant ground floor, the weather plays a big role in determining how much time people spend outdoors. While the seasons drive the character of public life in Toronto — from summer day trips to the Islands, to fall pumpkin parades across the city — it is no secret that outdoor activity is concentrated in the six-month period from late April through October, when the weather is pleasant.

For centuries, cities have used architecture to moderate the weather and keep public life active on the street. In the late 1800s, as historical photographs show, Toronto was filled with a maze of awnings that extended from storefronts and glass arcades to cover alleyways, providing protection from the sun, snow, and rain.

This approach of mitigating outdoor weather changed in the 20th century, as technologies like central heating and air-conditioning shifted activity indoors to climate-controlled, sealed environments. In Toronto, from November through April, the underground PATH network is the centre of gravity for commuting, and the home is the centre of gravity for social activity. Popular outdoor hangouts like Queen West and Trinity Bellwoods quiet down.

That effect is particularly noticeable on the waterfront, which is uniquely exposed to chilly winds. Using climate data collected at Billy Bishop Airport and a standard metric called the Universal Thermal Climate Index, Sidewalk Labs calculated that the waterfront is only comfortable, on average, for 30 percent of the year. The rest of the year is either too hot (29 percent), too cold (37 percent), or too wet (4 percent).[53]

Toronto's waterfront does not have to hibernate, because the capabilities exist to help streets and outdoor space retain their vitality year round. After analyzing climate data and studying how it impacts street grids and buildings, Sidewalk Labs has developed a replicable system of weather-mitigation tools and architectural interventions that could help dramatically increase outdoor comfort. This system would leverage the latest advances in lightweight material technology, and could respond in real time to changing weather.

Systematically applied in Quayside, this approach to weather mitigation would increase the hours it is comfortable to be outdoors by 35 percent, drawing more people into public spaces, together.

Implemented at the full scale of the IDEA District, this approach could go even further, potentially doubling the number of hours it is comfortable to be outdoors each year for key spaces.[54]

Quayside impact

Weather-mitigation tools create 572 more comfortable hours outdoors

Figure 1.
Typical development: Comfortable hours outdoors

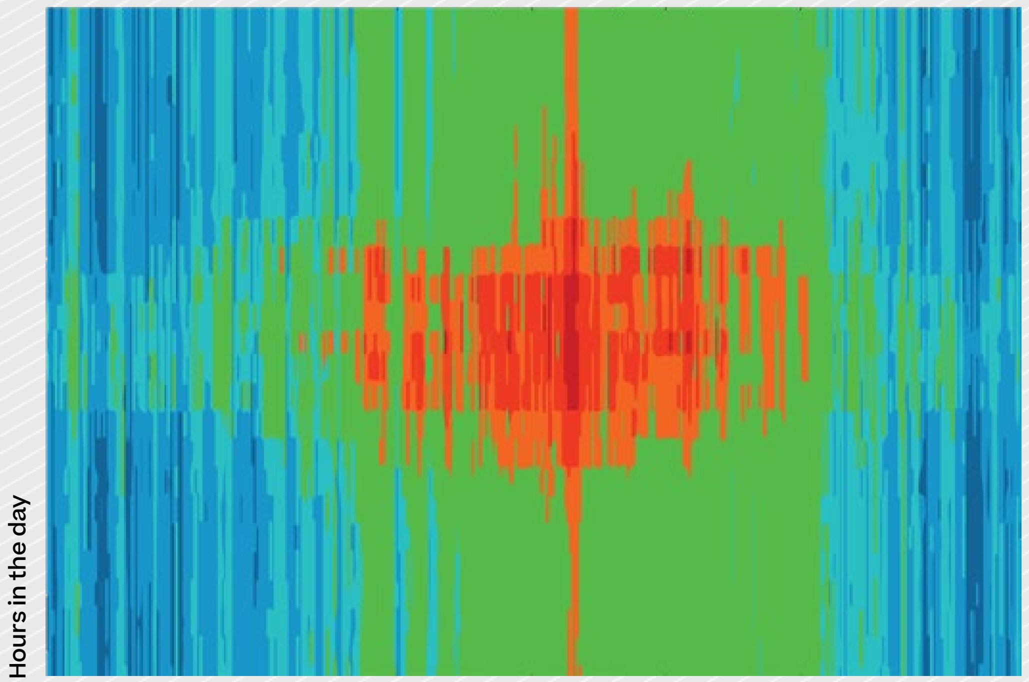


Figure 2.
Sidewalk Labs: Comfortable hours outdoors

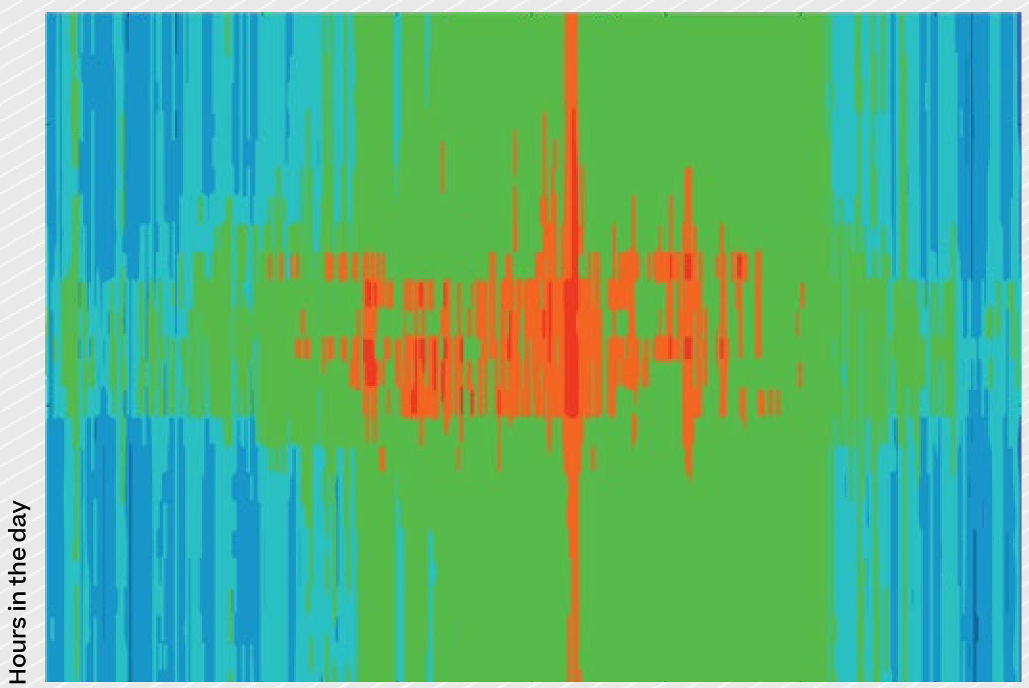


Figure 1 shows baseline outdoor comfort levels for Quayside, based on the Universal Thermal Climate Index. Red areas indicate times when it is uncomfortable to be outside because it is too hot, blue areas show when it is too cold. Green represents times that are comfortable. Because microclimates are complex and dynamic, this methodology focuses on improving comfort in key locations within a neighbourhood, such as pedestrian walkways, plazas, and parks. The metrics in this chart refer to these locations.

Figure 2 shows outdoor comfort levels for Quayside with planned outdoor comfort interventions applied to the neighbourhood site plan. Relative to a typical development on the waterfront, which is comfortable outdoors for 1,653 daylight hours per year, Sidewalk Labs' proposed suite of weather-mitigation tools would make Quayside comfortable for 2,225 hours — an increase of 572 hours, or 35 percent.[55]

Key

- Very strong heat stress
- Strong heat stress
- Moderate heat stress
- No thermal stress
- Slight cold stress
- Moderate cold stress
- Strong cold stress

This increase would be possible thanks to the impact of optimizing the street grid and building massings over a large area. And because the system's core components are modular, it could be replicated in other areas of the city — or adjusted to different climates in other parts of the world.

Partnering to develop a data-driven design approach

Designing for outdoor comfort requires studying an area's "microclimate." Microclimate refers to the weather patterns of a very specific geography. In an urban context, that could be down to the level of an individual street or plaza. It looks at factors like sunshine, temperature, humidity, precipitation, and wind chill — all of which are measured on the Universal Thermal Climate Index.

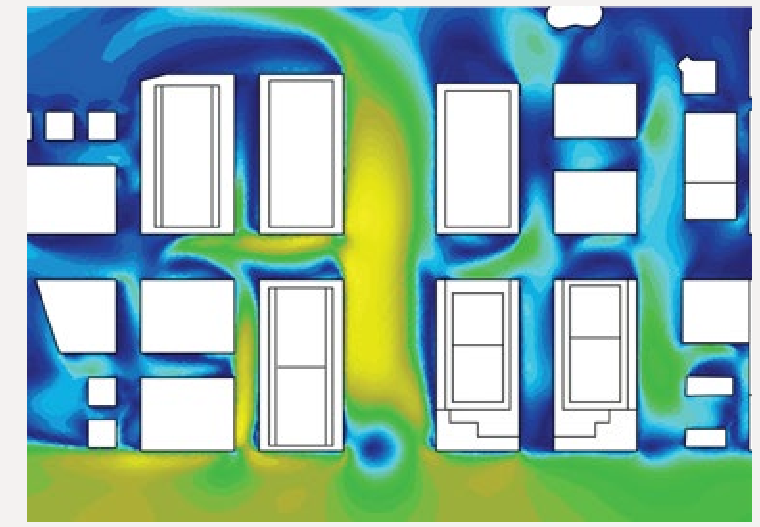
Precision is important when it comes to designing for comfort, because every nook of a city has its own conditions. One street might be in the shade and afflicted by a vicious windtunnel, whereas the next might be flooded with daylight and have only a pleasant breeze. The difference between these two spaces stems from planning and architecture choices, not inherent qualities of weather patterns.

To create a system that proactively predicts and plans for outdoor comfort, Sidewalk Labs worked in close collaboration with multiple partners. RWDI, a team of Toronto-based climate engineers, ran climate analyses for Quayside and the full IDEA District. They collaborated with PARTISANS, a Toronto architecture firm with expertise in new materials and tensile structures, to help iterate on architectural interventions in response to climate data.

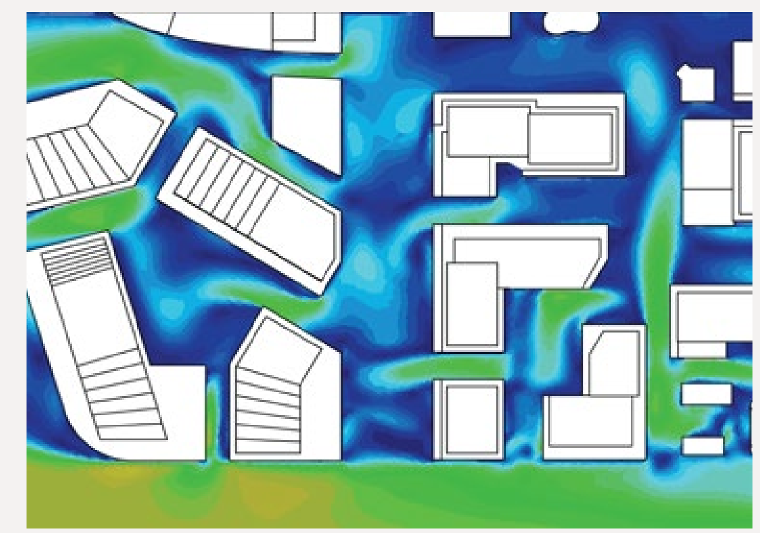
The first step in this joint exercise was to look at the street grid and building masses, and tailor each for wind protection and optimized solar gain. For example, on Cherry Street, adjusting the building facade reduced wind speeds by an average of 35 to 45 percent, and up to 80 percent in certain areas.[56]

Villiers Island: Adjustments to massing can reduce wind speeds and increase outdoor comfort

Precinct plan:
Villiers massing and wind speed



Sidewalk Labs-adjusted:
Villiers massing and wind speed



At Cherry Street, creating slanted building facades reduces wind speed. In the top diagram, the yellow areas represent wind tunnels; in the bottom diagram, those tunnels have been eliminated through the facade adjustment.

Key

- High winds (~4+ m/s)
- Moderate winds (~2-4 m/s)
- Low winds (~0-2 m/s)

(Wind velocity in metres per second)

Creating a core set of weather interventions: Raincoat, Fanshell, Lantern Forest

Next, to achieve an even higher level of comfort, the partners developed a toolkit to address microclimates in and around common urban environments planned for the waterfront. Three prototypical architectural interventions formed an initial set of tools that designers could adapt and recombine to meet the outdoor comfort targets of a specific site: a Raincoat for the building's edge, a Fanshell for open spaces, and a Lantern Forest for urban canyons (spaces between buildings).

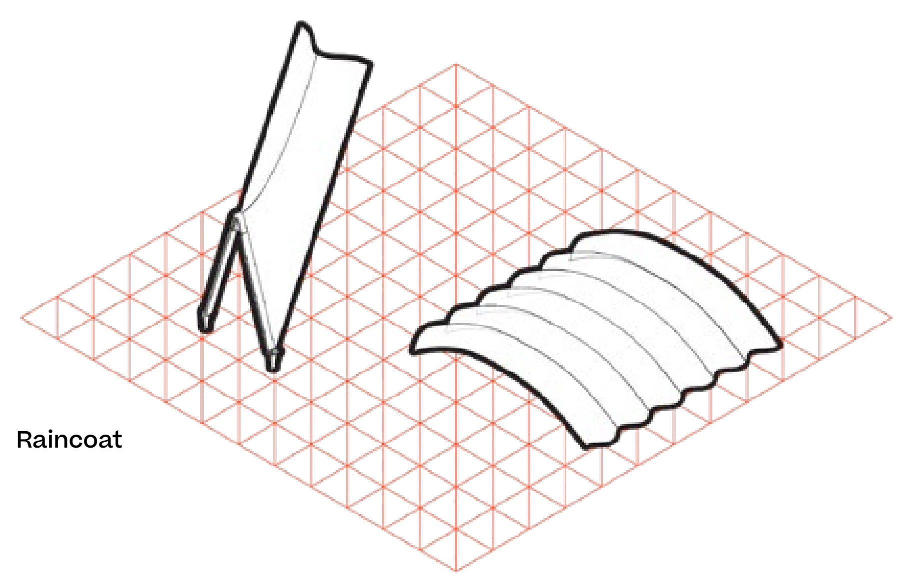
For the Sidewalk Toronto project, these interventions could be installed, managed, and secured through the joint efforts of the ground-floor operator and the Open Space Alliance, a new public realm non-profit entity described on Page 178.

Sidewalk Labs is currently testing these interventions through full-scale prototypes at its Toronto office, 307, which will provide a baseline to evaluate fabrication, installation, maintenance, durability, and comfort performance over the coming months. Design and fabrication partners will provide input on the structure, materials, and costing, and RWDI will measure the comfort performance through the collection of meteorological data around the prototypes.

Sidewalk Labs plans to work with local regulators to ensure AODA compliance for these systems, building on best practices for indicating low clearance zones with tactile cues, and to gain support for pilots in areas where a system (such as the Raincoat) would extend into the right of way.

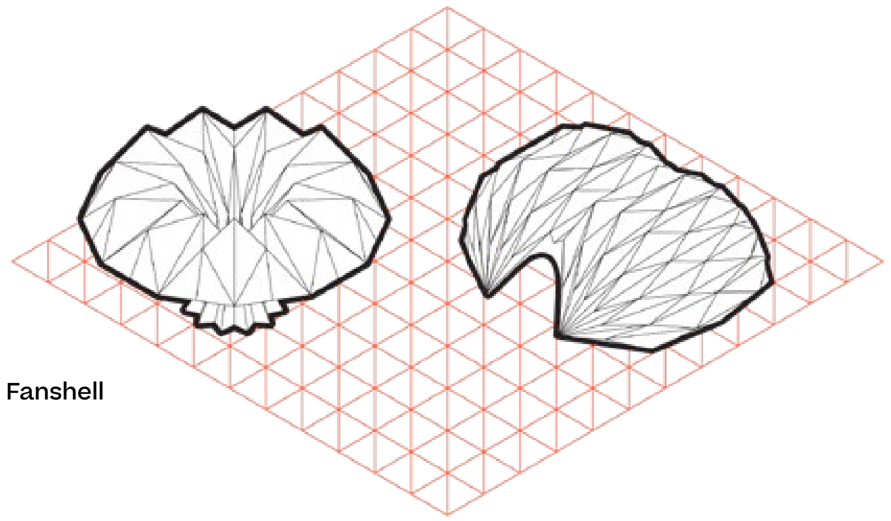
The outdoor comfort system would leverage the latest advances in lightweight material technology, and could respond in real time to changing weather.

The Raincoat extends a building's edge to protect the sidewalk from rain, wind, and sun.



Raincoat

The Raincoat consists of an adjustable awning or "second skin" that could extend outward from a building's edge to protect the sidewalk from rain, wind, and sun. It could attach to one side of a building and anchor into piles beneath the street pavers, or it could be applied as a retractable canopy, spanning from building to building. In that sense, the Raincoat follows the grand tradition of shop awnings, fixed arcades, colonnades, and other installations that help integrate street life into the ground floor of buildings — albeit with a greater capacity to adjust to outdoor conditions. Unlike awnings, the Raincoat is able to more effectively block wind, and change its transparency to allow in more sunlight on cold days and less on warm days.



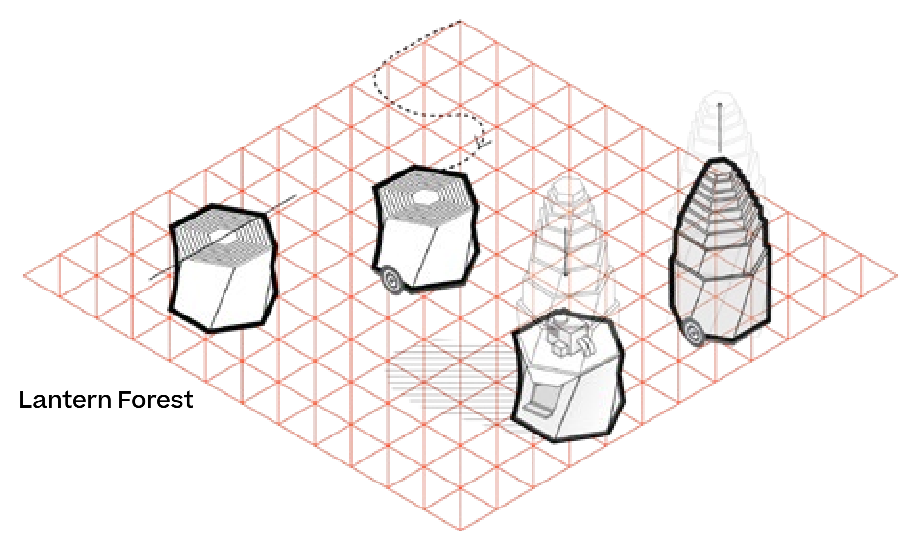
Fanshell

The Fanshell is a collection of large, temporary urban shelters that could provide outdoor comfort in open spaces, such as Silo Park. The system includes two distinct shelter types: the Shell type, a more enclosed system that protects from wind, rain, and sun, and the Fan type, a more open, umbrella-like covering that protects from sun and rain. Both types cover 80 square metres, can accommodate free-standing heaters, and have the capacity to shelter up to 100 people. Both types also employ an origami-style folded fabric construction, which allows them to achieve wide spans, deploy easily and quickly, and be packed flat and stored more easily than a tent.

The Fanshell provides open-space coverage for up to 100 people.

The Lantern Forest mitigates wind tunnels that form between buildings.

The Lantern Forest represents a collection of lightweight, tall, narrow structures that could create shelter from wind when grouped together on the ground (almost like a stand of trees), or when hung together from buildings (like paper lanterns). The Lantern Forest would help address the challenge of wind tunnels that form in the spaces between buildings, often called urban canyons. The structures, which could reach eight metres tall, could be useful in many different conditions: a few Lanterns could be placed along lanes, alleyways, and streets; a flock of Lanterns could be placed in larger open areas. The inside could be inhabited by a few people at once in a variety of ways, from kiosks for vendors to warming stations, and could be secured or collapsed during off hours.



Lantern Forest

ETFE is a lightweight plastic building material that can adjust its transparency in response to weather patterns. It is becoming increasingly popular for entertainment venues, such as The Shed at Hudson Yards in New York City, which opened in April 2019. Credit: Brett Beyer

Materials.

Across the outdoor comfort system, Sidewalk Labs plans to leverage the building material Composite ETFE (Ethylene Tetrafluoroethylene), a durable, highly transparent, lightweight plastic film. ETFE provides transparency without the heavy and expensive structure required to support glass, and is uniquely customizable through printed patterns that can control light and opacity.[57]

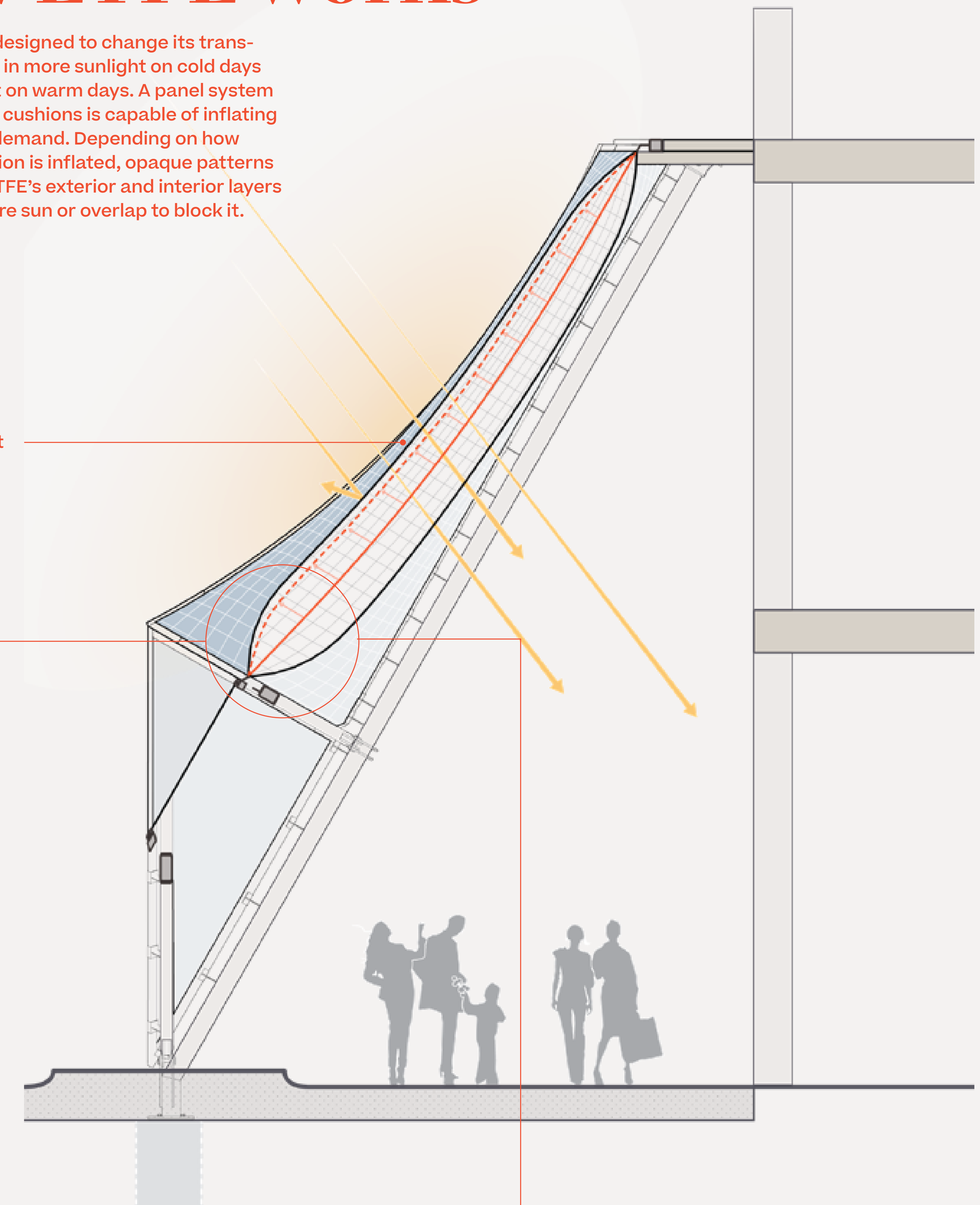
ETFE gained popularity as a building material around the turn of the 21st century, and it is now commonly used in venues like sports and entertainment stadia. As its use increased, a panel system of air-filled ETFE cushions was developed to improve energy performance.
Each cushion is capable of inflating or deflating on-demand. Depending on how much the cushion is inflated, opaque patterns printed on the film layers align to let in more sun or overlap to block it.

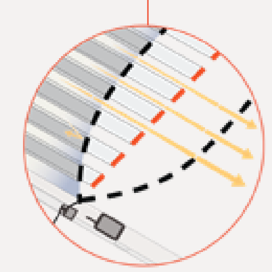
Today, ETFE panels are often applied on one-off projects — such as The Shed in New York City — but they are rarely used systematically as a building material across a neighbourhood. To Sidewalk Labs' knowledge, the Raincoat prototype at 307 is the first use of ETFE as a building material in Ontario.

Sidewalk Labs estimates that maturing the raincoat technology and installing Raincoats at multiple locations within Quayside would lead to a 71 percent cost reduction per installation (relative to the prototype). There should be an even greater drop in expenses per square foot at the scale of the full IDEA District. This scale also affords a great opportunity to explore diverse architectural expressions.

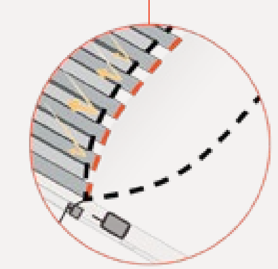
How ETFE works

The Raincoat is designed to change its transparency to allow in more sunlight on cold days and less sunlight on warm days. A panel system of air-filled ETFE cushions is capable of inflating or deflating on-demand. Depending on how much each cushion is inflated, opaque patterns printed on the ETFE's exterior and interior layers align to let in more sun or overlap to block it.





Scenario 1:
Opaque patterns printed on the exterior (shown in blue) and interior (in red) layers of ETFE film are aligned, allowing more sunlight to pass through.



Scenario 2:
As the pressure in the air cushion is adjusted, the internal layer (in red) shifts to cover more surface area and therefore block sun with its opaque pattern.

Environmental sensing.
Another key feature of the outdoor comfort system is an embedded network of microclimate measurement instruments, including wind anemometers, thermometers, and sunlight and rain detectors.

Many of these (non-personal) sensors have dropped dramatically in price over the last 10 years, and can now share information digitally rather than through cumbersome manual transfers.[58] While a wind anemometer may not seem innovative, the integration of many local sensors with a predictive and responsive weather-mitigation system is new.

To ensure real-time deployment, these sensors would gather daily data at key distribution points, such as on building rooftops and around Raincoat canopies, and would be capable of communicating live with the comfort system — for example, telling a set of Raincoat canopies to open in advance of rain, or providing instructions for the placement of Lanterns in response to wind patterns. This network could be further enhanced with computational weather-prediction systems to provide an extra layer of resilience and climate responsiveness to neighbourhoods and cities. The ground floor operator could use this data to make decisions regarding frequency of Raincoat deployment, and the Open Space Alliance could play a similar role for Fanshells and Lanterns.

For more on the proposed use of data in public spaces, see the "Digital Innovation" chapter of Volume 2, on Page 374.

Deployment.
Each structure in the outdoor comfort system intervention would be light and collapsible. The structures would all be capable of attaching to building facades or plugging into power and data outlets located at grade or on buildings. These features create a system that could be quickly deployed, moved, taken down, and stored. As kinetic technologies and autonomous delivery systems evolve, Sidewalk Labs anticipates that the set-up, take-down, and delivery of these structures could become increasingly automated.

For example, each Lantern would include a mobile base that could serve as a kiosk — similar to those used by street vendors today — as well as a roof structure that could expand to provide wind protection. The roof structures could be placed atop each kiosk, collapsed when the kiosk is moved or stored, and extended upwards to create progressively larger wind breaks when the kiosks are deployed. Alternatively, the Lantern roofs could be hung between two buildings on a catenary wire (included in the design of the street), keeping the ground free until their programing is needed. Some Lanterns could be leased by vendors, while others could be requested for special events.

Weather-mitigation tools can increase comfortable hours by at least
35%
annually in Quayside.

Scaling.
The outdoor comfort system's modularity would enable it to accommodate a wide range of community activities and needs.

For example, the Fanshell system is designed to provide large urban canopies that could be reserved and used for things like social events, art installations, and cultural gatherings. The coverage that each Fanshell provides could grow by placing additional Fanshells side-by-side: one Fanshell might be enough to provide shade for a family barbecue, while multiple Fanshells might help an arts organization put on a festival during a rainy spring day. Reservations and requests could be managed through a digital booking system, and two-to-four trained installers could deploy each Fanshell in a matter of hours — making this system much more agile than current rental tents, which require a large crew for setup sometimes a day or more in advance.[59]

Adaptability.
Each aspect of the system features adaptable materials and components that would respond to microclimate data in different ways.

For example, the Raincoat's ETFE panels have a sensitive exterior cushion that could respond to sunlight by inflating (creating more shade) or deflating (letting in more light). This adaptability would help the Raincoat protect ground-floor space from summer heat; it also would enable the system to transition easily between daytime and nighttime activities, as temperatures and light patterns change. Furthermore, the Raincoat could cover plazas and narrow streets, providing on-demand shelter for pedestrians.

Cost-Benefit.
The cost to build this outdoor comfort toolkit ranges from $500 to $2,100 per square metre, depending on the module.[60] Sidewalk Labs expects further cost declines as technology advances and the markets for new materials grow. The price of ETFE has already dropped significantly in the past decade, as it is used in solar panels and has benefited from economies of scale related to the growth of the renewable energy industry.[61]

Such costs can be justified when weighed against the increase in usable hours of public space. A study done at MIT showed that people were twice as likely to eat lunch in a public courtyard, and stay outdoors for longer, during weather that was comfortable according to the Universal Thermal Climate Index.[62] When more people are comfortable going out, restaurants, stores, and services see more business, offsetting build and operating costs with increased economic activity. Economic activity is known to drop during winter months throughout Canada, with retail sales falling up to 20 percent.[63]

Based on climate modelling of the outdoor comfort system in Quayside, Sidewalk Labs anticipates an increase in comfortable hours of 35 percent annually. While it is hard to determine the exact impact of more comfortable days on economic activity, it is reasonable to assume at least an incremental increase in spending derived by making outdoor spaces, streets, and shopping areas more comfortable.