How to Measure the Effect of Access on Value*

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The world you perceive is a drastically simplified model of the real world.

Herbert A. Simon, *Administrative Behavior*

ABSTRACT

The primary purpose of this article is to present a scientifically rigorous method that quantifies and measures access between a street and a parcel of real estate. It discusses why so many access takings are problematic and why applying a so-called reasonable access standard has been subjective and inconsistent.

It shows how access can be measured using the concept of functional distance, elementary plane geometry and simple network models. It presents a case study applying this methodology to a non-trespassory access taking resulting in substantial impairment and concludes with commentary about the broader economic impact of pervasive access constraints.

INTRODUCTION

Access between a street and a parcel of real estate is a use of land that falls on both privately and publicly owned real property. That a parcel of real estate needs access to have utilities is a commonsense notion, as is the notion that some forms of access are better than others.

A constraint on access can be permanent or temporary, full or partial and can arise from material barriers, spatial alterations and non-trespassory takings through eminent domain, the police power and access management. Diminished access can diminish value.

Many of the countless legal disputes that derive from governmental exercises of eminent domain are about government takings of real property for economic and real estate development.

Access takings are fundamentally different but have fallen under the radar. Eminent domain access takings are usually initiated to restrict so-called conflicts between through vehicle movement on roads and streets and on-off movement between real estate parcels and roads and streets. As discussed in the conclu-

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sion, access problems involve much more than eminent domain.

In California in the three-year period from July 1, 1996, to June 30, 1999, there were 3,783 eminent domain cases filed. During that period, of the 3,477 pending eminent domain cases disposed of, 3200 were disposed of either without trial or after trial as uncontested matters and 276 were disposed of as contested matters after trial (California Law Revision Commission 2000).

These figures indicate that over 1,200 eminent domain cases are filed annually in California. Since laws and taking activity vary from state to state, it is impossible to accurately estimate how many eminent domain complaints are filed annually in all the states but it could be several thousand.

Many focus on what Epstein[1] calls squarish plots of land: some of these involve large-scale economic/real estate development and often receive widespread attention. Epstein sees many of these takings as arbitrary uses of state power but regards takings involving what he calls the threads of infrastructure (which involve access) far less intrusive. About infrastructure he is mistaken.

WHY ACCESS TAKINGS ARE PROBLEMATIC

The following commentary, found in the annotations to Section 15 of the Bill of Rights of the Colorado Constitution, identifies the core issues. (The commentary cites a number of legal cases not reproduced here.)

Whatever permanently prevents the adjacent owner's free use of the street for ingress or egress to or from his lot, and whatever interference with the street permanently diminishes the value of his premises, is as much a damage to his private property as though some direct physical injury were inflicted thereon. . . . Right of access to and from a general street system must be substantially impaired, not merely inconvenienced, by modification of the system. . . . Rather, to constitute such a taking there must be an unreasonable or substantial deprivation of access. . . . Mere inconvenience and mere circuitry of route necessary for access or egress occasioned by a public improvement are not compensable items of damage. (State of Colorado n.d. art. II, § 15)[2]

In a systematic study of access takings, the only nationwide study of access impairment, Westerfield and colleagues[3] reviewed access litigation and studies involving land values. Among their findings are the following:

In most access litigation, acceptance of the view that only "reasonable" access need be provided is common. This allows states to liberally use their police powers as a means of controlling access, avoiding the need for eminent domain proceedings. Several factors come into play in determining whether reasonable access is provided to a property owner after a taking has occurred. Often, it is the combination of these several deciding factors which determines whether access, or loss thereof, is compensable. Cases from different states, and even within a state, will often contradict one another even though they would seem to have similar deciding factors involved.

Westerfield and colleagues[4] reviewed access litigation and studies involving land values. They quote from the United States Supreme Court:

The right of an owner of land abutting on public highways has been a fruitful source of litigation in the courts of all the States, and the decisions have been conflicting, and often in the *same state, irreconcilable in principle. The courts have modified or overruled their own decisions, and each state has in the end fixed and limited, by legislation or judicial decision, the rights of abutting owners in accordance with its own view of the law and public policy. They conclude their review with the opinion "that the definition of reasonable access is a purely subjective one. Inconsistencies in the analysis of reasonable access litigation indicate that no uniformity exists, and the individual judge may determine what he/she believes to be 'reasonable.' "*

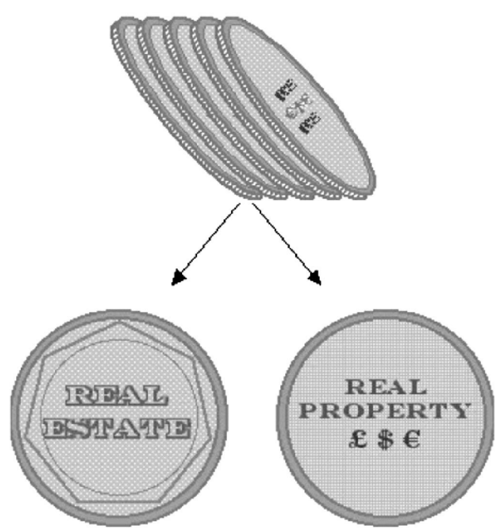
SUBJECTIVE AND INCONSISTENT DECISIONS

The many legal disputes about property access takings, many of which do not reach appeals courts, indicate there is no consistent understanding of "reasonable" access. Why? One reason is that real *estate* is confused and conflated with real *property*. Another is that access has not been measurable.

Formally, real estate *per se* denotes a parcel of land and the improvements on it; real property refers to the benefits and rights inherent in owned real estate.[5] Issues and concerns linked with and affecting real property are risk, returns, transactions and others addressed in legal, managerial and financial domains of knowledge.

What Americans refer to as real estate, British convention calls property. The common sense view of property is that it is objects or corporeal things. The dominant view in law is that it is a bundle of rights. For example, air rights (rights to a measurable three-dimensional volume of space that may not seem corporeal) are property rights.

Figure 1. Real estate and real property as two sides of a coin



Searle[6] distinguishes institutional facts, those sustained by human culture and convention, from brute facts, facts with no dependence on human convention.

Real estate refers to brute facts, the *spatial-materiality* of buildings, improvements and the land and space they both occupy and generate.

Real property refers to institutional facts, the abstract financial, legal, agency and other conditions and rights inherent in *ownership* of land and buildings.

As a legal right, access is an institutional fact, a convention. What Epstein[7] calls the threads of infrastructure include both. But he errs: unlike the land occupied by natural elements like rivers and lakes, man-made infrastructure elements like railroads, streets and highway, are there by human fiat.

In addition to failing to distinguish brute from institutional facts is the failure of natural language. Approaching access as a "right" forces a binary (all-or-nothing) solution. The notion of a bundle of rights, of which access is one in the context of property, says rights either exist or don't. The exercise of a right may be conditional, but either it is exercised or it is not. Smith and Zaibert[8] quote Reinach:

If property were a sum or unity of rights, it would be reduced by the alienation of one of these rights, for a sum necessarily disappears with the disappearance of all its parts. But we see that a thing continues to belong to a person in exactly the same sense, however many rights he may want to alienate. . . .

When considered only as a right, the only way access can be measured is as a nominal variable, as a category. Variables measured on a nominal scale allow only qualitative classification or categorization to determine whether what varies falls in distinctively different categories. They can not be ranked or quantified as with ordinal, interval, or ratio scales.

Hegel's law of the change of quantity into quality is at the core of defining when access is substantially impaired. Hegel used the example of boiling and freezing water. The quantitative change in its temperature leads to a qualitative change in its state: from liquid to gas and liquid to solid. Is this a substantial change—a change of substance, or a formal change—a change of form?

Both: but for access there has been no way to measure quantitative change and identify when it becomes a qualitative change. Larkin and Simon[9] compare sentential (natural language) representations of a problem with diagrammatic representations of the same problem (shapes positioned on a planar surface) in computational approaches in problem solving. A sentential representation can preserve temporal or logical sequences but not the geometric relations among a problem's components that are germane in access.

HOW ACCESS CAN BE MEASURED

Festinger, Schacter and Back[10] observed how social groups formed in residential settings and found spatial distance was a key factor. They also found this distance could not be measured with a Euclidean metric and coined the term *functional distance*.

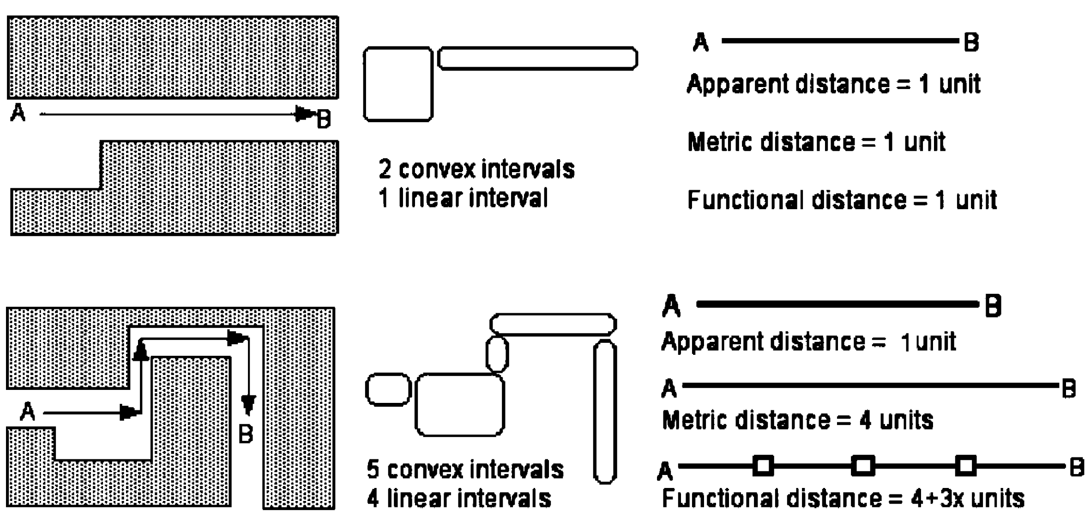
Functional distance, not part of the vocabulary of architectural functionalism, can be measured as a concatenation of two kinds of spatial intervals, a convex interval formed by barriers and borders, and a linear interval formed by the straight line of human central vision.

In addition to simple metric distance, functional distance consists of variables (indicated in figure 2 by x) that affect use: turns, stops and similar conditions formed by barriers, impediments and regulatory elements affecting visibility and movement that can result in interruptions, delays, changed routes and uncertainties. The variables can be measured.

Unlike apparent or metric distance, functional distance is non-linear. Shape-network™ models capture and measure functional distance using nodes (derived from intervals) and links (derived from interfaces or connections of intervals) to measure the complexity of the interface. Shape-networks™ not only measure access but show the transition from a quantitative state to a qualitative state.

Assume the grey configurations in Figure 2 are city blocks and that the apparent distance from A to B is 850 feet and there are no signals or stop signs at the turns. Let's say a traveler is at A in a city one moment and if she wants to go from A to B, a tall building, she looks for the easiest way to get there. In Figure 2 upper, it's simple; in Figure 2 lower, it's more complicated.

Figure 2. Comparative intervals and distance: apparent, metric and functional



In Figure 2 lower, a tall building, B, can be seen over buildings directly from A but, because of street layout, the traveler can't go there following this simple straight line of apparent distance. The route from A to B would have to follow the space bordered by the grey blocks of buildings. This route might slightly intrigue a pedestrian, but not a driver.

To move from A to B in Figure 2 upper would take about 20 seconds at 30 mph. To move from A to B in Figure 2 lower would take about 70 seconds because four non-stop or free flow turns at 10 mph would be necessary. If full stops were required (to allow pedestrians to cross), the length of time would increase and the route would likely require increased cognitive effort to negotiate. As can be seen, turns have a significant impact on functional distance

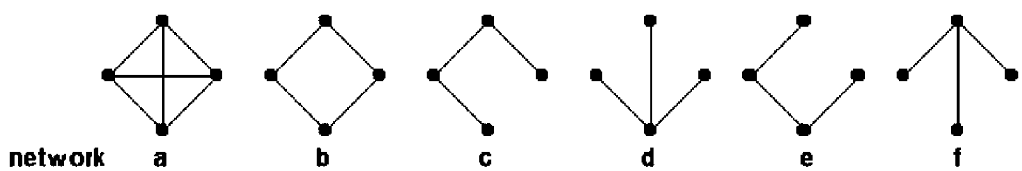
The space and movement in it are represented and measured by decomposing the space into underlying intervals and identifying a route through them. In Figure 2 upper, there are two abutting convex intervals making one link and one lineal node with no links.

In Figure 2 lower, there are five abutting convex intervals with four links and three lineal nodes with two links. One might also notice that the configuration in Figure 2 upper was once very common between streets and parcels while that in Figure 2 lower has become more common as applications of access management principles have been implemented.

A complexity measure captures the combination of physical and cognitive effort to reach the access destination. The following shows how the access interface, what Montague[11] calls access on-off (ingress or egress onto or off of a parcel), can be measured using network analysis.

Figure 3 shows networks of four nodes (corresponding to intervals) linked six different ways (a–f). The bottom node is the origin; the destination is the stepwise furthermost node. In actual conditions of moving from a street to get from the origin in the street to the destination on the parcel requires considering several alternatives.

Figure 3. Interface networks showing four nodes with multiple links



Each network has the same number of nodes but a different number of links affecting choice of routes from origin to destination. It is also intuitively apparent that network (a) is the most complex and that complexity diminishes in the networks to its right. Network (a) has six links and three nodes directly and indirectly linked to the bottom node. In (a) and (b), each node is equally linked with three links each in (a); two links each in (b).

In network (c), the top and left nodes, with two links, are more strongly linked than the bottom and right nodes with one link. In (d), the bottom node with three links is more strongly connected than each of the other nodes which have one link. In (e), the bottom and left nodes have the most links. In (f), the top node with three links is more strongly connected than each of the other nodes.

Weighted averaging (WA) of nodes operationalizes the relative location of all nodes from the destination node. Therefore, each of these three nodes is in the second level one step from the bottom node. In network (b), the top node is two links (two levels) from the bottom node, links away (four levels). The WA measure shows stepwise differences.

The weighted average measure is:

$$WA_x = \frac{\sum_{i=1}^{n} n_i(i)}{n}$$

where x = the terminus of the access,

n = the number of nodes, AND

i = the ordinal step level from and including x.

The WA measure will indicate whether there are relatively more nodes close to or farther from the destination. The closer the WA measure is to 1.0, the closer nodes are to the destination.

Convex and lineal complexity are measured identically: the square root of the product of the number of nodes times links times the square root of the weighted average times the ratio of links to nodes. The complexity of the access interface is the sum of convex and lineal complexity. See Table 1.

Formally, when both convex and linear intervals are measured, the interface complexity measure is:

$$C_{int} = \left[\sqrt{N_c L_c} \bullet \sqrt{WA_{xc} \frac{L_c}{N_c}}\right] + \left[\sqrt{N_l L_l} \bullet \sqrt{WA_{xl} \frac{L_l}{N_l}}\right]$$

where Cint = interface complexity,

Nc = the number of convex unit nodes,

Lc = the number of convex unit links,

Nl = the number of lineal unit nodes,

Ll = the number of lineal unit links,

WAxc = the weighted average for convex units from x and including x, and

WAxl = the weighted average for lineal units from and including x.

Table 1. Complexity measures of networks

Network:	Level	a	b	c	d	e	f
	4			1			
	3		1	1		1	2
	2	3	2	1	3	2	1
	1	1	1	1	1	1	1
Weighted average		1.75	2.0	2.5	1.75	2.0	2.25
# nodes		4	4	4	4	4	4
# links		6	4	3	3	3	3
Complexity		9.72	5.66	4.11	3.44	3.67	3.90

Because functional distance is non-linear, the number of links can make a difference. A small difference in the number of elements in the network can result in large difference in the relationships between the elements.

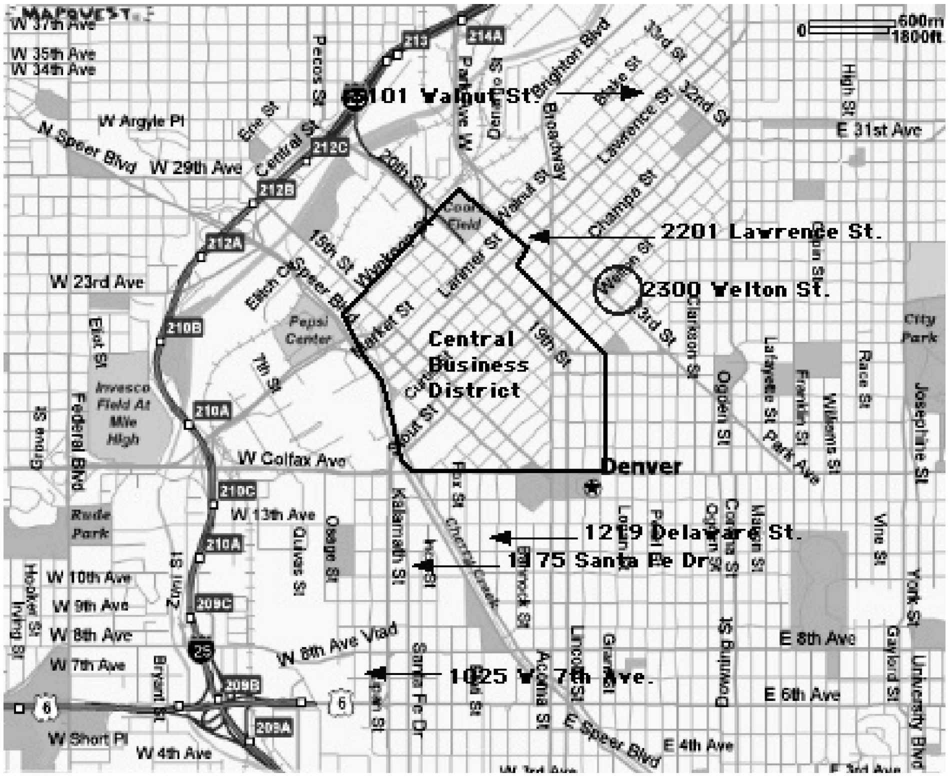
The measure of complexity corresponds with the intuitive grasp of each network's measured complexity and illustrates the nonlinear nature of access interfaces. The following case study illustrates this.

ACCESS AND MARKET VALUE: AN EMPIRICAL ANALYSIS

While this access taking was for the construction of a light rail line, it is no different from a taking that removes vehicle access to and from a street to improve through traffic flow. This parcel, at 2300 Welton Street, is a rectangular-shaped corner site just beyond the northeast edge of the Denver CBD in a zoning district allowing light industrial and warehouse uses. See Figure 4.

The site is adjacent to a major arterial street, across from a park with a baseball playing field, is highly visible and easily accessible by vehicles and pedestrians. Although vacant at the time of the taking, the buildings had been used for many years as a warehouse for the distribution of flowers to offices in the CBD. See Figure 5.

Figure 4. Location: context and comparables (source: MapQuest)



The lot is just over 25,135 SF; total building area is just over 30,400 SF. Figure 5 left shows what appears to be one two-story building. However, the improvements on the parcel consist of two buildings that, although abutting and with internal connections to each other, were of different construction, size and configuration, had separate utility metering and off-street loading areas.

Figure 5. View looking west (l); two abutting buildings appear as one (r)

Figure 5 right shows a cutaway axonometric view of the buildings. In eminent domain, distinctions are made concerning what is called the larger parcel and since there was an absence of unity of use, a larger parcel distinction was made.

This distinction had been overlooked in the appraisal for the government agency. As a result, it was clear the two components of the parcel were affected differently and the site of the two-story building could be analyzed separately. The land and building areas of parcel B are 18,850 SF and 24,540 SF. Because there is no elevator, the second floor was rarely used making the effective functional area 12,270 SF.

Network Models of the Parcel

The layout of the subject parcel before and after the taking is shown in Figure 6 upper.

Figure 6 middle left shows three convex units in sequence with the one in the middle providing access to the loading dock. Figure 6 middle right shows five convex units with the fifth providing access to the loading dock.

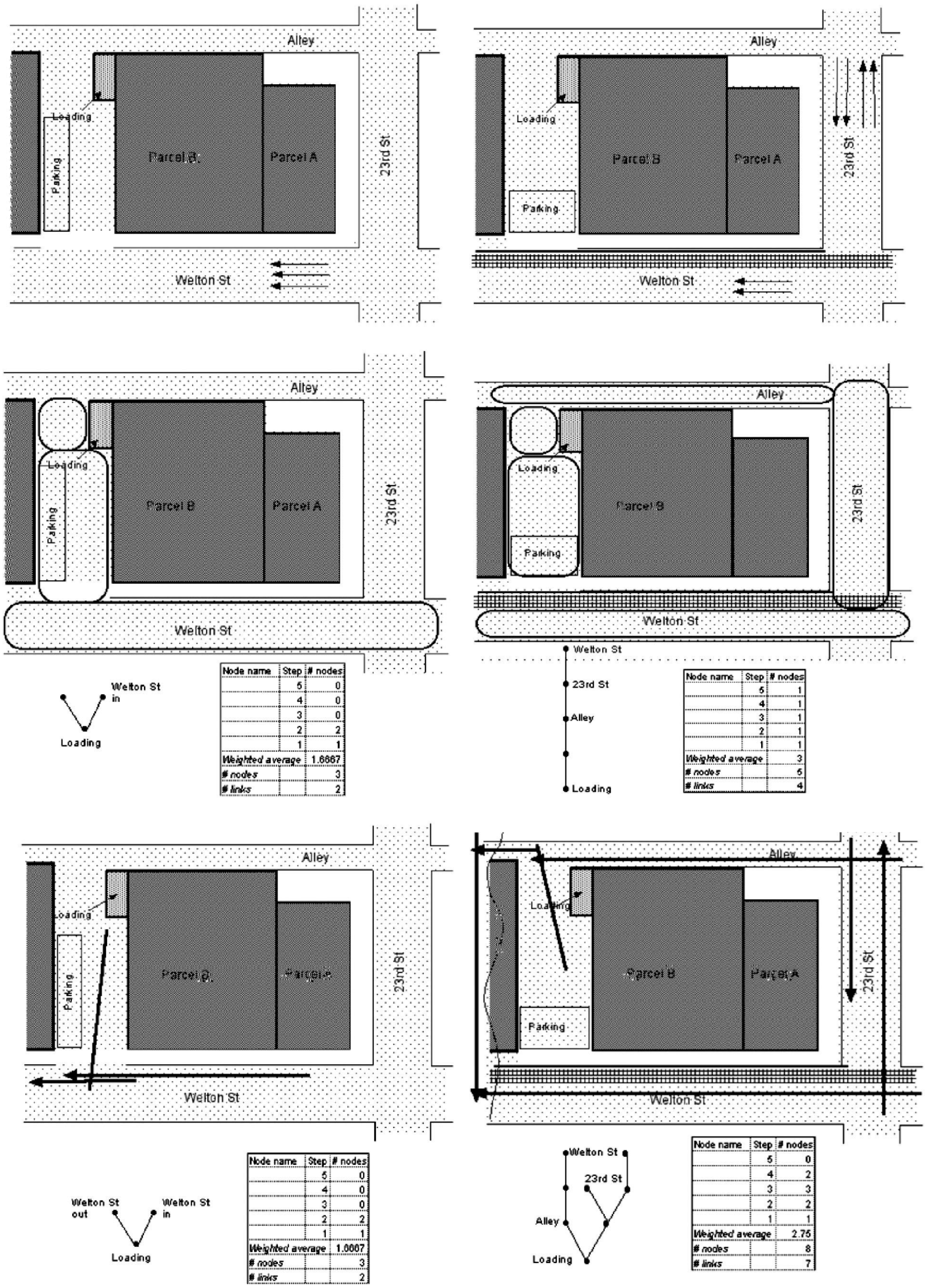
Figure 6 lower left shows three lineal units, indicating a truck would back in and drive forward out. Figure 6 lower right shows a more complex pattern is required resulting in eight lineal units for a truck to get to and leave the loading dock.

The diagrams below each layout show links stepwise from the access destination, the loading dock, and the tables show the weighted average functional distance. Table 2 shows complexity measures.

Table 2. Summary of results—2300 Welton St. and comparable parcels

Parcel comparison	Convex Intervals		Lineal Intervals		Weighted Averages		Convex Complexity	Linear Complexity	Access Complexity
	nodes	links	nodes	links	Convex	Lineal			
2300 Welton *before*	3	2	3	2	1.67	1.67	3.50	3.50	7.01
2300 Welton *after*	3	3	5	4	3	2.75	6.93	9.03	15.96
2201 Lawrence	4	3	6	5	2	2.5	4.24	6.92	11.16
1219 Delaware	4	3	4	3	2	1.75	4.24	4.61	8.85
3101 Walnut	2	1	2	1	1.5	1.5	1.22	2.28	3.50
1025 W. 7th	3	2	3	2	2	1.67	2.83	3.50	6.33
1175 Santa Fe	2	1	3	2	1	1.67	1.00	3.50	4.50

Figure 6. Before and after layouts: light rail line location (upper); convex units and analysis (middle); lineal units and analysis (lower)



Node name	Step	# nodes
	5	0
	4	0
	3	0
	2	2
	1	1
Weighted average		1.6667
# nodes		3
# links		2

Node name	Step	# nodes
	5	1
	4	1
	3	1
	2	1
	1	1
Weighted average		3
# nodes		5
# links		4

Node name	Step	# nodes
	5	0
	4	0
	3	0
	2	2
	1	1
Weighted average		1.6667
# nodes		3
# links		2

Node name	Step	# nodes
	5	0
	4	2
	3	3
	2	2
	1	1
Weighted average		2.75
# nodes		8
# links		7

Network models of the comparable parcels

Five parcels of similar size, location, configuration and use that had recently been in arm's-length sale transactions were identified for comparison. Their addresses are 2201 Lawrence St., 1219 Delaware St., 2360 Curtis St., 3001 Blake St., 3101 Walnut St., 1025 W. 7th St. and 1175 Santa Fe Drive. All are on the fringe of the CBD and the location of each is shown with an arrow in Figure 4.

Summary of results

Table 3 summarize the analysis of access for the comparable parcels and the 2300 Welton parcel. It is clear that the selling prices of the parcels fall into two well-defined clusters, one with an average price of almost $25/SF, the other with an average price of almost $13/SF.

It is also clear that the access complexity measures similarly cluster. The absolute and relative access complexity measures for those parcels with prices clustering around $25/SF are 10.17 and 1.01 respectively. For those parcels with prices clustering around $13/SF, the absolute and relative access complexity measures are much higher, 25.00 and 1.40 respectively.

The land area of the 2300 Welton parcel, 18,850 SF, and the building area, 12,270 SF, are in the middle of the range of the comparable parcels. The analysis indicates that the 2300 Welton Street parcel would likely have sold for about $300,000 before the access taking.

After the access taking, the sales price would be under $160,000, a loss of over $140,000 due to the loss of access. There is a clear relationship of the access complexity measures to sales prices of the comparable parcels. The government agency's appraisal was about half what this analysis shows.

Governmental agencies, especially those with a very narrow remit, often operate under a fiscal illusion assumption thus underestimating costs so that the proposed cost-benefit ratio is higher.[12]

Table 3. Access complexity and market values: 2300 Welton St. and comparable parcels

Parcel comparison	Price/SF	Area in SF		Access Complexity
		Building	Land	
2300 Welton before		12270	18850	7.01
2300 Welton after		12270	18850	15.96
2201 Lawrence	$ 13.81	13750	18800	11.16
1219 Delaware	$ 11.88	20280	18790	8.85
3101 Walnut	$ 26.53	19390	9250	3.50
1025 W. 7th	$ 25.24	10180	34360	6.33
1175 Santa Fe	$ 22.99	11960	16800	4.50
Low price/SF average	$ 12.85			11.52
High price/SF average	$ 24.92			4.89

CONCLUSION

The shape-network™ approach works as a general-purpose tool of description and measurement that can significantly improve access decisions. In general, an increase in a parcel's access complexity leads to a decrease in that parcel's value because it increases spatial transaction costs.

The aggregate effects of the combination of eminent domain access takings, police power reconfigurations and development regulations on networks of streets from collectors to controlled access throughways has been a pervasive channeling of urban area vehicle and pedestrian movement.

The past 40 to 50 years of controlling access parallels the clear decline in economic productivity over this same period described by Gordon.[13] Spatial transaction costs have pervasively increased costs to the point where spatial transactions have diminished. These and related issues are addressed in Brown.[14]

NOTES:

[1]Epstein, Richard A. 2001. “In and Out of Public Solution: The Hidden Perils of Forced and Unforced Property Transfer.” In *Property Rights: Cooperation, Conflict, and Law*. Edited by Terry L. Anderson and Fred S. McChesney. Princeton NJ: Princeton University Press.

[2]State of Colorado. *Constitution of Colorado, Article II—Bill of Rights, Section 15*. Taking property for public use—compensation, how ascertained. <http://64.78.178.12/cgi-dos/statdspp.exe?LNP&DOC=0-4-18>.

[3]Westerfield, H., Harrison, R., Gallego, A.V., Jarrett, J. and Machemehl, R. 1995. *A Model for estimating the value of property access rights, Study Report 1325-1F*. Austin, TX: Center for Transportation Research, Bureau of Engineering Research, University of Texas.

[4]Ibid.

[5]Appraisal Institute. 1987. *The Appraisal of Real Estate*, 9th edition, Chicago: American Institute of Real Estate Appraisers.

[6]Searle, John. 1995. The Construction of Social Reality. New York: Free Press.

[7]Epstein, Richard A. 2001. “In and Out of Public Solution: The Hidden Perils of Forced and Unforced Property Transfer.” In *Property Rights: Cooperation, Conflict, and Law*. Edited by Terry L. Anderson and Fred S. McChesney. Princeton NJ: Princeton University Press.

[8]Smith, B., and L. Zaibert. 2001. “The Metaphysics of Real Estate.” Topoi 20:2.

[9]Larkin, Jill H., and Herbert Simon. 1987. “Why a Diagram Is (Sometimes) Worth Ten Thousand Words.” *Cognitive Science* 11: 65–99.

[10]Festinger, L., Schacter, S. and Back, K. 1950. *Social Pressures in Informal Groups: A Study of Human Factors in Housing*. Stanford, CA: Stanford University Press.

[11]Montague, H. D. 2000. “The Circuitous Route to Deny Property Owners Damages in Access Cases: Where Has All the Fairness Gone?” In Planning, Zoning and Eminent Domain (30th edition). Plano, TX: Institute on Planning, Zoning, and Eminent Domain, ch. 16.

[12]Fischel, W. A. 1995. *Regulatory Takings: Law, Economics, and Politics*. Cambridge, MA: Harvard University Press.

[13]Gordon, Robert J. 2012. “Is US Economic Growth Over? Faltering Innovation Confronts the Six Headwinds.” Centre for Economic Policy Research Policy Insight No. 63. September.

[14]Brown, M. Gordon. 2016. *Access, Property and American Urban Space*. New York & London: Routledge/Taylor & Francis.

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Dr. Gordon Brown started Space Analytics in 1989 to focus on diagnosing and solving functional and economic failures of buildings and urban places from the perspective of owners and users. He has provided expert services including consultation, deposition and trial testimony in state and federal courts. Space Analytics is distinct in two things: 1) well-developed research capability applied rapidly and rigorously. 2) an award-winning spatial network approach that reveals and quantifies underlying spatial patterns and transforms them into hard evidence. This approach has been successfully applied in cases involving eminent domain takings, premises liability (eight figure awards), architectural copyright (largest damages award in the United States), First Amendment public forum and a variety of owner-designer-contractor-user disputes.

Dr. Brown was recently Adjunct Professor in the Architecture PhD program at Illinois Institute of Technology and Academic Fellow with the Urban Land Institute. From 2006 to 2010, he was Academic Dean and the ALDAR Dean of Business at the Higher Colleges of Technology in the UAE and before that Head of the Real Estate Management and Development Group at Eindhoven University of Technology in The Netherlands. In the 1980s, he taught architecture at the University of Colorado, the Illinois Institute of Technology and Arizona State University. He was a director of the Colorado MIT Enterprise Forum and is periodically involved in entrepreneurial ventures with and on the board of start-up companies.

His book, *Access, Property and American Urban Space*, was published by Routledge/Taylor & Francis in March 2016. Dr. Brown's degrees include a BS Communications, University of Illinois, Urbana; MBA, University of Pennsylvania, Wharton School; MSc (Architecture), University College London, Bartlett School; DTech (*higher doctorate*), University of Ulster, Northern Ireland.