Conduit Urbanism: Opportune Urban Byproducts of Bundled Megaregional Energy and Mobility Systems

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It is by now doubtless that the question of infrastructure will dominate the concerns of architects, landscape architects, urbanists and planners for the foreseeable future. Not only is the current stock of traditional infrastructure (roads, bridges, waste, water, power) in a state of physical decay and/or inadequate to meet the needs of contemporary urbanization and of social and ecological urgencies, but it is also becoming increasingly clear that infrastructure itself is operating not merely as an organizational apparatus but is becoming a primary locus of contemporary public life and social space for a large portion of the North American population.[1] With mobility and energy infrastructural transformations already underway, and with its manufacturing base and population currently shifting and growing, the Great Lakes Megaregion might capitalize on the intersections of necessary infrastructural retooling and expansion by developing an ambitious and robust regional vision that reconceives the entire network within an integrated physical, ecological and societal perspective.

NETWORK

The highway has arguably been the single most instrumental factor in structuring settlement patterns and economic development in North America during the second half of the twentieth century. An astonishingly efficient and strategically engineered system comprised simply of permutations of near horizontal asphalt surfaces, it is configured to optimize the logics and logistics of transit and transport throughout the continent. The development of this integrated infrastructural network is far from accidental. Although separate interstate highways had been constructed as early as the Lincoln Highway in 1913, it was Eisenhower's Federal Aid Highway Act of 1956 that promoted the interstate highways as an integrated and complete network in order to realize their maximum systemic potential.[2] (Figure 1, left) The 1956 Act provided not only funding for highway construction, but also gave a limit of twenty years for each individual state to build out the network, so that mobility could operate coherently and continuously throughout every part of the nation. Over fifty years later, rapidly evolving urbanization and energy needs demand a similarly totalized approach that realizes a synthetic networking of mobilities, energies and economies.

While the latter half of the twentieth century has witnessed the establishment of a fine- grained mobility network (Figure 1, right) and the production of a low density urbanism, the production of a low density urbanism, the twenty-first century will be defined by the consolidation of supersized, multicentered, networked urbanities, as the interconnection and densification of proximate urban centers create the emerging *megaregions* of North America. This urban formation, first identified by French geographer Jean Gottman's 1961 "Megalopolis"[3], is now more commonly referred to as "Megaregion" and has become the focus of several prominent land

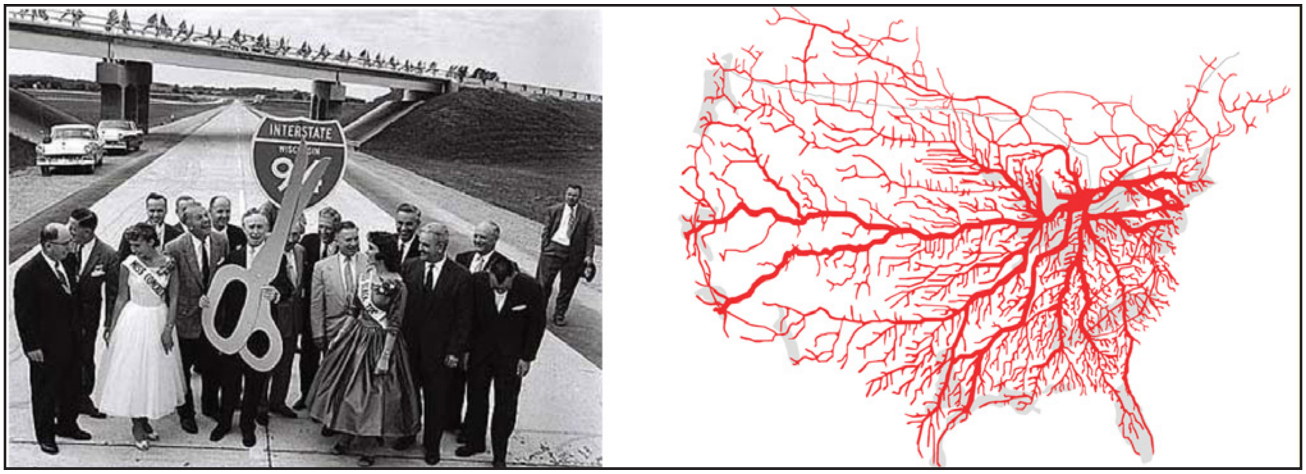

Figure1: (left) Ribbon-cutting ceremony at the first section of I-94 completed in Wisconsin, September 4, 1958 [Courtesy Wisconsin Historical Society Archives]; (right) Truck Based Freight Flow into the Great Lakes Megaregion (freight density in tons), with US Megaregional Footprints [US Dept. Transportation].

use and planning agencies[4]. Megaregions can be defined as agglomerated networks of metropolitan areas with integrated labor markets, infrastructure, and land use systems that share and organize complex and interdependent transportation networks, economies, ecologies, and cultures.

The geography of megaregions inevitably coincides with areas of maximal stress and congestion; population concentration and increased mobility and freight movement within current infrastructures, threaten immanent systemic failure. This geographic situation is conflated with the demise of plentiful and cheaply accessible carbon-based fuels and a time where energy is projected to transform from single-sourced fuel to a blended matrix of inputs from a variety of sources, including solar, wind, nuclear, carbon, geothermal, hydrological and biomass. Parallel to the current crisis of carbon-based fuel supply, planners, politicians, engineers and industrial leaders foresee a future of increasing, as opposed to decreasing, demands for mobility combined with an unprecedented intensity of projected urbanization.

Such a vision could opportunistically combine the agendas of regional mobility and renewable energies with potential new urbanities centered around the existing highway infrastructure, and connect existing urban centers and other modes of transport such as air, water and rail with critical resource supply. This infrastructural network could harness strategically differentiated economic clusters, reinforcing and supporting the diverse spatial logistics of *megaregional agglomeration economies*[5] as identified by globalization sociologist Saskia Sassen. Through such a lens, the megaregion becomes a primary socio-political unit, overshadowing the agency of individual state, provincial and even national boundaries and structures. Sassen's position on the social possibilities of megaregions is particularly interesting to note here. She sees the polycentric regional urbanity as a potentially positive and powerful enabler for diverse populations and economies than that of the "global city".[6] The megaregion spans and connects a more diverse range of economic and social milieus: mid-sized cities, middle class neighborhoods, service enclaves and exurban enterprise zones have the opportunity to share and have access to infrastructural improvements, thereby allowing for the possibility of more dynamic relations and more equitable opportunities for various populations.

FIELDS

The largest and most populous of the emerging North American megaregions is the Great Lakes Megaregion (GLM) which includes the cities of Chicago, Detroit, Toledo, Toronto, Buffalo, Pittsburgh, and Cincinnati and in some cases extends to the Atlantic port of Montreal, the and the Midwest cities of Milwaukee, Columbus, Indianapolis and St. Louis.[7] However, its geographic, ecological, and resource-related territory should also tactically expand this boundary to include the watershed of the five Great Lakes. As a regional territory it controls

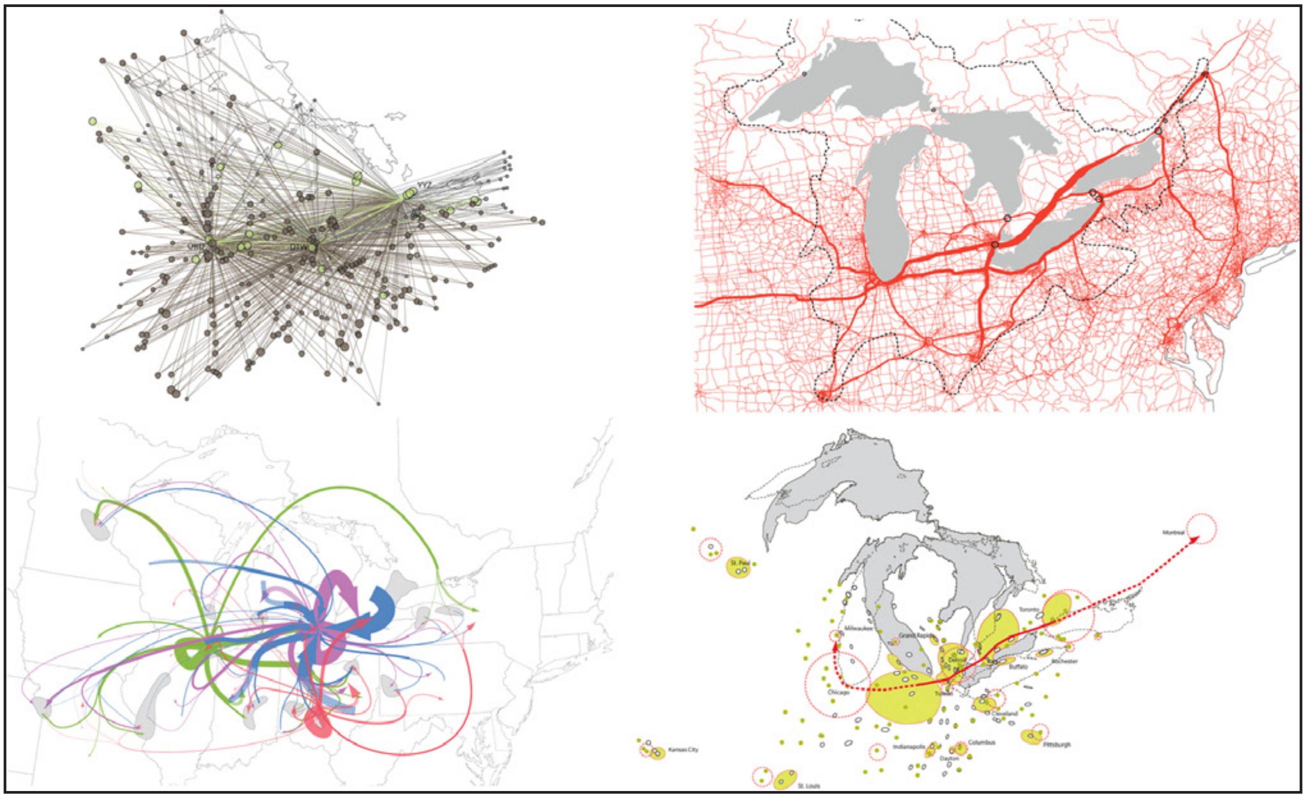

Figure 2: (top left) GLM PowerShed: Interlaced Electrical Interdependencies (Chicago | Detroit | Toronto) 2009 [NREL / OPG Data]; (top right) GLM Highway Freight Volumes [US Dept. Transportation / Ontario Ministry of Transportation]; (bottom left) GLM Commodity-Shed: Interlaced Economic Interdependencies (Chicago | Columbus | Detroit) [US Dept. Transportation]; (bottom right) YYZ-DTW-ORD City: Time-Space Compression at 300km/hr (Toronto-Detroit-Chicago)

one fifth of the world's supply of fresh water and 10,900 miles of shoreline, constitutes the world's largest concentration of research universities and is home to 30% of North America's and 11% of the world's Forbes' 2000 international company headquarters[8]. Daily, over $900 million worth of goods, or 25% of bilateral trade, crosses the Ontario-US border via the highway system within the GLM.

Visualization of the region's current Power-shed (Figure 2, top left), Highway Freight Volumes (Figure 2, top right), and Commodity-shed (Figure 2, bottom right) geographies further reinforces the necessity of conceiving of a synthetic, regionally-scaled interdependent infrastructure of resource development, distribution, and projection. These mappings serve to illuminate a spatial matrix that anticipates the emergence of a synthetically networked hybrid infrastructure to support and propagate emerging urbanisms. However, the geographic data also illustrates the infrastructural crisis facing the region.

Southern Ontario's Highway 401 holds the dubious honor of being North America's busiest highway (Figure 2, top right). The section of the 401 that cuts through Toronto has been expanded to eighteen lanes, and typically carries 420,000 commuter and commercial vehicles a day[9]. Being the primary conduit for both commuters and freight that runs between Montral and Windsor/Detroit, this artery is overloaded to the point of near terminal gridlock, and this condition will continue to be exacerbated by the provincial government's aggressive 2005 growth plan, which projects that Southern Ontario's population will grow by 30 percent, or four million people, in the next twenty-five years, primarily through immigration[10]. The plan proposes to concentrate densification in certain urban and exurban centers, the majority of which are located along the Highway 401 corridor, which the report identifies as the major economic driver for the region. On the US side of the border, while rust belt cities and former manufacturing centers are still experiencing depopulation, there

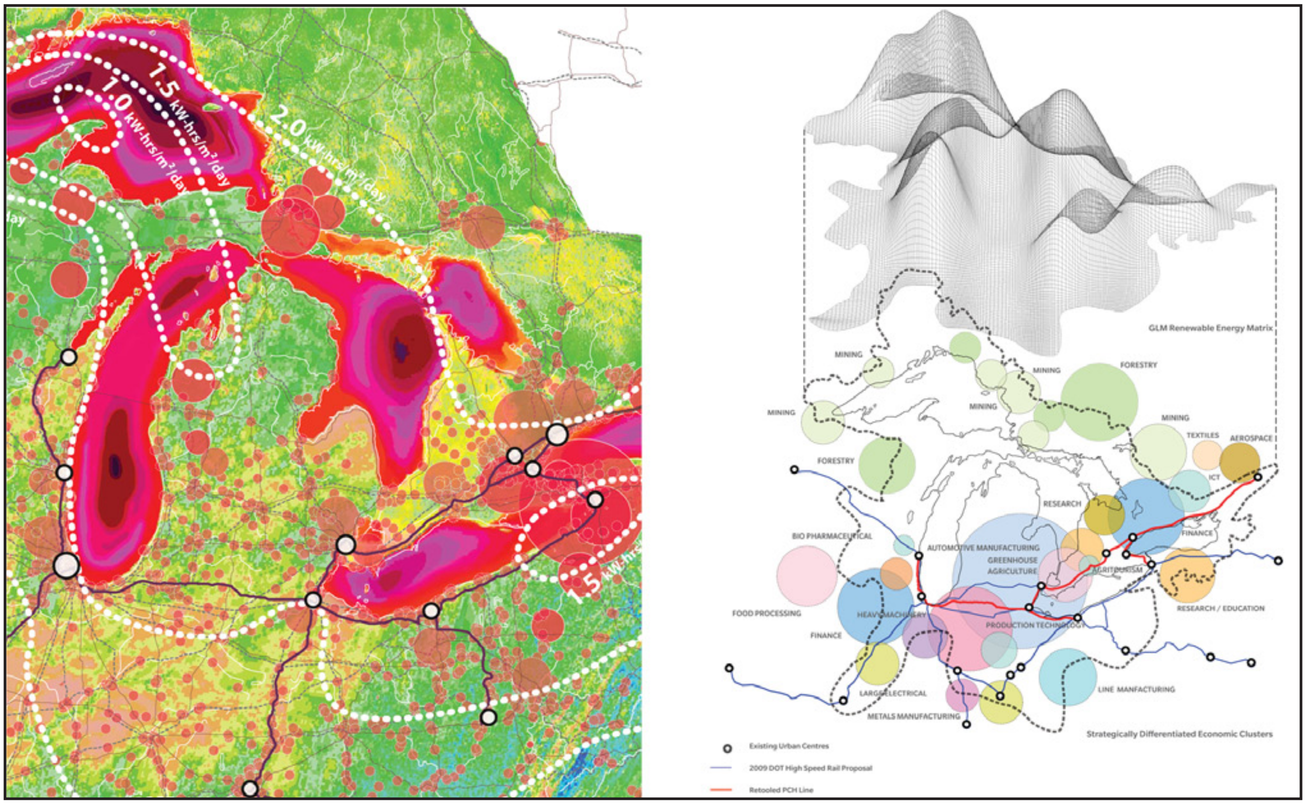

Figure 3: (left) GLM Renewable Energy Resource Geography: Wind, Solar, Hydroeletric and Biomass Source Potentials *[2008 NREL / OPG Data]*; (right) Conduit Urbanism: Interconnected renewable energy datafield, regional economic concentrations and intensified mobility lines [NREL / Brookings Data]

remains a population rise projection of 17%, or nine million people, by 2050[11].

The Great Lakes Megaregion territorializes significant amounts of renewable energy resources (figure 3, left), with currently approximately 7.2 Gigawatts (GW) of hydroelectric energy,[12] a copious potential for biomass energy production,[13] and 1.5–2 kW/hrs/m^2 of solar energy potential daily.[14]

However, the region's greatest potential Power-shed contribution lies in 320 GW of potential power that can be generated annually from the Great Lakes offshore wind farms. If fully exploited, it could provide 25% of the power needs of the United States[15] and constitute a significant inter-regional export base. This new source of power is being developed at an astonishing rate. As of October 2009, Ontario's Ministry of Natural Resources had received so many proposals from developers for offshore wind farms in the Great Lakes, that it has stopped accepting proposals so that proper assessments of environmental impacts, infrastructure requirements and logistics can be made[16].

Renewable energy sources not only necessitate the territorial construct of wind farms, dams and solar farms, but the drastically increased electrical capacity demands a new network of high voltage transmission lines. Existing energy distribution networks in the GLM are inextricably linked, bound, and limited by the footprint and logics of existing highway infrastructures (see Figure 2, top left). Fuel pipelines, refineries and service depots combine optimized transmission vectors with the cumbersome constraint of road based distribution dependent upon highway surfaces. Existing power corridors follow lines of expedience from resource origin to the highway's attendant population centers. Though robust, this matrix of energy delivery is inadequate to service the megaregion's projected growth as witnessed by "out of fuel" signage and system wide grid shut-downs.

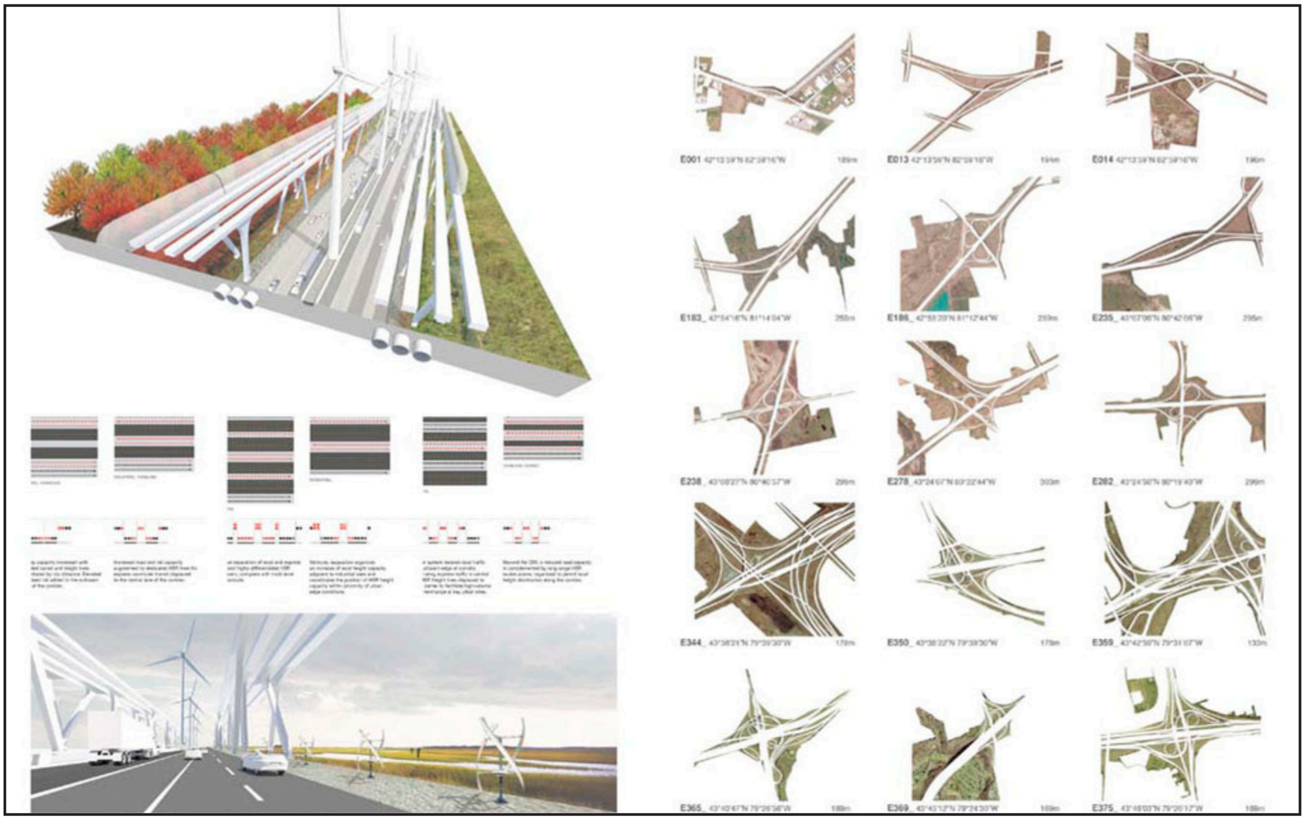

Figure 4: (left) The Post Carbon Highway: bundled conduit of parallel cooperative networks of energy and mobility; (right) Highway interchange orphaned land isolation [GLIN GIS Source]

In order to realize the potential strategic advantage of this suite of parallel opportunities what is required is a retooling of existing infrastructure, an adaptation of new technologies as well as overarching political visions and cooperation. Geographically and logistically, it is the existing network of the highway system, replete with strategic conduit channels, that might hold the key to the next generation of regional infrastructures.

CONDUITS

Transport experts argue that the most effective and efficient technology for a mobility revolution resides in electrified high-speed rail directly tied to renewable energies, productively crossing mobility and energy distribution infrastructures. Maximum speed is coupled with minimal electrical conversion and distribution losses as vehicles receive a steady supply of electricity from the grid[17]. Electrified high speed rail necessitates the construction of new elevated rail lines to achieve as horizontal a travel surface as possible for travel speeds of over 300 kilometers per hour. The introduction of this type of system has the capacity to link the GLM's urban centers from Chicago to Toronto in under 2:45 hrs; radically altering effective intra-regional time and space (Figure 2, bottom right). High speed passenger rail could also help alleviate congested highway surfaces and regular rail for freight mobility (projected also to double in the next twenty-five years) and could significantly decrease use of short-haul flights, which encumber airports and consume disproportionate amounts of fuel.

A significant opportunity emerges at the confluence of the distribution and mobility network of people, goods and energy: a rapid urbanization occurring proximate to existing highways, the need for increased capacity along existing highways, the efficiency of electrified high speed rail, and the need for new high capacity energy transmission lines to distribute the electricity produced by renewable energy resources (figure 3, right).

Given the highway's now far more strategic territorial relationship to urban growth, freight and production (as opposed to existing rail), intensification is assigned to the conditions of the line of the existing highway system. The new post-carbon highway cross-section, is retooled as a conduit of bundled cooperative networks of transport, transit and energy transmission infrastructures that could accommodate a variety of transportation and transit modes, including high speed rail and Mag-Lev electrified rail, dedicated vehicle lanes, high voltage power transmission and freshwater supply. (Figure 4, left) These capacity vectors are stacked and separated to maximize speed, safety, and accessibility thus increasing conduit bandwidth, in addition to forming a resource umbilicus that can service increasing densification and demand along the line. Dimensioned to operate within the existing right-of-way of major highways, this system facilitates ease of implementation by eliminating land acquisition and expropriation, and recognizes the geography of the highway as the driver for future urban growth.[18]

The development of these new conduit infrastructures has broader implications for the attendant territories proximate to the line. At a macro level, lands located along existing corridors, and those bounded between the corridor and adjacent infrastructural systems (such as existing rail) become distinguished with respect to their strategic advantage. Points of systemic crossing and crossover, currently understood through the ubiquitous and familiar landscape of the highway interchange, become charged with potential by virtue of their inherent availability for development and through the value they currently possess as points of transfer. With respect to its networked logic, the system privileges the node.

NODES

As the system intensifies, the new typology of the multimodal transfer interchange will become a key nodal type and a dominant megaregional construct. These interchanges will be places where the system, its travelers, and resource flows will interface with dependent population concentrations. The strategic sites and available footprints for such developments are already determined by the existing system. At the moment, each of the over 400 off-ramp interchanges along the I80-I75-401 conduit simply facilitates changes of speed and direction. However, the architecture of each interchange renders an average of 44.3 acres (18 hectares) of orphaned adjacent surface lands. (Figure 4, right) These sites provide an ideal location for modal switch sites, terminal and interchange structures, as well as the potential to house new typologies that will benefit from the proximity to the mobility and renewable energy conduit. The traditional highway service center with its minimal amenities—fuel station, fast food joint, strip motel—is no longer sufficient. In the post-carbon era of new fuels, a variety of refueling systems will be needed at every service point, each fully integrated with the differentiated modes of travel.

At the intersection of current urban centers where the high speed conduit systems of transport flows can intersect local arterials and LRT loops, transport terminals will house parking facilities for outgoing commuters, and provide secondary transit connections to local street systems. (Figure 5) For commuters arriving on the new rail system who require individual transport to places of work, rail passes will be integrated with electric mini-car rental facilities for 'last mile' travel between the terminal and final destination. Gateway sites such as those proximate to regional and international airports will be integrated with access to urban transit networks, while specialized nodes will be developed to manage the logistics of border crossing locations. Sorting and redistribution sites will include classification yards and consolidation terminals for freight flows, as well as sites for intermodal interface with existing rail networks. Considering the surficial requirements for warehousing and intermodal redistribution, horizontal fields of logistics zones could develop alongside the interchanges and may span spaces between the new highway and high speed rail system and existing rail lines. Strategic institutional sites along the conduit can be created to capitalize on the research and development base of the Great Lakes Megaregion.

Beyond logistics and transportation driven infrastructural provision, this emerging matrix of interconnectivity has the capacity to foster significant transformation in the distribution of social infrastructures. Nodal sites with strategic proximity to population centers will now be linked to a human talent base that spans and connects existing urban concentrations across the region. For exam-

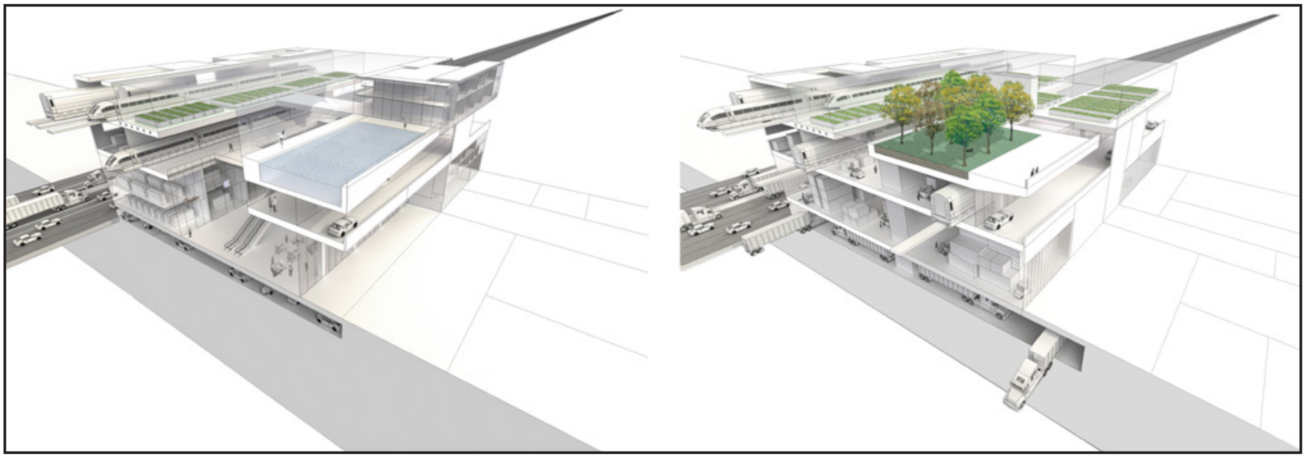

Figure 5:Multimodal Transfer Interchange Cross Sectional Development: Adjacency to the primary high-speed commuter system allow for a range of attendant programs to emerge ranging from freight transfer and logistics, to social infrastructures that will serve concentrations of highly mobile regional citizens.

ple, high quality and specialized services such as regional health centers can be both connected to major urban centers, as well as accessible to less affluent and diverse communities via the new line of rapid rail based mobility infrastructure. Public transportation systems will increase the availability of this type of social infrastructure to a wider constituency of participants than the traditional model of city-wide or local regional centers can currently facilitate.

At the scale of individual daily engagement with social infrastructural systems, connectivity offers significant advantage. Public education, daycare facilities, local food distribution centers, specialized athletic facilities, unique forms of medical service concentration, and other forms of highly specialized social infrastructure that evade the logistics of local economic provision, might emerge, connecting a wider population with facilities beyond the limitations of local urban budgets, programs and expertise. High-speed, publically available mobility without the necessity of individual vehicle ownership will foster new forms of demand and accessibility, that when coupled with a connection to regional talent pools, might foster altogether new forms of social infrastructure proximate to mobility.

Conduit Urbanism will catalyze intensification of existing highway corridors combined with emerging systems of renewable energy distribution, mass transit and freight intelligence. *Mobility* and *power* will activate currently dormant peri-urban protagonist landscapes. These territories, ranging from vast field conditions to precisely defined nodal points of transference will emerge as key points of friction and opportunity that will both condition and define the Great Lakes Megaregion, while offering its inhabitants new forms of collective social infrastructure, services, and spatial products that conflate these various programs into a linear system of intensification and connectivity.

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ENDNOTES

1. See for example Lars Lerup *After the City* (Cambridge: MIT Press,2001), Aaron Betsky, "Making ourselves at Home in Sprawl," *Pst Ex Sub Dis: Urban Fragmentations and Constructions* (Rotterdam: 010 Publishers, 2002) as well as the seminal text by Reyner Banham, *Los Angeles: The Architecture of Four Ecologies* (Los Angeles: University of California Press, 1971).
2. The Federal-Aid Highway Act of 1956, enacted on June 29, 1956, is also popularly known as the National Interstate and Defense Highways Act.
3. For the early history, see Jean Gottman's 1961 "Megalopolis", Constantinos Apostolos Doxiadis 1968

"The Emerging Great Lakes Megalopolis" as well as the regional planning visions of Lewis Mumford, Clarence Stein, and Benton MacKaye.

4. Institutes currently studying and publishing literature on Megaregions include: The Brookings Institute, the Loncoln Institute, the Regional Plan Association, the Metropolitan Institute at Virginia Tech, researchers at Urban and Regional Planning Program at the University of Michigan, as well as the Martin Prosperity Institute at University of Toronto's Joseph L. Rotman School of Management.

5. Sassen, Saskia "Megaregions: Benefits beyond Sharing Trains and Parking Lots," in Keith S. Goldfield, ed. 2007. "The Economic Geography of Megaregions", The Policy Research Institute for the Region, Trustees of Princeton University: New Jersey: 67

6. Ibid: 77. However, it is important to note that Sassen stresses the role and importance on progressive public policy in order for these potentials to be realized.

7. There remains no consensus between research agencies as to the definition of the boundary of the GLM, as identification parameters and methods vary from study to study. See for example Delgado, Epstein et. al. 2006 "Methods for Planning the Great Lakes MegaRegion", who provide a summary of the boundary definitions to date. One of the problems in the definition identified by Delgado, Epstein et. al. has been the inconsistency of available economic data between Canada and the United States and its resulting exclusion from most studies.

8. These statistics have been compiled and referenced from a range of sources including "Canadian Census Data "(2006) courtesy StatsCan, U.S. Department of Transportation, Research and Innovative Technology Administration, Bureau of Transportation Statistics, "Trans-border Freight" (October 2008), The Bureau of Economic Analysis, US Department of Commerce: "Regional Economic Accounts" (Sept 2008), Austin, Affolter Caine, Milway "The Great Lakes, A World Leading Bi-national Economic Region" (Mar 2007) as published by the Brookings Institute and the CIA World Fact Book https://www.cia.gov/library/publications/the-worldfactbook/ (retrieved Feb 20, 2009)

9. See Ontario Ministry of Transportation, "Goods Movement in Ontario: Trends and Issues" Technical Report (Dec 2004) for rigorous numeric data regarding Canadian transport statistics.

10. Ontario Ministry of Infrastructure Renewal, "Places to Grow: Growth Plan for the Greater Golden Horseshoe" (2006): 7. The American Association of State Highway and Transportation Officials (AASHTO) 2007 report. "A New Vision for the 21st Century", states that from 2007, "Truck volumes are expected to double by 2035, and rail freight to increase by over 60 percent": 57 (www.transportation.org; retrieved March 17 2008)

11. America 2050: http://www.america2050.org/great_lakes.html

12. Calculations extrapolated from data sourced via the "Wind Energy Resource Atlas of the United States" National Renewable Energy Laboratory / US Department of Energy (1986), existing data from OPG Data (2009).

13. US biomass potential data can be acquired through the National Renewable Energy Laboratory / US Department of Energy site http://www.nrel.gov/gis/maps.html

14. Solar potential data for the US: http://www.nrel.gov/gis/maps.html; Solar potential data for Canada from Natural Resources Canada: https://glfc.cfsnet.nfis.org/mapserver/pv/index.php.

15. For offshore wind potential of the Great Lakes, see the following studies: Land Policy Institute (September 2008 report). "Michigan's Offshore Wind Potential", Helimax Energy Inc. (April 2008 report). "Analysis of Future Offshore Wind Farm Development in Ontario" as well as the U.S. Department of Energy (July 2008 report). "20% Wind Energy by 2030".

16. "Province freezes Great Lakes energy proposals," *The Toronto Star*, October 23 2009. http://www.thestar.com/comment/article/714699

17. Gilbert, Richard and Anthony Pearl (2008). *Transport Revolutions. Moving People and Freight without Oil* (London: Earthscan): 311.

18. See visual analysis of urban morphology in Southern Ontario cities relative to the 401 Highway corridor by the authors in "The Post-Carbon Highway", *Fuel*, John Knechtel ed. (2008): 174-17