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Universal design is a design philosophy couched in a public discourse of social inclusion. Spurred by disability civil rights legislation, growth of the older population, the information revolution, and markets, universal design has become a global design paradigm. This article reviews global dimensions of the paradigm and implementation strategies related to public transportation. Given universal design's overall inclusionary values beyond American Disability Act standards, the article asks, What is universal design's potential for redressing sociospatial exclusion among mobility-disadvantaged populations? Using a multitiered social exclusion/accessibility framework, the article addresses this question and draws conclusions about universal design applied to transit in the United States.

Keywords: *transit; universal design; social exclusion and mobility; scales of accessibility; aging and disability*

Universal design (UD), a concept coined in the 1970s by North Carolina State University's Ron Mace, originated as a disability-inclusive architectural design approach. Since then, it has progressively become an international philosophy of design, spreading to many fields outside architecture, such as education, engineering, and information and communications technology. The philosophy has influenced many spheres of industry whose products, services, and environments are intended for human use. Transportation, and more specifically, transit, is one such area in which UD has made inroads. This article summarizes UD as a global paradigm of inclusion and assesses the potential of UD applied to transit to redress social exclusion in urban mobility.

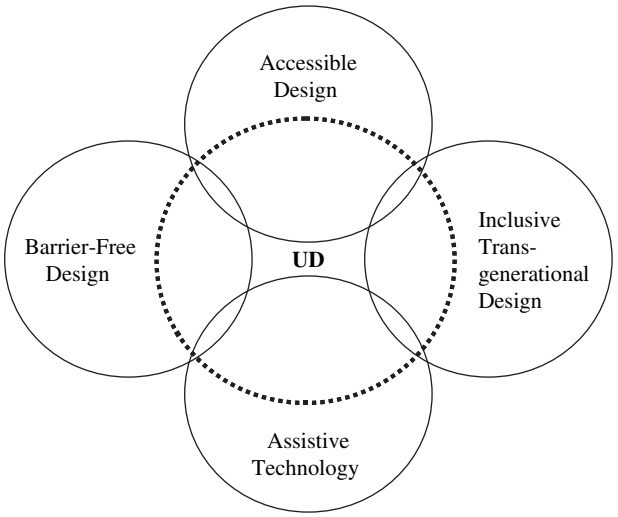
Universal Design

Universal design (as it is termed in the United States, Japan, and Scandinavia), or design for all (as it is known elsewhere), is a relatively new school of thought including the following design perspectives (see Figure 1):

- Barrier-free design—retrofitting of buildings or facilities to accommodate physically impaired people; design that strives to make the built environment barrier free for all persons.[1]
- Accessible design—designing for equal opportunity of access to mobility, facilities, devices, and services for people with disabilities, typically mandated (e.g., by the Americans with Disabilities Act [ADA]).
- Assistive technology—rehabilitative engineering that enables people with disabilities to perform previously not performable tasks by enhancing physical, sensory, and cognitive abilities.
- Inclusive design—designing products and services for the needs of the widest possible audience, irrespective of age or ability.
- Transgenerational design[2]—improving the quality of life for people of all ages and ability.

UD is a philosophy of design that not only subscribes to the ideals of accessible and barrier-free design and assistive technology, it also professes to be a broader paradigm of design that celebrates diversity and is inclusive of all users regardless of age or ability. Rather than solely responding to the mandates of disability rights legislation by removing or mitigating barriers, UD also relies on assistive technologies to help people with sensory and cognitive disabilities function more independently. It challenges the 5-to-95-percentile target of standard anthropometrics as being exclusionary and insensitive to the manifold differences of users (Hitchcock et al. 2001). UD tries to destigmatize aging by giving equal consideration to "those changes that are experienced by everyone as they grow from infancy to old age" (Pastalan as cited in Center for Universal Design 2000, 2), and it endorses transgenerational design—a design outlook that upholds the dignity and independence of all by placing disability and aging "within the context of normal expectations of the human condition" (Pastalan as cited in Center for Universal Design 2000, 2). In its broadest sense, UD is a philosophy of

Figure 1
Universal Design (UD)



design for process and products (systems, environments, facilities, and devices) for the greatest possible number of users with the greatest possible spectrum of abilities, in the greatest possible range of contexts (environments, conditions, situations) (Mace 1998; Trost 2005). The concept of UD is premised on a public discourse of disability inclusion as embodied in the following seven principles:

1. Equitable use—the design is useful and marketable to people with diverse abilities.
2. Flexibility in use—the design accommodates a wide range of individual preferences and abilities.
3. Simple and intuitive use—use of the design is easy to understand, regardless of the user's experience, knowledge, language skills, or concentration level.
4. Perceptible information—the design communicates necessary information effectively to the user, regardless of ambient conditions or of the user's sensory abilities.
5. Tolerance of error—the design minimizes hazards and adverse consequences of accidental or unintended actions.
6. Low physical effort—the design can be used efficiently and comfortably and with minimal fatigue.
7. Size and space for approach and use—appropriate size and space are provided for approach, reach, manipulation, and use regardless of user's size, posture, or mobility (Center for Universal Design 2000).

However, UD's social equity vision is included under a larger market discourse, and, in practice, UD's diffusion depends to a large extent on the economic opportunities for effectively expanding consumer choice in products, services, and environments. In this regard, UD has evolved into a global paradigm with discernible international differences.

Universal Design: A Global Paradigm

In both industrialized and industrializing countries, UD is spreading as a new design paradigm resulting from the convergence of four factors: (1) disability civil rights legislation and ensuing implementation programs; (2) the aging demographics, particularly in industrialized countries; (3) the information society's dual exclusionary (i.e., digital divide) and enabling effects (i.e., information and telecommunications innovations including assistive technologies); and (4) the corporate response to potential markets for UD products.

UD in Industrializing Countries

UD is being invoked to implement Rule 5 on Accessibility of the United Nations' Standard Rules for the Equalization of Opportunity for Persons with Disabilities (Designing for the 21st Century III 2004; Preiser and Ostroff 2001; RERC UD 2006; UN Enable 2007; Venter et al. 2002). This rule specifically recommends nations develop action programs to make the physical environment and information and communications accessible to people with disabilities and urges the planning, design, and engineering professions to actively engage in this effort (UN Enable 2007). Furthermore, signatories to the UN Convention on the Rights of Persons with Disabilities, whose purpose is to promote disability-inclusive development, explicitly pledge to "undertake or promote research and development of universally designed goods, services, equipment and facilities . . . , which should require the minimum possible adaptation and the least cost to meet the specific needs of a person with disabilities, to promote their availability and use, and to promote UD in the development of standards and guidelines" (UN Enable 2006, Article 4 [f]).

Implementing this convention in developing countries, World Bank–financed research projects have investigated state-of-the-art UD bus rapid-transit systems in Curitiba, Brazil, and Bogota, Colombia. Additionally, they have sponsored the development of design guidelines for barrier-free and assistive technologies in bus-based mass transit systems (Rickert n.d., 2006; World Bank 2006a, 2006b).

UD in Scandinavia and the United Kingdom

With a strong welfare-state tradition, Scandinavian countries lead the way in policy formulation implementing Rule 5 of the UN Standard Rules on Equalization of Opportunity and the European Union's e-Inclusion and e-Accessibility policies. The latter initiatives aim to bring the benefits of the information society to all segments of the population regardless of economic, educational, age, ethnic, or any other disadvantage or disability through the use and application of "design for all" approaches (EU e-Inclusion 2007).

Norway's "Programme of Action for Universal Design" has adopted and applied UD to the planning and design of physical areas, transportation, and information. The program, implemented in 2002 under the auspices of Norway's Ministry of the Environment, focuses efforts on UD research and development and on educating administrators and decision makers from both public and private sectors about the tenets of UD and their implementation. The Nordic Council on Disability Policy sponsored a six-year "town planning and design for all" program directed to more than 1,500 municipalities in the Nordic region. The program culminated with a competition that evaluated the ten most accessible Nordic cities. The city of Kristiansand, Norway, won the title with an "all-inclusive" comprehensive plan that hinges on UD applications for transportation infrastructure and public transit, public and private buildings, and public spaces and recreation. The plan incorporated employment incentives, citizen education on UD, and intensive stakeholder input and consultation (Petren 2004).

In Gothenburg, Sweden, a regional comprehensive plan sets the norms applying UD to transportation systems. Gothenburg's Flex Line is known for being one of the first centralized intelligent-demand-responsive transit systems that integrated previously segregated services provided by hospitals, schools, and social services for older, disabled, and isolated individuals (TCRP 2000, 2007).

In the United Kingdom, European Design For All e-Accessibility Network is an organization that seeks to implement the same EU's age-and-disability-inclusion policies by disseminating information and educating design professionals and public and private sector decision makers on UD innovations and their economic benefit (European Design For All e-Accessibility Network 2007). In addition to wheelchair-accessible taxis, UD applied to London's transit includes retrofitted bus stops with platforms and street curbs flush with low-floor buses, as well as intelligent door-to-door services run by users and volunteer drivers, which serve impaired citizens and transportation-disadvantaged groups (e.g., Hackney Community Transport; TCRP 2007).

Universal Design in Japan

In addition to UD's inclusionary goals, the market potential of the "graying" demographics in industrialized countries explains the rapid diffusion of UD ideas. The information and communications technology (ICT) revolution has also played an important role. In this regard, Japan is the country where UD can be found at the forefront of business and national policy. In 2001, the e-Japan Strategy aspired to make Japan the world's most advanced ICT nation through the development of advanced high-tech assistive technologies and corrective measures against the digital divide (Horihoshi 2005, 27). Then in 2004, inspired by Section 508 of the U.S. Workforce Investment Act of 1998 (which applies to the development, maintenance, and procurement of all electronic and information technology used by the U.S. Federal Government), Japan launched its U-Japan (ubiquitous) initiative for procurement of all products and services, which must be accessible by anyone, anywhere, and at any time. Japan sees UD as the means, through government procurement standards, to enable all citizens to access the information society. Hence, the Japanese Industrial Standards Committee officially announced a UD standard for products and services in the ICT sector (Kato and Iwazaki 2005, 5). By the same token, Japanese businesses have adopted the International Organization for Standardization and International Electrotechnical Commission Guide 71 for standards developers to address the needs of older persons and persons with disabilities. Giant corporations like Fujitsu and Toyota are launching UD product lines and promoting UD product award competitions with an eye on banking on the promising market of aging Japanese (Ikeda 2005). Together with China and South Korea, Japan is promoting UD procurement standards for Asia, presumably with the intent of influencing their worldwide adoption and capturing global markets (Accessible Society 2003).

In transportation, guided by the Ministry of Land, Infrastructure and Transportation's project for UD, which implements Japan's Transportation Accessibility Improvement Law (aka, the Heartful Building and

Table 1
International Disability Civil Rights Legislation and Transportation-Related UD Examples.

	Disability Civil Rights Legislation & Initiatives	Selected Examples
Developing countries	• Rule 5 on Accessibility of the UN Standard Rules for the Equalization of Opportunity for Persons with Disabilities • UN Convention on the Rights of Persons with Disabilities 2006.	• BRT Accessibility Guidelines (Rickert 2006), World Bank. Best practice from Curitiba Brazil; Bogota, Colombia; and Leon, Mexico • *A Design Manual for a Barrier Free Environment* (UN and SOLIDERE 2000).
Japan	• e-Japan Strategy, 2001, and U- (ubiquitous) Japan Strategy, 2004 • "Heart Building Law" or Law for Promoting Easily Accessible and Useable Building for the Aged and the Disabled, 1994, 2002 • "Barrier-Free Transportation Law" or Law for Promoting Easily Accessible Public Transportation Infrastructure for the Aged and the Disabled, 2000.	• Toyota RAUM van • Toyota Universal Design Showcase, Tokyo • Haneda Airport, Terminal 2, Tokyo, Heart Building Law (barrier-free certified) • Kumamoto City Light Rail Transit, 1st low floor system in operation since 1973.
Europe	• EC White Paper on European Transport Policy to 2010 • EU's e-Inclusion 2005 and e-Accessibility. • U.K. Disability Discrimination Act 1995.	• TX1 London taxi, world's most (wheelchair) accessible cab • Hackney Community Transport, (TCRP 2007) • Gothensburg, Sweden Flex Line (TCRP 2007) • Copenhagen Metro (designed for all) (Bendixen 2002) • Kristiansand, Norway, most accessible Nordic city (Petren 2004).
USA	• Americans with Disabilities Act, 1990 • Architectural Barriers Act, 1968 • Rehabilitation Act, 1973 • Safe, Accountable, Flexible, and Efficient Transportation Equity Act, 2006 (aims to reduce barriers to transportation and provide services beyond ADA requirements).	• Handbook for Improving Public Transit Options for Older Persons TCRP Report 82 (Burkhardt, McGavock, and Nelson 2002) • Independent Transportation Network, Portland, Maine (senior volunteer & paid door-to-door service; Niesz 2005). • Toolkit for the Assessment of Bus Stop Accessibility and Safety (Easter Seals Project Action 2005). • Berkeley, California: most accessible city (National Organization on Disability 2006).

Barrier-Free Transportation Laws for the Elderly and Disabled), Japanese prefectures and cities have established UD offices. Japan's rail transit and terminals, including Haneda Airport's second terminal, are considered the world's most advanced applications of UD. This is because, since the 1980s, Japanese physical planning (aka, welfare community planning) has required compact development and barrier-free improvements around rail stations (Akiyama 2005). Although the term *UD* was coined in the United States, a comparative study of American and Japanese facility managers' familiarity with UD suggested that more Japanese than U.S. managers were familiar with the term. This difference was explained by the recent interest of Japanese manufacturers in UD as a new marketing strategy and by the recent amendment of the Heartful Building Law. However, in practice, there was no difference between Japanese and American managers in the degree of application of UD to their workplace (Saito 2005).

UD in the United States

In the United States, UD's policy environment can be traced back to the precursors of the ADA of 1990. These include the Architectural Barriers Act of 1968 and the Rehabilitation Act of 1973—the first federal regulations requiring disabled citizens' access to facilities designed, built, altered, or leased with federal funds. UD emerged as a reaction to ADA's narrow codification of accessibility for disability, which in practice stigmatizes and differentiates users by disability. Rather than designing for two separate populations—the "normal" and "impaired"—under ADA's standards, UD aims to design for one population made of diverse individuals. Thus, for example,

instead of ADA-accessible buses with steps for "normal" people and lifts for "disabled" people, low-floor, ramp-based, and stairless buses, which all users board and alight in the same way, is a UD solution that does not segregate users.

However, because ADA standards are legally enforceable and are at the core of a normative institutional culture and compliance practice, UD in the United States is a movement that aims to influence planning and design professional practice beyond ADA, emphasizing widest usability. In this sense, UD is more a pedagogical process than a measurable outcome (Iwarsson and Stahl 2003), and its intellectual and creative force remains university based.[3] Architects, designers, and engineers offering a vast array of design consultancy services (including products and facility design, design review, and ADA expert witnessing) to various industries, developers, and aging and disability lobbies ostensibly drive the movement.

In sum, four broad approaches on UD have unfolded. First, a United Nations and World Bank program focused on inclusive development intended primarily for developing countries, which adopts UD as the preferred implementation strategy for the UN Convention on the Rights of Persons with Disabilities. Second, a Japanese multinational and corporate-led approach directed on access to the Information Society, chiefly postindustrial and production oriented, and focused on industrial procurement guidance and design standards with a global market scope. Third, a European (Scandinavia and United Kingdom) government- and NGO-led approach of planning at all levels for accessible products, services, and environments with an eye on servicing the older market. Fourth, an American network of think tanks, advocacy NGOs, consultancy groups, and university centers in which architects, industrial designers, and engineers lead the way, with the intent on influencing their respective industries about the social and market benefits of designing for the widest possible usability beyond ADA accessibility standards.

Social Inclusion and Universal Design Applied to Transit

Although influential transportation planners believe that given the low share of transit travel, transit cannot be the public strategy for improving mobility-disadvantaged individuals (Pucher and Renne 2003, 74),[4] disability theory and activism have challenged these views as exclusionary on several fronts (Corker and Shakespeare 2002; Pothier and Devlin 2006). First, on the basis that mode-split statistics are a poor measure of transit demand, since they do not account for suppressed trips (i.e., forgone trips for lack of transit service or impaired accesses to it) (Hine and Grieco 2002). Second, that mainstream transportation planning and design are based on the notion of a "universally able and disembodied" subject (i.e., without biological and social attributes) (Hine and Mitchell 2001; Imrie 2000; Langan 2001) and thus exclude not only impaired but also many nonimpaired people. Third, that transportation planning espouses the medical model of disability whereby the individual's body, rather than the built environment and social attitudes against disabled people, is the main debilitating cause in personal mobility (Langan 2001). Fourth, that the transportation disciplines and lobbies have endorsed and promoted a universal system of auto-mobility that alienates impaired people and discriminates against all who, for financial, physical, temporal, or psychological reasons, cannot access or use automobiles (Imrie 2000; Hine and Mitchell 2001; Langan 2001).

The literature on mobility and exclusion research identifies several forms of social exclusion (i.e., physical, geographical, from facilities) resulting from the organization of transportation and the quality of transit service provision and its relation to the built environment, urban form, and land use patterns (see Table 2). These mobility-limiting factors also include economic, fear-based, and time-based exclusions, which condition people's immobility and capacity to participate in mainstream society (Cass, Shove, and Urry 2005; Church, Frost, and Sullivan 2000; Grieco 2003; Hine and Mitchell 2001; TCRP 1999).

Accessing Transit as Universal Design

UD applied to transit is an inclusionary strategy that seeks to redress the aforementioned forms of social exclusion. Accessible transportation focused previously on technical solutions to removing physical barriers affecting specific disabled groups and providing dial-a-ride or specialized demand services. These strategies largely segregated and stigmatized users as "seniors" or "disabled." Instead, UD emphasizes transportation that caters to all users regardless of age and ability in a single integrated system that combines both mass transit and real-time demand-responsive systems (Grieco 2003; Mitchell 1997). Enabled by ICT and borrowing from freight logistics, the European literature refers to this system

Table 2
Mobility and Types of Social Exclusion

Dimensions of Social Exclusion and Mobility	Description	Accessibility[a]		
		Micro	Meso	Macro
Physical exclusion	Physical barriers of the built environment (streets, sidewalks, crossings) impede access to transportation; physical barriers in the transportation system itself (e.g., vehicles, bus stops and stations) exclude people with physical or psychological difficulties; individuals with impaired mobility, hearing, or vision; people with children or baggage; frail elderly people, and non-English speakers.	X	X	
Geographical exclusion	Lack of automobility and lack of transit; transit service's poor metropolitan reach limits accessibility beyond the neighborhood to economic opportunity, shopping, recreation, and social life. Increasingly found at the edge of expanding metropolitan areas.			X
Exclusion from facilities	Related to the above; exurbanization of retail and other facilities and relocation or reorganization of private and public services require more travel, more travel time, and/or more costly travel.			X
Economic exclusion	Low income, no automobile, and no transit service or poor transit service exclude mobility-disadvantaged populations from economic opportunity.		X	X
Time-based exclusion	Related to poor transit service (infrequent during the day and week, unreliable, unpunctual), affects all transit-dependent people but more so, caregivers, particularly single mothers.		X	X
Fear-based exclusion	Fear for personal safety in public spaces, which varies by time of day and gender and influences the use of public transportation.	X	X	
Operator-based exclusion	Lack of information and assistance about transit service, staff attitudes, and drivers' behavior toward impaired people contribute to suppressed journeys and social exclusion.	X	X	X

a. Physical accessibility levels: micro = immediate physical environment; meso = neighborhood, city; macro = metropolitan, regional.
Source: Church, Frost, and Sullivan 2000; Hine and Mitchell 2001; Iwarsson and Stahl 2003.

as the "complete transportation chain" (Mitchell 1997; Organization for Economic Cooperation and Development 2000; Ståhl 1999), while the American literature terms it the new "mobility management model" (TCRP 1999, 2000, 2002). These models require seamless integration of the supply side (i.e., system's operation, infrastructure, and quality of service delivery) with the demand side (i.e., mobility needs of the widest number of users). Consequently, this often entails a complete reorganization of transit operations from traditional fixed-route, hub-and-spoke, and set-schedule systems to flexible schedule systems with intelligent reservation centers that can identify passenger needs and aggregate individual preferences in real time, providing door-to-door service (Hine and Grieco 2002). Despite its technical feasibility in the current ICT era, institutional, organizational, legal, and old market structures remain important barriers to the full realization of these integrated-transit models touted as the means to bring about "a new relationship between accessibility, mobility and the previously socially excluded" (Hine and Grieco 2002, 4).

In a conceptual discussion of UD and accessibility, Iwarsson and Stahl (2003) differentiate between three dimensions of physical accessibility[5]: (1) micro accessibility related to the immediate proximal environment, (2) meso or neighborhood or city-level accessibility, and (3) macro or metropolitan or regional accessibility. This article applies these scales of accessibility to the previously discussed dimensions of mobility-related social exclusion (i.e., immobility) to assess the transit features requiring a UD approach.

As shown in Table 3, a UD perspective applied to transit underscores the notion that:

1. *Addressing physical exclusion at the micro level of accessibility* involves planning, designing, and operating transit systems that are easy for all users. This includes not only passengers with physical, sensory, or cognitive impairment but also those with language or cultural barriers, people with children, individuals carrying baggage or parcels, or those who are new to the area (Suen and Mitchell 1999). Micro-level accessibility requires barrier-free retrofitting of the existing physical built environment;

however, future development to be served with transit requires planning for UD to avoid the need for retrofitting or readaptation. This includes consideration of pedestrian infrastructure and streetscape (e.g., sidewalks, traffic signals, crosswalks, street crossings, and street furniture) and their interface with automobile facilities (e.g., park and ride, kiss and ride), and transit passenger facilities (e.g., terminals, stations, stops). Universally designed transit accessibility at the micro level requires bus-stop boarding pads and street curbs that are leveled with low-floor buses. This not only makes shorter and easier bus boarding and alighting for all (i.e., wheelchair passengers, frail and/or ambulant disabled people, patrons with small children or those carrying baggage or parcels), it also reduces bus dwell time. Low-floor buses with lifts or ramps meet barrier-free design criteria, but strictly speaking, ramps and lifts are ADA bus design readaptations that increase bus dwelling time and stigmatize wheelchair users or anyone needing them. Thus, although they are a form of inclusive design, they are not UD solutions to micro-level transit accessibility.

2. *Fear-based social exclusion* is another form of person-environment accessibility occurring at the micro and meso levels. Fear of crime holds many people without cars hostage in their own homes and prevents them from walking and using public transportation. Women, older, and disabled people are particularly affected. Although generally outside the scope of UD literature, crime prevention through environmental design (CPTED) is typically a planning and design intervention applied by transit facility designers in collaboration with transit managers and security personnel (Audirac and Higgins 2004). Implicit in these interventions is the belief that redesigning certain aspects of the physical environment can lower crime levels by enhancing "defensible space" opportunities that deter or discourage crime. A synthesis of practice on crime prevention and control by the Transit Cooperative Research Program (TCRP) found that CPTED is among the seven strategies most widely used by transit managers. However, video surveillance, staff involvement, police presence, and community outreach and education are necessary for CPTED to effectively work[6] (Needle and Cobb 1997). This raises the larger issue—further discussed below in operator-based accessibility—that "transit for all" requires close cooperation among all levels of transit personnel and external stakeholders, and it implies an equally strong emphasis on UD of services. Consequently, to deal with accessibility and social exclusion, attention to social and organizational barriers is as important as the emphasis on physical ones.
3. *Geographical exclusion at the meso and macro levels of accessibility* underscores the importance of transit for non–automobile users to reach neighborhood and metropolitan destinations beyond normal walking range. The characteristic low-density car-dependent urban form of metropolitan America and the scattering of services, employment, shopping, entertainment, and so on across the metropolitan region makes traditional mass transit (such as fixed and hub-and-spoke bus service systems oriented to the central business district) ineffective in reaching peripheral and suburban destinations and in taking people where they want to go. Effective transit accessibility at the meso and macro levels should address geographical as well as "from-facilities," economical, and time-based forms of social exclusion. This would require the aforementioned shift in transit service paradigm and full development of intelligent integrated systems under the "complete transportation chain" or "mobility management" models.

   At the system's level, achieving the above would require that conventional city transit agencies shift from being transit operators to mobility managers of a family of services. These would include fixed-route and fixed-schedule transit serving high-volume destinations together with feeder transit services, flexible-schedule and demand-response transit, and taxis and community-based transportation options[7] that cater to mobility-impaired individuals. (see Burkhardt, McGavock, and Nelson. 2002; Pagano and Metaxatos 2006; Spielberg and Pratt 2004; Suen and Sen 2004; Ståhl 1999).
4. In the above models, designed to offer the greatest possible choice of travel to all users, the mobility management agency provides fare subsidies to those in need, thus tackling this form of *economic exclusion*.
5. *Time-based exclusion* can be minimized with real-time information about vehicle arrival and trip duration available at bus stops or internet-based tracking via cell phones and other wireless devices. These systems have been used in Norway. The City of Kristiansand's Bussmetro offers to passengers GPS-based real-time info that tracks where the bus is located at all times. Bus stops have visual and audio displays showing count-down time for bus arrival. Hearing and visually impaired individuals can also receive this information via personal remote control devices.
6. *Operator-based social exclusion* is related to lack of information and assistance about service, discourteous staff attitudes, and drivers' behavior toward impaired and older people. These conditions contribute to suppressed journeys, and thus, to social exclusion. In addition to staff training and education, internet-based reporting of service quality hosted by disability and elderly advocacy NGOs have been proposed as a means to insure service accountability and quality assurance (Grieco 2003). Outside of UD of student services (Burgsthahler n.d.), customer

Table 3
Mobility and Social Exclusion, Accessibility, and Universal Design (UD) Applied to Transit

Dimensions of Social Exclusion and Mobility	Description	UD Approach
Physical (micro- and meso-level accessibility)	Physical barriers of the built environment (streets, sidewalks, crossings) impede access to transportation; physical barriers in the transportation system itself (e.g., vehicles, bus stops and stations), exclude people with physical or psychological difficulties; individuals with impaired mobility, hearing, or vision; people with children or baggage; frail elderly people, and non-English speakers.	UD low-floor bus with leveled curb Audible on-bus & station information in English and minority-spoken languages. Sidewalks, crosswalks, streetscape, & crossing signals accessible to mobility and sight/blind impaired. Proper bus stop siting to minimize walking distance. UD-based bus stops, shelters, stations, and parking. UD-based signs and wayfinding devices.
Geographical (macro-level accessibility)	Lack of automobility and lack of transit; transit service's poor metropolitan reach limits accessibility beyond the neighborhood to economic opportunity, shopping, recreation, and social life. Increasingly found at the edge of expanding metropolitan areas.	Route planning and service delivery to retail and other suburban destinations. Intelligent, real-time demand-response transit service with one call center—"Mobility Management or "Complete Transport Chain" models.
From facilities (macro-level accessibility)	Related to the above; exurbanization of retail and other facilities and relocation or reorganization of private and public services require more travel, more travel time, and/or more costly travel.	(same as above)
Economic (macro-level accessibility)	Low income, no automobile, and no transit service or poor transit service exclude mobility-disadvantaged populations from economic opportunity.	Universal smart-card systems with subsidies for people in need. Welfare-to-work assistance.
Time-based (meso- & macro-level accessibility)	Related to poor transit service (infrequent during the day and week, unreliable, unpunctual); affects all transit-dependent people but more so, caregivers, particularly single mothers.	More frequent and reliable fixed-route mass transit in combination with flexible-route intelligent mobility management models.
Fear-based (micro and meso-level accessibility	Fear for personal safety in public spaces, which varies by time of day and gender and influences the use of public transportation.	Crime prevention through environmental design (CPTED) approaches.
Operator-based	Lack of information and assistance about transit service, staff attitudes, and drivers' behavior toward impaired people contribute to suppressed journeys and social exclusion.	UD education of citizens and transit drivers and staff, consultation and program input with disability and aging advocacy NGOs.

Source: Church, Frost, and Sullivan 2000; Hine and Mitchell 2001; Iwarsson and Stahl 2003.

care system design has been less prominent in the UD literature. However, this is clearly an area where more UD research and development is needed, since to be truly accessible for all, complex systems like city transit require planning and design of both its physical and socioorganizational components.

UD applied to transit has focused primarily on planning and design guidance of the physical side at the micro-accessibility level. However, extending UD considerations to geographical accessibility, as intended in "complete chain" and "mobility management" models, has recently drawn attention to the fact that "accessible transit for all" implies that the physical chain of accessible transit must be seamlessly integrated with a regional administrative chain (Organization for Economic Cooperation and Development 2000; Steinfeld 2001). There have been a number of lessons learned in Nordic countries, where land use and transportation planning plays a major role in implementing universal design as "Town Planning for All" (Petren 2004). These include the importance of effective intergovernmental cooperation, smooth collaboration across administrative boundaries, successful consultation arrangements to obtain user input, and heeding the advice that "small mistakes in planning and implementation often have big consequences" (Petren 2004).

Despite the challenging complexity of implementing universally designed transit at the various micro and macro scales, a small but growing literature on UD performance evaluation is starting to appear (Preiser 2001; Preiser and Ostroff 2001). It offers user-driven feedback design methodologies that can be applied both to facilities at the micro-accessibility level and to the organizational level of agencies providing transit services. Nonetheless, UD performance evaluation research is still in its infancy. It will take time for design and planning education to fully embrace the UD paradigm and for public awareness to demand universally designed products and services before significant private and public UD research and development becomes the norm (Ostroff 2001).

Current State of Transit Services for Disabled and Older People

In an environment of diminishing public funding and transit patronage, to this day, some transit agencies have been slow in complying with ADA requirements. Disabled patrons complain of bus stops not being announced and bus drivers failing to stop for people with disabilities who are waiting to ride the bus (National Council on Disability 2005). Additionally, problems persist concerning maintenance of accessibility equipment (e.g., bus lifts), and ADA complementary paratransit systems are fraught with quality-of-service, reliability, trip-booking, and pick-up problems. Finally, inaccessible streets, sidewalks, bus stops, intersections, and crossings for people with disabilities remain a persistent problem throughout the United States (National Council on Disability 2005).

Experience shows, even in European countries with the most advanced and integrated transit systems, that inaccessible pedestrian and transit facilities, vehicle fleets, and information and way-finding devices and services are the most difficult to get right. They also require the most attention from planners and operators, as well as the largest share of operating funds (Ireland National Disability Authority 2004, 16). Furthermore, inaccessible pedestrian and transit facilities are partially the result of poor coordination between local governments and transit agencies.

In the United States, metropolitan planning organizations under the Intermodal Surface Transportation Efficiency Act of 1991 and subsequent reauthorizations are mandated to address these issues in Metropolitan Transportation Plans specifically focused on pedestrian and transit mobility and ADA-mandated accessibility. Yet funding shortages limit the capacity of many transit agencies to adequately meet these mandates.[8] Furthermore, the notion that all users benefit from transit that meets the needs of Americans aged 65 and older, whose population is estimated to increase 80% by the year 2025, has encountered both skeptical and optimistic assessments.

Giuliano's (2004, 204) research finds that rather than shifting to transit, older people "prefer automobile travel and compensate for physical limitations by traveling less." Her research also "suggests caution in considering more transit environments as a mobility strategy for the elderly," since the transit service will have to be very high quality and mimic the car to effectively attract the elderly to transit (p. 204). Similarly, Rosenbloom (2003) asserts that older Americans prefer to drive and that restructuring transit and development patterns will provide more travel choices but not necessarily cause older drivers to switch to walking and transit for the majority of their trips.

On the other hand, Bailey (2004), using data from the 2001 National Household Transportation Survey, finds that in 2001, public transportation trips by older nondrivers totaled an estimated 310 million—with older minority populations more than twice as likely to use transit than their white counterparts. Bailey (2004, 1) also finds that social exclusion through suppressed travel is high among older citizens with "more than 50% of non-drivers age 65 and older—staying home on any given day partially because they lack transportation options." This confirms that for many older nondrivers, public transit is the only alternative to asking for a ride. Bailey recommends substantial increases in funding and investment in the Federal Transit Administration's Section 5310 Grant: Specialized Transportation Program for the Elderly and Persons with Disabilities.

Having carried out focus-group research on travel preferences of driver and nondriver senior citizens, proponents of the new "mobility management" both agree with the above skepticism and concede suppressed travel. They underscore the fact that tomorrow's older persons are likely to have been car drivers all their lives, having lived in suburban and exurban areas lacking good public transit, and would be likely to demand high-quality door-to-door services that can compete with cars. However, concurring also with the need for transit that addresses the immobility of impaired and senior citizens, they emphasize that geographical inaccessibility to jobs and regional services and facilities demands a regional approach beyond the neighborhood and city (Burkhardt, McGavock, and Nelson 2002).

Metropolitan planning organizations and regional transit authorities are poised to tackle this issue by becoming mobility managers of traditional and nontraditional transit services that expand mobility choices for all (TCRP 1999). This implies "cost-effective public transit solutions for low-density areas that can address the travel needs of high-income and high-mobility seniors while at the same time addressing the travel needs of low-income and low-mobility seniors" (Burkhardt, McGavock, and Nelson 2002, 44). Lack of funding and reluctance to change transit to fit users' needs (rather than the current practice of fitting users to transit) are major roadblocks for which multiple studies and research, commissioned by the TCRP, offer guidance for addressing and overcoming (TCRP 1997, 2000). Although a review of this research is outside the purview of this article, it would suffice to say that TCRP literature converges on a paradigm shift along the line described here as UD of transit.[9] Time will tell whether cities, transit authorities, and the Federal Transit Administration will fully embrace the paradigm. However, some progress in this direction has started to occur.

In the United States, a few transit agencies have restructured their service model from fixed-route models focused on downtown to a family of services combining fixed and rider-request routes designed to serve both downtown and suburban demand. Fort Worth's Transportation Authority made such a shift, ostensibly supported by constant user feedback and service assessment. Also, nonprofit service organizations, such as the Independent Transportation Network in Portland, Maine, are starting to offer a variety of demand-responsive services to older citizens on a 7-day, 24-hour basis. The Independent Transportation Network uses a combination of paid and volunteer drivers and a variety of payment innovations, including "gift-ride programs," "trip-cost sharing" with merchants and professional offices visited by riders, "frequent-rider miles," and a "road scholarship fund" for low-income users who cannot afford to pay full fare (Burkhardt, McGavock, and Nelson 2002). These examples are being emulated in different parts of the country and prove that a wider range of geographical accessibility and social inclusion can be achieved through transit designed for all. However, strapped for funding, transit agencies in the United States have been slow to embrace these and other UD innovations, perceived as "interesting" but beyond ADA's legal mandate.

Nonetheless, encouraged by the American Public Transportation Association, transit managers are starting to move beyond ADA accessibility concepts and are becoming more receptive to UD ideas and innovations. A 2007 TCRP research report of "transit for all" in eight European cities[10] explored the partnerships, technology, communications, financing, and politics underpinning UD that could be applicable to the United States. The report, authored by American transit managers, found that European accessibility legislation is more flexible than American ADA, and allows more degrees of freedom for innovation. It also highlights that European transit accessibility is more broadly concerned with social inclusion of mobility-disadvantaged populations than specifically with aging and disability, as in the United States. Additionally, the study found varying degrees of achievement among transit organizations professing UD goals, and not surprisingly, that user participation was a key component of planning and operations resulting in better quality services. Moreover, a variety of funding mechanisms from dedicated appropriations to congestion charges and road user fees were used to fund UD programs (TCRP 2007).

Conclusion

UD or "design for all" is a design philosophy couched in a public discourse of social inclusion. Spurred by disability civil rights legislation, graying demographics, and the ICT revolution, UD has become a global design discourse with Japanese, European, and American variants. Among these, Japanese UD seems to be at the forefront in the level of national government and industry implementation. Applying UD to transit accessibility at the micro, meso, and macro scales can assist American cities and metropolitan planning organizations to redress the various forms of social exclusion related to suppressed travel of mobility-disadvantaged populations.

While UD has progressively become a catch-all word for a variety of ability and age-inclusive design approaches, there are subtle differences between barrier-free and UD. In regard to physical exclusion at micro and meso accessibility levels, barrier-free design is generally associated with ADA design or retrofitting and readapting vehicles and existing physical environments, such as bus stops and terminals. UD strives from conception to be anticipatory and to avoid the need for future readaptation. It aims to seamlessly fit physical environments to vehicles and services. Hence, at the micro and meso levels of accessibility, universally designed transit facilities

imply the design of new facilities and services. At the macro scale of accessibility and geographical exclusion, universal design of transit involves planning and design for seamless integration of fixed-route and flexible door-to-door services, under "mobility management" or "complete chain" models. However, this is an area needing more UD research and development as well as guidance.

A review of practice from Europe shows that successful, though piecemeal, application of the complete chain involves comprehensive land use and transportation planning coupled with extensive stakeholder service monitoring and user input. In the United States, universally designed transit is slowly and selectively being applied at the micro level of accessibility, but at the macro level, adoption of a mobility management approach still faces many obstacles. These obstacles are related to funding, resistance to change old service models, and a current culture of minimal compliance with ADA standards, which has slowed down UD adoption by transit agencies. Nonetheless, and in spite of skepticism about transit's potential to be the public strategy for improving transportation-disadvantaged populations, new forms of community-based, nonprofit demand-responsive services for older and impaired individuals are sprouting in some U.S. cities. They are emerging to fill current transit service gaps that otherwise would result in suppressed travel and social exclusion.

Notes

1. Ron Mace (1998) differentiated between barrier-free, universal design, and assistive technology in the following way: barrier-free, Americans with Disabilities Act (ADA), and building codes are disability mandates; assistive technology is devices and equipment needed to be functional in the environment; and universal design is design of built environments and consumer products "for a very broad definition of user . . . the reality, however, is that the three blend and move into each other."

2. See the Transgenerational Design Matters Web site: http://www.transgenerational.org/

3. It is largely based in the Center for Universal Design at North Carolina State University–Raleigh and the Inclusive Design and Environmental Access Center and the Rehabilitation Engineering Research Center on Universal Design (RERC UD) at State University of New York–Buffalo.

4. Despite the low share of transit for all types of urban travel in the United States, transit remains an important mode of transportation for low-income households. In large- and medium-size metropolitan areas and in large cities of 3 million or more people, transit serves 28.7% of households without cars (Pucher and Renne 2003).

5. While "accessibility" in the universal design literature is related to physical barriers and defined by mandated technical norms and standards such as ADA (Mace 1998), "accessibility" in the transportation literature is intimately related to mobility and defined as the ease of reaching destinations. Accessibility is constrained by distance, time, and other impedance factors at origins and destinations.

6. For instance, Needle and Cobb (1997, 13) report that in Washington, D.C., "WMATA's CPTED program requires a transit police crime prevention officer, transit system engineer, and an architect to work together to reflect security considerations in design prior to construction of rail stations. Security design focuses on lights, locks, alarms, fencing, CCTV cameras, and landscaping. Houston METRO's CPTED program features three basic strategies: natural access control, natural surveillance, and reinforcement of territory. Phoenix Transit System security personnel participate in the design of new facilities and in the remodeling of existing facilities."

7. One example is the Independent Transportation Network in Portland, Maine—a volunteer and paid driver door-to-door service (Niesz 2005).

8. For an example, see the San Antonio–Bexar County Regional Metropolitan Planning Organization's (2004) document, "Mobility 2030."

9. The paradigm involves a shift in mission from operation of vehicles to management or brokerage of services provided by many diverse transportation service operators. The central mission is the customer; the shift relies on "expanding partnerships and alliances to assure responsiveness to customer needs; is built on state-of-the-art information technology that provides real-time information on market requirements and service quality throughout the organization; provides a basis for reintroducing meaningful incentives for innovation and improvement at all levels of the organization; and separates decision-making authority on a strategic level from decision-making authority in service production" (Transit Cooperative Research Program 2000, 24).

10. The cities and agencies were London's TfL, The Hague's HTM, Rotterdam's RET, Amsterdam's GVB, Stockholm's Transportation Authority, Gothenburg's (Sweden)

Västtrafik, Grenoble's (France) SMTC, and Île-de-France, Paris's STIF.

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