Chicago: Vision for the Future

Responsive Transport

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Preface

The Project

1909 marks the Centennial of Daniel H. Burnham's and Edward H. Bennett's 1909 Plan of Chicago. The Burnham Plan, as it become known, redirected Chicago's development from disorganized industrial and commercial growth to a planned movement toward the "city beautiful". Along the way, Chicago became a green city with a necklace of parks and boulevards recognized around the world for its beauty. The Burnham Plan challenged Chicago's leaders to arrest the uncontrolled development that characterized the late 19th and early 20th centuries. Challenged by Burnham, Bennett and the Commercial Club of Chicago, the city committed to Burnham's vision, an environment that could be both functional and beautiful.

One hundred years later, Chicago and major cities worldwide face different but equally portentous problems and opportunities. New and powerful forces, both destructive and constructive, confront cities and society. Global warming is changing climate and energizing unpredictably destructive weather. Population growth and movement to the cities are at an all-time high. Global economics are reshaping trade and disrupting established patterns of supply and demand. Voracious energy needs are depleting traditional energy resources, forcing an increasingly urgent search for energy sustainability. High-tech materials sciences along with communications, computing, biological and engineering sciences are reshaping what is possible. Negative and positive, the agents of change have raised the stakes.

Established cities like Chicago must evolve more quickly. Entirely new cities now springing up almost overnight in fast-developing countries, -- like China's Shenhzen -- need to plan for change from the beginning. Both will need vision to weave new technologies into their urban fabric. Both will need wisdom to adapt evolving structure to tomorrow's pressing changes. Daniel Burnham's famous dictum -- "Make no small plans" -- is most timely and appropriate in this year of centennial celebration.

"At no period in its history has the city looked far enough ahead. The mistakes of the past should be warnings for the future. There can be no reasonable fear lest any plans that may be adopted shall prove too broad and comprehensive. That idea may be dismissed as unworthy of a moment's consideration. Rather let it be understood that the broadest plans which the city can be brought to adopt today must prove inadequate and limited before the end of the next quarter of a century. The mind of man, at least as expressed in works he actually undertakes, finds itself unable to rise to the full comprehension of the needs of a city growing at the rate now assured for Chicago. Therefore, no one should hesitate to commit himself to the largest and most comprehensive undertaking; because before any particular plan can be carried out, a still larger conception will begin to dawn, and even greater necessities will develop." --Daniel Burnham

In keeping with Burnham's thinking, this project freely explores urban possibilities for the next century. Rather than a conventional "plan", however, as might be proposed in a blueprint for a cityscape, this study examines a variety of physical, procedural and organizational concepts now emerging or that soon could emerge from evolving technologies and changing social forces. Overall, the project is composed of four separate but integrated studies focusing on urban infrastructure, transport, environmental features (river and lake front), and the role of nature in the city.

The component covered in this report is Responsive Transport: possible futures for personal and commodity transportation in the city.

Preface

The Course

The design concepts presented are results of a project-based course at IIT's Institute of Design. The semester-long Systems and Systematic Design course is a workshop in which teams of graduate students, deliberately of mixed international origins and different academic backgrounds, apply the computer-supported Structured Planning process to complex design planning problems. The goal for each project is to develop information thoroughly, propose innovative solutions that take maximum advantage of the information, and integrate those ideas into system concepts that can both be evaluated in their own right and (in a real situation) be the comprehensive project specifications for a follow-on detailed development project.

Course Issues

Complexity. What is the nature of "systems" concepts where policy, products, processes, services and communications are organized to act together to achieve multiple goals? What can be done to assure that a system concept is as complete as possible, covering many functions and attaining a high degree of "wholeness" and organic reliability?

Design planning methods. What is Structured Planning and how can its tool-kit of methods be used to collect, structure and synthesize information in projects of greater complexity than can be comfortably dealt with intuitively? How can such methods be used by a team to extend the effectiveness of all?

Teamwork. How do individuals with different cultural origins and different academic backgrounds work together successfully on teams? What roles are there to be played and what difficulties must be overcome?

The Project Team

Eighteen graduate students from the U.S. and abroad were assigned to four teams for study of Chicago's and other large cities' future. Background experience for team members included degrees in fine art, art history, painting, marketing, strategic management, business management, interior design, product design, graphic design, communication design, psychology, ethnic studies, Spanish and Latin American studies, teaching, economics, political science, cognitive science, comparative media studies and semiotics.

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Project Leader

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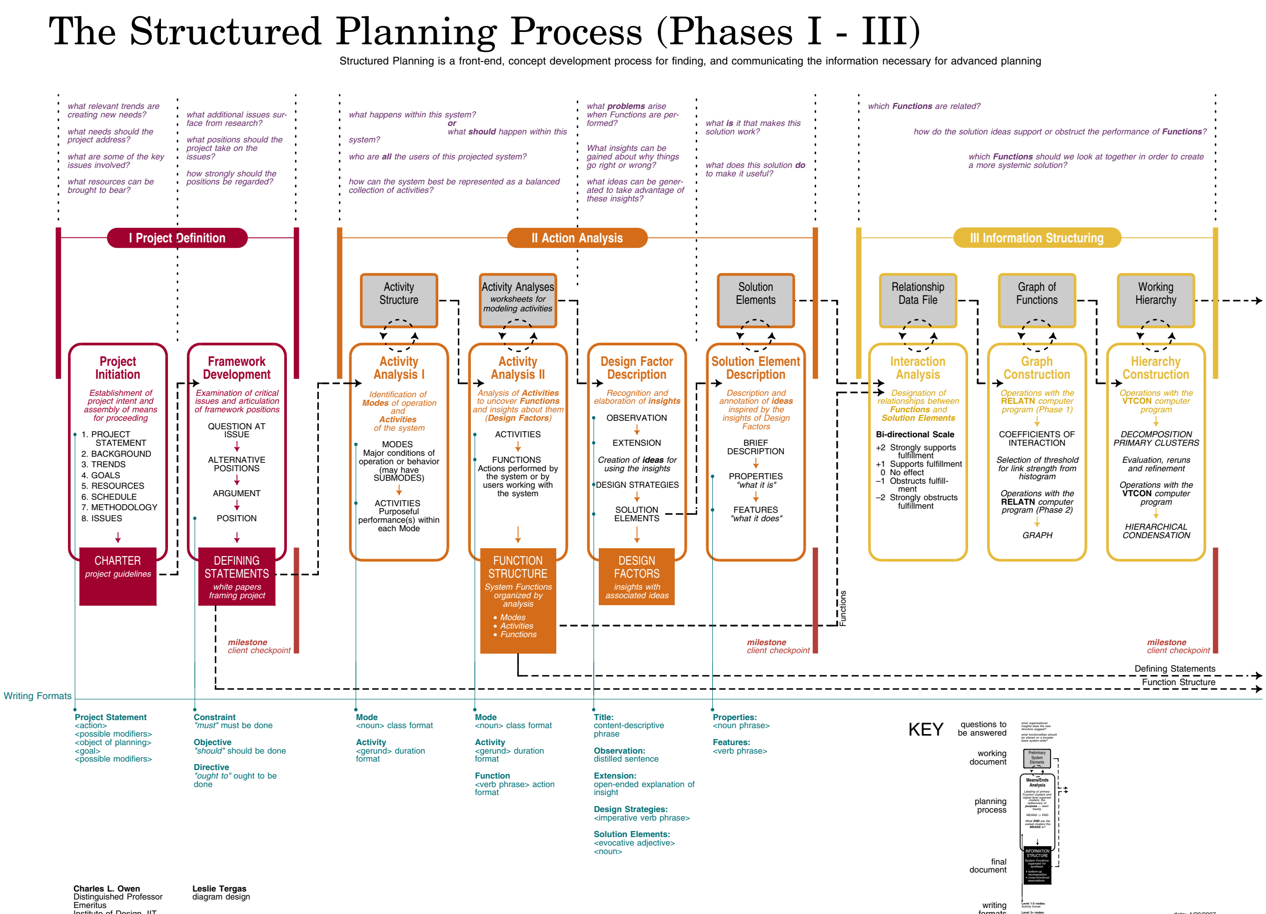
The Planning Process: Structured Planning
Structured Planning, the systematic planning process taught in the course, is a process for finding, structuring, using and communicating the information necessary for planning. It is a front-end process for developing concepts thoroughly and cohesively.

A number of projects have been undertaken with it and used to further its development. Among more than 100 of these, an early published project for Chicago's transit authority (CTA) was Getting Around: Making the City Accessible to Its Residents (1971). In 1983, the House of the Future project won the Grand Prize in the Japan Design Foundation's First International Design Competition. In 1985, the design of a habitation module for Space Station was undertaken for NASA. In 1987, the Aquatecture project won the Grand Prize again in the Japan Design Foundation's Third International Design Competition. In 1991, Project Phoenix (on global warming) was honored as Environmental Category Grand Winner in Popular Science magazine's "100 Greatest Achievements in Science and Technology" for the year. In 1993, two award winning projects, NanoPlastics and Aerotecture, were widely publicized in Europe and Japan; in 1995, the National

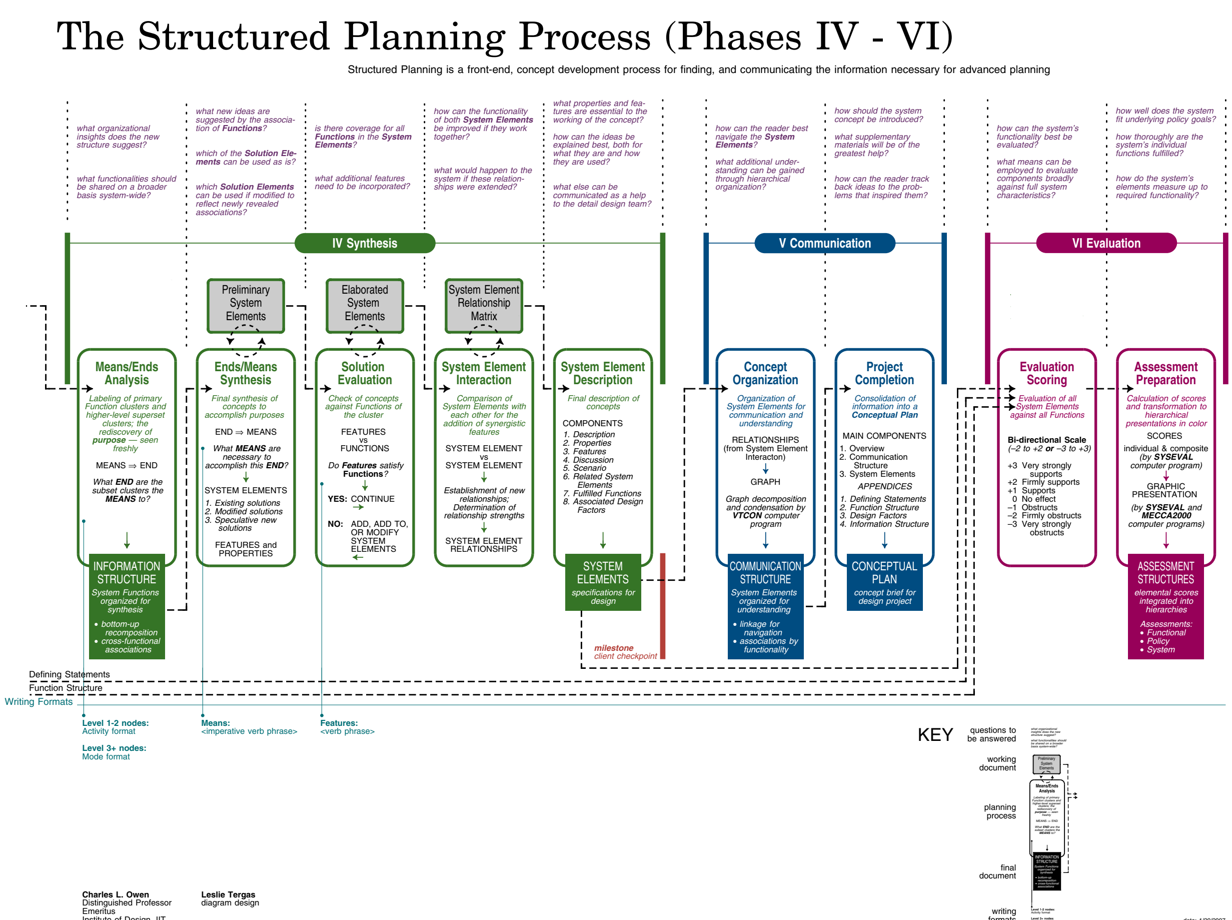


The Structured Planning process: phases I through III.

Preface

Parks project developed plans for the future of the U.S. National Park Service. In 2001, Access to Justice, a project sponsored by the National Center for State Courts, was implemented for use in state courts in Chicago and across the United States, and in 2005, four projects on Home, Play, Work and Health were finalists in four of the five competition categories for Denmark's INDEX Awards, the world's richest design prizes. Most recently, the 2006 project on Massive Change studied adaptation strategies for global warming in Chicago and similar cities, and the 2007 project outlined design planning concepts to complement policy planning for national health care. As the process has evolved, it has become an increasingly useful planning tool for business, institutions and government.

A diagram of the process, shown here in two figures, sets out the activities that make up Structured Planning along with the working documents and final products produced along the way. The general description below follows the diagram. The process and its products are discussed here in the abstract; specific examples created for this project may be seen in the appendices that accompany the report.



The Structured Planning process: phases IV through VI.

Preface

I Project Definition

The Structured Planning process begins with Project Initiation and the production of a Charter. This is a "brief" that serves as an initial communication vehicle between client and planners. It contains background, context, basic goals, a project statement that cuts to the heart of the planning task, resources to be used, a schedule and an initial set of issues to be investigated. Defining Statements are mini "white papers" produced in the Framework Development portion of Project Definition. They focus the project within the direction of the Charter, concentrating on the issues and arguing specific directions that the project should follow with regard to them. Together with the Charter, they frame the project.

II Action Analysis

Any system can be viewed as a complex entity working with its users in different ways appropriate to its modes of operation. To plan effectively, a planning team must recognize these Modes, identify Activities that occur within them, and isolate the Functions that the users and system perform or are intended to perform within each Activity. The result of the Activity Analyses is a Function Structure.

Half of the purpose of Action Analysis is the enumeration of Functions. The other half is the development of information about them that reveals insight about what happens as they are performed. During Action Analysis, insights are sought about why things go wrong in performing some Functions, and how other Functions manage to be performed well. These insights are uncovered in the Design Factor Description procedure and developed in documents that become part of a qualitative knowledge base. Activity Analyses record information at the Activity level; Design Factors document insights and ideas associated with Functions.

To capture as fully as possible the ideas suggested on Design Factor documents, solution ideas are written up in the Solution Element Description portion of Action Analysis. This is done on simple one-page forms designed to capture enough detail about ideas to give them substance when they are needed later. They have three important sections: "Description" -- a short explanation, "Properties" -- what the idea is, and Features -- what it does. The product of Action Analysis is three sets of critical information: a set of Functions (the Function Structure), a set of insights (Design Factors) and a set of preliminary ideas (Solution Elements).

III Information Structuring

Paradoxically, as useful as the Function Structure is for establishing coverage, it is not the best form of organization for developing concepts. Reorganizing information for use in concept development is the job of two computer programs, RELATN and VTCON.

The controlling factor for whether two Functions are associated from the planning standpoint is not whether they are categorically "related" in some manner, but whether a significant number of their potential solutions are of concern to both. Which Solution Elements are of concern to each Function is established in an Interaction Analysis procedure. The RELATN program uses this information in a Graph Construction process to establish links between Functions.

Another program, VTCON, completes the information structuring process. In the Hierarchy Construction activity, VTCON finds clusters of highly interlinked Functions and organizes them into an Information Structure, a visually understandable, very general form of hierarchy most appropriate for planning.

IV Synthesis

In its form from the VTCON program, the Information Structure is simply a hierarchical reorganization of Functions. Nodal points above the Function level do not have names. The task of Means/Ends Analysis is to create labels for all nodes in the hierarchy. Moving bottom-up from the known Functions in the bottom level clusters, names are found to label nodes as "ends" for which lower-level nodes are "means". The process continues to a completely labeled Information Structure.

The process is then reversed as a top-down, structured brainstorming procedure: Ends/Means Synthesis. In this process, the planning team asks of high level nodes, “what means do we need to meet this end?” As means are established, they are treated in turn as new ends for which means must be found, until the means become concrete enough to be described as final elements of the system (System Elements). Existing Solution Elements are reviewed as potentially usable directly; others are modified or combined to make them usable, and new ideas are added to fill unmet needs newly recognized.

System Element Interaction compares System Element with System Element in a search for additional synergies that can contribute to systemic qualities. More than simply recognizing relationships, the planning team proactively seeks out inventive new ways for System Elements to work together -- the invention and design of relationships. Changes and additions are incorporated in the properties and features of the individual System Elements.

The last Synthesis task, System Element Description, completes the specification of System Elements, including a succinct description, all relevant -- now essential -- properties and features, and extensive Discussion and Scenario sections that contain detailed expositions of the ideas in both conceptual and operational terms.

V Communication

Because the result of the Structured Planning process is a complex system, usually with a number of System Elements, a Communication Structure is frequently included as an aid to understanding. This is created during Concept Organization by the VTCON program from an assessment of how important the System Elements are to each other’s operation. Using this structure, the reader can understand the system more easily and navigate its concepts with efficiency.

The product of the Structured Planning process, assembled in the Project Completion section, is a Conceptual Plan, made up of an Overview that provides background and introduces the system, the System Elements that describe the ideas and their relationships, and Appendices that contain all relevant support information, including the Defining Statements, Design Factors, Function Structure and Information Structure.

VI Evaluation

Structured Planning incorporates evaluation among the steps of the process, most notably during Synthesis. It also offers an optional full-system evaluation technique that can be employed to evaluate final results against policy-level and/or function-level criteria. Used for this, it provides merit values hierarchically for the system, its component parts and individual system elements. It can also create similar hierarchical evaluations for the assessment of functional performance and policy performance. Used to compare systems, it can provide system, functional and policy assessments for multiple competitive candidates measured against common function and system structure frameworks.

Introduction

Transportation has long served as a key component to the growth and development of Chicago throughout its history. From its beginning, Chicago's activity has been shaped by its role as a transportation center for the entire country – first on water and later by rail. Not only did Chicago manage to establish itself as the central railroad hub between the eastern and western regions of the United States early on, but the city has always taken advantage of its connections to both the Great Lakes and the Mississippi River systems for both its basic needs and as an economic resource.

In present day, Chicago continues to be a leading city in transportation. The Chicago Transit Authority (CTA) is the second largest public transportation system in the country currently serving approximately 500,000 customer trips per day over 222 miles of tracks to 144 stations with its elevated train services alone. Unfortunately, the region has not yet tapped into its full potential by building on this framework and creating a world-class intermodal network for personal mobility. This is in part due to the region's continued reliance on the automobile as a primary means of transportation.

The Problem of the Automobile

When it comes to driving, traffic congestion currently costs the Chicago region approximately $7.3 billion per year in wasted fuel and lost time; moreover, if this problem remains unaddressed congestion will grow to an $11.3 billion dollar burden by year 2030 (Hilkevitch 2008). Across the United States, average vehicle occupancy hovers at approximately 1.08 passengers per vehicle (University of South Florida 2008) and according to Brian Richards, "the car has caused the most problems to city life" by causing death and injury from traffic accidents, intensifying health problems due to poor air quality from vehicle exhaust, and contributing to the climate change problem through pollution (Richards 2001, 2). Furthermore, current car technology feeds into heavy dependence on non-renewable resources, and thereby plays a significant role in escalating socio-political and economic tensions around the world.

Automobile dependency has also contributed to urban sprawl in the Chicago region, a phenomenon characterized by spacious homes, large land lots, "big box" stores with vast parking lots, and low-density populations. Jobs have migrated along with new affordable housing out to the suburbs, and polycentric, or multinucleated, urban areas have become increasingly common. While it is out of the scope of this project to provide solutions for regional transport, Responsive Transport solutions serve as models that could eventually expand into Chicago's suburbs and beyond.

A New Vision for Responsive Transport

It is crucial to the future of Chicago's transportation system to develop alternatives to today's automobile addiction and the problems left in its wake. It is from this point that we must begin to build a new Vision for the Future for Responsive Transport. However, a major transition to significantly reduce car use seems unlikely without taking into account the benefits and convenience that have led so many people to choose cars over options such as public transit options in the first place. "No other form of transport can compete with the private motor vehicle in terms of door-to-door mobility, freedom to time one's arrivals and exits, protection from inclement weather, and comfort, security, and privacy while in transit" (Johnson 2001, 32). Not only do cars offer a sense of autonomy to drivers, but they also enjoy a romanticized appeal in the United States where they are often regarded as a reflection of the car owner's identity.

While current car congestion and traffic is a problem that should be addressed in the short run, a new longer-term concept of how people and goods move around and through the city is also necessary. Keeping this in mind, Responsive Transport supports the growth and activity of Chicago's transportation system to improve the quality of urban life with three overarching guiding principles.

Introduction

Guiding Principles

1. Encourage urban connectedness so that citizens can both contribute to and benefit from the system.

Connectedness in the city is not just physical but also social, cultural, emotional and cognitive. By leveraging advances in areas such as technology, communication, and planning, Responsive Transport proposes a system that is integrated into people's daily lives and ultimately promotes a sense of shared ownership of the system through such connectedness.

2. Make the city's transportation system easy to understand and accessible to all.

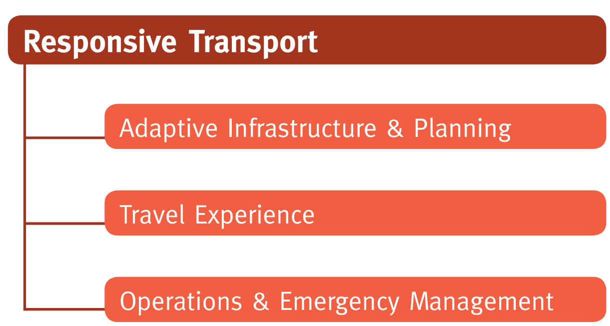
Chicago, like most urban environments, owes much of its growth and success to the contributions of a richly diverse population. This requires responsibility on the city's part to ensure accessibility to the system in all forms – be it physical, economic, linguistic, or otherwise. One in three Americans will be over the age of 50 by the year 2010 (Lewis 2007), and "with age, people change physically, mentally and psychologically. For most people these changes involve multiple, minor impairments in eyesight, hearing, dexterity, mobility and memory. At present, such changes...are challenging common assumptions about how products and services should be designed if they are to meet the needs of the majority" (Coleman 2007). As a result, providing multidimensional accessibility in a future transport system becomes imperative if it is to effectively serve all of Chicago's citizens.

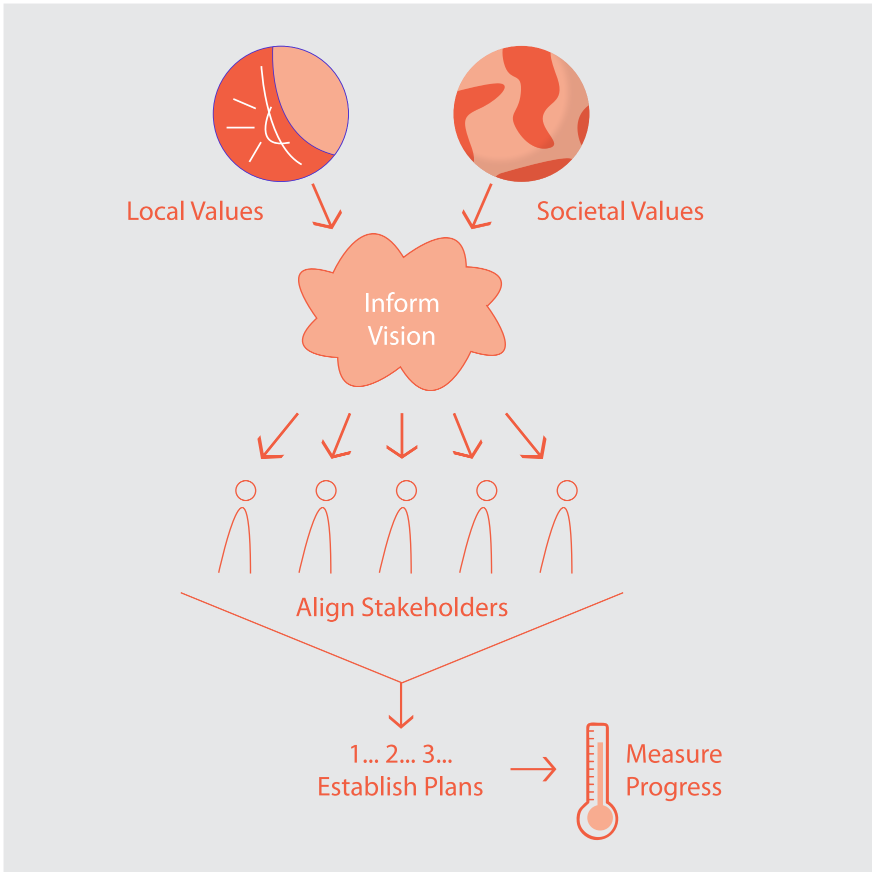
3. Serve both current and future generations while respecting the city's past through a dynamic, safe, and sustainable system.

Jonathan Gifford writes that "transportation planning must strike a balance between stability and agility. The companion of stability is predictability, and the companion of agility is uncertainty" (Gifford 2003, 176). The future is certain in that change is inevitable; transportation planning for the future should indeed respect both stability and agility. Planning with stability in mind involves acknowledging culture, heritage, customs, habits, routines, traditions, property rights, and all other artifacts and institutions of the city's history; planning with agility in mind requires being opportunistic, responsive, flexible, and adaptable. (Gifford 2003, 176). This includes preparation for emergency situations, climate change and other environmental concerns, as well as the shifts in technology and society over time that cannot be fully predicted but should be anticipated.

System Elements

Solutions for Responsive Transport fall into three major categories. *Adaptive Infrastructure and Planning* lays out solutions for infrastructure development and maintenance while proposing possibilities for continued planning for an effective and sustainable transport system through **Chicagotopia,** the **Inhale/Exhale Initiative, New Connected Infrastructure,** and **Evolutionary Maintenance.** The **Transcom Network, Delightful Travel, Privlic Transport, Vehicle Storage,** and **Cargo Concierge** outline solutions to improve the movement of both people and goods through the *Travel Experience*. Finally, *Operations and Emergency Management* are explored through **Operational Excellence, Optimized Infrastructure, Distributed Information Management, Wilde Times,** and **Nimble Response.**





Chicagotopia

Chicagotopia is a strategic development team that establishes vision and direction for future transportation efforts. After setting this new vision, Chicagotopia coordinates and executes steps toward this revised plan through both internal analyses and external partnerships.

Related System Elements:
Inhale/Exhale Initiative
New Connected Infrastructure
Evolutionary Maintenance
Delightful Travel

Fulfilled Functions

1 monitor traffic
2 identify patterns
3 anticipate problems
4 prioritize needs
5 implement adjustments
6 gather feedback
7 revise approach
8 establish goals
9 assess needs
10 delegate authority and responsibility
14 evaluate quality of system
22 specify organizational relationships
23 gather data
24 manage information
25 communicate between system components
96 gather and interpret data
97 simulate scenarios
98 make predictions
99 manage risk
100 find consensus
101 revise goals
102 establish action plan
103 assess existing infrastructure
104 generate viable options
105 align stakeholders
106 identify resources needed
107 coordinate activity and budget
111 acclimate system users

Properties

- Census information
- Surveys
- Employers
- Risk database
- Forecasting software
- Conference rooms
- Research and development teams
- Working betas for pilot tests
- New signage
- Public education and announcements
- Test zones
- Measurement tools
- Convention centers
- Artists (illustrators, renderers)
- Visits to other cities
- Historians
- Office of tourism
- Politicians
- Environmentalists
- Engineers
- Urban planners
- Community representatives

Features

- Manages database of problems and risks to assuage
- Gathers info about current demands
- Surveys public opinion
- Forecasts trends and future demands
- Illustrates vision of chicago to inspire public and other stakeholders in the system
- Collaborates with politicians and Office of Tourism to start shifting policies that affect goals
- Canonizes a revised plan that prioritizes the environment, efficiency, and respect for Chicago's architectural history.
- Constructs text zones to pilot new ideas
- Develops proposals based on pilot tests and consultations
- Sends directives to involved parties to implement change
- Monitors effects of change
- Adjusts directives

Associated Design Factors

- Resources not readily available
- Measuring system quality is difficult
- Conflict between long and short term goals
- Opinions may change later and stop a project in progress
- Expanding means destruction of nature or current developments
- Difficult to determine what infrastructure is worth saving
- Bureaucracy and internal politics impede action
- Stakeholders may not agree with proposed solutions
- Budget issues may impede or interrupt progress
- May be difficult to pass laws and regulations

Discussion

Setting the Vision
Chicagotopia's vision for the future is informed by both local and societal values. Local values refer to the voice of the people. Intergrated client interface technologies, such as the **Transcom Network** of kiosks and handheld web applications, facilitate **Participatory Feedback** from system users. Complaints, comments, suggestions, and general information about system load and congestion illuminate areas for improvement. Feedback on new concepts also come from **Pilot Zones**. **Pilot Zones** are small areas of the city set up as test zones for new system configurations prior to system-wide adoption.

Societal values refer to the voice of external forces upon the system such as population growth, environmentalism, culture, and technology. **Demand Forecasting** pushes the system to become more efficient by measuring population growth, urban sprawl, and usage trends. **Sustainability Requirements** and a desire to respect Chicago's architectural past inspires the system to **Prioritize Existing Infrastructure**. **Prioritizing Existing Infrastructure** means that infrastructure expansion will be non-permanent and non-destructive to existing building and green spaces. The Chicago transportation system alsos take inspiration from other cities. By visiting **Model Cities**, transportation planners can integrate the most successful aspects of other transportation systems into that of our own city.

Executing the Plan
After a new vision has been set for Chicago, action must be taken. In order to smooth out the adoption of new ideas, **Chicagotopia** makes use of the **Alignment Initiative**. The **Alignment Initiative** is a set of moderating and compromising strategies for working with stakeholders outside the system. One application of the **Alignment Initiative** is the use of **Collaborative Decision Making** and **Pre-compromised Proposals. Collaborative Decision Making** invites stakeholders to participate in the decision making process. For instance, system administration, CEO's of local companies, labor unions, and community representatives may all attend a meeting on congestion and how to minimize effects of rush hour through schedule adjustments and system performance. **Pre-compromised Proposals** means that a significant amount of research is conducted before any actions are proposed so that disagreements are preempted and resolved internally beforehand. This reduces time and money spent on proposals destined to fail. As plans are implemented by **Chicagotopia,** they are measured against **Adaptation Benchmarks** by **Goal Tracker. Goal Tracker** software breaks long-term goals down into smaller more manageable short-term

Discussion, cont'd

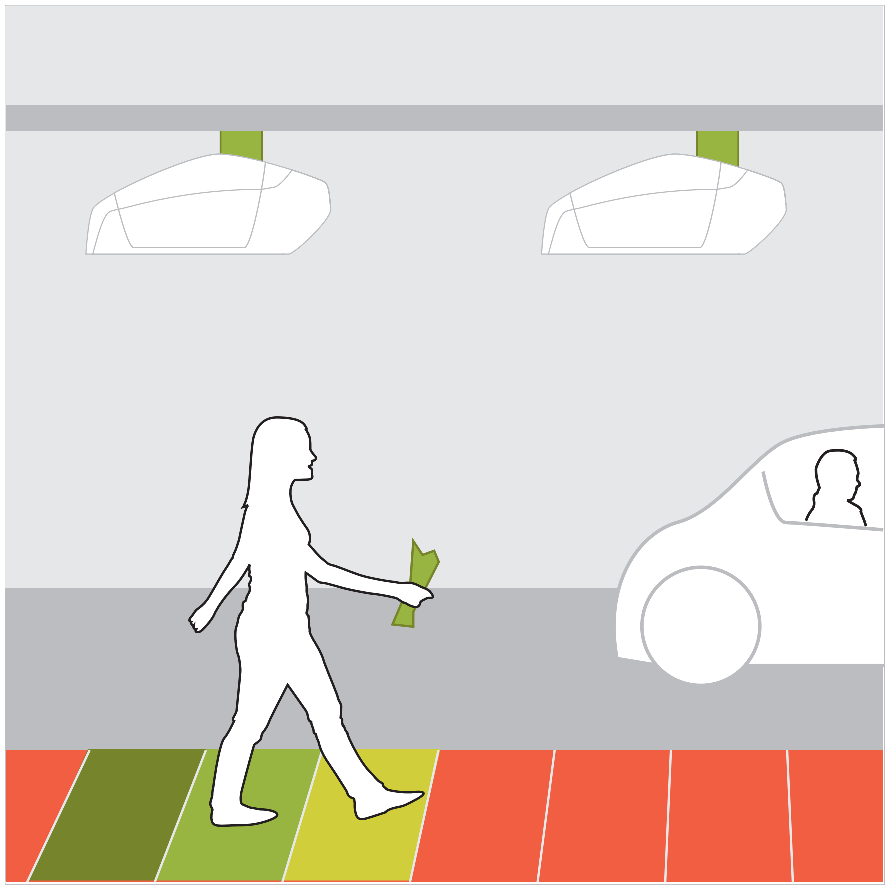
plans. It then analyzes differences and similarities between goals to help maximize efforts to create change.

By gathering information driven by internal and external values, **Chicagotopia** is better equipped to establish strategic vision and subsequently oversee effective execution of its plans.

Scenario

Susan is glad to finally have a say in these things. She actually chose her current apartment just to be near a **Pilot Zone.** This way, she can try out different ways of traveling to work and give **participatory feedback** to the transportation department. Susan feels like her voice is being heard and that her contributions are making a difference. She also tries to help out by reporting accidents and incidents via her personal mobile device.

Today Susan is on her way to the **Alignment Initiative.** Held in the McCormick Tribune Center, this convention allows Susan to participate in **collaborative decision making** and exploratory workshops. Before **Chicagotopia,** Susan felt as though her opinions and viewpoints were not being heard. After getting involved, she now feels a sense of empowerment and ownership about riding and shaping her transit experience.



Inhale/Exhale Initiative

The Inhale/Exhale Initiative is a set of regulations, networks, programs, and material standards that is based on the common notion that "one man's trash is another man's treasure."

Related System Elements:
Chicagotopia
Operational Excellence
New Connected Infrastructure

Fulfilled Functions

11 identify resources
12 gather resources
13 allocate resources
22 specify organizational relationships
26 establish quality requirements
30 analyze cost benefit of repair or replacement
32 gather repair resources
33 recycle or dispose of unneeded parts
38 select substitute
39 recycle or dispose of old parts
103 assess existing infrastructure
104 generate viable options
105 align stakeholders
106 identify resources needed
107 coordinate activity and budget
108 modify system
109 manage waste

Properties

- Standards for sustainability
- Trash-burning fare systems
- Energy-harnessing components
- Multipurpose modular parts
- Network of sister cites and industries
- Local repurposing projects
- Greenways

Features

- Regulates material choices for expansion, contraction, and operation of infrastructure that yields minimal negative impact on environment
- Utilizes public contribution of energy/fuel resources (e.g., trash, recyclables, compost material) as fare or credits
- Generates resources internally by harvesting energy created by system movement (e.g., pedestrian traffic, vacuums in tunnels, water displaced by boats)
- Creates multipurpose modular parts for use across the system
- Shares used infrastructure or other output with sister cities and industries
- Repurposes used system parts for local public projects
- Utilizes nature to reduce harm of output

Associated Design Factors

- Resources not readily available
- User access vs. system costs
- Expanding means destruction of nature or current developments
- Disposal of parts can be environmentally harmful

Discussion

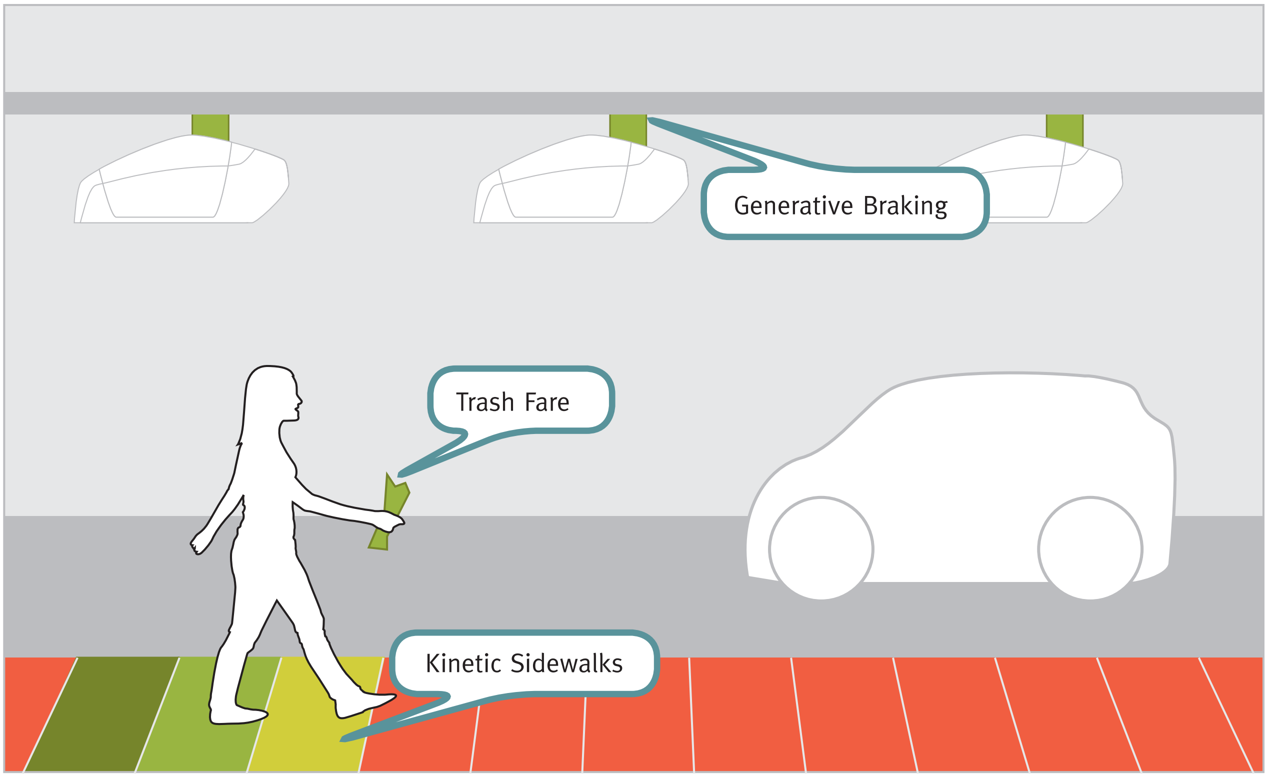
The **Inhale/Exhale Initiative** recognizes that the Responsive Transport system impacts the environment both in acquisition and expenditure of resources. Focusing only on greener outputs means incompatible materials are still being introduced into the system. Focusing only on greener inputs means ignoring the mark left on the environment by the construction, operation, and demise of a transportation system. Just as breathing in cannot be separated from breathing out, the system must always operate sustainably in times of expansion, contraction, and everyday operation.

Inhale
The **Inhale/Exhale Initiative** influences the Responsive Transport system from start to finish. Before tracks are laid, routes are planned to showcase the **Featured Environment.** For example, trees instead of fencing are used to buffer sound and mitigate the effects of air pollution. Additionally, any new infrastructure avoids interrupting existing ecosystems, prioritizing the use of existing pathways before expanding further. New infrastructure also pushes the boundaries of **Non-permanence,** so that the removal of infrastructure does not leave permanent artifacts. All the while, any expansion of the system must meet certain **Sustainability Requirements,** much like vehicle emissions standards, before plans are approved. This ensures that materials chosen for construction are harmless or at least biodegradable. With the **Inhale/Exhale Initiative,** the system always begins with the end in mind.

Once up and running, the system is partially fueled by **Trash Fare,** supplied by its patrons. For example, compost materials are used to generate electricity. Contribution via **Trash Fare** is rewarded with ride fare or credits for future travel. Self-sustaining **System Resource Generation** harvests energy created by the system's moving parts (e.g. pedestrian traffic, water displacement from boats, and pneumatic pressure from underground or other enclosed travel).

Exhale
As the system operates, waste is inevitably be created. Some system outputs are made useful through **By-product Synergy,** wherein sister industries make use of system waste, to the betterment of both the environment and the transport system's budget. Waste generated by other industries could also fuel the transport system. Similarly, the deconstruction of system infrastructure is either donated or shared with **Sister Cities** or repurposed as useful **Envirostructures** within our own city (e.g., park benches, homeless shelters, bus stops). Lastly, the **Inhale/Exhale Initiative** minimizes its need to "exhale" at all by utilizing **Multipurpose Modular Parts** within the system. These "hot-swappable" parts reduce the need to accumulate a large inventory

Discussion, cont'd

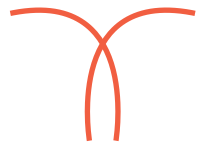


of specific parts that will likely go to waste when system infrastructure or technology change in the future. For instance, multiple modes may all use the same seating or hardware.

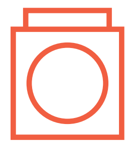
With these regulations, networks, and programs in place, Chicago lays to rest old destructive models of urban transportation and forges a new symbiotic relationship with nature.

Scenario

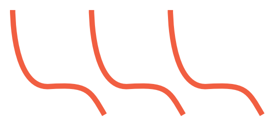
Amber boards the transit systems made from infrastructure previously used to build the Chicago Olympic Stadium.



Her ride is free because system output is purchased by a local appliance manufacturer for use in new dishwashers.

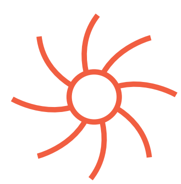


Her seat on the train is the same as those found on the bus.

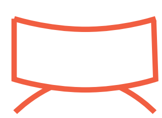


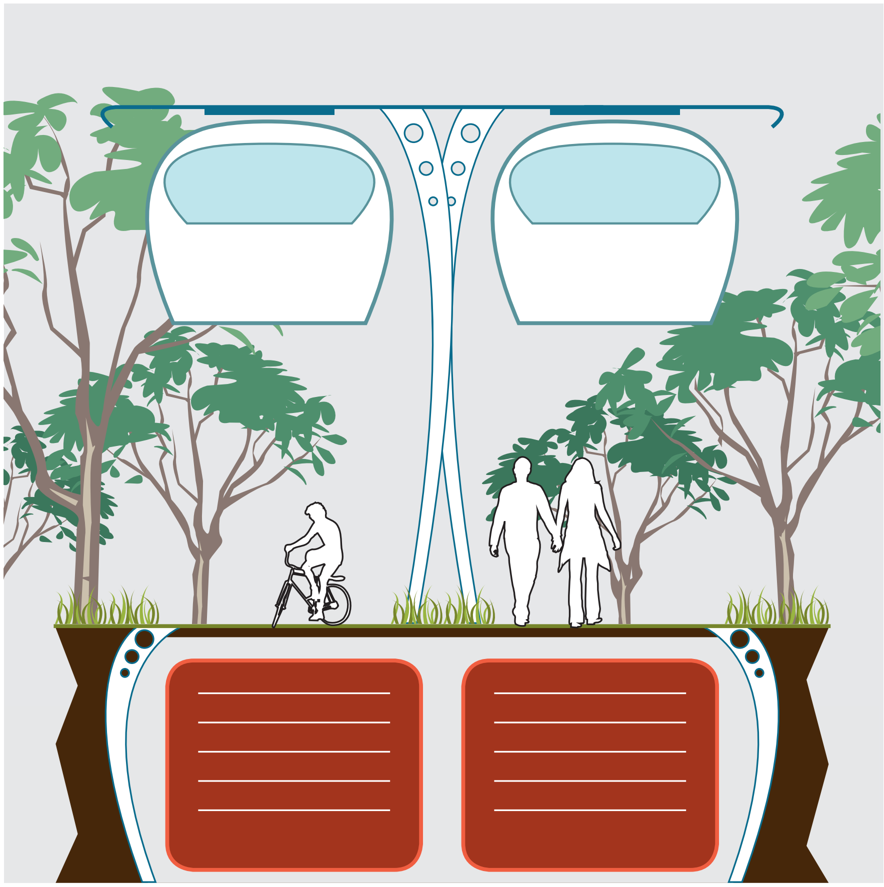
Her journey takes her past the beach, delighting both commuters and tourists.

The rush of wind generated by her train is harvested by turbines which redeposit this energy back into the system.



After exiting the train, Amber has lunch on a bus bench, now repurposed as a park bench.





New Connected Infrastructure

New Connected Infrastructure is an interconnected multi-modal web of transport options that allows for both convenient and efficient travel.

Related System Elements:
Chicagotopia
Inhale/Exhale Initiative
Evolutionary Maintenance
Transcom Network
Delightful Travel
Privlic Transport
Vehicle Storage
Cargo Concierge
Optimized Infrastructure
Nimble Response

Fulfilled Functions

46 select optimal mode

48 conduct transaction for departure

51 signal for departure

54 experience journey

55 make travel adjustments

59 move to new departure point

60 await next departure

61 signal for arrival

Properties

- Interconnected network of vertically layered multi-modal arterial express thruways/corridors and “ring roads”
- Localized “webbed” connections of light infrastructure
- Protected bike lanes and walking areas
- On-demand transport services
- Easy-entry stations and stops

Features

- Eases multi-modal travel through park-and-rides, easy-entry bus stops, free taxis, and other on-demand options
- Conveniently reduces wait times and transfer distances
- Allows for express travel between distant points and comprehensive coverage between proximate points
- Facilitates the coexistence of bike, pedestrian, and vehicular traffic through protected lanes
- Protects exposed bikers and pedestrians from inclement weather
- Increases efficiency by offering mode alternatives
- Promotes polycentric urban development which increases flexibility to meet transport demands of changing city
- Increased entry/exit points between main arteries

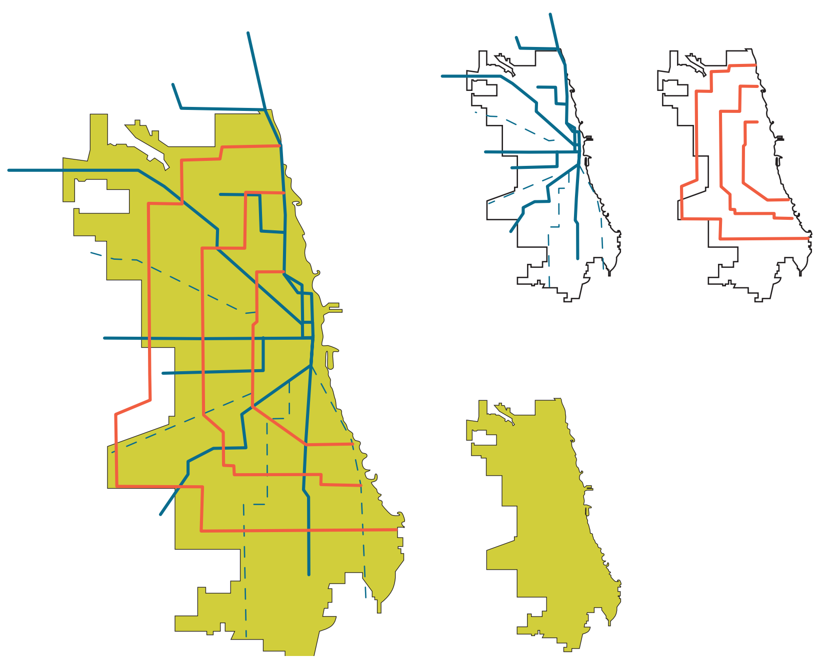
Associated Design Factors

- Expanding means destruction of nature or current developments
- Urban storage of vechicle is costly and insecure
- Optimal mode selection for mass transit can vary
- Communication is not always efficient or effective
- Far distance to new departure point
- Long waits before departure
- Poorly designed waiting areas
- Unclear or lack of information and communication hinders travel

Discussion

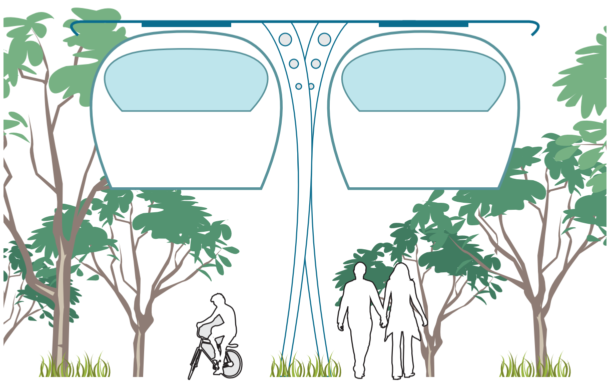
When Chicago's mass transit system was first developed, it was primarily focused on movement to and from the downtown hub. However, patterns of movement around the city have changed over time. **New Connected Infrastructure** seeks to shift the current system from a hub-and-spoke model into a more extensive web of coverage while taking into account the strong presence that already exists in the layout of the city's elevated train and highway system

New Connected Infrastructure is a set of infrastructure adjustments that connect previously disparate points in the transportation skeleton. This increased coverage is achieved through a combination of infrastructure expansion and multi-modal optimization. **New Connected Infrastructure** consists of a network of **Vertically Layered Arterial Thruways** and **Secondary Express Routes** combined with localized webs of light infrastructure transport to allow for express travel between distant points and comprehensive coverage between proximate points. Specifically, mass transit is broken down roughly in to 3 major levels illustrated below: 1) **Vertically Layered Arterial Thruways** (blue), 2) a lighter and more flexible infrastructure of **Secondary Express Routes** (red), and 3) **On-Demand Localized Services** working within specified boundaries (green).

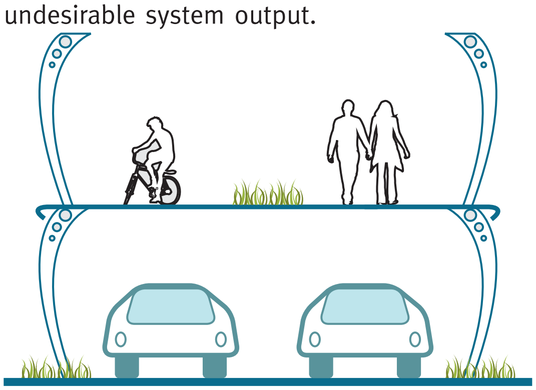


Discussion, cont'd

Vertically Layered Arterial Thruways
Chicago's transportation currently has a strong presence in the layout of its elevated trains and highways. In order to preserve the city's architecture, landmarks, and green spaces, most thruways are constructed vertically over the existing footprint of Chicago's major transportation infrastructure routes.

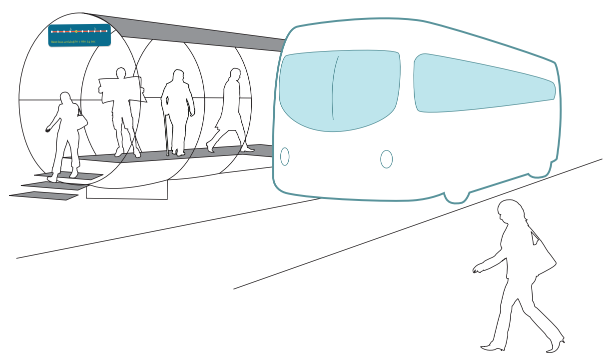


New Connected Infrastructure converts these rails into a system of **Vertically Layered Arterial Thruways**, with infrastructure that accommodates both rapid transit on one level and protected space on another for bicycles, pedestrians, and other lightweight local travel. Such a layered system facilitates the coexistence of bike, pedestrian, and vehicular traffic; **protected thruways** allows cyclists and pedestrians to enjoy the surrounding nature of **Greenways** and open air on pleasant days but is designed with retractable protection over the path to shield users from inclement weather. The surrounding green serves two purposes – not just to make the travel experience a little more pleasant, but also to serve as a buffer for noise and other undesirable system output.



Depending on existing infrastructure and new demands, **Vertical Layers** may accommodate a variety of modes and configurations in different parts of the city, but always dedicating at least one layer to public or shared transportation modes – for example, with bicycle and pedestrian above over existing highways, canals below, or any combination of modes.

Secondary Express Routes
In the second layer of express infrastructure, new routes that get people around the city without the necessity of heading downtown into the Loop. As new thruways are being developed, they first begin with **Secondary Express Routes** using transport modes that rely on lighter infrastructure such as buses or light rail to allow more adaptive and flexible development of routes.



Similar to models that currently exist in places like Curitiba, Brazil, express surface transport runs on **dedicated lanes** with **green flow prioritization** and limited stops equipped with movable **easy-entry stops.** These stops provide efficient and fluid bus traffic for several reasons:

- Transactions occur at the stop before rather than upon entering the bus to improve efficiency.
- Stops are raised to provide easy and fluid physical access.
- Stops provide protection from inclement weather and are equipped with **Transcom Network InfoBoards** to provide waiting passengers with real-time travel information.
- Currently buses have systems for on-board pas-

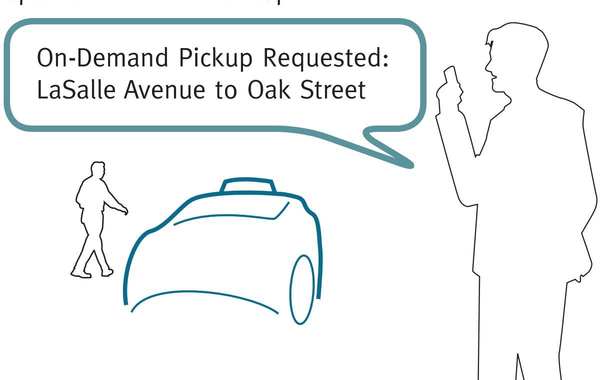
Discussion, cont'd

sengers to request stops; **easy-entry stops** are also equipped with a similar call system so that buses can easily anticipate passenger pick-ups and bypass stops without waiting passengers.

Since **easy-entry stops** are non-permanent, movable, and adjustable units, infrastructure can be easily adapted as routes are adjusted and transportation technology changes over time.

Lightweight **Secondary Express Routes** introduces and provides express services with the flexibility of learning and adjusting routes to achieve optimal routes. Since this type of infrastructure is both movable and adjustable, changes in transport technology or even express routes themselves over time are not a major burden to the system.

On-Demand Localized Services
When the coverage of **Arterial Thruways** and **Secondary Express Routes** do not take passengers close enough to their final destination, the next layer of transport services includes point-to-point **On-Demand Services**. These services consist of dedicated taxi and mini-bus services (included as part of system fare) that take passengers to and from major stations anywhere within a specified boundary relative to pick-up locations (e.g., 1 mile radius from pick-up location). To use **On-Demand Services,** the user calls for a specific pick up which may be shared or private, depending on calls from other users within the same time and area. Requests are anticipated and coordinated through the **Intelligent Transportation System** and **Transcom Network** Interfaces so that **On-Demand Services** are waiting upon user arrival at stop.



The goal of **New Connected Infrastructure** is to provide adaptability in transport options as the city develops polycentrically by increasing availability and convenience of public transport while maintaining optimal flow according to demand.

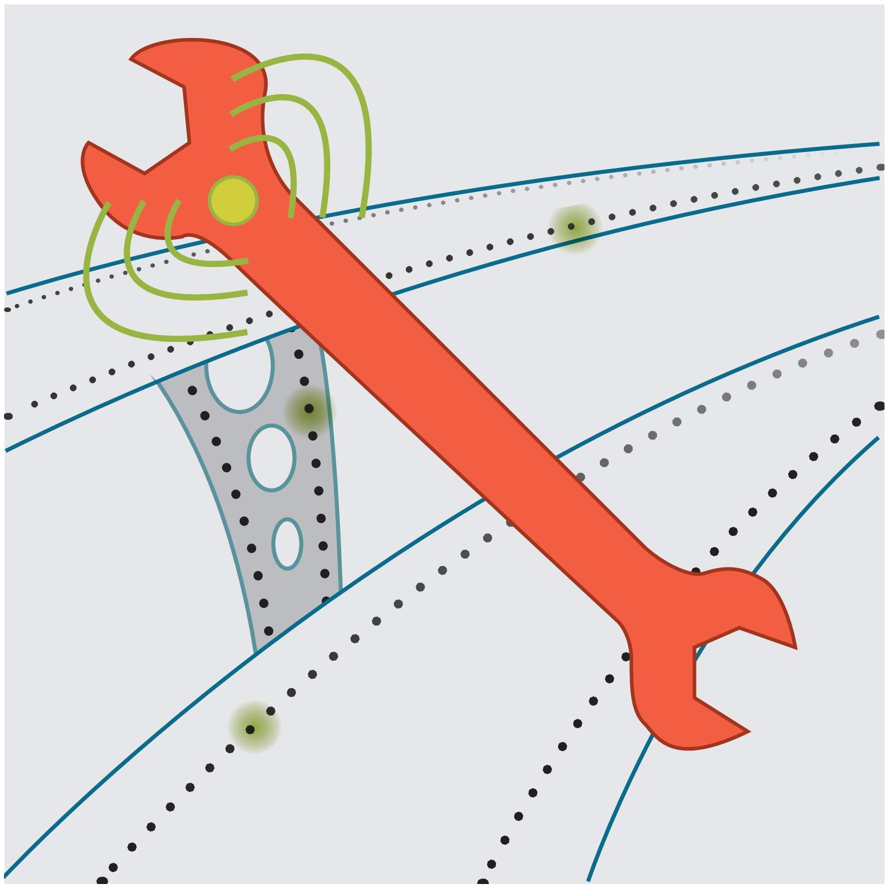
Scenario

Chuck is on his way to work in the morning. As he does nearly every day, Chuck makes his way to an **easy-entry bus stop** on a **Secondary Express Route** about one block from his home. Approaching the stop, Chuck remembers that he forgot some student evaluations at home and looks at the **InfoBoard** above the bus stop entrance and sees that there is a bus coming in one minute, five minutes, and eight minutes. He decides that he has time to return home to pick up the papers and return.

When Chuck gets back, he sees that next bus is will arrive in two minutes. He uses his **Intellicard** to pay, presses the request button, and waits in the stop. It starts to drizzle but it doesn't matter since he is protected. The bus arrives and Chuck boards.

On Fridays, Chuck likes to exercise and has arranged to meet with John to bike together to work. Chuck gets off the bus halfway to his downtown destination. While riding the bus, he uses his handheld to access the **Transcom Network** and reserves a bike at the **Bike Dispenser** where he'll be getting off.

As he arrives, the rain is getting worse and **protective shields** have already closed over the bike path below the thruway. He waits for John who arrives in an **on-demand minibus,** picks up his bike with his **Intellicard,** and they bike together and drop off their bikes at a nearby share lot when they arrive at work.



Evolutionary Maintenance

Evolutionary Maintenance is a set of system components and guidelines that work together to simplify, standardize, and sustain the existing infrastructure while supporting plans for future infrastructure development.

Related System Elements:
Chicagotopia
New Connected Infrastructure

Fulfilled Functions

9 assess needs
14 evaluate quality of system
26 establish quality requirements
27 monitor system components
28 report observations
29 highlight anomalies
30 analyze cost benefit of repair or replacement
31 identify maintenance need
34 make repairs
36 document repair
38 select substitute
40 make replacement
42 document replacement
72 identify risks

Properties

Infrastructure Assessment

- System components with built in cues to indicate malfunction
- Combination of human inspectors and automated infrastructure inspection
- Adaptation benchmarks
- Open inspection rubrics
- Sensors throughout system
- Periodic intensive testing of healthy infrastructure
- Expiration dates for all inspection reports
- Leveled reporting and identification

Infrastructure Maintenance

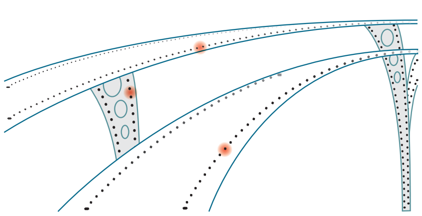
- Automated robot maintenance mechanics
- On-call maintenance crews
- Self-healing infrastructure materials
- Modular parts
- Handheld devices connected to Distributed Information Management system
- Maintenance tools with built-in sensors
- Real-time inventory displays

Features

- Provides quick and easy identification of potential problems
- Reduces human workload stressors and error without compromising accuracy of inspections or maintenance
- Aligns short-term decisions with long-term goals
- Allows flexibility for inspection processes to evolve
- Maintains ubiquitous system awareness
- Prevents reliance on outdated inspection information
- Rates infrastructure status along a continuum to identify and monitor potential problems early on

Associated Design Factors

- Risk of harm to people performing maintenance
- Resources not readily available
- Measuring system quality is difficult
- Conflict between long and short term goals
- Difficult to determine what infrastructure is worth saving
- Restoring and testing system may take too long
- System may deteriorate further between inspection and repair or replacement
- Some anomalies may not fit rubrics and go unreported
- Human attention extremely limited for routine “monitoring” tasks
- Maintenance documentation can be cumbersome
- System maintenance can disrupt service



Discussion

Infrastructure maintenance is fundamental in influencing the ongoing effectiveness and future direction of a cohesive transport system. **Evolutionary Maintenance** is a set of system components, devices, guidelines, and protocols that work together to simplify, automate, streamline, standardize, and sustain the existing infrastructure while supporting plans for future infrastructure development.

As technology continues to develop and automation plays an increasingly role in daily life, **Evolutionary Maintenance** combines the strengths of human and automated maintenance. The goal of **Evolutionary Maintenance** is not to replace human activity with automation completely, but rather leverage technology to play a supportive role in reducing the burden of repetitive or dangerous tasks. This allows humans to focus more time on tasks requiring higher-order thinking and judgment so that they can make the crucial maintenance decisions that contribute to moving the transport system toward its long-term plans and objectives.

Infrastructure Assessment
For successful **Evolutionary Maintenance,** it is key to consider not only if services are not only meeting current demands but also whether each modification, repair, and replacement to the system moves infrastructure forward to serve future demands.

To begin, **Evolutionary Maintenance** efforts are closely tied to the **Adaptation Benchmarks** developed through **Chicagotopia.** Relying on solutions such as **Goal Tracker**, the system ensures that short-term maintenance decisions are aligned with long-term system goals.

When setting standards for inspections, **Open Inspection Rubrics** are used to capture observations and relevant information. In an effort to allow for maximum flexibility in inspections and thereby support infrastructure evolution, such **Open Inspection Rubrics** include open-ended components and are periodically reviewed for revision.

During inspections, **Evolutionary Maintenance** provides solutions to provide quick, easy, and accurate identification of potential problems. **Malfunction Cues** are built into components to assist inspectors in more easily identifying problems that often require meticulous observation; for example, parts such as bolts, lights, or flooring materials change color to indicate cracks or other problems that degrade system quality. **Shared Monitoring** and **Automated Inspections** work together to further reduce human workload stressor and error without compromising the accuracy of inspections or maintenance. **Automated Inspections** utilize ubiquitous sensing technology to work systematically through system components for regular inspections. In order to

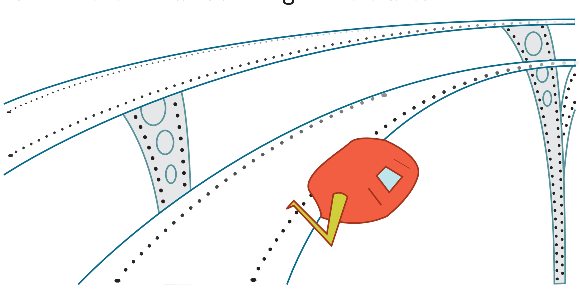
Discussion, cont'd

catch potential problems that may by missed by **Automated Inspections, Shared Monitoring** partners human inspectors to share and trade off in inspection duties in order to maintain attention through long detailed inspections. Moreover, **Inspection Expiration** dates are attached to all reports in order to prevent reliance on outdated inspection information.

To ensure that infrastructure is capable of meeting both immediate and long-term quality standards, periodic **System Biopsies** deeply analyze healthy infrastructure components and take anticipate potential problems as changes in system demand and technology shift in the future.

To support the results of **System Biopsies** and other system inspection reports, a system of **Leveled Reporting and Identification** rates the status of infrastructure health along a continuum to identify, address, and monitor potential problems as necessary. **Leveled Reporting** enables system redefinition by working to identify struggling infrastructure and prioritize maintenance and adaptation needs according to long- and short-term objectives outlined by the **Goal Tracker.**

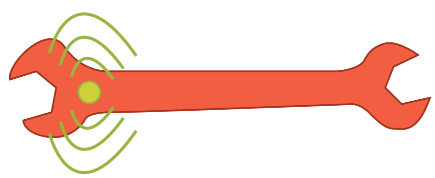
Infrastructure Maintenance
Once ongoing assessments identify maintenance needs, **Evolutionary Maintenance** implements repairs, replacements, and modifications expediently, efficiently, and with minimal damage to environment and surrounding infrastructure.



Similar to the inspection process, modification duties are shared between human workers and automated system components. **On-Call Automated Maintenance Mechanics** are used in situations where risk of injury may be high, and also work on basic repairs during off-peak system hours. **Automatic Replacement** is another solution that regularly removes and replaces components subject to heavy system use. When removed these components can be inspected more thoroughly with minimal disruption to system services; if components are still fit for use, they can be returned to service.

Additionally, the introduction of **modular parts** simplifies maintenance and inventory management. For example, standardizing parts ranging from bolts to doorways to flooring materials will support unified maintenance efforts across the city and allow for the potential of cohesive intra-system compatibility of modes and components over time.

In order further reduce the burden of system maintenance – especially in heavy-use areas of the system – **self-healing infrastructure materials** based on nanotechnology are introduced to the system in the future. Components such as road beds, rails, and sidewalks that are subject to wear from frequent use can incorporate nanotechnology-based materials to slow deterioration.



Through **ToolTracker,** maintenance tools are embedded with sensors that track use of such tools to automatically document maintenance activities and send this information to **Distributed Information Management** in order to simplify record-keeping processes.

As replacements are carried out and monitored, system programs establish **Dynamically Adjusted Timelines** in which maintenance activity collected through **ToolTracker** and other maintenance communication systems such as handheld devices and real-time inventory displays is compared to projected completion dates. **Timelines** are adjusted to achieve optimal balance of quality and timeliness.

Scenario

Amber is a maintenance inspector whose job today is to inspect a recently renovated thruway station at Irving Park. She spends her morning looking at the station structure at point of passenger entry into the station. Utilizing the **Open Inspection Rubrics,** Amber systematically works through the different components of the entry way, making note of changes visually indicated by **Malfunction Cues.** While looking at one of the **Targeted Scanners,** she notes that a few supporting bolts have turned green, indicating that it is time for replacement.

Amber also notices that there is some water from the **Waterfall Wall** that has been regularly splashing onto the edge of the walkway, and makes note of this pattern in the **Open Inspection Rubrics** as a potential hazard she has noticed at a few other stations she's inspected in previous days and suggests that perhaps it is a low- to medium-level problem that might need to be addressed in the near future.

Meanwhile, John, a system maintenance mechanic is supervising a **Personal Mass Transit** vehicle **Biopsy**. Vehicles are regularly removed with **Automatic Replacement** from service for inspection and maintenance so that problems can be avoided before they surface during use.

Automated Maintenance Mechanics complete regular maintenance work under the carriage of the vehicle while John detects some evidence of a recently self-repaired crack that had developed on the exterior shell of this vehicle since its last periodic check-up, although there is nearly no trace of it left thanks to **self-healing nanomaterials.** He uses his handheld device to confirm that sensors in the vehicle have already automatically submitted this information to the **Distributed Information Management** system.

While looking at the displayed maintenance information on his handheld, John sees that a low-level report has been submitted that requests inspection of some loose wiring of the interior **personal console.** John responds and discovers a loose wire. He uses some pliers to secure the connection. Since these pliers are embedded with **ToolTracker** technology, a record of his activities are automatically submitted to the **Distributed Information Management** system with a simple "confirm" action on John's part. There is only one more vehicle on John's list that will need regular maintenance before he goes to his afternoon meeting to discuss possible solutions for the **Waterfall Wall** splash patterns that inspectors had recently brought up for department discussion.

Transcom Network

The Transcom Network is a system of interconnected interfaces that informs users of transportation system status and allows user contribution to continuously make the system more efficient. An integrated interface design driven by the Intelligent Transportation System simplifies the travel experience.

Related System Elements:
New Connected Infrastructure
Privlic Transport
Vehicle Storage
Cargo Concierge
Optimized Infrastructure
Distributed Information Management

Fulfilled Functions

48 transaction for departure
51 signal for departure
52 monitor position
53 communicate between user and system
54 experience journey
55 make travel adjustments
56 communicate transfer to users
58 orient to new departure point
59 move to new departure point
60 await next departure
61 signal for arrival
64 transaction for arrival
79 alert system of emergency mode

Properties

- Information display boards and kiosks to inform users
- Information for departure and arrival
- Universal cards to standardize payment method
- Card with display to guide users
- Hanheld and in-vehicle devices to receive/send cruicial information
- On-board communication systems for user-to-system or system-to-user feedback

Features

- Informs user of departure and arrival time of specific public transports
- Guides users from one point in the transportation system to another
- Standardizes transaction methods to maximize efficiency and minimize inconvenience and confusion
- Maintains consistency of equipment, interior design and layout
- Gets important system status from handheld or on-board devices
- Informs system of status through handheld or on-board devices

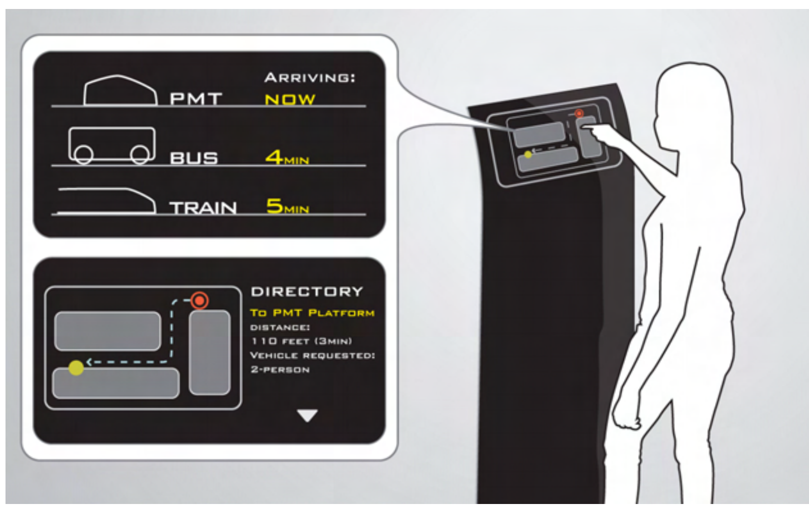
Associated Design Factors

- Difficulty in finding, locating, remembering storage points
- Optimal mode selection for mass transit can vary
- Communication is not always efficient or effective
- Payment methods can be unclear and inconvenient to users
- Far distance to new departure point
- Long waits before departure
- Unclear or lack of information and communication hinders travel

Discussion

Traveling from one place to another is not always easy. Without proper information and guidance, it can be a time-consuming, confusing, and unpleasant experience. The public transportation system in the city of Chicago is made up of CTA trains and buses, Metra Rail, taxis, and car shares. Each of these modes have different methods of providing useful information to users and different transaction types. The inconsistency in the interface design and inefficient system/user communication cause inconvenience and slows down travel.

As a means to provide users with a smooth and enjoyable travel experience, clear and efficient communication between the system and user is a top priority in the transportation network design. The **Transcom Network** is a system of interconnected interfaces that informs users of transportation system status and allows user contribution to continuously make the system more efficient. **InfoBoards**, **IntelliCard**, **Handheld/Web Info Interfaces** and **Onboard Comm Systems** are integral components of the **Transcom Network.**



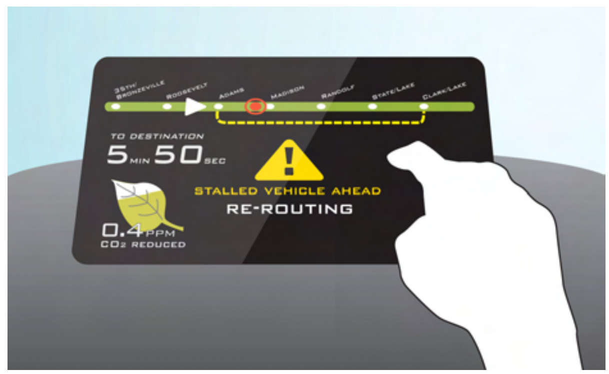
In an effort to minimize confusion and delays, **InfoBoards** in the form of digital signs and kiosks are strategically placed in every train and bus, as well as in the stations. Systems users who are departing, transferring or arriving can use **InfoBoards** to check their current locations and departure, transfer, or arrival time as well as location information. Users can find out exactly when their train or bus is arriving so that they can be more productive with their time. **InfoBoards** also inform users of construction status, current weather, traffic conditions, real-time position of all mass transit vehicles, and transportation recommendations.

Discussion, cont'd

In the current train and bus systems, many types of transaction methods are available, such as the Chicago card, magnetic card and cash. Multiple payment methods also mean multiple types of equipment for making transactions. This system not only causes confusion to users and slows everyone down, but also wastes precious space inside public transits. The **IntelliCard** unifies all payment methods in every mode of public transportation, including trains, buses, taxis, water taxis as well as car and bicycle shares. The card is for users to keep and can be refilled from a vending machine, convenience store, or website. Embedded in the **Intellicard** is a RFID chip that is automatically scanned upon entry and exit as users pass by a sensor. This relieves users from the hassle of looking for their cards and taking them out, and dramatically speeds up traffic flow. By scanning at both departure and arrival points, the card also keeps track of the distance traveled by users.

Another feature of the **IntelliCard** is to provide users with system information to help them easily navigate from one place to another efficiently and effectively. The **IntelliCard** displays animated images and text, and is also touch sensitive for users to make selections. The **IntelliCard** provides travel information and guides users in real-time to departure points with an animated direction arrow. It also gives users arrival notice so that they know exactly when and where to get off.

Handheld/Web Info Interfaces is a multi-channel platform that utilizes handheld devices and other communication channels such as public boards, internet, television, and radio to distribute specific and relevant emergency information and instructions in real-time to individuals (see **Nimble Response**. Information and instructions also adjusted in real-time in response to what user does, where user is, or how emergency changes. **Onboard Comm Systems** are vehicle-based personal console interfaces that add another dimension to the accessibility and convenience of the **Transcom Network.**



Scenario

Bob wakes up on Monday morning ready to start the busy work week ahead. After looking over at his alarm clock, he grabs his mobile phone and quickly logs into the **Transcom Network.** Bob's starting destination, his home, is automatically detected when the network connects to his GPS signal. A prompt asks him where he would like to travel. He browses through his "favorites" to find work and selects this destination.

Within moments, Bob's travel options are outlined. He has many transportation modes to choose from. Because his first meeting is not until 9:30am, Bob selects and reserves an **on-demand** pickup in 20 minutes; this leaves him the exact amount of time he needs to get ready. Bob's transaction for the **on-demand** pickup occurs automatically through the **Intellicard** he carries in his shirt pocket. The **on-demand** pickup drops Bob off at the closest **Personal Mass Transit** station. When Bob passes through the entrance, his **Intellicard** is automatically scanned for transaction and a **Personal Mass Transit** vehicle is reserved to await Bob's arrival.

As Bob walks up the stairs to the departure platform, he references the animated arrow on his **Intellicard** to locate his waiting **Personal Mass Transit** vehicle as well as double check his departure time. On board the vehicle, Bob monitors his location and time to destination via the **OnBoard Comm System.** Bob is also able to monitor his real-time location and time-to-destination on his mobile phone interface.

Bob arrives at the Merchandise Mart stop, and gets out of the **Personal Mass Transit** vehicle. As Bob walks to work, the **Transcom Network** is able to inform him via mobile phone that his walk will take approximately 10 minutes and 5 seconds based on his pace, human congestion around him, and expected pedestrian cross-walk signals.

All told, Bob's journey to work took exactly the amount of time that the **Transcom Network** had estimated.

Delightful Travel

Traveling is made enjoyable and convenient by creating a pleasant environment along travel paths and offering services along the journey.

Related System Elements:
New Connected Infrastructure
Privlic Transport

Fulfilled Functions

54 experience journey
55 make travel adjustments
58 orient to new departure point
59 move to new departure point
60 await next departure

Properties

- Natural elements intgrated into stations and pathways
- Protected bike paths under railways
- Waterfall walls on paths
- Amenities such as TVs, couches, music, lounges, and benches in waiting areas of bus and train stations
- Standardized interior layouts of train stations
- Shops, restaurants, cafes, work stations inside train stations

Features

- Provides natural landscape to make travel more enjoyable
- Provides safe bike paths
- Makes walk paths more pleasant
- Makes waiting for buses and trains more comfortable
- Standardizes interior layouts of stations for predictable and convenient access to reduce user confusion
- Creates new source of income and allows people to use their time more effectively by providing places to shop, eat and work

Associated Design Factors

- Other users affect journey
- Uncomfortable journey
- Long waits before departure
- Poorly designed waiting areas
- Unclear or lack of information and communication hinders travel

Discussion

Beyond creating a fluid and efficient transport system, the travel experience itself becomes attractive with **Delightful Travel.** By incorporating natural elements, providing year round access to bicycle and pedestrian thruways with protection from the elements, and offering amenities to make waiting time more entertaining in convenient areas, **Delightful Travel** invites Chicago citizens to enjoy the city and look forward to moving around in it.

Waiting for buses and trains can sometimes be an unpleasant experience. **Standardized stations** for bus, train, and other mass transit stations and transfer points serve many purposes. Enclosed **easy-entry bus stops** protect waiting passengers from inclement weather, while standardized and predictable locations for useful tools such as **InfoBoards** helps riders easily anticipate not just real-time travel information but also where they can find that information every time. Likewise, stations, stops, and vehicle interiors with standardized layouts support seamless and predictable navigation that help reduce navigational stress and confusion.

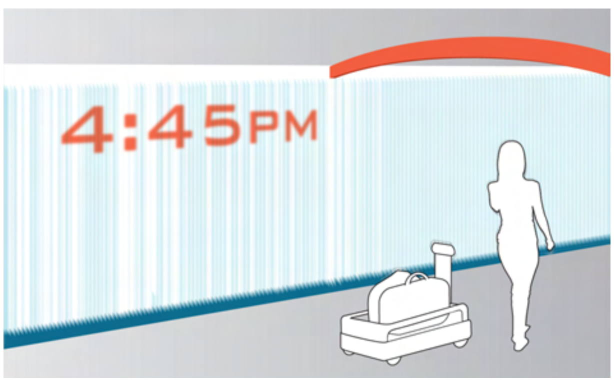
Shops, restaurants, cafes, and work stations inside stations allow people to use their time more effectively by providing places to shop, eat, and work while also creating a new source of income for the system. **Enterwaiting** builds on these offerings by providing amenities to waiting passengers, helping the time pass a little more pleasantly should the need arise. Entertainment in the form of television, music, and public art as well as inviting lounges filled with couches and private work stations all come together to entertain while one waits.

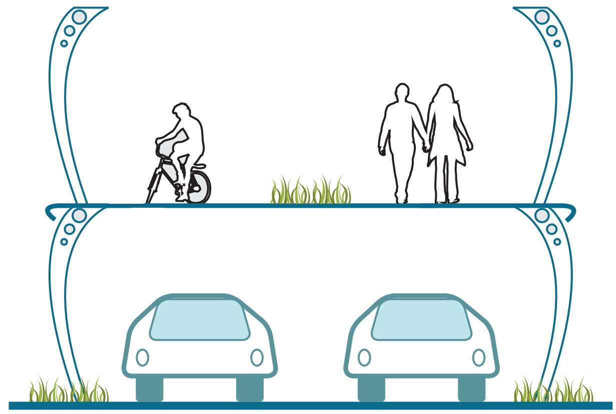
When riding on **Personal Mass Transit** vehicles and other forms of public transportation, **personal consoles** load personalized settings

Discussion, cont'd

and preferences for seat positions, music, and ambient conditions through the **Intellicard** to provide a personalized travel experience.

In an effort to remind travelers of the fundamental connection between the city and nature that is sometimes neglected, natural elements such as trees, plants and water are integrated into station components and pathways. One example of such incorporation of natural elements includes a **Waterfall Wall** in interior corridors that adds visual interest while providing a calming atmosphere in a busy environment. Real-time travel and other relevant information such as current time, travel information, weather, and even advertising can be projected onto the **Waterfall Wall.**



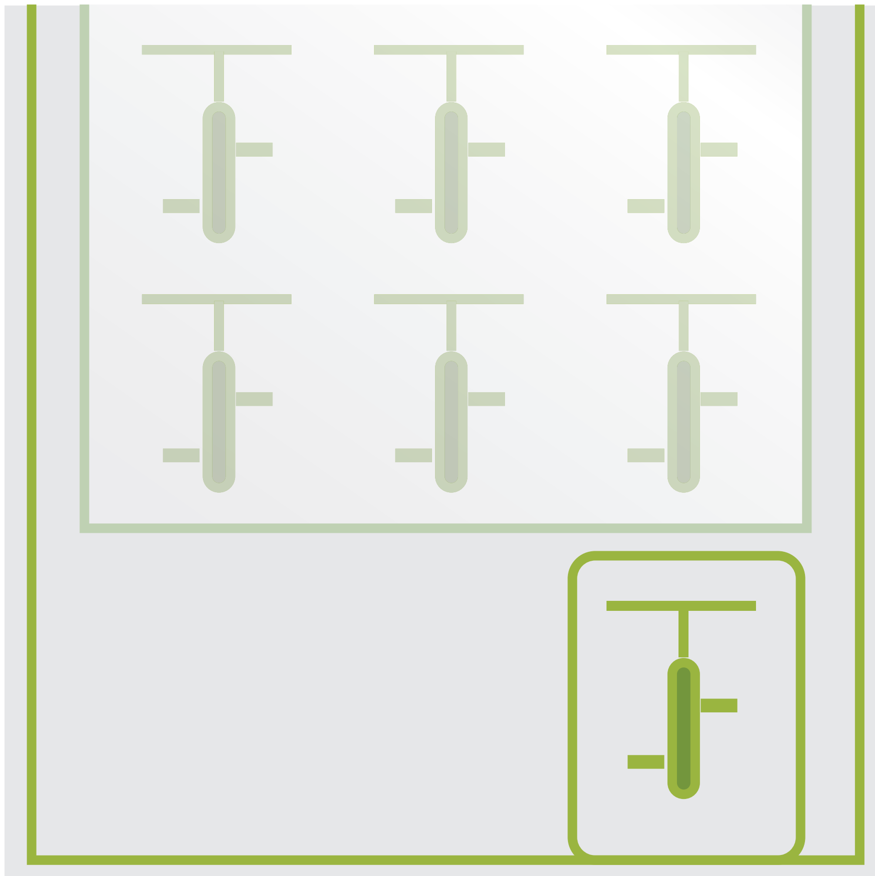


Blurring the line between inside and out, **protected bicycle and pedestrian pathways** safely separate this traffic from that of larger vehicles such as cars and buses. In order to provide such options year round, retractable protection over paths shields users from inclement weather but opens up on pleasant days to allow for enjoyment of the open air.

Scenario

Jane leaves her apartment in Streeterville on a Saturday morning and decides to go for a bicycle ride. She rents a bicycle from her neighborhood **Bike Dispenser** and decides to head up to the Logan Square area. As she rides her bike over to the nearest **Vertically Layered Thruway** it begins to rain. Jane isn't worried because during inclement weather, protective barriers are raised to prevent thruway travelers from the elements. She's particularly pleased with this feature because it allows her train for her triathlon year round.

Along the way, Jane gets a little hungry and decides to stop by a nearby **Personal Mass Transit** station. When she enters the station, she walks by a beautiful **Waterfall Wall.** On the wall, real-time travel information is projected along with the daily news and weather reports. In the cafe Jane is able to select from a variety of food options. While eating, Jane surfs the Internet and takes care of some business at a workstation.



Privlic Transport

Privlic Transport merges traditional notions of public and private transport to bring the benefits of both together in ways that contribute to an overall enjoyable and effective travel experience in Chicago.

Related System Elements:
New Connected Infrastructure
Transcom Network
Delightful Travel
Vehicle Storage
Optimized Infrastructure

Fulfilled Functions

12 gather resources
18 enforce protocol
44 establish itinerary (destination/route)
46 select optimal mode
54 experience journey
55 make travel adjustments
59 move to new departure point
60 await next departure
65 identify storage point
67 put vehicle/item in space
68 secure vehicle/item
70 retrieve vehicle/item

Properties

- 2-to-4-passenger public transport cars
- Public express systems that accommodate public and private cars
- Private vehicles with public-system compatibility
- Personalized preferences and work orentertainment consoles in public and shared vehicles
- Car and bicycle share lots dispersed throughout the city

Features

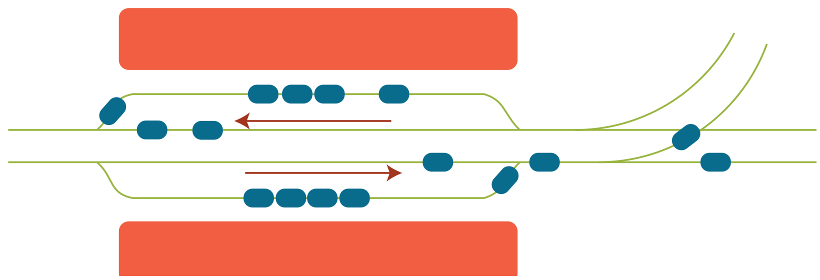
- Provides rapid station-to-station travel and more personalized routes through personal transport cars on system-run public express infrastructure
- Personalizes travel experience in public and shared vehicles through Intellicard, which stores and loads personal preferences (e.g., ambient, work, or entertainment conditions) to individual consoles on public and shared vehicles
- Creates private spaces in public areas such as mass transit vehicles and stations
- Optimizes flow, reduces driver stress, and reduces risk of accidents when private vehicles are switched to system-directed auto-pilot mode in high-traffic zones
- Optimizes energy use and efficiency when cars have capability to opt into system's express rail infrastructure
- Offers benefits of private travel (point-to-point on-demand convenience) while reducing user's burden of storage, cost, and maintenance through car and bicycle shares

Associated Design Factors

- Other users affect journey
- Uncomfortable journey
- User access vs. system costs
- Urban storage of vechicle is costly and insecure
- Difficulty in finding, locating, remembering storage points
- Payment methods can be unclear and inconvenient to users

Discussion

Privlic Transport merges traditional notions of public and private transport to bring the benefits of both together in ways that contribute to an overall enjoyable and effective travel experience in Chicago. Through **Privlic Transport,** public transportation options incorporate benefits of private travel such as personalization as well as point-to-point and on-demand convenience, while private transportation can leverage the overall efficiency and economy of public transport.



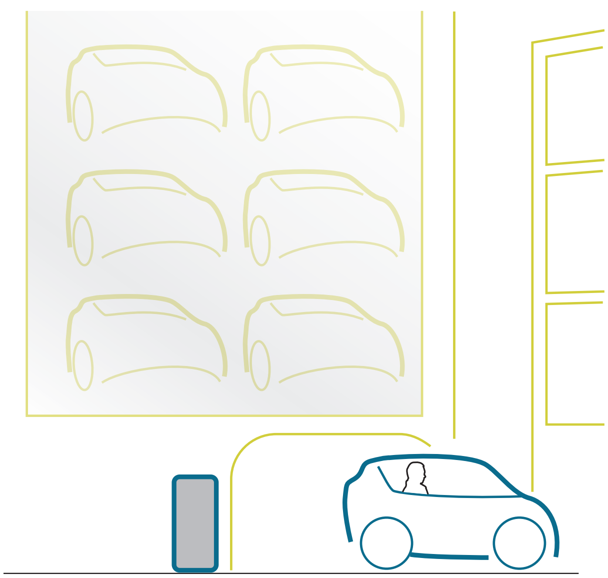
Major express thruways offer **Personal Mass Transit** with 2-to-4-passenger public transport cars waiting at each guideway station and independently riding on public express guideways. Upon entry, a passenger's destination is recognized. Since station stops are off the main line, these vehicles run express on central guideways, bypass any intermediate stations, and take passengers directly to a requested destination without intermediary stops. Passengers at stations board waiting vehicles that re-enter main express guideways upon departure. The concept is that now vehicles wait for people rather than people waiting for vehicles. Transfers and slowdowns are minimized, and service is on-demand.

In the far future, for those users who may still desire private vehicle ownership and usage, the system is able to accommodate privately owned **multi-mode vehicles** that plug into and out of the public system according to need and traffic conditions in 3 ways: 1) independent navigation on roads (similar to current cars) when users move beyond public system scope, 2) **plug-in access** to automated navigation on express guideways so that public and private vehicles may share the same express guideways, and 3) automatic "switch on" system-directed **Auto-Pilot** in high-traffic road areas so that traffic flow is optimized by the system and driver stress and risk of accidents are reduced.

Another aspect of **Privlic Transport** utilizes the emerging concept of **car and bicycle shares,** a service in which a fleet of vehicles traditionally considered private transportation are dispersed throughout the city and available to the public for rental for short periods of time. This reduces the need for individuals to shoulder the cost of

Discussion, cont'd

private vehicle ownership. Users can request a car or bicycle for a short period of time for private use as needed with point-to-point services. Utilizing the **Intellicard**'s unified pay system, users conveniently check out a vehicle at a nearby **Vertical Dispenser**, drive or ride to a desired destination, and drop off at a different **Dispenser** near the arrival point. Since these vehicles are for shared use, the individual burden of storage, cost, and maintenance is reduced and becomes shared across the system. With the help of the **Intelligent Transportation System** and the **Transcom Network,** vehicle locations are coordinated and managed by the system, and users have instant access to such information. For more information about storage of shared vehicles, see **Vehicle Storage.**



Within all public and small shared vehicles, travel experiences are further personalized through the **Intellicard,** which conveniently stores and loads into vehicle consoles **personal preferences** for entertainment, comfort, and work. In this way, users can conveniently and consistently enjoy a personalized travel experience every time they engage with the transportation system.

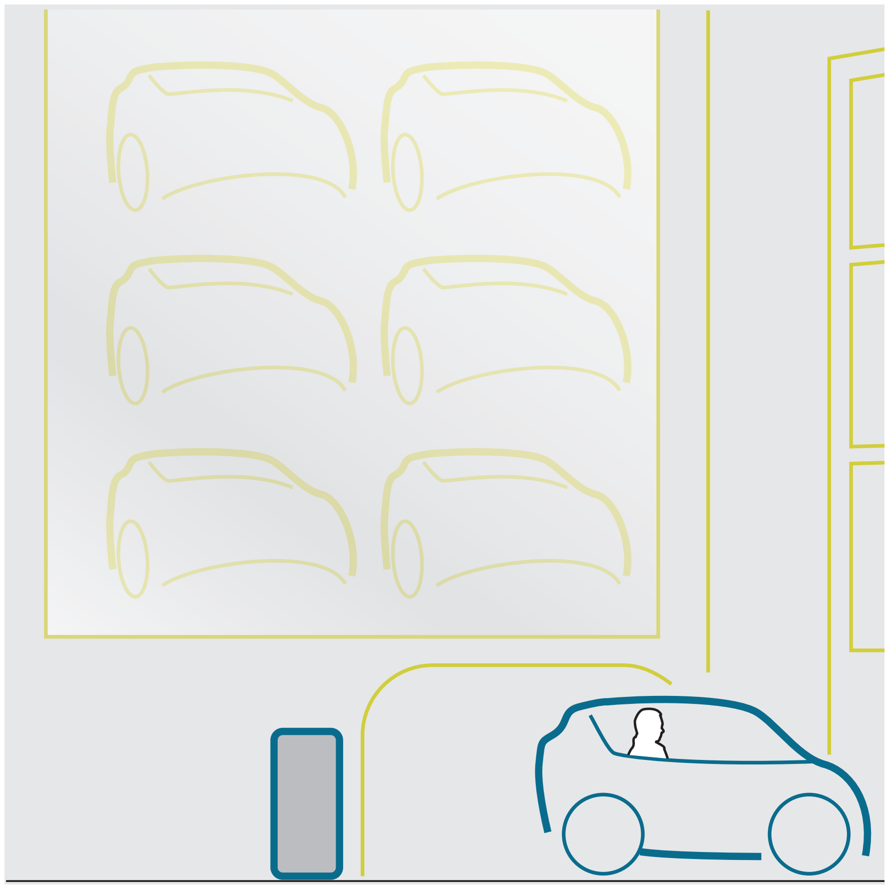
Scenario

On a lovely Wednesday morning, Amber and her husband leave home together for their morning commute to work. To enjoy the weather, Amber and Chris walk to the end of their block to the closest **bike dispenser** and use their **Intellicards** to pick up a bike with an optional bag rack. After strapping their bags on to their bicycle racks, Amber and Chris ride together under a **Vertical Thruway** for a couple of miles while chatting together and enjoying the open air and trees surrounding the path.

At Belmont and Broadway, Amber and Chris must go their separate ways to work. As Chris pedals on, Amber decides that she is a bit tired after her morning ride. Since there is a thruway station above, Amber decides to drop off her bike at the **Bike Dispenser** on the corner and makes her way up to the **Personal Mass Transit** station above.

Amber walks through the entry point and into a waiting **Personal Mass Transit** vehicle at the station. The vehicle senses her **Intellicard**, loads her favorite radio station, seat position, and adjusts the air temperature inside the cabin. On the **personal console,** Amber selects her final destination and the vehicle zips out of the station to join the passing vehicles on the central guideways. Since the console shows Amber's destination to be approximately 10 minutes away, she decides to use the console to check some email before getting to work.

Upon arrival to the Merchandise Mart, Amber's vehicle pulls of the central guideways to the station stop where she steps out of the vehicle. A passing rider immediately steps into Amber's vehicle and settings are readjusted for the new passenger as Amber exits the station. She goes downstairs and walks and easy 3 blocks to her office to begin her day.



Vehicle Storage

Intelligent coordination of vertical vehicle storage to provide convenience in storing and locating vehicles.

Related System Elements:
New Connected Infrastructure
Transcom Network
Privlic Transport

Fulfilled Functions

49 load cargo
50 secure cargo
53 communicate between user and system
57 retrieve cargo
63 unload cargo
65 identify storage point
66 conduct transaction
67 put vehicle/item in space
68 secure vehicle/item
69 record storage location
70 retrieve vehicle/item

Properties

- Vertical construction of parking structure
- Dispersed car and bike dispensers
- Automated car parking to maximize parking space usage
- Network of car and bike shares
- Handheld devices to find car and bike storage
- Unified transaction method for car and bike storage

Features

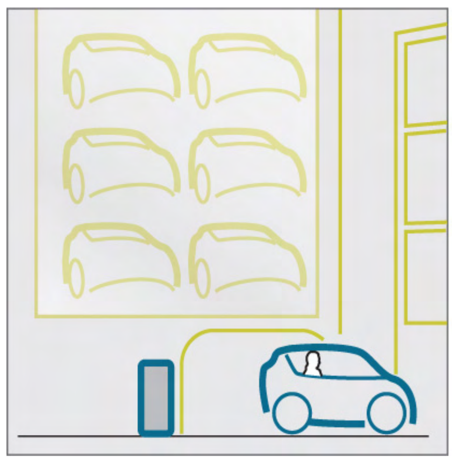
- Reduces footprint of parking lots
- Rents cars and bikes from automatic dispensers for point to point convenience
- Uses valuable parking space efficiently and saves time for users
- Provides convenience of accessing a car or bike when they're needed
- Provides storage locations for bags or bikes via IntelliCard or handheld devices
- Provides a unified transaction method for car and bike storage spaces with IntelliCard

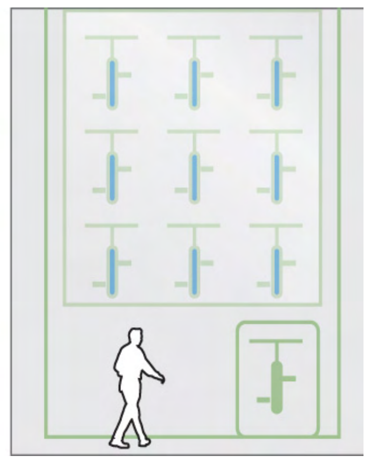
Associated Design Factors

- Urban storage of vechicle is costly and insecure
- Difficulty in finding, locating, remembering storage points
- Payment methods can be unclear and inconvenient to users

Discussion

Vertical car and bicycle dispensers are dispersed throughout the city near train and bus stations. People can these dispensers to rent a car or bike after they exit a bus or train station. The vehicle brings them to their final destinations where it can be returned through point-to-point service options. The vehicle type can be selected from a touch-screen kiosk and charged on the **IntelliCard**, which is a standardized card for making transactions for all modes of public transportations and storage in Chicago.





In an effort to minimize land space usage, parking lots are housed within vertical building structures. **Automated car parking** can relieve the driver the task of finding parking spaces within a parking structure. The driver pulls the car to one of the designated spaces inside the parking structure and exits the car. After scanning the **IntelliCard,** the car is automatically pulled into a parking space by car elevators. The car is retrieved by simply scanning the **IntelliCard** again. Amount of payment is determined by number of minutes parked.

Countless hours are wasted searching for parking spaces in downtown Chicago. Driving around to search for a parking space is aggravating, wastes gasoline, and causes pollution. This problem is solved by using **Parking Locator**, which uses handheld or in-car devices to locate available parking spaces in the vicinity via the **TransCom Network.** All parking meters are equipped with proximity sensors that detect the presence of vehicles. This information is sent to the **Intelligent Transportation System (ITS)** and relayed to hand-held or in-car devices.

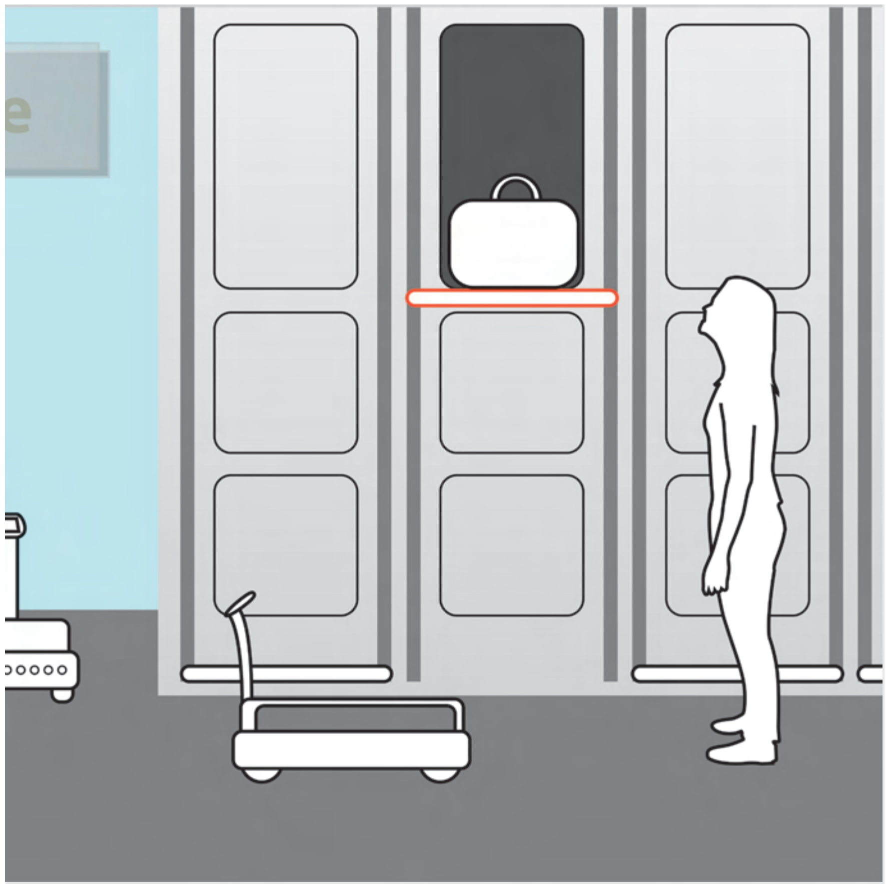
Storage Applications offer many storage locations for bikes are dispersed throughout the city. They can be found with handheld devices or the **IntelliCard.** With a push of a button, the nearest storage is displayed on a map along with a route to get there.

Scenario

Dan Smith is a resident of the Wicker Park neighborhood of Chicago. After arriving home from work one day, Dan discovers that the main light in his living room as burned out. Because Dan doesn't have any other lights in his apartment, he needs to buy a new bulb immediately. Realizing that he needs to visit the hardware store to gather a few other odds and ends anyway, Dan walks over to a neighborhood **Car Dispenser.** There he scans his **Intellicard.** Within a few minutes, a car is automatically dispensed, and Dan is on his way to the hardware store.

After buying what he needs, Dan starts his drive home. On his way home, Dan accesses the CTA **Parking Locator** application on his mobile phone. When he reaches his neighborhood, the application locates and guides him to an available public parking spot near his home. After parking and unloading all of his purchases from the hardware store, Dan drives over to his neighborhood **Car Dispenser** down the block to return the automobile.

Later in the evening, a friend of Dan's asks him if he's free for dinner. Dan says he is and that he's happy to meet up at a River North sushi restaurant. Since he hasn't had time to complete his workout today, Dan walks over to a nearby **Bike Dispenser** and rents a bicycle using his **Intellicard.** After he bikes over to the restaurant, Dan returns the bicycle to a nearby **Bike Dispenser.**



Cargo Concierge

Cargo Concierge is a system of interconnected cargo and freight delivery, storage and security services enhanced by the Intelligent Transportation System to make cargo related services more efficient, reliable, convenient, and secure.

Related System Elements:
New Connected Infrastructure
Transcom Network
Optimized Infrastructure

Fulfilled Functions

47 package goods
49 load cargo
50 secure cargo
57 retrieve cargo
62 unsecure cargo
63 unload cargo
65 identify storage point
66 conduct transaction
67 put vehicle/item in space
68 secure vehicle/item
69 record storage location
70 retrieve vehicle/item

Properties

- Robots that carry people's cargo in stations
- Simple transaction method for moving cargo
- Mechanical assistance to make lifting cargo easier
- Uniform large cargo spaces in public transportations for baggage and bikes
- Protected cargo with RFID tracking
- Underground tunnel network for cargo

Features

- Assists in carrying cargo with robots while they walk from one point to another in bus or train stations
- Provides a convenient transaction method for cargo assistance with IntelliCard
- Provides cargo spaces that are easy to access and large enough for suitcases and bikes
- Assists in lifting heavy bags into storage bins with hydraulics or spring loading
- Prevents cargo from theft or transferred incorrectly with RFID tracking
- Provides high-speed shipping of cargo using underground tunnels to reduce surface traffic and road maintenance

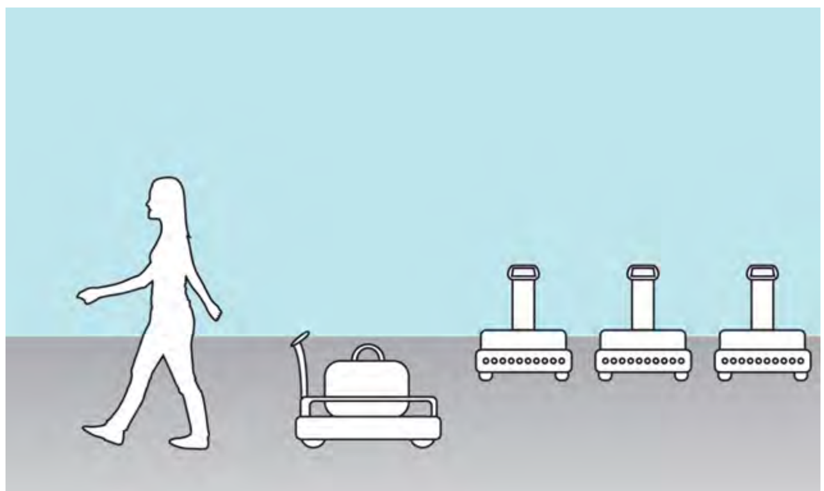
Associated Design Factors

- Uncomfortable journey
- Difficulty in finding, locating, remembering storage points
- Inconvenience with cargo degrades travel experience

Discussion

In order make cargo-related services more efficient, reliable, convenient and secure, emerging technologies are explored and utilized in train and bus stations as well as underground shipping of freight.

Cargo Assistants are available at bus terminals, train stations and airports in order to eliminate the pain of people lugging around heavy bags and suitcases. **Cargo Assistants** are automatic carts eqipped with RFID and proximity sensors that carry cargo. Once transaction is made by scanning the **IntelliCard,** the **Cargo Assistant** comes to the user and constantly maintains a specified distance. After the cargo is placed onto the **Cargo Assistant,** the user walks away and it continues to follow until it is disengaged with another card scan. It automatically returns to the nearest standby point to recharge. Multiple **Cargo Assistants** can be checked out simultaneously if needed.

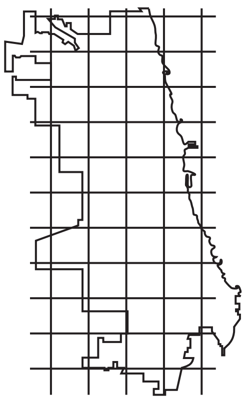


Most people traveling with large cargo do not consider using public transit due to the inconvenience of moving cargo up and down narrow paths and the lack of storage space. A way to encourage the use of public transits is to provide users with sufficient storage space for their bags, suitcases and bikes on every bus and train. **Standardized Cargo Storage Bin** designs shared between buses and trains makes identifying them and loading cargo easier. **Assisted Loading** consists of mechanical loading equipment that lifts cargo with hydraulics or spring loading. It eliminates fumbling with suitcases and may even prevent injuries. Working in conjunction with **Cargo Assistants, Assisted Loading** makes traveling with large cargo effortless.

In order to protect cargo from theft or transferred incorrectly, it is tracked from the beginning to the end of the journey. **Cargo Tracking** starts with tagging of the cargo with a RFID tag, which is dispensed

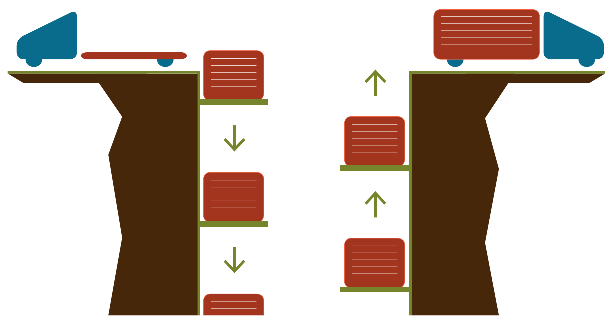
Discussion, cont'd

from a device at the storage bin by scanning the **IntelliCard.** The tag, linked to the **IntelliCard,** is placed onto the cargo. The proximity between the cargo and storage bin is constantly monitored. In case the cargo is taken away by anyone other than the owner at arrival, a warning message is announced and owner is notified via **IntelliCard.**



Freight
Moving freight on trucks on highways and streets is problematic for several reasons. First, moving freight with big trucks on roads shared with other modes of transportation takes up valuable space and slows down traffic flow. Second, with large trucks outweighing cars 40 to 1 and having much longer stopping distances, they are the major cause of serious accidents and fatalities. Lastly, heavy truck axle loadings shortens the life of road pavements. Construction and reconstruction of pavement for truck usage, which is less than one-third of the traffic, does not make sense economically. A solution is to reduce the number of trucks on surface roads by moving freight underground.

Underground Freight is a system of multi-level tunnels interwoven in grids below the city, controlled by the **Intelligent Transportation System (ITS).** Containers are brought to drop-off and pick-up sites dispersed throughout the city and lowered to a tunnel with an elevating platform. The container is placed on a ramp and gradually picks up speed with electromagnetic propulsion. As the container reaches a sufficient speed, the container merges into the high-speed tunnel, going in between other containers. The containers can reach speeds up to 100 miles per hour. Speed and position of each container is automatically monitored and controlled by **ITS** to avoid collisions. On arrival, the container is raised to the surface and picked up by a truck. The truck's driving distance is never greater than two miles due to the close proximity of pick-up and drop-off sites.



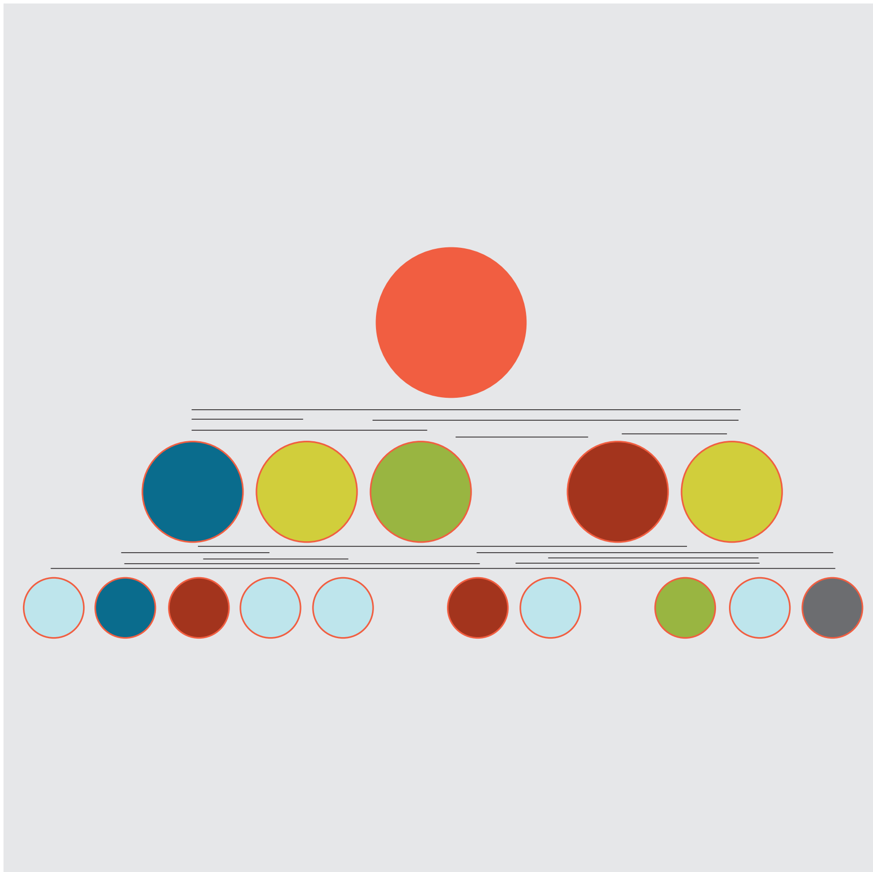
Scenario

Cargo Concierge
On a sunny Saturday afternoon, Jenny decides to go shopping on Michigan avenue. After a day of shopping, Jenny has accumulated many purchases. Having arrived to Michigan Avenue via **Express Bus,** Jenny carries her belongings to the closest bus stop for her trip home. When the bus arrives, Jenny stores her purchases in a **Standardized Cargo Storage Bin.** Realizing that she is going to be late for dinner, Jenny decides to switch to a **Personal Mass Transit** vehicle, and requests one on her mobile phone. After getting off the bus, Jenny enters the Armitage **Personal Mass Transit** station and is greeted by a line of **Cargo Assistants.** She effortlessly drops her shopping bags on one of them and as she walks towards the platform, the **Cargo Assistant** follows her by linking to the RFID and proximity sensors installed in her **Intellicard.** Concurrently, the **Cargo Assistant** charges her for the service. When Jenny boards the vehicle, she picks up her shopping bags and brings them with her into the passenger cabin. The **Cargo Assistant** detects that Jenny has departed, and automatically returns to its charging station. Alternatively, if Jenny happened to have many bags, she could opt to have the **Cargo Assistant** board her **Personal Mass Transit** vehicle.

Underground Freight System
Acme Incorporated is an Indiana-based company that manufactures nuts and bolts and regularly has these parts delivered to manufacturing companies on the west side of Chicago. Ted's Shipping typically handles Acme's deliveries and has been exceedingly pleased with Chicago's new **Underground Freight** system. Ted's Shipping is able to arrange shipments through Chicago's **Transcom Network** interface.

On an early Monday afternoon, Ted's Shipping receives a request from Acme to pick up an order of nuts and bolts to be delivered to a company in Chicago the same day. Ted's Shipping picks up the order and drops off the cargo at a shipment point just south of the city. The shipment is lowered into the underground tunnels and while traveling to a drop off point on the west side of Chicago, Ted's Shipping is able to track the shipment and monitor the stability of the cargo via RFID tagging.

Acme's shipment safely reaches the south side drop off point quickly, and on time. After the shipment is brought up to street level, a truck awaiting its arrival delivers the shipment to its final local destination.



Operational Excellence

Operational Excellence is an essential part of maintaining a world-class transportation system. It stresses the need to continually improve through teamwork, communication, collaboration, and partnership. This results in quality and safety improvements for customers and employees alike.

Related System Elements:
Inhale/Exhale Initiative
Distributed Information Management
Nimble Response

Fulfilled Functions

6 gather feedback
14 evaluate quality
16 communicate expectations
17 identify violations
19 educate violators
23 gather data
53 communicate between system and users
77 educate public
78 process feedback
90 evaluate situation
96 gather and interpret

Properties

- Qualitative data collection
- Quantitative data collection
- Periodic "job swaps" between system operators across areas of expertise
- Incentive programs for success recognition
- Deliberate cross-departmental collaboration
- Decentralized services and administration
- Vertical information system
- Decentralized reporting
- Lateral relations emphasized through shared reliability.
- High transparency and transient speed

Features

- Provides more comprehensive picture of user experience in the system through merge of qualitative and quantitative data through Participatory Feedback, Response Incentives, Random Ride Days, Effectiveness surveys, and Distributed Information Management.
- Builds common vision and understanding of system for system operators through Job Swaps and decentralized administration
- Builds internal morale and individual sense of responsibility/investment through Success Recognition
- Encourages cooperation and collaboration through Lateral Relations initiatives, Integrated and Collaborative Organizational Structure
- Synchronizes and Filters system-side information through Vertical Information System.
- Integrates work-flow through mandating Shared Reliability in operational objectives
- Connects system and users through transparent information exchange

Associated Design Factors

- Measuring system quality is difficult
- Departments use different communication and info technologies
- Sometimes responsibilities/ capabilities unclear
- Bureaucracy and internal politics impede action

Discussion

Operational Excellence is a philosophy of leadership and teamwork resulting in continuous improvement throughout the organization by focusing on 1) the needs of the customers and users, and 2) empowering employees, system operators, and business partners. **Operational Excellence's** values lie within: quality; productivity and human development; and efficiency and effectiveness. It stresses the need to continually improve through teamwork, communication, collaboration, and partnership. This results in quality and safety improvements for customers and employees alike.

Active Feedback
The Responsive Transport system greatly depends on constant interaction with its users to assess the efficiency and effectiveness of the system. Transport system users should have the opportunity to contribute to the efficiency and effectiveness of the system. By incorporating **Participatory Feedback** information, the system encourages users to utilize cell phones and other forms of everyday communication to help system gather feedback such as accident or emergency notification, congestion issues, traffic backups, and other general suggestions. When a user contributes information to the system, they are rewarded with **Response Incentive Credits.** By providing various opt-in information, system users increase the level of system knowledge, awareness, and intelligence, thus contributing to its efficiency and effectiveness. Lastly, system users contribute a great deal to emergency situation awareness. **Call & Response** is a communication protocol built into system that requires responses; depending on level of importance, response may be more or less complicated (e.g., signature for higher security, simple "button press" response for low security).

Empowering Employees and Partners
The Responsive Transportation system requires an equally responsive and adaptive workforce of system employees and partners. A reflective culture focused on internal institutional self-improvement is likely to contribute more to the city of Chicago. This is accomplished through a variety of ways.

- Cross-departmental cooperation and information exchange
- Strong sense of morale, contribution, and accomplishment
- Collaboration
- Encouragement of a work culture that recognizes success

A workforce that embodies **Operational Excellence** actively recognizes success. For example, **Inter-Departmental Job Sharing** rewards those who work together and actively find a way to share responsibility.

Discussion, cont'd

Within a Responsive Transportation system, operations data is gathered and analyzed, and success defined in a number of different ways.

Collaboration, Cooperation & Information Exchange
Decentralized modes of operation – both in terms of optimization and administrative hubs as well as in information management – allow for efficient and effective coordination of human and information resources. An example of such decentralization is **Polycentric Optimization.** By distributing optimization resources, the system limits the processing demand placed on any single hub. Should any optimization center be affected by an emergency situation, outage, or is simply overwhelmed, a nearby center with available processing power and human resources capacity is engaged in efforts to maintain operational efficiency.

Similarly, a new organizational structure can employ resource and information sharing practices. This is not to imply that the system organizational structure is not both integrated and collaborative. The concept of decentralization when applied to organizational structure and practice facilitates **Lateral Relations** and **Shared Reliability.** The former is a system work culture that not only encourages but also mandates a significant measure of cross-functional competency and cooperation. **Shared Reliability** is a family of work culture protocols that creates system-wide understanding of roles and responsibilities. **Water Cooler Exchange** is a strategic reorganization towards interdepartmentalism. Those who need to communicate are in closer contact both physically and virtually. This practice expedites internal negotiations, decision making, and perhaps most poignantly, action.

Lastly, a system that embodies **Operational Excellence** strives to instill a strong sense of morale, contribution, and accomplishment in the hearts and minds of their workforce. With forthcoming automation, technology, and other "human-free" initiatives, it is imperative that the system never under-value the contributions of a human staffed workforce and always strives to create capacities requiring the creativity, sincerity, and flexibility that only human resources can provide.

Scenario

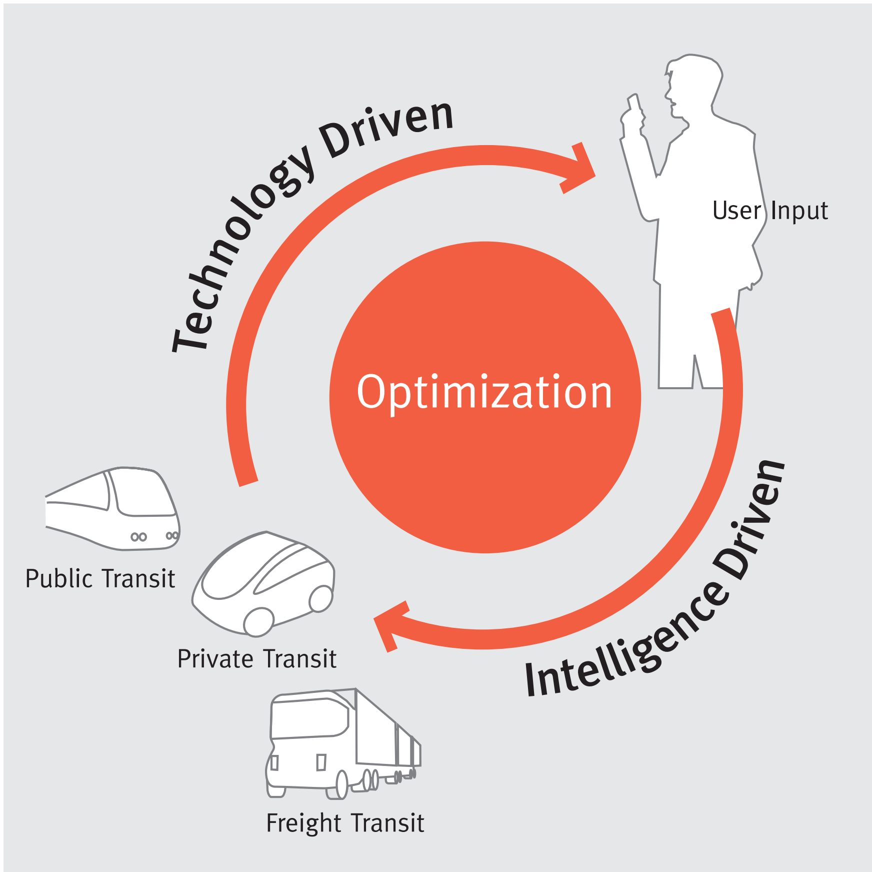
When Bob begins his work day within the Operations Department within the Chicago transportation system headquarters, the first thing he does is review aggregated **Participatory Feedback** records from the day before. All system employees receive a brief every morning via email that summarizes transport system user sentiment across all transport domains including private, mass, and freight transportation. Because responding to **Participatory Feedback** is incentivized, the rate of response to system information requests is extremely high. Bob is particularly impressed this morning by the number of **Response Incentive Credits** awarded the previous day. This means that user satisfaction is at all time high and Bob is pleased that the needs of customers and users are being met.

Bob and his colleagues clearly understand the work philosophy within the Chicago transportation system. Their work culture is very self-reflective and is always trying to improve. They believe in continual improvement because if they work together better, the entire city benefits.

Just recently, Bob found a way to share some job responsibilities with a colleague working on a similar project. He believes that **Inter-Departmental Job Sharing** allows both him and his colleagues to produce better work because they get to pool their skill sets, and also because they rely on each other for success.

Bob also knows that his role within the Chicago transportation system is appreciated because he is rewarded for his efforts both financially and by continuous acknowledgement of his contributions. Bob knows that his success would not be possible if the organizational structure within his department didn't emphasize integration and collaboration. The company encourages a strategic reorganization through interdepartmentalism, and just last week, Bob's workspace was quickly moved closer to his other team members so that they could more easily work together. Virtually, Bob is able to communicate with partners of the Chicago transportation system, and has been able to negotiate deals, make decision, and take action swiftly via the **Water Cooler Exchange.**

Bob knows exactly how important understand the roles of his colleagues us, so recently, he went on a series of **Ride Alongs** on a variety of sass transit options to get a first-hand impression of transportation experiences in the system. He learned a great deal and even gathered a few insights about how operations could improve. Because Bob knows a variety of colleagues all across the company, and because they share common goals, these insights are likely to rapidly turn into ideas that can be implemented.



Optimized Infrastructure

The capabilities of Optimized Infrastructure will largely be carried out by the Intelligent Transportation System (ITS). ITS facilitates the flow of information between travelers and system operators to improve mobility, transportation productivity, and enhance safety.

Related System Elements:
New Connected Infrastructure
Transcom Network
Privlic Transport
Cargo Concierge
Distributed Information Management
Wilde Times
Nimble Response

Fulfilled Functions

6 gather feedback
14 evaluate quality
16 communicate expectations
17 identify violations
19 educate violators
23 gather data
53 communicate between user and system
77 educate public
78 process feedback
90 evaluate situation
96 gather and interpret

Properties

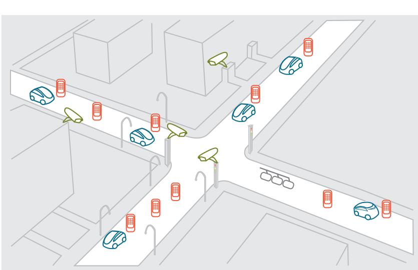
- Global positioning capabilities in mobile devices (GPS)
- Floating wireless signal (wireless beacon)
- Wireless access in vehicular environment such as cars and trucks (WAVE)
- IEEE 802.11 standards in all wireless hardware installed within infrastructure such as buildings and roads.
- Dedicated short range communications (DSRC) between optimization components
- Real-time operating system
- Beacon sensing hardware
- RFID (Radio-Frequency Identification)
- Video detection system (cameras, sensors)
- Inductive loop technology (coiled wire, rubber compound, radar, laser)
- Closed-loop interconnects
- Process control/artificial intelligence (centralized signal control)

Features

- Uses GPS/Floating Cellular/WAVE to determine transport mode location
- Actively monitors system with Beacon/VDS/Embedded sensors to gather system operation information
- Transmits optimization information and adjustments via DSRC
- Processes real-time system information
- Manages local optimization and administration via Distributed Information Management Centers
- Leverages artificial intelligence to anticipate optimization and process control needs and requirements

Associated Design Factors

- Delay between detection, process-ing, and reaction amplifies problem
- Measuring system quality is difficult
- System may not have access to information required to respond



Discussion

The Responsive Transport system of the future contributes to the efficiency and effectiveness of the system by providing critical optimization information in the system optimization process to the private, public, and freight transportation sectors. The **Intelligence Transportation System (ITS)** refers to efforts to add information and communications technology to transport infrastructure and vehicles in an effort to manage factors that typically are at odds with each other such as vehicles, loads, and routes to improve safety and reduce vehicle wear, transportation times, and fuel consumption.

The Current Reality
A Responsive Transport system of the future will need to leverage **ITS** technologies to manage private traffic on 3,800 miles of streets, at 26,000 intersections, and 2,900 signalized intersections, and 24 signal interconnects (480 signals). Signal interconnect technology leverages video detection systems and sensing technology to make real-time adjustments at intersections. Interconnected signals communicate via fiber optics, and adjustments are made by sophisticated computers at the Chicago Traffic Authority in the West Loop. Of the 24 signal interconnects currently in place, six use centralized signal controls, and 19 use closed-loop interconnects. The city of Chicago is well on its way to equipping 400+ signals with signal interconnect technology.

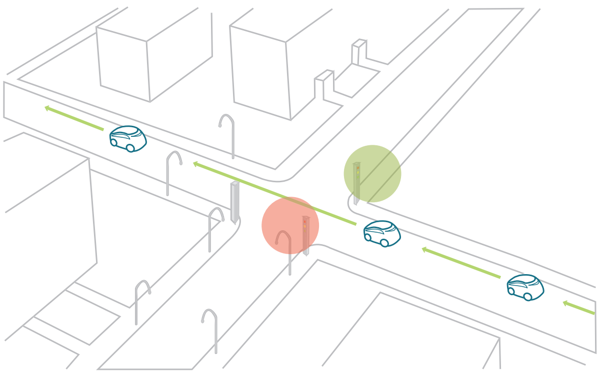
Future Possibilities
While the city of Chicago has already begun to implement state-of-the art traffic optimization technology, truly **Optimized Infrastructure** requires the implementation of emerging technologies that enables transportation system users to provide the system with information.

Private Transit
In the foreseeable future, private automobile traffic will continue to be a part of Chicago transport system activity. Real-time knowledge of individual vehicle location could greatly facilitate traffic optimization. Technology is now available that can provide vehicle location information via **GPS/Floating Cellular Signal, or WAVE (wireless access in the vehicle environment)** technology. GPS is already present in a variety of mobile phones, and WAVE technology is likely to become installed in all private automobiles as **ITS** becomes ubiquitous.

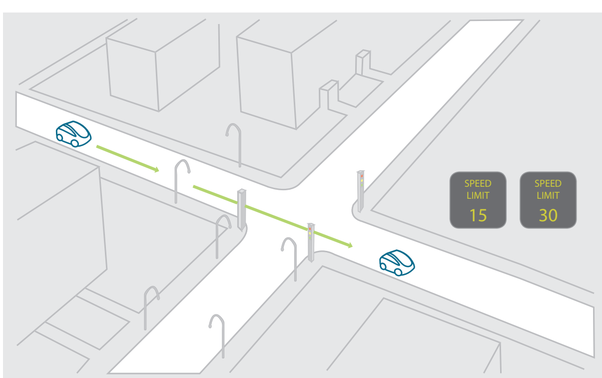
In the future, GPS navigation technology is widely available, affordable, and adopted. Private transit travelers wirelessly and anonymously share their location, starting point, route, and end destination with a nearby **Distributed Information Management Center.** This information enables even greater optimization of transit system activity in a very important way. The system suggests routes and alternative

Discussion, cont'd

routes to travelers depending on system activity that not only expedites a particular users journey, but optimizes traffic flow for all road users.



Successful optimization greatly depends on awareness of system demand. Chicago's **ITS** manages a variety of system flow and efficiency solutions such as **Adaptive Signal Controls** and **Variable Speed Limits. Adaptive Signal Controls** change traffic signals based on anticipated demand. Because the system has awareness of vehicle locations and intended routes, signals are dynamically adjusted to accommodate travelers.



The aforementioned demand driven control also informs **Variable Speed Limits. Variable Speed Limits** are dynamic speed limit signs that change speed regulation based on traffic patterns. For example, if it makes little sense to maintain 20mph on a street with virtually no traffic, and a driver should be able to drive faster without fear of punishment.

ITS also enables **Intelligent Lane Management** in times of construction, congestion, and emergency. Sensing, Surveillance, and GPS technology provides **ITS's Real-Time Operating System** with the information necessary to execute **Reversible Flow Lanes.** For example, should the system anticipate traffic flow demand in a particular direction, a lane is dynamically reversed to accommodate rush hour travelers. Alternatively, in times of heavy congestion, the system incentivizes drivers to take an alternate route. Drivers are encouraged to comply due to **Congestion Pricing.** If drivers do not comply, they must pay a monetary charge for staying on the congested road. **Intelligent Lane Management** is also particularly useful in emergency situations (see **Nimble Response**). Evacuation or re-routing is sometimes the safest and most logical response to significant emergencies. By proactively diverting traffic around or away from an accident, congestion is relieved and lives are saved.

Lastly, city traffic is sometimes created by resident and visitors driving around in a seemingly endless search for parking. By equipping all Chicago public parking spots with in-road **Infrastructure Sensors,** this problem is significantly mitigated.

Mass Transit

ITS can also be applied to Chicago's Transit Authority. Because CTA entities are also part of the greater transportation system, they also leverage all aforementioned technology in efforts to expedite service for their bus, train, light rail, and mini-bus patrons. Mass transit travelers wirelessly and anonymously share their location, starting point, route, and end destination with a nearby **Distributed Information Management Center.** Because their location is anonymously monitored by **ITS,** when they arrive to a mass transit departure point, their mode of transport is already there waiting for them. **ITS** allows the Chicago Transit Authority to intelligently optimize and coordinate the availability of transportation modes to more effectively meet the demands of mass transit users in a timely and efficient way. This requires the implementation of WAVE technology in all mass transit transport modes.

Discussion, cont'd

Freight Management
WAVE, or wireless access in the vehicle environment, is particularly applicable in freight management and is installed in fleets of trucks. **RFID** tagging also contributes to system optimization information as it enables freight management entities to track their assets, further streamline their freight terminal processes for loading and unloading, and stabilize and monitor boxes and crates. **ITS** technology is installed in the **Underground Freight Management System (UFMS),** monitoring and adjusting the movement of cargo in the **UFMS.**

The Brain
ITS runs on a highly sophisticated **Real-Time Operating System (RTOS).** In order to process system activity information and deploy optimization adjustments in a timely fashion, **ITS**'s operating system must run in real-time, and requires significant amounts of computing strength. **RTOS** also incorporates **Artificial Intelligence** and **Process Control** technology to immediately anticipate and mitigate optimization issues. The intelligent system learns from previous system activity, and can generate and analyze the patterns that inform optimization efforts.

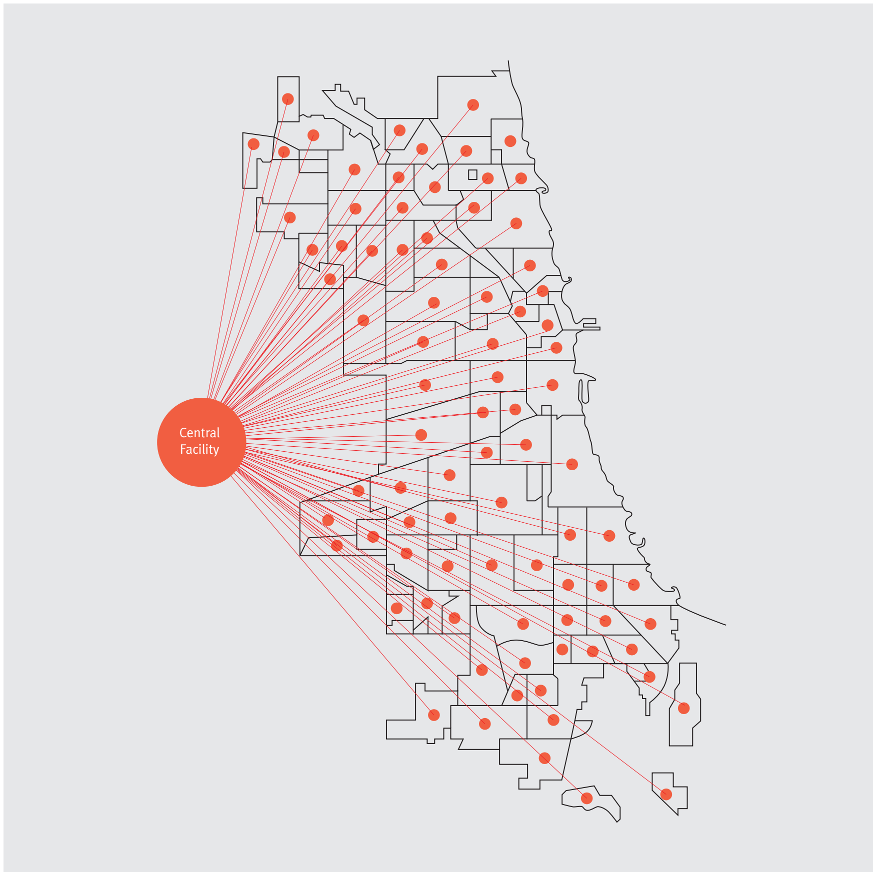
Decentralized Optimization
Decentralized modes of operation – both in terms of optimization and administrative hubs, as well as in information management – allows for efficient, and effective coordination of both human and information resources. An example of such decentralization is the concept of **Distributed Information Management.** By distributing optimization resources, the system limits the processing demand placed on any single hub. Should any optimization center be affected by an emergency situation, outage, or is simply overwhelmed, a nearby center with available processing power and human resources capacity is engaged in efforts to maintain operational efficiency (see **Distributed Information Management).**

Active Feedback
The Responsive Transport system greatly depends on constant interaction with its users to assess the efficiency and effectiveness of the system. Transport system users have the opportunity to contribute to the efficiency and effectiveness of the system. By incorporating **Participatory Feedback** information, the system encourages users to utilize cell phones and other forms of everyday communication to help the system gather feedback such as accident and emergency notification, congestion issues, traffic backups, and other general suggestions. When a user contributes information to the system, they are rewarded with a **Response Incentive Credits.** By providing various opt-in information, system users can increase the level of system knowledge, awareness, and intelligence, thus contributing to its efficiency and effectiveness.

Scenario

At 5:30pm, Bob Jones leaves work as a shipping executive at Boeing headquarters in the Loop and heads home to Wicker Park where he and his family own a home. Before leaving the office, Bob arranges for a large cargo unit to be shipped across town on the **Transcom Network's** freight interface on this computer. As he is leaving his office, Bob programs his journey into the **Transcom Network** interface on his mobile phone. When he steps into his car, the journey he programmed into his phone is then transferred to his on-board GPS navigation interface. As soon as Bob left his office, his physical location in terms of his intended and actual journey is being monitored by **ITS** for the purpose of optimizing system components. When Bob exits the Boeing smart garage, he refers to his GPS navigation for point-to-point directions to his home. The suggested route provided to Bob is not the same route everyday; this is because **ITS** is carefully coordinating and optimizing the journey's of millions of people. By sharing his intended travel plans, Bob experiences a much faster journey home than if he had opted not to share his location information with the system. When Bob approaches his first intersection, the light is green. This happens because this particular traffic light anticipated his presence. **Adaptive Signals Controls** like this one are interconnected to all other signals in Chicago. While driving, Bob looks out of his window to enjoy the beautiful **greenway** in the downtown Loop. When he does so, he takes is eyes off the road and quickly approaches the automobile in front of him. Because both his car and the car he is approaching are equipped with **WAVE technology,** his car automatically slows down and prevents a collision. At about 5:45 Bob notices that the traffic progressively getting worse on Upper Wacker, but isn't worried because **ITS** is already aware of the increasing demand on roads in this area, and quickly initiates **Reversible Lane Flow** so that both lanes of Upper Wacker are soon flowing north. At this point, in efforts to move along as much traffic as possible, the **Variable Speed Limit** signs dynamically adjust from 30mhp to 40mph. As Bob approaches his car-free Wicker Park neighborhood, he accesses the **Transcom Network** parking interface on his mobile phone. Because the roads are imbedded with **infrastructure sensors,** Bob is quickly notified of an available public parking space and wastes no time finding the spot and parking his car. Upon arriving home, his children remind him that he had promised to take them for ice cream. The kids are especially excited because this will involve taking **Personal Mass Transit.** Bob quickly programs their journey into the **Transcom Network** on his phone, and as they walk down their drive way, an **on-demand** mini-bus pulls up to pick them up. The mini-bus drops them to the nearest rail station. As they walk up the stairs, their **Personal Mass Transit** vehicle is already waiting for them.

As his kids are eating gelatto, Bob takes out his laptop to check on the cargo shipment that he had arranged earlier in the day. Because each cargo shipment is trackable, Bob knows exactly how long it will take for the shipment to reach it's final destination across town. All crates within his shipment are equipped with RFID, so Bob also knows how stable and secure his shipment actually is. Similar to how Chicago monitors vehicle traffic on roads and on mass transit, **ITS** enables the city to manage and optimize the flow of all cargo in the **Underground Freight** network. When Bob's cargo arrives within a few miles of it's final destination, a cargo transport truck is already awaiting is arrival.



Distributed Information

Distributed Information Management is a practice whereby the collection, processing, and distribution of system information is decentralized across a number of information management facilities. The decentralization of information allows for dynamic and autonomous system operations that improve overall system effectiveness.

Related System Elements:
Transcom Network
Operational Excellence
Optimized Infrastructure

Fulfilled Functions

1 monitor traffic
4 prioritize needs
5 implement adjustments
10 delegate authority
18 enforce protocols
22 specify organizational relationships
23 gather data
24 manage information
25 communicate between system components
36 document repair
42 document replacement
71 monitor activity
73 train system operators
80 monitor and report response progress
81 coordinate emergency response components
82 update system status
83 erioritize emergency response
84 manage/authorize emergency resources
92 prioritize response to vital runctions
107 coordinate activity and budget

Properties

- Enterprise-class distributed information technology
- Information coordination, distribution, and translation technologies
- Real-time operating system
- Synchronization with all system-wide real-time information
- Information filtering and technical data management capabilities
- Upward information filtering through vertical information system
- Strong lateral relation maintained through shared reliability
- Highly transparent to other information management facilities
- Standardized information interface
- Decentralized archival information database
- Decision support system with managerial qualities
- Training and education requirement assessment tool

Features

- Aggregates optimization and emergency information gathered from intelligent infrastructure with distributed grid computing network
- Processes hub specific information according to priority protocols
- Interfaces with synchronized information database to gain understanding of real-time activity
- Coordinates information and implementation
- Manages information needs and functional capabilities for a specific jurisdiction
- Intelligent decision making based on priority protocols and the optimization constitution
- Ensures up-to-date data by following Data Cycles
- Creates common business language across facilities via Info Filter
- Distributes functional resources based on system demands and delegates authority accordingly
- standardizes technical resources across all facilities (computing, mobile, telecommunication)
- information flows securely via fiber optic data connections
- in the situation of facility failure, remaining locations absorb jurisdiction and responsibilities via polycentric controls
- Uncovers data outliers and anomalies via Comparative Database shared amongst all facilities
- Securely documents and backs up all new and existing system information on a regular basis via Electronic Vaulting
- Determines training needs of particular facilities

Associated Design Factors

- Delay between detection, processing, and reaction amplifies problem
- Backup solutions can burden regular system operations
- System efficiency can be affected while enforcing protocol
- Communication is not always efficient or effective
- Backups can fail

Discussion

Distributed Information Management is a practice whereby the collection, processing, and distribution of system information is decentralized and distributed across a number of information management facilities. Each of these information management facilities processes all functional information – operational, administrative, maintenance, regulatory and emergency – for a particular geographic jurisdiction.

Currently, Chicago manages all information processing demands through a central facility. The **Distributed Information Management** system is a network of smaller, information management facilities distributed across the city. Each facility is equipped with state-of-the-art enterprise class distributed information technology equipment. All **Distributed Information Management Facilities (DIMFs)** share information processing capacity through the utilization of a grid computing network. **Grid Computing** allows the virtualization of distributed computing and data resources such as processing, network bandwidth and storage capacity to grant system users and system applications access to vast IT capabilities. Each **DIMF** manages the information processing demands for its particular geographic jurisdiction within Chicago and is connected to all other **DIMFs** via wireless technology as well as secure fiber optics. All system information is transmitted to a shared **Real-Time Operating System** database. **The Real-Time Operating System** is a software engine that collects, organizes, and distributes system-wide information. Each **DIMF** interfaces with the **Real-Time Operating System** and database and is constantly transmitting up-to-date information to it. All data is electronically vaulted via **Off-Site Data Storage.** Said data is managed and stored by a third party specializing in the commercial protection of off-site data.

Each **DIMF** operates according to pre-determined protocols. For example, each **DIMF** gathers information from the **Optimized Infrastructure** within its jurisdiction via optimization sensors. This information is processed and traffic adjustments are made according to an **Optimization Constitution.** The **Optimization Constitution** enables automated intelligent decision making by managing the implementation of adjustments to system activity.

Administrative information gathered, stored, and managed by the **DIMFs** is standardized and synchronized across the entire system. The system utilizes **Data Warehousing** technology. **Data Warehousing** is a comprehensive technology that provides all **DIMFs** within the system with access to relevant levels of required information within the enterprise. It is an enterprise-wide framework that permits the management of all enterprise information.

Discussion, cont'd

System maintenance information and documentation is gathered and managed on handheld wireless documentation devices. Said information, once gathered, is transmitted to the **Data Warehouse.** In the event that a maintenance worker needs to access maintenance documentation, a request can be sent via mobile handheld to the **Data Warehouse. Data Cycles** ensure that the most up-to-date data is available in maintenance efforts, as well as across all functional operations. Each **DIMFs** is also in charge of all maintenance and remote artificial intelligence gathered data within its jurisdiction.

Regulatory information gathered from system-wide sensors are transmitted to the nearest **DIMFs** for processing. Said regulatory information includes ticketing and other offenses.

In the event of an emergency, the **DIMF** that manages information for the particular jurisdiction where the emergency occurred gathers and distributes information throughout the entire system. Each **DIMF** responds to emergency situations according to **Priority Protocols**. **Priority Protocols** enable the prioritization of regulatory situations that demand attention.

The **Distributed Information Management** network distributes shared information processing resources based on demand. Should a particular jurisdiction be overwhelmed by information processing requirements, neighboring **DIMFs** with available capacity automatically volunteer processing capacity. In the event of a power outage or other technical obstacle where a single **DIMF** is no longer functioning, surrounding **DIMFs** absorb the responsibilities of the non-functioning or non-performing jurisdiction. Demand-based information management therefore ensure continuous, non-interrupted information processing.

Scenario

The following scenario describes the five operational areas across which **Distributed Information Management** functions.

Operations
Imagine that traffic congestion is occurring near a major intersection in Chicago. The traffic issue is detected by the video-surveillance and sensors embedded in the **Optimized Infrastructure** within that particular jurisdiction. This information transmitted to the nearest **DIMF** via fiber optics. Simultaneously, this information is also distributed to all tangentially neighboring **DIMFs.** The information gathered at the primary **DIMF** is analyzed against pre-determined **Optimization Protocols** as well as real-time traffic patterns in neighboring jurisdictions. A traffic correction decision is made by artificial intelligence and implemented via **Distributed Information Management** fiber optics to all relevant traffic signals.

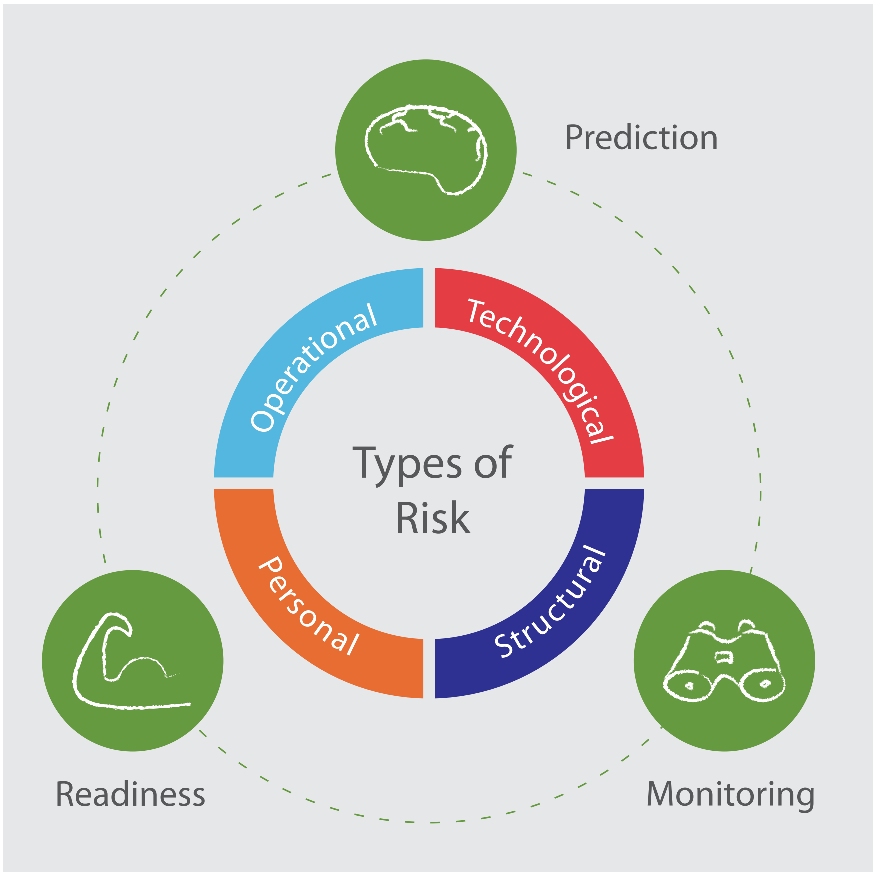
Administration
When accessing the transport system information database, Jamie, a transportation system employee, works with a standardized dashboard information interface for all input and output capabilities. All administrative functions share the same database of information, or **Data Warehouse.** This is enormously important to Jamie because each **DIMF** relies on the other **DIMFs** for up-to-date, easily understandable and accessible information. This **Data Warehouse** accommodates all archived information, and always keeps the most up-to-date and recent data available by time-stamping. Because the day-to-day flow of information is largely standardized, Jamie doesn't waste any time struggling to understand information and is be able to fluidly communicate with other **DIMFs.**

Maintenance
When maintenance needs to be implemented, Javier, a maintenance worker, accesses the **Distributed Information Management** network for all relevant maintenance documentation and records. Because of the **Distributed Information Management** system, Javier is not limited to working in a particular jurisdiction. Maintenance workers operate according to on-demand scheduling; should Javier find himself in the Streeterville neighborhood, and in need of additional supplies and man power, the local **DIMFs** instantly assess and process this request, and locate and deliver additional manpower and equipment.

Regulation
After work, Jamie, in a rush to get home, flies through a red light. Video cameras and sensors detect this offense. The local **DIMF** interfaces with the police information network and quickly receives approval to ticket Jamie. The local **DIMFs** sends an order to ticket Jamie directly to her mobile phone.

Emergency
When Vinay is driving home, he gets into a three car pile-up at the intersection of Upper Wacker and Adams. The **DIMF** that manages the information sensors in this jurisdiction gathers all emergency information and distributes it to the rest of the **DIMFs** network. This capability results in the following: 1) Emergency resources are quickly dispatched from a variety of neighboring jurisdictions, 2) emergency vehicles avoid traffic because their route has already been generated and traffic has been diverted around their path, and 3) Vinay is quickly transferred to the nearest hospital that treats his particular injury (see **Nimble Response**).

Demand-Based Information Management
A terrorist group manages to detonate explosives within city limits and destroy the **DIMF** that manages the River North jurisdiction. All neighboring **DIMFs** with available capacity automatically volunteer processing capacity. Because this **DIMF** is no longer functioning, surrounding **DIMFs** absorb the responsibilities of the non-functioning jurisdiction.



Wilde Times

Oscar Wilde said, “To expect the unexpected shows a thoroughly modern intellect.” Wilde Times is how the system identifies, assesses, and treats risk scenarios. Relevant risk domains include: Operational, Technological, Structural, and Human Safety.

Related System Elements:
Optimized Infrastructure
Nimble Response

Fulfilled Functions

2	identify patterns
3	anticipate problems
4	prioritize needs
5	implement adjustments
6	gather feedback
7	revise approach
8	establish goals
9	assess needs
15	set parameters
20	identify violation patterns
21	re-assess system
26	establish quality requirements
27	monitor system components
29	highlight anomalies
71	monitor activity
72	identify risks
73	train system operators
74	generate backup solutions
75	test and maintain backup-systems
76	institute preventive action
77	educate public
78	process feedback
96	gather and interpret data
97	simulate scenarios
98	make predictions
99	manage risk
101	revise goals
102	establish action plan

Properties

- Database of risk patterns
- Risk assessment software
- Testing facilities
- Infrastructure mock-ups such as model streets or cars
- Off-service sections of actual infrastructure
- Simulation software
- System staff
- Staff of Emergency Response Network (ERN) cities
- Engineers
- Construction crews
- Model makers
- Additional licensing tests at entry points
- Monitoring equipment (cameras, scanners, etc.)
- Enforcement staff
- Response coordination communication equipment (to communicate and organize response)

Features

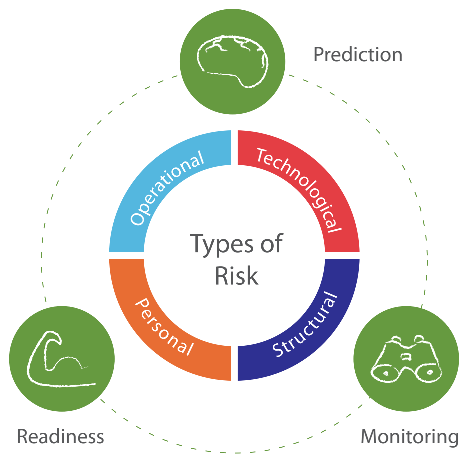
- Evaluates risk against system goals and objectives
- Evaluates potential severity of loss
- Determines probablity of risk occurance
- Determines potential impact of risk related event
- Constructs system mockups or test zones
- Practices for combinations of risk
- Provides feedback to development teams
- Trains internal staff
- Trains ERN staff
- Educates riders of emergency procedures
- Runs drills during normal service

Associated Design Factors

- Protecting civil liberties vs. monitoring the system
- Subjectivity of risk identification
- Cannot establish parameters/ requirements around unforeseen events
- Patterns are limited by inherent unpredictably
- Adequate adaptation risk management systems do not exist

Discussion

The purpose of **Wilde Times** is to identify and mitigate system risks. Dimensions of risk include operational, technological, structural, and personal risk. Operational risks include events such as worker strikes, epidemics, or weather emergencies. Technological risks range from power outages to data pirating. Structural issues refer to physical system damage, including command centers and system infrastructure. Finally, safety risks include human components such as danger resulting from system malfunction or terrorism. **Wilde Times** mitigates these risks through prediction, monitoring, and readiness.



Prediction
Through various prediction and testing techniques, future transportation systems can better prepare for disasters. One such technique is a **Variables Database** which tracks key factors in prior disasters, such as locations of employees, client demand, weather, or fire locations. These variables then inform a **Scenario Testing** division, which combines random variables to create hypothetical situations for which to prepare. Preparation is also enhanced by consulting an **Emergency Patterns Database (EmPatt)**. This compilation of information from around the world allows the system to continually increase awareness of potential risk scenarios.

Monitoring
In addition to predicting areas of risk, **Wilde Times** introduces new ways to monitor for and prevent human risk within the system. In this technological age, data piracy poses a signficant risk. **Off-site Data Storage** with two-person password protection ensures a copy of critical system information or programming remains intact. Deviant human behavior is also monitored within system infrastructure. **Targeted Scanners** detects dangerous materials or weapons while **Leveled Risk ID** monitors human behavior for predictors of vio-

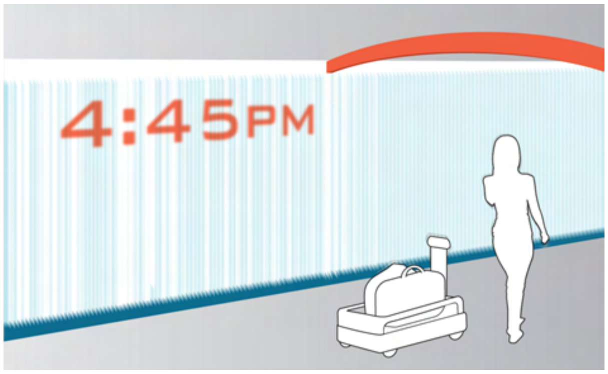
Discussion, cont'd

lence or other illegal activity. Infrastructure is also monitored. **Struggling Infrastructure Identification** ensures that repair resources are focused on at-risk infrastructure. However, when the level of risk cannot be determined, **Automatic Infrastructure Replacement** requires certain components to be replaced at regular intervals, even if no signs of damage exist. The coordination of these monitoring efforts is carried out by the **Transportation System Risk Management Tool (TSRMT)**, a collection of software that prescribes the best plan of action based on current information, relevant variables, and potential outcomes.

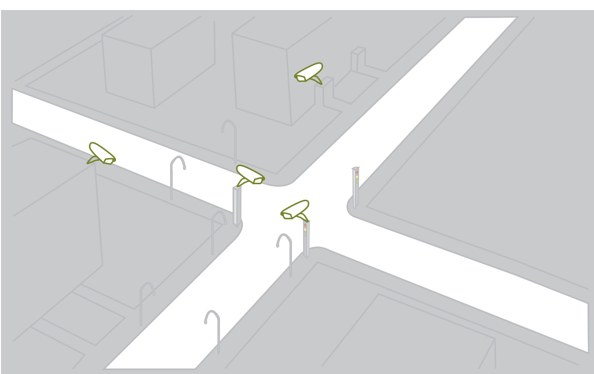
Readiness
There will always exist situations for which the system could not prepare. For this reason, the system practices readiness so that novel situations will not diminish risk treatment. Because the system's **Nimble Response** components have networked with response teams from other cities, **Scramble Drills** are conducted in swapped locations as part of a larger **Backup Response Network** between neighboring cities. For example, Milwaukee Emergency Medical Technicians practice driving emergency runs on Chicago roads to Chicago hospitals so that when they are called to assist here, the city is already familiar to them. Passengers are prepared to follow risk-evasive protocol due to new **Passenger Licensing**, which requires system users to undergo brief training before entering the system. Previously-mentioned **Scenario Tests** are pushed to extreme levels by groups of experts known as the **Pattern Thinktank** so that the unimaginable calamity can be imagined and prepared for. Lastly, **Pilot Tests** of new risk mitigation strategies are carried out so that new safety concepts can be tested and refined.

Through predictive testing, monitoring, and readiness, **Wilde Times** aims to diminish all forms of operational, technological, structural, and personal risk.

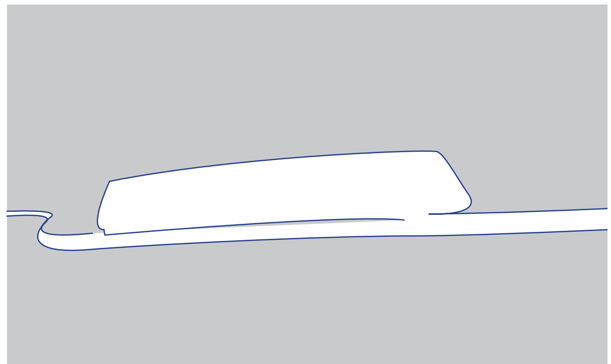
Scenario



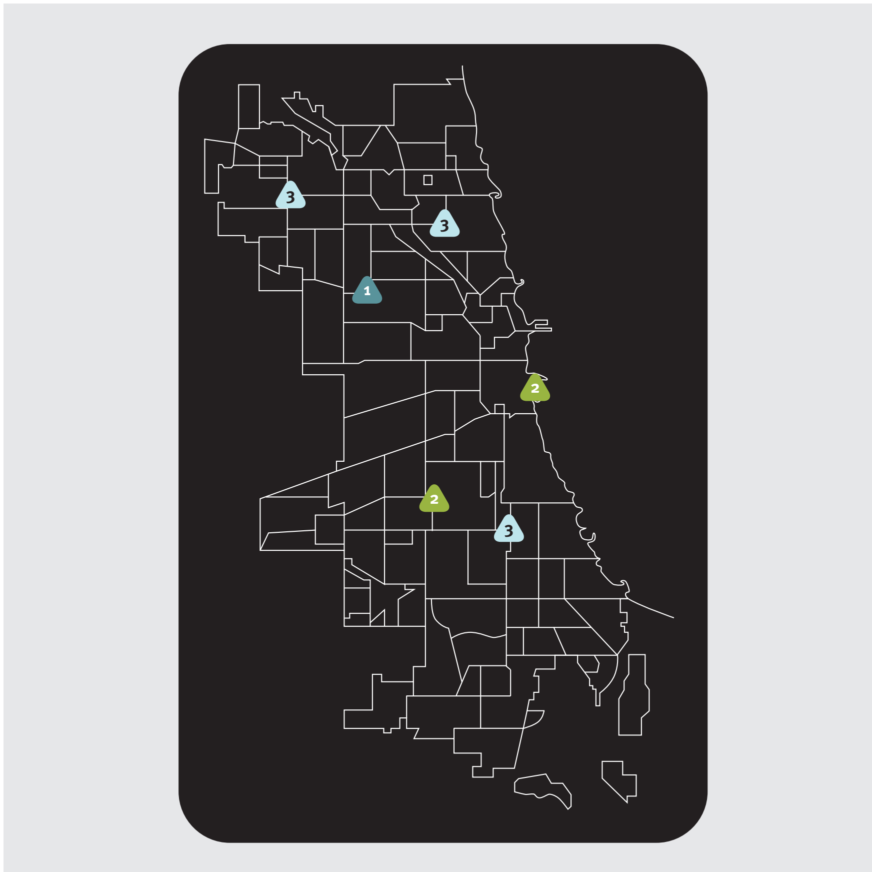
Judy passes by a **Waterfall Wall** equipped with a **Targeted Scanner** as she boards the train; it doesn't feel like the slow, invasive security checkpoints that she used to know. Airports and travel terminals of the past required spending hours in line to ensure a safe travel experience. But now, Judy simply walks through the gates with her luggage and is passively scanned for dangerous materials along with her fellow riders.



From the platform, Judy notices the cameras around her. She feels safe and knows that her privacy is protected. The cameras' recordings are not scrutinized by humans until suspicious behavior is identified by the behavior-tracking cameras. Judy had her reservations, but is willing to trade her conspiracy theory for personal safety. After all - these systems have been successfully in place for decades in England.



Judy boards her train and secures her belongings. On the way, she hears an announcement that her train is being piloted by a guest conductor from Milwaukee. This drill is a way for members of other cities to practice operating Chicago's transportation systems in the case of emergencies. Most of the time, Judy doesn't notice all of the precautions being taken around her. But whenever she feels uneasy about traveling, she reminds herself of the layers of protection, monitoring, and readiness blanketed around her.



Nimble Response

Nimble Response is a collection of action plans, preparation, partnerships, and technologies that come together to provide a fluid and unified system response to emergency situtations.

Related System Elements:
New Connected Infrastructure
Transcom Network
Cargo Concierge
Operational Excellence
Optimized Infrastructure
Distributed Information Management
Wilde Times

Fulfilled Functions

22 specify organizational relationships
25 communicate between system components
71 monitor activity
72 identify risks
73 train system operators
74 generate backup solutions
76 institute preventive action
77 educate public
78 process feedback
79 alert system of emergency mode
80 monitor and report response progress
81 coordinate emergency response components
82 update system status
83 prioritize emergency response
84 manage/authorize emergency resources
85 Protect users from immediate harm/danger
86 Contain Emergency
87 Evacuate System
88 Activate backup protocols
89 Initiate Emergency Recovery
90 evaluate situation
91 assist victims
92 prioritize response to vital functions
93 restore system
95 resume service
96 gather and interpret data
99 manage risk

Properties

Emergency Planning

- Distributed/decentralized response and service centers (see Distributed Info)
- Prepackaged response plans
- Backup response partnerships (contractors and cities)
- Emergency patterns database
- Targeted scanners
- Ubiquitous sensors
- Software that uses collected data to identify risks and rate according to risk level (e.g., needs immediate response, warning to monitor)
- Backup data, communications, and coordination systems with multiple communication routes, off-site data backup systems, and capability to be activated gradually

Emergency Action

- Handheld devices and other communication interfaces with GPS capabilities to link system and users
- Info/Action Coordination Dashboard
- Semi-Automated Operators
- Communication protocol requiring varied levels of communication responses depending on importance of message
- Multiple transport modes used to respond to emergencies (e.g., air, water, surface, rail)

Features

- Minimizes emergency response time
- Stores and protects critical information in alternate locations
- Expands emergency response network and capabilities by building supportive relationships outside of Chicago
- Anticipates potential problems and solutions for more effective response by learning from the past and from other cities
- Identifies potential risk by monitoring activity patterns
- Activates comprehensive back up systems as necessary without overburdening the regular system
- Provides personalized real-time emergency information and instructions to system users through Transcom Network interfaces, including handheld devices
- Allow system to locate potential victims through GPS linked interfaces
- Coordinates and optimizes interagency response
- Supports effective human judgment in emergency situations

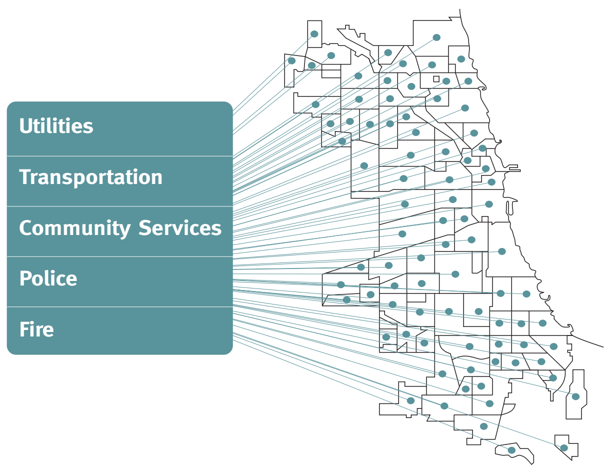
Associated Design Factors

- Coordination between many agencies is difficult
- Delay between detection, processing, and reaction amplifies problem
- Public education of emergency protocol not effective
- Backup solutions can burden regular system operations
- Effective operator safety training can be inconsistent
- Protecting civil liberties vs. monitoring the system
- Restoring and testing system may take too long
- System may not have access to information required to respond
- System may be incapacitated or inoperable
- Communication is not always efficient or effective
- System may have trouble locating victims
- Containing emergency may involve risking lives
- Backups can fail

Discussion

Nimble Response is a collection of action plans, preparation, partnerships, and technologies that come together to provide a fluid and unified system response to emergency situations. While it is of utmost importance to build an efficient and responsive system for everyday use, it is also crucial that the transportation system be capable of equally efficient and responsive services in case of emergency. To this end, **Nimble Response** provides solutions for both emergency planning and action.

Emergency Preparation & Planning



Nimble Response builds on **Distributed Information Management Facilities (DIMFs)** and the current model of fire and police service stations by distributing services across the city. All of these distributed transportation and emergency services within each localized zone are housed together in comprehensive polycentric **Distributed Service Centers** to facilitate inter-agency communication. With emergency planning and response distributed across the city and housed together with related transportation and city services, response time to any specific location is minimized without diminishing response capabilities. Moreover, if any particular **Distributed Service Center** is incapacitated, neighboring **Distributed Service Centers** are available to coordinate and take over responsibilities as needed.

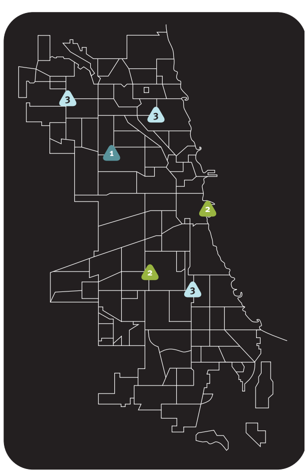
Whenever possible, **Nimble Response** preparation teams assemble comprehensive **Prepackaged Response plans (PpRp). PpRps** serve as a quick and robust starting point for easily anticipated emergencies in the city such as weather emergencies (e.g., blizzards, tornados, heat waves), small-to-medium system fires, and system evacuations. These multidimensional **PpRps** include components such as initial drafts of public announcements, actions to be taken by transportation, police,

Discussion, cont'd

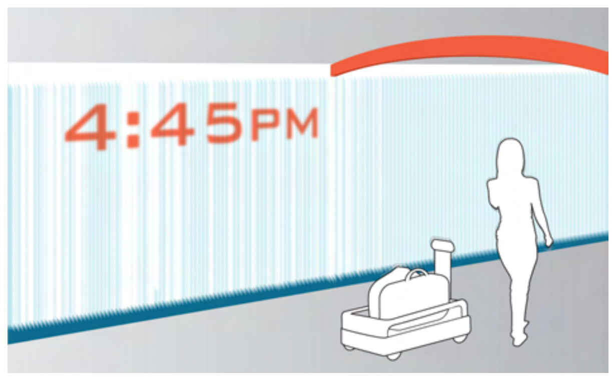
fire, and other service personnel, and communication plans for affected municipal services and utilities. Having **PpRps** on hand aids in rapid response for predictable emergencies to reduce delays in response time.

Since many emergencies are not easily anticipated, **Nimble Response** makes use of the **Multi-Mode Response Council** and solutions such as an **EmPatt, Leveled Risk ID, Targeted Scanners,** ubiquitous sensing technology, **Graduated Backup,** and **Backup Response Networks** for further planning. Together these preparations anticipate and identify potential problems or risks; collect, archive, and package possible response solutions; and establish backup supports.

EmPatt, the **Emergency Patterns Database,** is a security tool used to help collect, organize, and analyze information from past emergency cases and security threats in Chicago and other cities around the world. As part of Chicago's preparation and planning for future emergencies, **EmPatt** helps **Nimble Response** planners identify possible preventative action for various situations based on patterns and multiple factors along with the source of both successes and failures of various cases in order to continually improve emergency planning and action.



Leveled Risk ID, in conjunction with the information generated by **EmPatt,** is a supporting tool that incorporates and matches real-time transportation activity patterns to identify potential risks through the use of **Targeted Scanners** and ubiquitous sensing technology monitoring activity patterns within the system. **Leveled Risk ID** helps **Nimble Response** prioritize action by rating potential risks according to different levels of attention needed (e.g., needs immediate response, warning to monitor, currently non-threatening but with potential depending on specific factors).



Targeted Scanners arch over key transportation points (e.g., station entry points, points of transaction) and scan all system users unobtrusively upon system entry. They are similar to present-day metal detectors, but **Targeted Scanners** are capable of scanning for all security-threatening materials and substances through **EmPatt**'s regularly updated database of material types, combinations, proportions and other key patterns that match the makeup of potentially threatening items. Instead of focusing security scans and searches on specific users, **Targeted Scanners** and ubiquitous sensors shift the focus of security to potentially harmful materials moving through the system (see scenario). Together, **EmPatt, Leveled Risk ID, Targeted Scanners,** and ubiquitous sensing technology provide **Nimble Response** with a system-wide awareness that aids in emergency preparation.

Nimble Response includes an inter-agency **Multi-Mode Response Council (MMRC)** to maximize rescue access in any given emergency situation. Examples of **MMRC** plans include identifying and

Discussion, cont'd

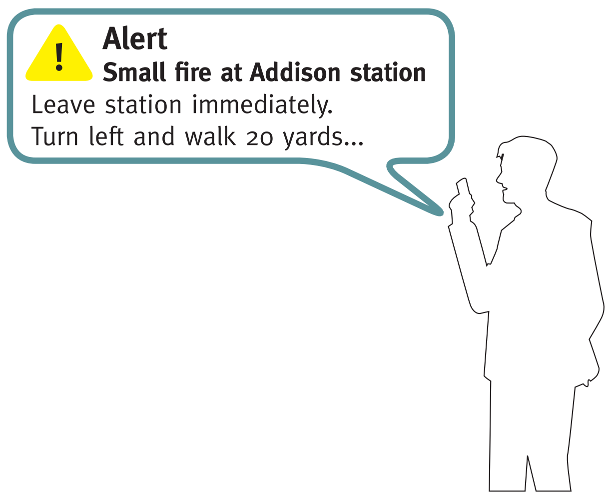
organizing the use of air, water, surface, rail, and underground freight as available modes for emergency system access. The **MMRC** also finds opportunities for multidimensional preparation and use of system components such as **On-Call Automated Maintenance Mechanics** (see **Evolutionary Maintenance**) for emergency rescue efforts.

For the backup components of **Nimble Response, Graduated BackUp** and **Re-Routing Communications** are used to protect critical information and communication and provide backup support without overburdening the regularly run system. **Graduated BackUp** exists in discrete modules of support separated into categories (e.g., geographic location, transportation mode, maintenance-related systems) that provide a continuous range of backup services rather than a simple "all systems on/off" for appropriate support as alerted without overburdening the entire system.

For communication backup specifically, **Nimble Response** plans for multiple communication routes through the use of **Re-Routing Communications. Re-Routing Communications** begins with the use of self-healing materials for the core network of vital communications. In cases where extensive damage makes this impossible, then communication is automatically re-routed through alternate routes and channels to maintain vital communications and access necessary data that has been regularly copied and stored off-site.

The final component of **Nimble Response's** planning and preparation includes building Chicago's **Backup Response Networks (BRN). BRNs** are partnerships between the city and various contractors or neighboring cities such as Gary, Indiana or Milwaukee, Wisconsin. These mutual **BRN** partnerships are regularly negotiated so that in large-scale emergency cases that may overwhelm the capacity of **Nimble Response,** relationships and responsibilities are already in place for **BRN** partners to come in for immediate support if necessary and thereby expand the capabilities of coordinated response and backup.

Emergency Response
When emergencies cannot be prevented, **Nimble Response** takes action with coordinated efforts through **Bird in Hand,** the **Info/Action Coordination Dashboard, Call & Response** protocols, and **Semi-Automated Operators** to protect users and secure the system.



Bird in Hand works with the **TransCom Network** and **Distributed Information Managment** as a multi-channel platform that utilizes handheld devices with GPS capabilities, other **TransCom Network** interfaces, and multiple communication channels (e.g., TV, radio) to link the system and users with personalized real-time emergency information, depending on the scope of the emergency. **Bird in Hand** distributes specific and relevant emergency information and instructions to individuals; communications are adjusted in real-time in response to what the user does, where the user is located, and how the situation changes. The GPS technologies embedded in the **TransCom Network** also aids **Nimble Response** teams in locating potential victims in the case of disaster emergencies.

During an emergency, the **Distributed Service Centers** utilize the **Info/Action Coordination Dashboard** program within each center and across centers to automatically collect and organize coor-

Discussion, cont'd

dinated activity. **Info/Action** provides emergency responders with ongoing access to activity of other relevant parties across the city and across agencies. Additionally, **Info/Action** is used to organize and implement **MMRC** solutions and plans when appropriate. If there is overlap or holes in emergency action, **Info/Action** immediately identifies and flags these cases to help response teams make better informed decisions of how to prioritize and distribute response resources effectively.

To further maximize the impact of emergency action, communication protocols known as **Call & Response** are built into the **Nimble Response** communication system. These response actions are more or less complicated depending on the priority and importance of the communication; for example, message received e-signatures may be required for higher security communications while simple "button press" responses may be used for low priority communications. Where there is no response to a communication, **Call & Response** follows up more or less aggressively depending on the urgency of the message.

Finally, in order to support effective human judgment in emergency situations, **Nimble Response** includes the use of **Semi-Automated Operators** in the transport system. **Semi-Automated Operators** consist of a partnership between human system operators (e.g., station employees, vehicle operators) and automated response technologies. If a problem in the system is identified, options for appropriate action are suggested by the system to operators to support decision-making in the moment of emergency, but ultimately the decision is left to human operators and actions reported through **Nimble Response** communications.

Scenario

Emergency Preparation & Planning
Like any other regular work day, William is at the North Center **Distributed Service Center (DSC)** seated in front of his **Distributed Information Management (DIM)** console monitoring transportation system activity. He notices that a **Targeted Scanner** at the Montrose thruway station has identified the entry of a potentially harmful substance into the system. Ubiquitous sensors track the movement of this substance; by itself, the substance is harmless, but when combined with a specific catalytic chemical it can be used as an explosive, which is why **EmPatt** has it tagged as a low-level risk. However, **Targeted Scanners** and ubiquitous sensors have detected the movement of that very second catalytic chemical in another part of the system on the west side of the city. It is also flagged, and William sends a message to the Humbolt Park **DSC** and all **DSC**s between them are informed as well. William almost instantaneously receives a "message read and noted" response through **Call & Response** protocols. As sensors monitor the movement of both of these substances, it becomes noted that they are moving toward the same station. **Leveled Risk ID** automatically raises the risk to medium and all nearby **DSCs** are alerted. William continues to watch the exchange of messages and movement of flagged risks, but within a few minutes it is noted that the primary substance has left system, eliminating the potential risk of harm to the system. The activity is automatically logged into the **DIM** system and William returns to his regular work.

Emergency Response
One week later, William sees that there is a small fire that has broken out at the Addison thruway station. He has been alerted to the event and sees on the **DIM** console that there are three passengers still in the station who have been sent **Bird In Hand** emergency instructions via **Transcom Network** interfaces to their handheld devices. William can see through the **Info/Action Coordination Dashboard** that the firefighters downstairs have already been alerted and moments later he hears the fire trucks leaving the **DSC** with sirens blaring. Since traffic has already been cleared by **Optimized Infrastructure** for a direct fire truck route, William knows that the firefighters will arrive at the Addison station in a matter of minutes.

William turns back to the **DIM** console to note that through **Call & Response** protocols that all three passengers had received the **Bird In Hand** instructions, left the station, and were already on their way headed east on an alternate route.

Conclusions

Transportation is undoubtedly an integrated part of Chicago's urban environment. That said, the aforementioned elements were crafted in an effort to imagine a transportation system that is not only integrative and diverse, but responsive. Imagining the future is unquestionably a daunting and challenging task filled with an innumerable number of variables. Though innately unpredictable, the future by no means encapsulates a scenario unimaginable by the curious and determined minds of today.
It is without reservation that we admit that the power and influence of imagination can only go so far; inherent in imagination is a counterbalance of viability where idealism is tempered by pragmatism. That said, one could only begin to imagine the future after successfully understanding the past and present.

This of course brings us right back to where we started: today. Today Chicago's urban environment is burdened by its transportation system; inefficient, outdated, and inadequate, somewhere along the tracks of history Chicago's transportation system derailed and failed to evolve with the changing world.

The aforementioned solutions are a product of structured design thinking and planning. Imagining the future of a transportation system requires an impetus to systematically analyze constantly evolving system relationships. That said, the journey towards a Responsive Transportation system is never concluded. Our solutions are inspired by the controlled development that Daniel Burnham imagined and thus are structured, viable, sustainable postulations of what could be.

Imagining *what could be* requires a keen understanding of the defining issues of our time. As mentioned in the preface of this report, the structured planning process utilized visual, procedural, and organizational system concepts that are capable of responding to the changing social forces that await. When continuing to design for the future of transportation, the city of Chicago will need to keep in mind the following.

Adaptive Infrastructure & Planning
The transportation system of the future requires flexible, adaptive, and sustainable infrastructure. Continued urban population growth and urban sprawl will continue to increase the demands on infrastructure. Transportation system success will largely be determined by Chicago's ability to provide safe and responsive transportation solutions to an increasingly dynamic and transient population of city dwellers. Inherent in being able to provide said experience to travelers is an unrelenting insistence on quality and evolutionary maintenance. With each repair and replacement, Chicago will be proactively extending the life of its system through application of emerging technologies originating from sincere research into the material sciences. Of paramount importance is a keen understanding and substantial investment in the transportation system life cycle. Every material brought into the system should one day be able to return to the natural environment. Chicago's transportation system must take a leadership position in adopting earth-friendly energy practices. By setting bold sustainability goals and planning for the future, Chicago will enable itself to explore smart infrastructure options that last longer and are less detrimental to the environment. Furthermore, a transportation system that truly bears in mind the interests of the greater environment will harvest energy from the movement it promotes through technological advancements such as regenerative braking and piezoeletronics.

The Travel Experience
A truly progressive and world-class city must take into consideration the quality of travel experience it makes available for its inhabitants and visitors. Of primary importance are applied information technology capabilities leveraged to create seamless and responsive connectivity between the system and its users.

Chicago's transportation system of the future will require facilities that enable travelers to move about the city in an exceedingly comfortable way. That said the comforts of today are unlikely to be

Conclusions

the comforts of tomorrow. The transportation systems users of tomorrow will demand transportation facilities that support fluid maintenance of lifestyles and productivity while travelling. As nature continue sto be reintroduced into Chicago's urban environment, transportation system planners and developers will be challenged to integrate it into the travel experience.

Travelers have long been at the mercy of scheduled service and capacity limitations. Transitioning travelers away from heavy private automobile usage will require innovative solutions. Future transportation systems will be on-demand in nature, and thus provide a viable alternative to inefficient and wasteful car usage. That said wasteful car usage could be mitigated by progressive infrastructure installations such as vehicle and bicycle shares. These installations will contribute to building community spirit within the city as well as a sense of shared responsibility amongst all citizens.

Operations & Emergency Management
Due to multiple cars in most households, new roads are filling up as soon as they are constructed. Continuously adding new roads may have been an option in the past but the city of Chicago is running out of space and construction becoming prohibitively expensive. Except where urban sprawl prevails, city street widening will require sacrificing sidewalks and buildings. Moreover, public opposition to additional new freeways is already great and probably will intensify (Ball 2005).

As population continues to grow in urban Chicago, traffic flow will be severely impacted if more effective transportation management systems are not implemented. The system should prioritize management over expansion as a means to minimize congestion. In order to make this goal a reality, significant investments will need to be made in information technology and intelligent infrastructure.

The future is inherently unpredictable, but it is possible to plan for potentially challenging or destructive situations. The responsive transportation system of the future will demand sophisticated risk management systems and scenario planning. In order to be truly prepared for the uncertain, one must have imagined if first.

Perhaps the most poignant phrase within Daniel Burnham's now immortal quote is the following; "Aim high in hope and work. Remembering that a noble, logical diagram once recorded will not die."

It is with great humility that we profess our sincerest wish that these plans might breathe new life into generations of bold thinkers to come.