By likening the process of urban design to the diagnostics and intervention of the routine blood test, **Keith Besserud, Mark Sarkisian, Phil Enquist and Craig Hartman** of Skidmore, Owings & Merrill (SOM) provide a powerful biological metaphor for the city and its metabolic flows. Through their descriptions of SOM's work on the Great Lakes Vision (2009), Chicago Lakeside (2012) and the Pin-Fuse Joint (2009), they illustrate the impact of metabolic flows of energy, information and matter at the scale of the regional, urban and architectural.

Keith Besserud, Mark Sarkisian,
Phil Enquist and Craig Hartman

SCALES OF METABOLIC FLOWS

REGIONAL, URBAN AND BUILDING SYSTEMS DESIGN AT SOM

One of the most common medical procedures prescribed by doctors to get a sense of a patient's health is a routine blood test. This is because the blood that circulates through the body is teeming with molecular indicators of health. The bloodstream is like the body's 'postal service', delivering critical molecular signals to all of its physiological systems. At any given moment, billions of chemical molecules are flowing throughout the body, attaching themselves to specific cells and triggering chemical reactions within the cells to keep the body functioning properly. By measuring the chemical content in a patient's bloodstream, anomalies can easily be identified that help the doctor diagnose illnesses and establish how far the patient is deviating from a normal or healthy condition.

This biological process of coordinating interactions between all the physiological systems of the body via the reading, processing and transformation of chemical molecules is what is commonly referred to as 'metabolism'. Metabolic systems are essentially information-processing systems, regulating the flows of biological information and instructions.

Pharmaceutical scientists are also very interested in metabolic processes. The drugs they develop are doses of molecular chemical information that get absorbed into the body, thereby introducing new signals into the body's metabolic flows. Ideally, the drugs are designed to address very specific cells and to communicate very specific instructions. However, because of the enormous biological complexity of our bodies, the great challenge is to accurately predict that the chemicals released will bind only to the specific cells targeted and will introduce only the specific instructions intended. The result of a poor design is side effects. The result of an effective design is a better quality of life.

Within this framework there are two related but discrete modes: diagnosis and intervention. Procedures like blood tests provide important diagnostic indicators of the metabolic status of the body. Intervention, on the other hand, whether it involves medicine, surgery or genetic engineering, is a very different mode, requiring the ability to predict that a certain intervention will achieve the preferred outcome. This second mode is fundamentally a process of design.

BIOLOGICAL ANALOGIES WITH THE URBAN DOMAIN

Going back at least as far as Jane Jacobs, the history of urban theory is replete with analogies between biological systems and metabolic metaphors. Like biological systems, cities and their various urban systems are perpetually 'metabolising' flows of information, energy and matter to drive their processes. People are constantly processing the signals of the city and making decisions based on those signals as they socialise, engage in commerce, interact with the city's infrastructure and consume local natural resources. Information is constantly in motion, enmeshing people, transit systems, retail systems, governance systems, environmental systems, energy systems, educational systems and all the other urban systems into one enormously complex organism.

As with biological systems, we may also consider the metabolic flows of cities through the same two related but distinct lenses of diagnosis and intervention. The diagnostic question of how to measure a city's health is one that is attracting a great deal of global attention. In the absence of predefined standards, cities are crafting their own sets of urban metrics in order to better manage their affairs. Categories of measurement include public safety, public health, education, transportation, jobs, cost of living, local culture and the environment. Specific indicators range from the near universal (for example, commuting times, graduation rates) to the more local (manatee deaths in the city of Jacksonville's local waterways).

The enormous amount of information that feeds into these metrics represents a form of 'big data', which comes from open data movements within governments and NGOs, the physical instrumentation of the city, and the explosion of social media. As a result, new and innovative forms of urban 'blood tests' are quickly emerging to help understand urban metabolic flows. The idea that better metabolic flows, enabled with big data, will lead to better cities underpins the philosophy of the 'smart' cities movement.

SOM, Poly International Plaza, Beijing, due for completion 2015
The multistorey, elliptically shaped diagrid system is designed to support the perimeter of the structure without columns, and to create a double-wall exterior enclosure to control temperature effects on internal spaces.

However, as with the design of drugs, the move from diagnosis to intervention with respect to urban systems is not simple. The great challenge for urban designers and policy makers in dealing with the complexities of urban systems is to intervene with the existing metabolic flows to achieve the intended results without triggering undesirable side effects (for example, lack of affordable housing, ineffective public spaces, unsustainable development). Currently, our abilities to reliably predict the holistic fallout of an urban design or public policy proposal – in terms of social, economic and ecological effects – are limited to relatively simplistic pairings and based primarily on experienced intuition.

SCALES OF FLOWS

The metabolic processing of energy, information and matter happens at a wide range of scales, from the molecular to the cosmic. As urban designers, architects and engineers we are most familiar with the band within this spectrum that ranges from the regional to the urban to the architectural.

SOM, King Abdullah City for Atomic and Renewable Energy, Saudi Arabia, 2011
For the conceptualisation studies for a new city in Saudi Arabia, designers wrote a 'raindrop' algorithm that used topographic data to simulate the flow of water into the wadis from different points on the ridges, constrained to different angles of descent. The paths of the water drops served as the starting point for formally organising some of the early design schemes for the project.

The Regional Scale

The story at the regional scale begins with an understanding of how the introduction of humans and human systems impacts the metabolic flows of energy, information and matter within the vast natural ecosystems of the region. In addition to issues such as habitat modification, resource overconsumption and pollution, these problems often become even more complicated at the regional scale because of the introduction of artificial information barriers in the form of jurisdictional geopolitical boundaries.

The Great Lakes watershed in North America provides a very good study of the complexities of the regional scale. The current challenges are related not so much to the human consumption of the water (only about 4.2 per cent of the population's drinking water comes from the Lakes), but rather the systemic treatment of the water and the aquatic ecosystems. The ecosystems are being impacted by multiple factors that cause changes to the molecular constitution of the water of the Lakes, rendering it unable to perform critical metabolic functions and leading to cascading breakdowns of metabolic flows throughout the connected ecosystems.

Harmful farming practices include the use of toxic pesticides, fertilisers that are rich with phosphorous (which accelerates the growth of oxygen-depleting algae blooms that lead to aquatic 'dead' zones), and the lack of erosion control. Logging practices remove shading from streams, altering solar exposures, increasing water temperatures and upsetting spawning patterns. More than 180 non-native species of plants, fish, molluscs and other living things now inhabit the Lakes, altering the aquatic food chain and threatening food supplies and fishing economies. The majority of the industrial energy production plants in the region are coal powered, releasing high levels of carbon dioxide into the atmosphere and depositing toxic mercury into local water sources. Damage from urbanisation includes runoff of untreated storm water, periodic outflows of untreated sewage from combined sewer systems, and the depletion of local water tables.
Greatly complicating efforts to coordinate

remediation strategies is the fact that the watershed region spans the border of two different countries. Stakeholders on the US side include eight different states, 213 counties and 58 Native American reservations. In Canada, there are two provinces and 87 First Nations reserves. Combined, there are over 15,000 cities and towns. All of these jurisdictional borders tend to create impervious barriers to information flows that are critical to the preservation of this vital natural resource. In the absence of this free flow of information to coordinate behaviour, self-preservation instincts will prevail and will only accelerate the deterioration of the Lakes.

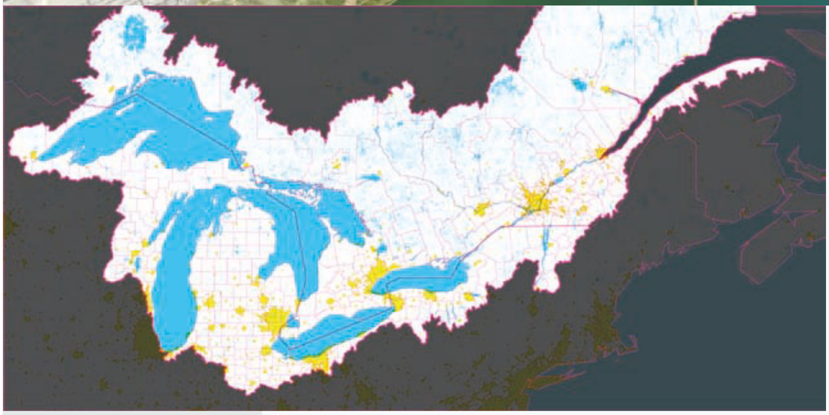
In response to this breakdown of trans-jurisdictional information flows, and in the absence of any unifying doctrine, SOM has developed a comprehensive, transnational 100-year vision for the Great Lakes and St Lawrence River region. Conceived as a contribution to the centennial commemoration of Daniel Burnham's 1909 *Plan of Chicago* (which itself was a regionally focused vision that understood Chicago within its greater context), the Great Lakes Vision (2009) presents a message intended to cut through jurisdictional boundaries. Its components address the challenging issues described above, organised into themes relating to urban design best practices, tourism, the enlistment of local research universities, water stewardship advocacy, renewable energy, regional transit systems, moving beyond a carbon-based economy, and local food initiatives. SOM's active promotion of the Vision among countless government and community groups led to its unanimous approval in 2010 by the Great Lakes and St Lawrence Cities Initiative, an organisation representing 73 cities in the US and Canada.

The Urban Scale

At the urban scale, the focus on metabolic flows shifts largely to engineered infrastructure systems built to accommodate the movement of people, energy, water, waste and data across the city. As an example, Chicago Lakeside (2012) is an almost 243-hectare (600-acre) brownfield redevelopment project located on the south end of Chicago where the US Steel South Works steel plant once anchored a vibrant urban neighbourhood. Closed in 1990, dismantled and environmentally remediated, the project site now presents a unique opportunity: the design of a major urban

SOM, Great Lakes Vision, Chicago, Illinois, 2009
top: Agricultural practices represent as significant a threat to the aquatic ecosystems of the Great Lakes as urban pollutants. Increased runoff of sediments and chemicals creates disruptions of natural metabolic processes in the lakes as well as in the soils.

bottom: The network of Great Lakes shipping routes represents the largest freight transport system in North America, delivering iron ore, coal, agricultural grains and other commodities to national and international ports where they are processed into steel, energy, food and many other products.



intervention, integrated into a major developed city, on a waterfront site that is essentially a blank canvas.

The urban design is essentially a study of urban systems flows, starting with the flows of people. The masterplan for the transportation/mobility systems builds on the need to accommodate three different types of connections. The first are the connections to downtown Chicago, which is about 18 kilometres (11 miles) to the north. The second are the connections to the adjacent existing communities. The third are the interconnections within the Lakeside development itself. For the connections to Chicago, proposed schemes include the addition of a spur to the existing commuter train line that runs to the west of the site, the introduction of a water taxi service running along the Lake Michigan shoreline, and an extension of Lake Shore Drive, which is a principal vehicular artery running along the eastern edge of the city.

Connections to the adjacent communities are intended to break down perceptions of the Lakeside development as an island, and instead integrate it with the adjacent communities, particularly by creating links to connect the communities to the publicly dedicated lakefront. Proposals here include east–west bike routes that stitch together the communities and the development, and a plan to reinforce the existing commercial corridors by developing extensions that run through the new development.

Movement within the Lakeside community is addressed with strategies to enhance walkability. In order to encourage pedestrian activity, the project incorporates design principles that emphasise small blocks which enable walkable access to a wide mix of essential uses, appropriate levels of density to activate the public spaces, pedestrian comfort through the strategic shading of the sidewalks, and the creation of a network of public green spaces that weave throughout the development, providing contiguous flows across the development not only for humans, but also for local wildlife species.

The management of water at Lakeside represents an attempt to restore natural hydrological balances to the site. The city of Chicago manages storm water in a combined sewer system that mixes the storm water with the sewage from buildings, and then subjects it all to the same energy-intensive purification processes. Furthermore, Chicago draws its

SOM, Chicago Lakeside, Chicago, Illinois, 2012
top: Strategies for grafting and assimilating the proposed Lakeside community into its greater urban context include proposals to reinforce three different scales of connectivity: connections to the commercial core of the city; connections to the adjacent communities around the development; and connections within the various districts of the development itself.

SOM, Great Lakes Vision, Chicago, Illinois, 2009
bottom: A coordinated international strategy to protect the Great Lakes remains a work in progress, meaning thousands of individual city and county jurisdictions are obliged to define their own terms of engagement with the Great Lakes basin and its ecological systems.

water from Lake Michigan, but releases its treated sewage into a watershed that flows into the Mississippi River, creating an undesirable open-loop system. For Lakeside, a respect for the natural hydrologic flows is proposed. In the masterplan, both the storm water and the water drawn from the lake ultimately end up in the lake. On-site district-scale treatment facilities are planned, as well as the incorporation of bioremediation strategies for treating the storm water in a more natural, less energy-intensive way. Furthermore, again tapping into the local hydrologic resources, the cold Lake Michigan water that is drawn to support the city's water consumption needs passes through a heat exchange system that would pre-cool the water used for the air conditioning of buildings in the development, creating a reduction in the energy required for building cooling.

The management of the water touches on the final area of focus with respect to flows at the urban scale: the infrastructure systems. Several strategies that develop a high level of synthesis among the energy, water, waste, heating and cooling systems are proposed, and particularly those that leverage heat exchanges in order to reduce energy demands. The information exchanges between the infrastructure systems that are necessary to build these kinds of efficiencies will require appropriate investment in broadband information communication technology (ICT). This ICT investment is also critical to the human component of Lakeside, enabling the people to connect with each other and with the outside world.

The Architectural Scale

Like cities and regions, buildings also metabolise energy, information and matter. Metabolic flows of water, electricity, waste, data, heat, daylight, solar radiation and, of course, people are constantly being processed to keep the building's systems operating effectively. Like a cell within its larger biological context, these flows integrate the building and its systems into the larger urban and natural context.

It may not be readily apparent, but the structural system of a building is actually a good example of a metabolic system. In this case it is energy that is being metabolised – in the form of structural loads and forces. The live and dead loads that are applied to the building are systematically transferred from structural subsystem to subsystem, ultimately finding resolution in the ground. One of the main objectives in designing the structural system is to size the components according to the forces that will be flowing through them; an optimal system is one that allocates the least amount of material and/or cost necessary to accommodate these flows while maintaining a prescribed factor of safety.

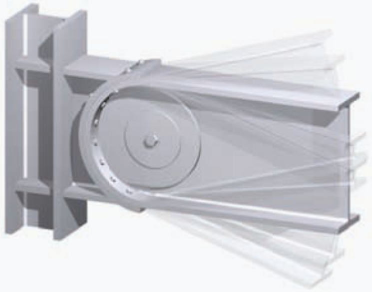
Seismic events present a special challenge to the design of a building's structural system because of the largely unpredictable nature of the force trajectories, magnitudes and durations. These types of shocks are fundamentally different from the forces of gravity and wind, and require a special approach to design that deals with the building's stiffness and damping characteristics. By lengthening a building's characteristic period (making it less stiff), the demands on the structural systems from ground motions can be lessened, and the probabilities of minimising damage and returning the building to safe service can be increased.

top: Open green spaces within the masterplan serve multiple functions with respect to flows across the site. They provide an opportunity for people to connect with their natural environment, a network of corridors for migration of wildlife, and mitigation for storm water flows through detention and bio-purification capacities.

bottom: The design of the storm water management system for Lakeside advocates changes to the Chicago regulatory framework to allow for separate systems for handling storm water and sanitary sewage, and to allow for the bio-filtered storm water to be directed into Lake Michigan.

Three common types of active strategies for lengthening the building's period include damping, seismic isolation and dynamic fixity. Damping strategies are used to reduce the amplitudes and resulting accelerations of the building motions, and are an effective way of reducing seismic demand as well as the effects of wind. Seismic isolation is a response strategy that relies on the ability to isolate the building from ground motions.

A third type of seismic response strategy involves dynamic fixity. SOM's Pin-Fuse Joint system is an example of such a system. It behaves with a rigid demeanour much like a conventional moment connection between a beam and a column when subjected to typical wind and gravity loads, or even moderate earthquakes. However, if a dynamic shock is sudden and strong enough, the joint is designed to release and rotate, allowing the connection to slide while dissipating energy through friction heat rather than yield or fracture.

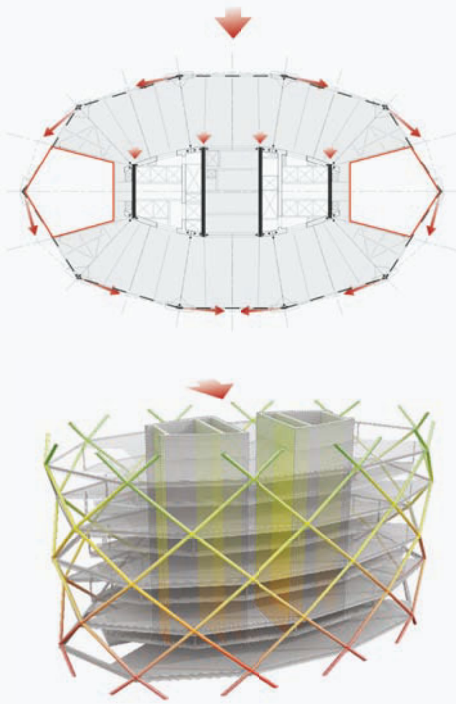


Once the seismic event has passed, the joint is intended to return to its original configuration, using, for example, a sinew-like material such as nickel titanium or some other shape memory alloy. In the future, another type of fixity joint system could incorporate the modulation of clamping forces by introducing heat into the joint fastenings to elongate the bolts.

Implicit in this type of structural system is a feedback loop of flows in which a response is triggered by the detection of induced energy. The detection mechanisms may be localised to the building or may take the form of a sensory field that blankets the entire region and connects to all the buildings within the coverage area. In this scenario, the ability to detect seismic motions at the epicentre could not only provide valuable seconds of advance warning to 'smart' seismic response systems in the building, but could also generate important data about magnitude and motion trajectories. Following the earthquake, additional sensors embedded in the structural

SOM, Digital model of San Francisco, California, 2012
top: SOM's research into the creation of more intelligent urban modelling frameworks includes the incorporation of buildings, infrastructure systems and various dynamic agents that can be attributed with different types of data, integrating across multiple urban systems to reveal insights into urban behaviour and allow for the study of hypothetical urban interventions.

SOM, Pin-Fuse Joint, 2009
above right:The Pin-Fuse Joint (US Patent 6681538) is designed to alter the characteristics of a structure during a strong earthquake by fusing or slipping, dissipating energy through friction, and reducing inertial forces while remaining elastic and allowing for immediate reuse.



system could be designed to report back on the condition of the structure, making it much easier to understand the building's fitness for safe occupancy. All these flows of energy are examples of structural metabolic processes in which the energy flows become information inputs that lead to physical transformations of materials or mechanisms.

DRAWING FROM BIOLOGY FOR FUTURE POSSIBILITIES

Metropolitan regions, urban districts and even individual buildings all exhibit similarities to biological systems with respect to the ways in which they process (metabolise) energy, matter and information in cascades of feedback loops in order to sustain their vital functions.

In the fields of biology and the medical sciences, revolutionary advances in knowledge have been made in recent decades with respect to understanding the metabolic processes of various natural systems. These leaps in knowledge have been generally preceded by advances in scientific technologies. Brain imaging technologies have transformed the field of neurobiology, enabling doctors and scientists to observe the movements of electrical signals and the sequences of triggers across the neural pathways of the different regions of the brain, and to correlate these movement patterns with other physiological functions. DNA sequencing technologies have allowed biologists and scientists to begin to decode the relationships between strings of nucleotides and processes of cellular and physiological development. In fact, these advances have fundamentally transformed the field of biology from a focus on flows of energy to one on flows of information.

These recent advances in biology have led to the development of much more sophisticated parametric biological models that can simulate the complexities of interactions between the various physiological systems and agents, and test the efficacies of various proposed treatments in virtual experiments. These virtual experiments, in turn, help build stronger theoretical foundations of biology that drive medical innovation at an ever deeper and faster pace.

As computational technologies continue to work their way into architecture, urban design and related fields of study (for example, sociology, economics, natural ecologies, infrastructure engineering), a similar paradigm is beginning to emerge. Fundamental principles of urban design relating to concepts like density and land use designation that have been incorporated into practice based largely on anecdotal evidence are now poised for a much higher level of scientific insight.

As more sophisticated computational tools begin to emerge we will be able to explore more and more difficult questions such as 'What is the ideal distribution of development density across the city to maximise quality of life?', 'How do design decisions impact the development of social capital in urban neighbourhoods?', and even something so basic as 'What constitutes a neighbourhood?'. As other sciences like sociology and economics continue to develop computational modelling paradigms, the abilities to leverage knowledge embedded in models across discipline boundaries promises to enrich all of those engaged.

Metabolic flows and transactions are at the heart of all of these types of models. Through the use of these technologies we stand to gain a much better understanding of the metabolic patterns of cities, a stronger theoretical foundation regarding the fundamental nature of cities, and a greater ability to intervene. AD

SOM, Poly International Plaza, Beijing, due for completion 2015
Force flow diagram through the perimeter structural system consisting of concrete-filled steel pipes. In the future, perimeter systems will be designed to be self-reflective, capable of state changes or interactive material placement through recorded information inputs based on energy flows.

Wolf Mangelsdorf

METASYSTEMS OF URBAN FLOW

BURO HAPPOLD'S COLLABORATIONS IN THE GENERATION OF NEW URBAN ECOLOGIES

When regarded as a whole, the flows of a city – made up of people, water, energy, information, materials and waste – constitute a large and complex 'metasystem'. **Wolf Mangelsdorf**, Head of Structural Engineering at Buro Happold, describes a number of projects that Buro Happold has collaborated on with architects, urban planners and landscape architects that mark a significant shift in the design of urban infrastructures, recognising the importance of the metasystems of flow.

Ludwig Hilberseimer, Hochhausstadt, 1924
The concept of utilitarian infrastructure, based on the calculation of transport flows and the separation of spaces and usages, was one of the main concepts that governed the design of the city in the 20th century.

Ecology is the study of the relations of living organisms to each other and to their environment. For ecologists, 'sustainable' biological systems are those, for example forests or wetlands, which persist through time by adaptation at multiple scales to fluctuations and changes in the processes and flows of their environmental context. By contrast, the current emphasis in urban 'sustainability' is all too frequently reduced to energy efficiency and the reduction of emissions. There is, however, a growing trend towards a broader approach in city and infrastructural design projects that is closer to a true ecological concept.

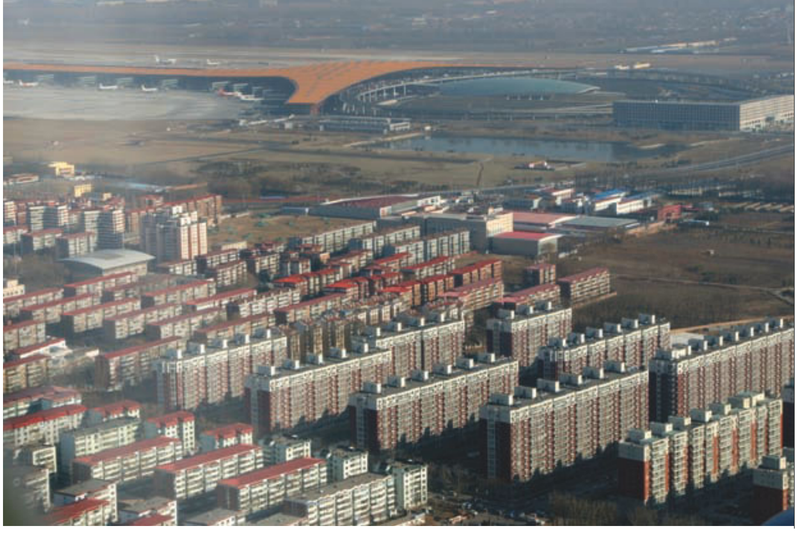
Urban ecology may be considered as a special subset of ecology, one that is focused on the distinct biota and processes that have emerged within urban areas and, more rarely, may also include the study of human cultural systems and their spatial phenomena. In regard to the infrastructure of urban flows, its individual components such as railway stations are embedded in, and inextricably entwined with, all the systems of the city. They contribute to an integrated network of systems that organise the patterns and distribution of flows: primarily of people, but also of water, energy, information, materials and waste. Each of these systems of flow has an effect on the other systems as well as on the urban morphology. When regarded as a whole they constitute a large and complex 'metasystem' that emerges from a collective of subsidiary systems, with many connections and feedback loops between them.

The Efficient City

The design of urban infrastructure has for decades been driven by a notion of technical efficiency determined by simple equations of flow. Number of cars at a given speed determines the width of roads, and pedestrian flows generated by key attractors – stadia or railway stations for instance – result in route layout, width and surface design with little notion of the spatial qualities generated; spaces are separated according to their usage.

Facilitated by increasing car numbers and individual transport, the American city freeway has become the icon of modern urban development. This image of the 20th-century city is now being replicated in the megacities of the Arab world – Dubai is perhaps the best-known example – and applied in the design and planning of 'new cities' in East Asia, particularly the rapidly growing urban centres in China, such as Shanghai, Chongqing or Changsha. This is generating interchangeable masterplans that have their roots in a notion of technically efficient flows, with zoned urban sprawl developing alongside traffic arteries.

There are some fundamental flaws in this approach. The focus on primary measurable flows, which results in a city based on a technical notion of infrastructure, negates any aspect of the informal meta-flows that depend on not being predicted, predictable or designed, but are emergent, allowing for human activity, change and adaptability. As cities are a reflection of our culture, a universal approach to urban development seems an absurd concept. While culture is not static and develops over time, there is a clear understanding that cultural background and development have shaped the spaces and appearance of our cities as well as our urban infrastructure. Moreover, urban ecology and culture are directly linked to climatic conditions. In the past these have been powerful drivers in the development of both city layouts and individual building typologies, creating unique urban or architectural features such as shaded streets, protected squares and courtyards that greatly contribute to the identity of the city they are creating and influence the lives of their inhabitants.



Freeway City
left: American city developments have taken the idea of primary flow systems to the extreme.

Beijing suburb
above: Twentieth-century Western thinking still influences the rapid growth of cities, particularly in the Arab world and in Asia.

Metasystems of Flow

A number of projects in which Buro Happold has collaborated with architects, urban planners and landscape architects mark a shift in the design of urban infrastructure based on recognition of the importance of the metasystems of flow.

Most literally a project of urban ecology is the regeneration (with Moriyama & Teshima Planners) of the Wadi Hanifa in Riyadh. Once a waste dump with virtually no life remaining, this important watercourse in the arid climate of the Saudi capital has been reshaped using a bioremediation facility and natural means to improve the water quality. More significant, however, is that it has been designed as a landscaped park that now attracts visitors as a place of rest, play and social interaction. Early participation of the public in the project and the subsequent adoption by those that use the newly created naturalised parkland will prevent it from returning to being a waste dump again. The ecological aspects of this project, which won the Aga Khan Award for sustainable architecture in 2011, are evident, but the success and transformation of a piece of urban natural landscape lies in the cultural aspects as well as in its climatic qualities.

The High Line in New York City (James Corner Field Operations, Diller Scofidio + Renfro, Piet Oudolf and Buro Happold) works with a similar principle, however rather than transforming a piece of deteriorated natural landscape, it re-appropriates a stretch of 20th-century railway infrastructure. The sequence of urban development here is interesting: originally conceived as a linear park with some extraordinary spatial qualities and a rather unusual perspective on to the city fabric, the High Line alters the pace of movement and becomes an attractor in itself. Over time it has been acting as a catalyst of urban regeneration with a positive impact on the development of the surrounding areas. The definition of the spaces it provides depends primarily on how they are adopted by the users, generating a high level of flexibility and potential for future change reflected in the diversity of developments that have been springing up along its path, including new hotels, street markets, theatres, restaurants and highly sought-after condominiums.

It is this element of future adaptability and lack of definition that increasingly proves to be a means of flow management as well. While the High Line generates an undefined flow alongside being a rather efficient pedestrian connection, exactly the opposite problem occurs in the design of transport infrastructure around key attractors with peak demand, such as stadia. The masterplan for the land around the New Wembley Stadium (Richard Rogers Partnership with Buro Happold) provides a good example of how this thinking became an underlying design principle and at the same time made perfect sense for the developer.

The stadium was initially developed in isolation from the surrounding land characterised by its car park and connection routes to roads, the London Underground and train stations. And pedestrian flow and vehicle traffic stretched the capacity of the supporting rail and road network before and after every event when up to 90,000 people are attracted and released in a very brief period of time. However, in developing the masterplan, this problem was seen as an opportunity. Rather than looking at the impossible task of upgrading the transport system necessary to ease peak flows, the design instead provides the area with enough attractions to entice the spectators to arrive early and remain longer so that the flows can be drawn out over time. This concept finds its analogy in the role of the flood plain in alleviating peak water runoff. An additional benefit of the scheme is the revenue generated by the pubs, restaurants and retail opportunities. As a completely new development that is evolving over time, the biggest challenge here will be to maintain an element of the informal and non-defined as well as the future adaptability required to maintain this.

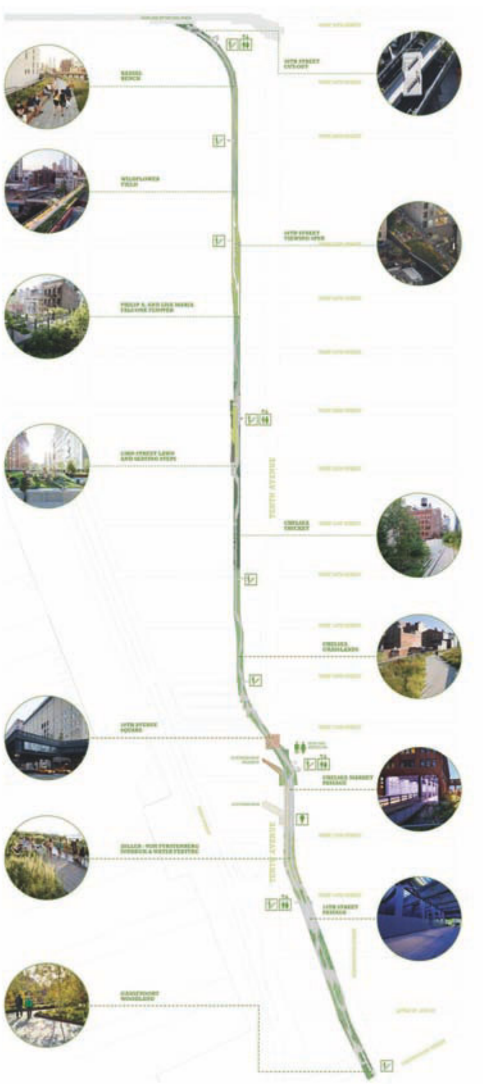
EARLY PARTICIPATION OF THE PUBLIC IN THE PROJECT AND THE SUBSEQUENT ADOPTION BY THOSE THAT USE THE NEWLY CREATED NATURALISED PARKLAND WILL PREVENT IT FROM RETURNING TO BEING A WASTE DUMP AGAIN.

Richard Rogers Partnership with Buro Happold, Wembley Masterplan, London, 2003–
left: Originally developed by Richard Rogers Partnership with Buro Happold providing all engineering services, the masterplan for the development of the land around the Wembley Stadium addressed the peak flows of the stadium and arena by providing holding spaces, post- and pre-event entertainment and retail. With limited scope for the upgrade of the surrounding transport infrastructure, the delay of arrival and departure alleviates maximum flows. It is planned that the masterplan would be built out over several years by developer Quintain with the possibility for adjustment to maintain the basic concept.

James Corner Field Operations, Diller Scofidio + Renfro, Piet Oudolf and Buro Happold, High Line, New York City, due for completion 2014
below: Key elements of the High Line phases one and two.

bottom right: The third and final phase of the High Line is currently being designed and will complete the loop to the north of the Hudson rail yards.

below top: New York's High Line started as a community concept for the preservation of the derelict elevated industrial railway that runs parallel with 10th Avenue from 14th to 42nd Street. Now entering Phase 3, it is the catalyst for one of the most successful urban regenerations. While the High Line has become a major attraction for locals and tourists, the former industrial areas of the Meatpacking District and Chelsea have been transformed into a prime retail and residential quarter.



The Wadi Hanifa and High Line are creating opportunities for meta-flows, and the Wembley regeneration provides the area with the spaces and uses required to ease peak flows to and from the stadium at its heart. However, the situation is slightly different for the XRL terminus in West Kowloon (Aedas with AECOM, with structural and envelope engineering for the roof by Buro Happold). Here, the project itself is the endpoint of a primary flow, the station for the high-speed railway that connects Hong Kong with mainland China. Flows also do not experience the same peaks as is the case with stadia, but are constant. Embedded within the fabric of the city, and in particular the new waterfront developments of the West Kowloon Cultural District, the station building provides spaces that allow the reduction of speed and provide possibilities for social interaction that are intended to ease the transition from high-speed train to pedestrian flow. This happens in two ways. First, the station is directly connected into the existing urban street network with a series of additional streets, walkways and bridges. More importantly, though, the vast roof structure that spans over the platform and concourses is designed as an accessible park with views out over the water and back into the streets of Kowloon. In creating these unusual spatial qualities and uncommon perspectives, the roof provides both a physical and a nonphysical connection with the surrounding environment. The project is now under construction, and it will be interesting to see how successful this connection with the surrounding city, on these different levels, will be.

The projects described here illustrate that the provision of an infrastructure with emergent qualities that develops around attractor points has the ability to enhance the quality of urban spaces and transform entire urban quarters. Returning to the initial argument, they exemplify the ideas behind a widened approach to sustainability that not only looks at the immediate aspects of energy and resource consumption, but at the urban ecology, its development over time, and the informal spatial requirements to facilitate this future flexibility and adaptability.

The masterplan for Keski-Pasila in Helsinki (Cino Zucchi Architects and One Works with Buro Happold), which is currently being worked into an urban framework, addresses sustainability criteria according to the three levels outlined by the LEED Neighbourhood Plan. These are: choice of location to provide links into the existing infrastructure and particularly public transport; the creation of a neighbourhood pattern based on local cultural and climatic conditions; and, as a last step, the sustainability of the building design itself. Using this assessment tool, which captures these wider sustainability factors in a measurable way, it was possible to shift the debate away from a focus purely on energy and to actively engage the client.

The project itself, a masterplan for a medium-sized mixed-use development in the north of Helsinki, is placed strategically at the intersection of major rail and metro lines and the road network. As such, by allowing easy, and car-free, access from all areas of the city, it would greatly reduce the impact on the surrounding transport infrastructure. Taking advantage of the transport connections, buildings are based on a concept of high density and embedded in a series of public spaces at ground level, which themselves are connected to a pedestrian network. All of the buildings work with an orientation that maximises solar gain while providing buffer spaces in the form of winter gardens and doubled

Moriyama & Teshima Planners with Buro Happold, Wadi Hanifa Wetlands, Riyadh, Saudi Arabia, 2007
The regeneration of the Wadi Hanifa has created a key attraction and a space of previously unknown qualities that facilitates recreation and social interaction. Its acceptance by visitors, users and the local population has changed attitudes towards this former dumping ground, providing the basis for its success and longevity.

Aedas with AECOM and Buro Happold, XRL West Kowloon Terminus, Hong Kong, due for completion 2014
The new terminus of the Guangzhou–Shenzhen–Hong Kong Express Rail Link (XRL) is based on parkland that stretches over the roof of the station, creating an informal set of connections as well as a holding space for waiting, lingering and social interaction.

facades, offering protection from wind, rain and snow. Most importantly, though, the masterplan is not meant to be the basis for just one single development, but a framework that allows for further building over time. Buildings will be designed by different architects, and these projects will fill the current placeholders and allow for the development of the urban and communal spaces that form the emergent metasystems of the infrastructure.

A Revised Approach

The projects above demonstrate that patterns of infrastructural systems of flow can produce spatial configurations that organise and facilitate the development of the ecological processes of the urban environment and human cultural activities. This way of thinking requires a multi-scalar approach to infrastructure design that is focused on the interrelations of spatial patterns and their functions, and places a special emphasis on connectivity. Beneath a primary level of infrastructure, attractors – the XRL terminal falls into this category, as do spatial configurations whose usage is not fully predetermined (as is the case with the High Line or Wadi Hanifa projects) – provide the catalyst for an emergent metasystem of urban flow. This does not need to be planned, but rather facilitated, enabled and encouraged to provide the adaptability, flexibility and regeneration catalysts necessary for a city that can grow, flourish and develop sustainably as well as maintain its distinct cultural and architectural identity. ⌂

Cino Zucchi Architects and One Works with Buro Happold, Keski-Pasila Masterplan, Helsinki, 2007
top: The masterplan was developed according to the LEED Neighbourhood Plan. Sustainability drivers were evaluated and incorporated into the project at all levels, from connection to the city infrastructure to the quality of public spaces and design of the individual buildings.

centre and bottom right: Public spaces are determined by pedestrian and cycle paths that are embedded in the communal usages and allow the emergence of a secondary network and connections over time.

bottom left: Developed over several levels in the urban landscape, the masterplan for Keski-Pasila is based on a vertical layering of uses and a clear public zone at the base of the proposed towers.