Under the Ground: Planning, Management, and Utilization.2
Subsurface Transformations for a Smart, Sustainable and Resilient City
April 28, 2021, 8:30 a.m. to 1:00 p.m.
***via* Microsoft Teams**

AGENDA

8:30 a.m.—8:40 a.m.	**Utilidor Working Group Update** Terri Matthews, Town+Gown:NYC
8:40 a.m.—8:55 a.m.	**The Subsurface Challenge** Priscilla Nelson, Colorado School of Mines
8:55 a.m.—9:40 a.m.	**Modelling Utilidor Location and Cost-Sharing** Amin Hammad, Concordia University
9:40 a.m.—10:40 a.m.	**Functional Contexts for Subsurface Infrastructure Management** Mark Reiner, Jacobs Ilan Juran, NYU/Tandon
10:40 a.m.—10:45 a.m.	**Break**
10:45 a.m.—11:45 a.m.	**Subsurface Infrastructure Management and Data—Case Studies** Vivienne Edwards, Stantec Matthew Peterson, Chicago Department of Transportation Debra Laefer, NYU/Tandon
11:45 a.m.—12:30 p.m.	**NYC Subsurface Context—Discussion** David Burney/Pratt Institute Eric Macfarlane/NYC DDC Thomas Wynne/NYC DEP Christopher Hamby /NYC DOT Bob Tuttle/NYC DCP Lynda LeGrand/ConEdison
12:30 p.m.—1:00 p.m.	**Discussion**

Introduction to Event and T+G's Subsurface PROW Action Learning Sets. This event picks up from the January 29, 2020 *Under the Ground: Planning, Management, and Utilization* symposium event that served as an introduction of the topic of subsurface PROW utility infrastructure in the context of subsurface management, data and conditions to a broader audience to support interdisciplinary research with facilitated collaboration on workable solutions. For several academic years, T+G focused considerable research efforts on the subsurface PROW, which went into hiatus in 2014-2015 and re-emerged in 2018-2019, with the creation, in January 2019, of the Utilidor Working Group,[1] after conversations from the ether filtered down with ideas for subsurface utility infrastructure acquisition that revealed no understanding of systemic subsurface PROW conditions or any concern with the future burden imposed by the inherited infrastructure condition.[2] The presentations at this event and this précis will provide information from the Utilidor Working Group's efforts since January 2020 to work through identified impediments to utilidor implementation in the City. (Definitions of terms used throughout this précis but not defined in the text can be found in Appendix A.)

> *The utilidor and the "spaghetti subsurface problem":* The utilidor is a designed "system of systems" infrastructural solution to a well-documented series of operations and management problems associated with subsurface infrastructure elements delivering public services across several sectors. This problem has been termed the "spaghetti subsurface problem," which has been caused by the historic *ad hoc* practice of subsurface PROW direct burial that followed the creation of the services as technology developed (see **Planning and Managing Subsurface PROW Utilization: Sustainable, Resilient and Smart** below). Many other synonymous terms include multi-utility or utility tunnel, service gallery, pipe subway, utility channel, service tunnel, service corridor, service gallery or gallery, utility corridor, multipurpose gallery or technical

[1] The Utilidor Working Group is one of five working groups within T+G after its initiation of knowledge co-creation sessions to engage in "real time" co-creation of knowledge, identifying what we know and what we don't know and need to know on a particular topic to support changes in practice and policy based on research in T+G and elsewhere. After years of conducting research, disseminating research results in *Building Ideas* and holding symposium events to reflect on results and move them toward action, the working group format has become a mechanism to accelerate the action research cycle and move T+G's work to the "thought leader" stage and toward a more systemic form of decision-making. In addition to the Utilidor Working Group, the other working groups consist of Urban Resource Recovery (URR, formerly known as Construction+Demolition Waste or CDW) Resilient People, Places and Projects (RP3), Systemic Construction Data Analysis (SCDA), and Sounds of New York: Construction Noise (SONYC).

[2] Conversations in the ether have been joined by more tangible—and public—proposals. See Scott Stringer, as candidate for mayor, proposing the creation of a public utility to power the city with 100% renewable energy by 2035 at https://stringerformayor.com/plans/climate-action/; and, Ben Furnas, Director of Mayor's Office of Climate and Sustainability, proposing the creation of a city utility-like structure to build and own geothermal infrastructure in certain areas of the city at https://www.crainsnewyork.com/politics/citys-new-climate-chief-discusses-big-dreams-geothermal-energy-emissions accessed 04-24-21 @ 2:33 p.m.

> gallery. Each of these is “a transitable structure, usually underground and linear, isolated or inserted in a network of similar structures, which contain the conduits of public (or private) services and which permit the servicing, maintenance, repair, renewal or enlargement of the service with no necessity of carrying out any excavation."[3]

In academic year 2010-2011, T+G began its focus on the subsurface PROW during an NYU/Wagner experiential learning project for DOT to explore how the City might incorporate long-term life cycle cost and full cost/benefit analyses for projects adhering to DOT’s sustainable street design guidelines.[4] This student team identified significant data gaps to use for the model, and the “spaghetti subsurface problem”[5] kept rearing its head during agency discussions with the student team. At the February 22, 2012 *Lifecycle Costing Data for Roadways* symposium event,[6] the participants began to explore where data or proxies might exist for use in the model when the conversation quickly and decidedly became a collectively experienced introduction to the “spaghetti subsurface problem.” A key takeaway from that conversation, which led to additional research within T+G, was that state regulatory practices governing the portion of approved rates attributable to private utility capital programs contributed to the spaghetti subsurface condition and the dysfunctional data environment.

The second phase of this work, in academic year 2012-2013, involved extensive legal policy research conducted by several Brooklyn Law School students that focused on the nature of the regulatory environment in which the private utilities operate in the context of a hypothetical utilidor.[7] Systemic elements consisting of multiple commodities and provider entities

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[3] José Garcia and José Berrade, "Service Tunnels as an Element for the Regeneration of Historic Centres: The Case of Pamplona," from *Selected Proceedings from the 13th International Congress of Project Engineering* (Badajoz, July 2009), p. 119.

[4] See *Building Ideas*, Vol. 2, at https://www1.nyc.gov/site/ddc/about/town-gown-archives.page#building for the project abstract.

[5] Julian Canto-Perello (“C-P”) and Jorge Curiel-Esparza (“C-E”), "Assessing Governance Issues of Urban Utility Tunnels” (“Assessing”), *Tunneling and Underground Space Technology,* Vol. 33 (2013), pp. 82-87 *https://riunet.upv.es* accessed 12/08/19 @ 10:12 p.m., p. 1.

[6] See precis document at https://www1.nyc.gov/site/ddc/about/town-gown-archives.page#symposia.

[7] See *Building Ideas*, Vol. 4, at https://www1.nyc.gov/site/ddc/about/town-gown-archives.page#building for abstracts of projects. In 2006, before T+G’s start in academic year 2009-2010, City agencies involved in roadway construction engaged in a *Value Management Study on Roadway Repair Technology and Best Practices* to investigate ways to improve and maintain street infrastructure at a lower cost per mile, with less disruption. A primary objective was developing a menu of technologies and techniques to maintaining roadway life expectancy between resurfacings in the context of limited resources. Among the study’s recommendations was a proposal to implement a pilot program for utility tunnels in various locations with concentrations of underground utilities, which would allow utility lines to be installed, upgraded and repaired without road disruption and also permit utilities to install remote sensor equipment to monitor flow for system monitoring to identify potential breaks requiring emergency repair and predict state of good repair needs for effective and efficient state of good repair capital programs. This recommendation was expected to reduce the need for street cuts, to achieve design life, extend the time between resurfacing and improve street conditions.

individually operating within the same constrained physical subterranean spaces and multiple regulation at all levels of government for the commodity providers either create or exacerbate the conditions for what is known as "recursive collective action" under the City's roadways (see **Subsurface Spaghetti Problem—Poster Child for Recursive Collective Action Problem** below). After the second event, *Roadway.2—A Work in Progress* on February 12, 2013, focusing on the regulatory environment, a city budget expert suggested that financing utilidors, which would be a joint public and private asset, was a significant impediment to implementing utilidors for rational subsurface planning, management and utilization.

At an invitation-only event that was a pre-cursor to the creation of T+G working groups, *Roadway.3—A Work in Progress Continues* on April 23, 2015,[8] a small group of academics and practitioners considered how to use the results of other projects, in particular an academic year 2013-2014 Columbia/SIPA capstone on life cycle cost benefit analysis (LCCBA) modelling for green infrastructure roadway elements, to develop an experiential learning project to create an LCCBA model for utilidors.[9] Despite active pitching of a LCCBA utilidor modelling project to experiential learning programs, no project jelled until academic year 2019-2020, as discussed below.[10]

At the May 30, 2019 event, *Construction+Finance in 2019: Innovative Delivery and Finance,* which represented T+G's initial foray into expressly linking construction with finance, there was a case study presentation on a specific type of public-private finance that tied back to the earlier identification of finance as an impediment to utilidor implementation. This presentation on the federal Revenue Procedure 82-26 (formerly Revenue Ruling 63-20) "63-20" financing vehicle was intended to lay the foundation for utilidor finance analysis due to public and private use aspects of utilidors.[11]

The most recent action learning set for subsurface infrastructure planning, management and use was an academic year 2019-2020 Columbia/SIPA capstone project, *Lifecycle Cost Benefit*

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[8] See precis document at https://www1.nyc.gov/site/ddc/about/town-gown-archives.page#symposia.

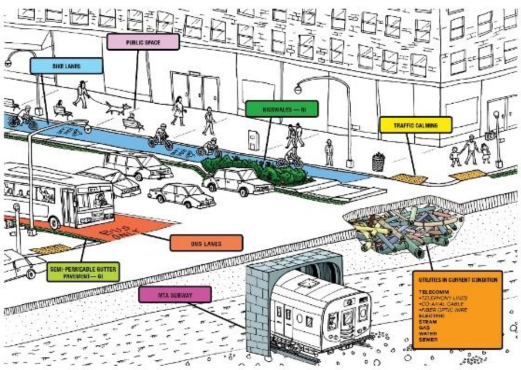
[9] See *Building Ideas*, Vol. 4, at https://www1.nyc.gov/site/ddc/about/town-gown-archives.page#building for project abstract. Also discussed at that meeting, was an academic year 2014-2015 Pratt/Communications Design project, *Making the Invisible Visible*, in which student teams developed concepts for communicating the City's subsurface infrastructural and public right of way projects to the public; see *Building Ideas*, Vol. 5, at https://www1.nyc.gov/site/ddc/about/town-gown-archives.page#building for project abstract.

[10] Work continued, however, in the communications design space with an academic year 2016-2017 *Build with Us: Communicating Capital Projects* (see *Building Ideas*, Vols 8+9 at https://www1.nyc.gov/site/ddc/about/town-gown-archives.page#building) and an academic year 2019-2020 Pratt/Communications Design project about closing the soil loop with subsurface soil designs (not yet abstracted).

[11] Pacifica Law Group, *Fifty Years of 63-20 Financing: Revisiting an Alternate Development Tool for Washington State Agencies and Municipalities*, p. 1. https://mrsc.org/getmedia/530A597A-4D81-41AE-9279-3523D1BE0BAC/m58-63_20.aspx, accessed 01/22/20 @ 2:26 p.m.

Analysis Project—Road to Smart City, that created a LCCBA model for implementing utilidors in the City as part of the City's routine roadway reconstruction program. This project is discussed in detail below under **Utilidor History and Modelling for Life Cycle Benefit and Cost Sharing**—*2019-2020 Columbia/SIPA Lifecycle Cost Benefit Analysis Project—Road to Smart City*.

Elevator Pitch (in 1 WTC Elevator). While what follows is intended to provide background for this event as well as to provide resources for future projects and events, the reason to read on depends on one's interest in, or knowledge about, moving from the current archaic subsurface condition to a modern subsurface condition as shown in the illustrations below.[12]



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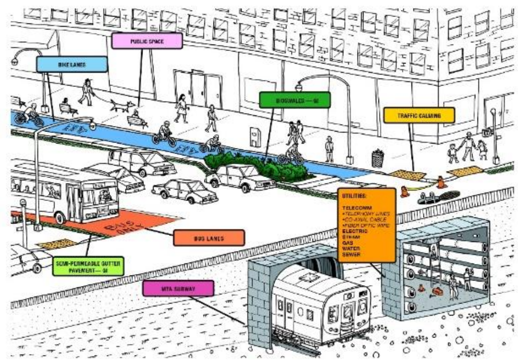

The reasons to be interested are varied, numerous, inter-connected and they depend, to an extent, on where you fit in the conceptual "stakeholder" chart (see stakeholder chart in Appendix B-- Potential Revisions to LCCBA Stakeholder Assessment) and related reasons discussed in greater detail below. The unseen nature of the subsurface PROW and subsurface PROW utility infrastructure by most people, most of the time, is, however, the biggest impediment to having any interest. To see is to begin the process of understanding, but the PROW, with its subsurface spaghetti problem, is like the elephant in the room that is down the hall.[13]

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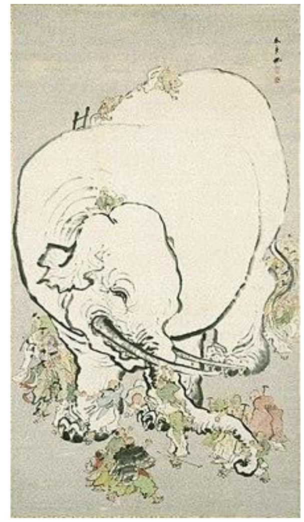
[12] DDC Creative Services, David Akey, graphic designer.

[13] For another analogy, with respect to the generalized lack of and/or sharing of subsurface utility location data, to a surgeon performing surgery on the body knowing the location of only one body system, see Greg Milner, "Nobody Knows What Lies Beneath New York City," *Bloomberg*, August 10, 2017 @ https://www.bloomberg.com/news/features/2017-08-10/nobody-knows-what-lies-beneath-new-york-city accessed 04-17-21 @ 6:33 p.m.

Unless you are taking care of this elephant, you only become aware of it when it makes a ruckus—explosions, unanticipated main breaks with leaking commodities, utility excavation work in the road creating impediments to travel, and open street pits for roadway reconstruction projects that do the same and seem to last forever in neighborhoods where these projects are underway. And, when the elephant makes the loud ruckus, the parable of the elephant and blind men comes to mind.[14] Depending on the nature of the ruckus, people only see parts of this elephant, and those involved in the system that is that elephant tend to solve for as much of the ruckus as is necessary to make necessary "real time" fixes and put the elephant back to its room down the hall. Few people study the elephant and come to understand what it needs.



In the absence of a meaningful constituency for subsurface PROW utility infrastructure, it may be helpful to play out the consequences of not implementing utilidors as a long-term program in conjunction with the City's ongoing roadway reconstruction program.

No Smart City. Despite the rhetoric, it is simply not possible to have a smart city and its benefits when utility infrastructure is buried directly in the dirt. Subsurface burial of utility infrastructure is as primitive now as it was when the underlying technology and commodities were created. Subsurface burial increases, *for all utilities*, physical degradation from direct exposure to subsurface environmental conditions, which amplifies reciprocal risks from leaking commodities from degraded infrastructure, and an absolute inability to easily access the infrastructure to fix or upgrade it or, for smart city purposes, apply integrated computer technology (ICT) sensors to the subsurface infrastructure facilities to monitor both the infrastructure condition and the quality of the commodity flowing through it (see **Planning and Managing Subsurface PROW Utilization: Sustainable, Resilient and Smart** below). And, the promise of connected and autonomous vehicles to improve roadway safety and environmental sustainability due to their ability to communicate with the roadway itself and *vice versa* will remain a promise.

"Cities, especially megacities, generate new kinds of problems [such as d]ifficulty in waste management, scarcity of resources, air pollution, human health concerns, traffic congestions,

[14] *Blind Men Appraising an Elephant* by Ohara Donshu, Edo Period (early 19th century), Brooklyn Museum Online Collection of Brooklyn Museum; Photo: Brooklyn Museum, 1993.57_IMLS_SL2.jpg @ https://en.wikipedia.org/wiki/Blind_men_and_an_elephant#/media/File:Brooklyn_Museum_-_Blind_Men_Appraising_an_Elephant_-_Ohara_Donshu.jpg accessed 04-07-21 @ 12:45 p.m.

and *inadequate, deteriorating and aging infrastructures [that] are among the more basic technical, physical and material problems (emphasis added)*."[15] Applying this idea of "smartness" to the City, which is considered to be a megacity, means that devising technical solutions to technical problems must be attempted within a "wicked and tangled" environment consisting of "multiple and diverse stakeholders, high levels of interdependence, competing objectives and values, and social and political complexity."[16] Since a smart city means solving problems of a city, "smart" action will be as "wicked and tangled" as the problems of the city it seeks to solve.[17]

Continued Excess City Capital Investment in Maintaining Surface Road Conditions. The utilities' cuts and excavations in the roadways across the City, which they need to access their buried infrastructure for repairs, rehabilitation and expansion, degrades the roadway surface in ways that reduces the designed life of the road surface[18] and requires pothole repairs and resurfacings in excess of what would be needed were utilidors in place. This translates into avoidable externality costs imposed by utilities' direct burial practice, but not paid by them, which consist of direct costs paid by taxpayers for associated capital to finance the resurfacings that could otherwise be directed to other capital needs, and avoidable social and environmental costs borne by residents, businesses and the travelling public. (See **Utilidor History and Modelling for Life Cycle Benefit and Cost Sharing** below.) In order for DOT to maintain 71.8% of City streets with a pavement rating of good in Fiscal Year 2020, DOT repaired 157,102 potholes on local roads and resurfaced, with its in-house resources, 1,092.7 lane miles at an average citywide cost per lane mile of $158,620.[19] This direct and indirect payment of externality costs imposed by the utilities' *ad hoc* direct burial practices represents waste of public and private resources unless the City adopts the modern design alternative that requires all utilities to account for externality costs of their operations, while reducing their long-term costs.

Water System Vulnerability to Regional Environmental Change. While everything about subsurface utility infrastructure, including environmental sustainability and resiliency issues,

[15] Robert E. Hall, Brookhaven National Laboratory, Upton, New York (under U.S. Department of Energy, Contract No. DE-AC02-98CH10886), *The Vision of a Smart City*, presented at the 2nd International Life Extension Technology Workshop, Paris, France, September 28, 2000, p. 1.

[16] Hafedh Chourabi, Taewoo Nam, Shawn Walker, J. Ramon Gil-Garcia, Sehl Mellouli, Karine Nahon, Theresa Pardo and Hans Jochen Scholl, "Understanding Smart Cities: An Integrative Framework", *2012 45th Hawaii International Conference on System Sciences*, p. 2289. https://ieeexplore.ieee.org/document/6149291 accessed 11/11/19 @ 12:19 p.m.

[17] *Idem*

[18] The design life of a City roadway is 40 years.

[19] *Fiscal Year 2020 Mayor's Management Report*, p. 265. FY 2019 value for cost since FY 2020 value not available; does not include costs of DOT's road resurfacing investments as part of the City's roadway reconstruction projects managed by DDC. See https://www1.nyc.gov/assets/operations/downloads/pdf/mmr2020/2020_mmr.pdf.

applies equally to public (water and sewer) and private utilities (electricity and steam, gas and telecom), focusing on water supply especially engages the mind because without water there is no life—urban or otherwise. The City, as a city, and all other utility services are derivative of, and dependent on, the available of plentiful clean water resources. The historical driver for New York's great infrastructure systems planning has been water first, with sanitary sewers and everything else that followed.[20] A little remembered historical fact pertinent to the future of the City's water system, is that Brooklyn's desire for access to water from the City's first water system—the Croton system—was a significant reason for its impetus to become part of New York City in the 1898 consolidation because "[b]y the late nineteenth century the rapid growth of Brooklyn strained" its supply of clean water from the system that collected water from stream-fed surface water from Long Island's southern shore.[21]

Even with the experience of droughts in the past,[22] one cannot predict whether and to what extent predicted climate change will turn the City into a water-constrained system, but due to historical and continuing pollution of Long Island's aquifer, which serves Long Island communities within the New York City metropolitan area, there is the possibility that the State could tap a water system it created for the developing New York City metropolitan area and expand its service area to include a large part of Long Island that is within the greater New York City metropolitan area.[23] In such an event, the currently unmonitored water loss component

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[20] In contrast to the City's sanitary sewer system and, one could argue, its transportation system. ". . . the physical infrastructure designed to improve the city's water supply was conceived of, and largely executed, as a *system.*" Joanne Goldman, *Building New York's Sewers: Developing Mechanisms of Urban Management* (West Lafayette IN: Purdue University Press, 1997), p. 71. In contrast to the City's sewer system, which was administered locally by "by the Common Council in a decentralized manner characteristic of this elected body," underlying the City's water system was *State* legislative "intent to supply water to the whole city" and a State-created centralized entity to plan, finance and manage construction of the water system, that did not rely on local property taxes as was the case with the fragmented and lagging development of what became the City's sewer system. Goldman, *op. cit.*, pp. 71-72. Compare Paris and Haussmann's initial focus on sewers to the exclusion of water, which was added later, as well as London and Bazalgette's initial focus on sewers, with a side interest in compatible underground uses related to subsurface transportation. Terri Matthews, Terri Matthews, *Toward "Smart" Cities: Case Study of Three Cities' Implementation of Utilidor Infrastructure and Relation to "Smarter" City Efficiencies*, December 15, 2019, pp. 9-29.

[21] Kenneth Jackson, Ed., *The Encyclopedia of New York City* (New Haven and London: Yale University Press, 1991); entry for "water" by Eric A. Goldstein and Mark A. Izeman, p. 1245. It is important to remember that the underlying distribution infrastructure for the original Brooklyn system under North and South Conduit and Force Tube Avenues is still in place.

[22] *Ibid.,* p. 1246; droughts within the City's watershed have occurred during 1963-1965, 1980-1982, 1985, 1989, 1991, 1995 and 2002. See https://www1.nyc.gov/site/dep/water/history-of-drought-water-consumption.page accessed 04-18-21 @ 10:21 a.m.

[23] See David Schwartz and Paul Larocco, "The Plume: What's in It, and What's Being Done," Newsday, February 18, 2020 at https://projects.newsday.com/long-island/plume-defined/ accessed 04/17/21 @ 7:29 p.m., and Irene Plagianos, "Down Chemical Backs Effort to Use New York City's Drinking Water on Long Island," *Wall Street Journal*, December 29, 2020 at https://www.nysenate.gov/newsroom/in-the-news/todd-kaminsky/dow-chemical-backs-effort-use-new-york-citys-drinking-water-long accessed 04/17/21 @ 7:38 p.m.

due to leaking subsurface water distribution infrastructure, of which utilidor installation would facilitate state of good repair and remote monitoring, becomes a potential system threat. It is not hard to imagine 50 years out in 2071, years after the State has mandated the City's watershed resources go to Long Island, people wondering why the City did not embrace proven systemic infrastructure design solutions that permit remote assessment of water pipe condition as part of system's ongoing state of good repair operations to pro-actively and efficiently reduce water loss due to undetected incipient pipe damage.[24]

Starts, Misses and Potential. A brief trip through New York City history provides historical context for future research within the Utilidor Working Group, and abstracts of prior New York City-based studies that included cost benefit analysis provide additional research resources and suggests the potential for analysis to support policy change with respect to planning and managing subsurface PROW use.

Earliest Origin of New York City's Subsurface Spaghetti Problem. From the early days of the City's water and sewer systems, early relations between the then two separate public utilities and their contractors suggest the origins of the spaghetti subsurface problem in New York:

> The city's Croton Aqueduct Department defined water districts in which pipes would be laid and oversaw their installation. It is likely that the aqueduct's engineers provided guidance when needed, but, as Moehring demonstrated, actual construction proceeded in a haphazard fashion. The committee charged individual contractors with the construction of facilities in different parts of the city simultaneously, precluding any logical coordination of their efforts. Further complicating matters, the gas company frequently sank main in the ditches opened up to install water pipes in an effort to reduce their own installation costs, often without any coordination with water-line contractors. The water contractors then found gas mains blocking connections that still had to be made between water pipes and hydrants. The water contractors were not innocent of this practice themselves; they sometimes laid water pipes in sewers, creating a situation where the Croton water supply was likely to become contaminated. Unreliable suppliers failing to deliver materials in a timely fashion further delayed construction.[25]

[24] The average age of NYC water mains is 66 years old; about 1/3 of the system is over 100 years old, which has exceeded its expected useful life; and, 90% of water main breaks over the past 10 years are on water mains installed prior to 1970. The average age of NYC sewers is 69 years old; about 30% of the system is over 100 years old, which has exceeded its expected useful life. From DEP presentation at Clean Water 2021 @ at https://www1.nyc.gov/site/ddc/about/town-gown-archives.page#symposia.

[25] Goldman, *op. cit.,* pp. 70-71.

Creation of the Subways: Earliest Lost Opportunity for Utilidor Implementation. Moving from the establishment of the water and sewer infrastructure networks to the next big infrastructure network—the subways—reveals an early opportunity consciously not taken to follow London's practice of installing "pipe subways," which are subsurface utility tunnels that originally developed out of Bazalgette's practice of taking advantage of opportunities provided by the sewer works' hidden vertical aspects for aspects of the sewer works program involving street improvements and making provision for laying underground services, such as gas and water pipes under street improvements so that "the streets may not be pulled up from time to time afterwards."[26]

An often-repeated impediment to utilidor implementation is the legacy of inherited utility systems, but at the time of New York City's MRT's original construction, when the inherited utility systems were not as congested as they are now, politics were a formidable overriding force to feasible engineering proposals involving utilidors of a "pipe subway" nature.[27] At the time of the construction of the BMT line in 1901, engineers had been satisfied that it was possible to create a pipe subway along the BMT lines to house "gas, electricity cables as well as H_2O plumbing."[28] Despite engineering sign-off, "the pipe galleries were in time discarded in support of traditional trenching methods [, and] the principal reasons for this shift was [reported to be the] result of semi-political pressures proffered consequent to the Railroad Commission."[29] Conclusions in a contemporaneous *Scientific-American* article about this turn of events were prophetic:

> The present interruptions to traffic, the interminable and absolutely stupid way in which our choicest streets are dug up, re-laid and dug up again, is a perpetual and obtrusive nuisance which would not be tolerated in any provincial town, and cannot be too soon removed from the streets of the second greatest city in the world.[30]

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26 Denis Smith, "Sir Joseph William Bazalgette (1819-1891) Engineer to the Metropolitan Board of Works," *Transactions of the Newcomen Society*, Vol. 58, No. 1 (1986), DOI: 10.1179/tns.1986.006 , p. 99. Available at https://www.tandfonline.com/doi/abs/10.1179/tns.1986.006?journalCode=yhet19; this practice continues as part of the Cross Rail initiative during the Thames Tideway Tunnel Scheme and as opportunities to convert existing disused transit subways into pipe subways. W. McMahon, R. W. Jordan and J. C. Nicholls, Creating the Future of Transport, Interim Report (Transport Research Laboratory (Web Version, March 2012), slides 103-104. [PDF] trl.co.uk, accessed 11/29/19@ 4:55 p.m.

27 Lewis Makana, *Development of a Decision Support System for Sustainable and Resilience Evaluation of Urban Underground Space Physical Infrastructure,* Ph.D. Dissertation, October 2014, p. 104. https://etheses.bham.ac.uk/id/eprint/6262/1/Makana15PhD.pdf accessed 12-05-19 @ 6:20 p.m.

28 *Idem*

29 *Idem*

30 *Idem*

It should be noted, however, that to the extent utilidors are implemented, eliminating the need for future road cuts and excavations, there will be a corresponding reduction in work for contractors doing this type of work.

Late 1970s Major Roadway Reconstruction Projects: Another Lost Opportunity for Utilidor Implementation. In the late 1970s, when DEP was modernizing its subsurface infrastructure along several major Manhattan thoroughfares (e.g., Columbus, Amsterdam and Fifth Avenues), DEP had proposed a coherent system of separation of all subsurface utilities, if not a utilidor, for those projects, which OMB rejected. [31] It should be noted, however, that the City, having recently emerged from the 1975 Fiscal Crisis, was then subject to a "control period" system of external monitoring by the State-created Financial Control Board, comprised of experts external to the City who were tasked with ongoing review and approval of the City's annual budget, including the capital budget, prior to adoption by the City's legislative body.

Post 9/11 Lower Manhattan Roadway Reconstruction: More Lost Opportunities. Lower Manhattan was the site of many major roadway reconstruction projects after 9/11, and the idea of utilidors resurfaced during that time. The impediments outlined in this précis that exist today existed then as well and, under a constrained post 9/11 budget environment, the time was not right to move toward implementation. These proposals, however, formed the foundation for T+G's action research sets (see **Introduction to Event and T+G's Subsurface PROW Action Learning Sets above)**, of which this event represents the latest evolution.

<u>2006 Con Edison Utilidor Proposal.</u> After noting the subsurface burial practice and subsurface spaghetti condition from the beginning of the last century that had continued in the beginning of the next,[32] Con Edison the identified its major tunnels across the city, utilidor practice in Paris, London and Tokyo, and highlighted several planned subway expansion and major development projects in the City as opportunities for utilidor implementation.[33] Con Edison concluded with a list of benefits of utilidors—shared initial construction costs, maintenance in a controlled environment, safer access to facilities, minimizing interference costs and issues, and minimizing the necessity to open and excavate in City streets.[34]

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[31] From interview, dated April 3, 2021, with Francis X. McCardle, DEP's first Commissioner.
[32] Con Edison, *Multi-Utility Tunnels*, March 3, 2006 presentation document, slides 4-5.
[33] *Ibid.*, slides 6-10.
[34] *Ibid.*, slide 11.

2006 VE Roadway Study. Also in 2006, a Value Engineering (VE) Study, *Roadway Repair Technology and Best Practices*, conducted by OMB with DEP, DOT, and DDC (2006 VE Roadway Study), aimed at several objectives including maintaining roadway life expectancy between resurfacings; minimizing cost and expediting schedules; developing a protocol for differing conditions and areas; and, developing a menu of options given limited resources.[35] VE proposal M-25 recommended implementing a pilot program for utilidors at various locations with concentrations of underground utilities to allow utility lines to be installed, upgraded and repaired without road disruption and permit utilities to install remote sensor equipment to monitor flow for system monitoring to identify potential breaks requiring emergency repair and predict state of good repair needs for effective and efficient state of good repair capital programs, which would reduce the need for street cuts, achieve design life, extend the time between resurfacing and improve street conditions.[36] During the 2006 VE Roadway Study, participants also observed that it does not take long for the private utilities to cut into a completed City roadway reconstructed project for emergency repairs and infrastructure upgrades. They also noted data problems and repeated a widely-held observation that the City's inability to require the private utilities to upgrade their infrastructure at the same time the roadway is open for the upgrading of DEP infrastructure contributes over time to a reduction of the designed life cycle of the new construction and less than optimal roadway conditions.[37]

Earlier Cost Benefit Analyses. While the 2019-2020 Columbia/SIPA project, *Lifecycle Cost Benefit Analysis Project—Road to Smart City*, represents a significant step in resolving impediments to long-term utilidor implementation (see **Utilidor History and Modelling for Life Cycle Benefit and Cost Sharing**—*2019-2020 Columbia/SIPA Lifecycle Cost Benefit Analysis Project—Road to Smart City* below), research for this précis uncovered some earlier cost-benefit analyses, which demonstrate on-going analytical efforts to modernize subsurface utility practice and which will be helpful as the Utilidor Working Group continues with its work.

Estimating Social Costs to Support Trenchless Technology Use on the City's Roadway Reconstruction Projects. To support the City's adoption of trenchless technology for water main rehabilitation,[38] Polytechnic Institute/UCC conduced an assessment, for DDC, using the Madison Avenue Water Main Rehabilitation as the case study project, that observed and

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[35] *Roadway Repair Technology and Best Practices*, prepared by Olympic Associates Company, dated June 30, 2006.
[36] VE Proposal M-25, *Ibid.*, pp. 117, 178-184.
[37] *Idem*; see New York City Administrative Code § 24-521 for private utility companies' obligations and **The City's Capacity to Act—Primer on Applicable Laws--**DOT Charter Powers with Respect to PROW below.
[38] For the current state of trenchless technology use, see DDC, *A Strategic Blueprint for Construction Excellence*, p. 45 @ https://www1.nyc.gov/assets/ddc/images/content/pages/press-releases/2019/2019_DDC_Strategic_Plan.pdf accessed 04-18-21 @ 12:42 p.m.

summarized lessons learned at different stages of the use of trenchless technology on the case study project.[39] The case study project utilized a Rehabilitation Interference Management SUPPORT System methodology, a joint project of Polytechnic/UUC and ProceMX, and the research also "determined how to quantify social costs during project construction" as part of a cost-benefit analysis of the case study project. [40]

The researchers reviewed preliminary investigations conducted by DDC on a trunk water main rehabilitation project to determine the watermain's condition and assess trenchless technology rehabilitation options in order to develop a methodology for use on future projects. The researchers also summarized observations made during the first year of the project as well as guidelines that were implemented in the second year of the project. The researchers reviewed methodologies to evaluate the social costs associated with major infrastructure rehabilitation projects, as well as bidding methods to optimize the match between construction method and cost, and conducted a survey of businesses affected by the project under investigation using trenchless technology, which was then compared to a similar survey related to a nearby project that did not utilize trenchless technology. The resulting methodology to review options permitted more efficient selection of candidate technologies using a performance record-based rating system, and the comparative survey analysis indicated that using trenchless technology on infrastructure rehabilitation projects was less disruptive to adjacent businesses than using conventional excavation techniques. This project not only demonstrated the need to include social costs in a cost benefit analysis in project planning and contracting, with contract options that permit inclusion of social costs and the ability of contractors to make risk-based tradeoffs, but also its feasibility in a public works setting.[41]

Each type of available trenchless technology[42] has different associated direct and social costs, and while construction project analysis traditionally only includes "direct costs in the bid process and in contracts," construction project analysis has developed to take social costs into consideration, which, compared to direct costs, "are not as easily quantified [since] social cost parameters are difficult to identify and measure."[43] Once the type of technology has been identified, based on rehabilitation extent and technical feasibility, analysis of project costs can

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[39] Report to DDC completed in 2010-2011, and abstracted in ***Building Ideas***, Volume 2, which is available at https://www1.nyc.gov/site/ddc/about/town-gown-archives.page#building.

[40] Yael Brodsky, *Decision Support Systems for Optimal Selection of Trenchless* Technology, May 2013; NYU/Tandon-USEM MS thesis, pp. 2-3.

[41] *Ibid*., pp. 157-158.

[42] *Ibid*., pp. 22-27, discusses trenchless renewal categories for underground utility infrastructure renewal projects, the use of which depends on the required extent of repair and which include structural, semi-structural and non-structural. *Ibid*., p. 22.

[43] *Ibid.*, p. 5.

include social costs.[44] Social costs of construction result from "impacts on and around the work zone" and include "traffic disruption, environmental pollution and disturbance to local business," all of which can be evaluated during the project planning phase.[45] These social costs can be quantified, and the bid processes and construction contracts of public owners can take them into account.[46] From the literature, social costs fall into four broad categories consisting of "the natural environment, public property, local economy and human society", with evaluation metrics for each category.[47] The social impact costs directly related to the project, incurred during the design and construction phases, are quantifiable; the social impact costs in the local economy, such as traffic disruption, private repair costs, business loss, construction noise, increased dirt and dust, and related reductions other infrastructure service life are quantifiable with a degree of uncertainty; and, social impact costs in the natural environment and human society are difficult to quantify, but these impacts "remain long after the construction project is complete."[48]

Social costs explored in connection with this project included three aspects of the second category, which were traffic delay and pollution, quantified using special software programs, and business impacts, assessed *via* surveys.[49] Construction owner identification and quantification of social costs imposed by their projects "aid in their prevention and mitigation," which include reducing project duration, through the use of alternative construction techniques, such as trenchless technology; off-peak scheduling of work; coordinating all subsurface utility repair work at the same time as public construction that requires opening of streets for a greater expanse and longer time period; and using social cost methodology in the bid evaluation process.[50] Of use to future cost benefit analyses of subsurface infrastructure policies are the assumption underlying the three types of social costs studied.[51] Since subsurface utility repair work requires lane closings, which reduce roadway capacity and increase congestion, it is possible to estimate traffic delays and apply monetary value to the delays.[52] Increases in air pollution emissions due to traffic delays can be quantified.[53] Private

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[44] *Ibid*., pp. 28; along with selection of an alternative contract method that supports optimal project duration to minimize social costs during construction. See pp. 13-22 for a discussion of alternative contracting methods.
[45] *Ibid*., p. 7.
[46] *Idem* See pp. 13-22 for a discussion of alternative contracting methods.
[47] *Ibid.*, pp. 7-8.
[48] *Ibid.*, p. 8.
[49] *Ibid.*, p. 9. See pp. 120-128 for the cost-benefit analyses, including social costs, for open-cut trenching, close-fit lining and cured-in place piping, the last two of which are trenchless technology options.
[50] *Ibid.,* pp. 10, 14.
[51] For the optimization model specifications, see *Ibid*., pp. 79-97; for its application to the case study project, see pp. 100-119
[52] *Ibid.*, pp. 9-10.
[53] *Ibid.* pp. 10-12. It was determined that a methodology for estimating costs of incidental accidents due to construction as a social cost was not sufficiently well-defined.

business loss—loss to the business and related loss of revenue to the municipality to the extent taxed—arises in traditional utility repair work from associated above-ground interventions that require lane and sidewalk closures causing loss of business and delivery delays to adjacent business owners, which scope of business loss can be assessed through surveys.[54] Quantifiable costs incurred by the other utilities as a result of the public project, such as utility relocation costs, were considered to be indirect costs of the case study project.[55]

2013 *Utilization of Underground and Overhead Power Lines in the City of New York Report.* Of some use to future cost benefit analyses of subsurface infrastructure policies is the December 2013 report by the Office of Long-Term Planning and Sustainability (OLTPS) on *Utilization of Underground and Overhead Power Lines in the City of New York* (OLTPS Report), which was required by Local Law 13/2013, adopted after 2012 Superstorm Sandy.[56] Local Law 13/2103 required OLTPS to study the utilization of underground power lines in the City, which, among other things, was to include a list of neighborhoods or service areas where relocating aboveground power lines to underground locations would not be practical or would result in more severe power outages and a list of neighborhoods or service areas where relocating above ground power lines to underground locations would be most advantageous.

The OLTPS Report relied on a feasibility report, prepared in 2007 for Con Edison in 2007 and updated in 2013 for the OLTPS Report, by Clough Harbour & Associates LLP (CHA) that had provided professional engineering services to evaluate the feasibility of converting Con Edison's *entire overhead distribution systems in Westchester County, Bronx, Brooklyn, Queens and Staten Island* to underground systems.[57] Though the scope of the feasibility report was broad and not expressly a cost-benefit analysis, it contained data and analyses that would be useful for future cost benefit analyses. With respect to data, the OLTPS report contains geographic locations of overhead electric and other utility distribution infrastructure and old cost data; with respect to analyses, the OLTPS report evidences a scope of analysis that tended to predispose toward a negative result and a total failure to consider social costs that also tended to predispose toward a negative result.

OLTPS referred to an initial consideration cost under the feasibility study's scope that was a "potentially prohibitive expense of moving electric service underground in one of the most

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[54] *Ibid.* p. 10; open data and other publicly available data, not available at the time of this study, may also be used to estimate business losses and municipal revenue reductions attributable to construction in the PROW.

[55] *Ibid.*, p. 13; see also pp. 120-157.

[56] At https://www.nyc.gov/html/planyc2030/downloads/pdf/power_lines_study_2013.pdf, accessed 04-13-21 @ 3:14 p.m.

[57] OLTPS Report, p. 5, Appendix A, p. i.

densely populated areas of the city."[58] OLTPS noted the total estimated costs for whole-scale burial in New York City was $18.5 billion, and compared that cost with Con Edison's then entire "capital investment budget for all its system-wide infrastructure improvements [that was] approximately $1.5 billion annually," which would translate into significant user fee increases.[59] The Edison Electric Institute, a national utility industry trade group, in its January 2013 report, *Out of Sight, Out of Mind* (the EEI Report), noted that its surveys indicated residential customers would be "willing to pay an additional 0-10% on the monthly retail bill for enhanced security from undergrounding" and that "the capital cost associated with undergrounding *entire utility systems (emphasis added)* would on average, double the residential retail bill charges."[60]

Contributing to the estimated costs in the City, were the areas' surface density, "multiple competing uses for underground space," and multiple utility use of current above-ground electric utility poles requiring their subsurface relocation as well, with variable costs depending on surface density of particular areas.[61] OTLPS noted that while the perceived benefits of subsurface re-location included increased system reliability and improved surface aesthetics, it noted as additional problems those associated with current direct subsurface burial practice in addition to costs related to operation and maintenance concerns, such as longer repair times and lessened component lifespans, as compared to aerial location.[62] Moreover, references to the EEI Report noted higher costs in the City that confirmed CHA's estimates.[63]

These costs and related user fee increases focused OLTPS on a trade-off approach, suggesting that "[a]pproaches other than wholesale conversion of the overhead system, such as a more targeted or selective approach, potentially could realize many of the expected benefits at a fraction of the cost of full conversion" especially taking into consideration available "less costly improvements that could be made to the overhead system on a much greater scale to markedly increase its resiliency and resistance to storm damage."[64] OLTPS suggested that "[a] potentially beneficial avenue to address the resiliency of overhead utility distribution infrastructure is a strategic approach that utilizes three principle elements: a) the targeted use of undergrounding in certain areas, b) the strengthening of overhead poles and lines, and c) the

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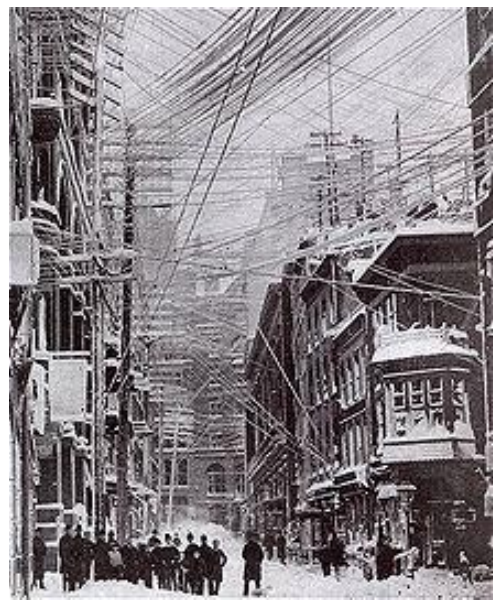
[58] *Ibid.* p. 4.
[59] *Ibid.*, pp. 5-6.
[60] *Ibid.*, p. 7.
[61] *Ibid.*, pp. 6-7.
[62] *Ibid,* OLTPS Report, p. 7. "[P]otentially only 30 years for underground system elements [buried in the dirt] versus as long as 50 years with overhead facilities." *Idem*
[63] *Idem*; see Appendix A, Section 16 for summary of project costs for system-wide undergrounding.
[64] *Ibid.*, p. 8

wider use of a sectionalized or segmentation approach on both underground and overhead systems," which would also address the cost concerns.[65]

Planning and Managing Subsurface PROW Utilization: Sustainable, Resilient and Smart. The historic practice of burying utility infrastructure directly in the dirt "has meant that the large cities have their underground sections occupied by numerous pipes, many of them out of use, which cross it with no coordination and not programmed, and this in spite of the efforts of rationalization and planning made by public administrations, and by the private companies themselves who supply these services to the inhabitants."[66] "The transfer from the surface toward underground burial was historically made without real planning by moving it underground in the best technical and financial conditions [leading to a common urban phenomenon where] all urban underground space beneath the pavement is densely filled with urban utilities [with a] mess of cables and pipelines [that] has been termed 'the spaghetti subsurface problem.'"[67]



All through the 19th century to the later part of the 20th century, the generalized burial of utility infrastructure in an increasingly dense city was not only necessary but also would not have seemed primitive. In fact, the burial of electric and telephone utilities infrastructure was a technical improvement over their initial location on sidewalk poles. The density of these overhead lines shown on the image at right,[68] which visually reflects the surface land density of residences and commercial establishments at the time, posed safety hazards to all

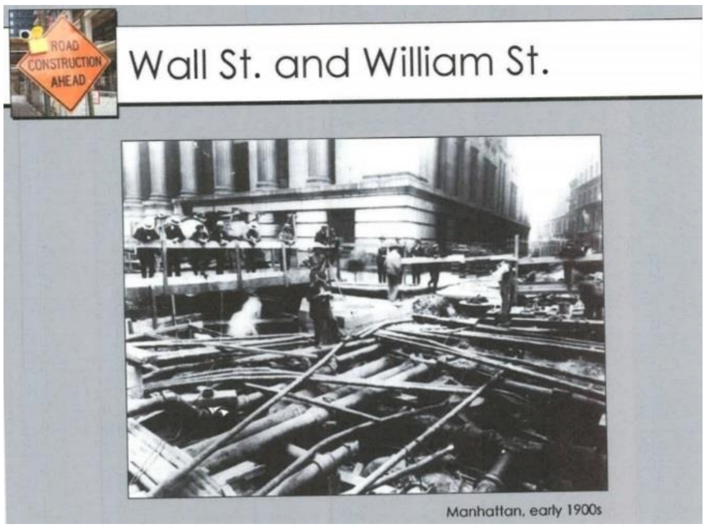
[65] *Ibid*, p. 14-15. The assertion in the report that the significant cost of conversion would benefit a relatively small number of customers trade-off calculus did not reflect any consideration of social costs or negative externality costs by not undergrounding, which costs are mostly borne by government. *Ibid.*, p. 17.

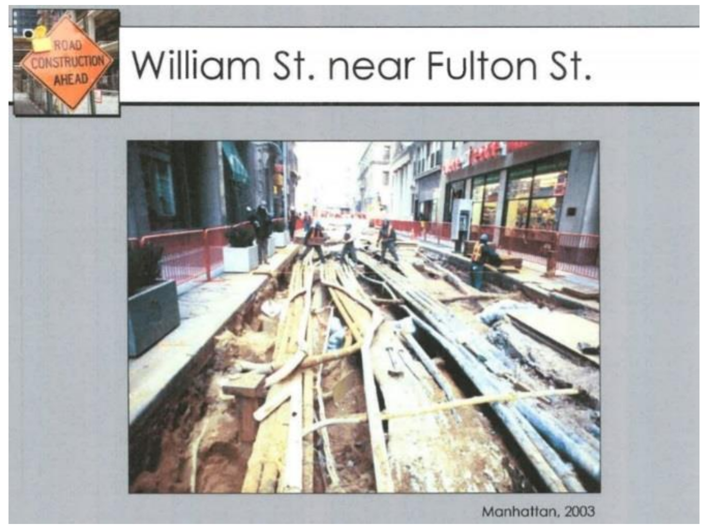
[66] Garcia and Berrade, *op. cit.,* p. 119.

[67] C-P and C-E, "Assessing," *op., cit.*, p. 1. See also Loretta von der Tann, Raymond Sterling, Yingzin Zhou, Nicole Metje, "Systems Approaches to Urban Underground Space Planning and Management—A Review," *Underground Space* 5 92020), p. 146, and Raymond Sterling and Priscilla Nelson, "City Resiliency and Underground Space Use," from *Advances in Underground Space Development*, Zhou, Cai and Sterling, editors, The Society for Rock Mechanics and Engineering Geology (New York: Research Publishing, 2013), p. 44.

[68] From https://www.google.com/imgres?imgurl=https%3A%2F%2Fupload.wikimedia.org%2Fwikipedia%2Fcommons%2Fthumb%2Fa%2Fa9%2FBlizzard_1888_01.jpg%2F220px-Blizzard_1888_01.jpg&imgrefurl=https%3A%2F%2Fen.wikipedia.org%2Fwiki%2FWar_of_the_currents&tbnid=ccJidvoH9icelM&vet=12ahUKEwiHqNaopY7pAhWKG98KHd9GDF0QMygFegUIARD5AQ..i&docid=dPebiUjCMGiW1M&w=220&h=269&q=new%20york%20city%20telephone%20electric%20wires%20on%20poles&ved=2ahUKEwiHqNaopY7pAhWKG98KHd9GDF0QMygFegUIARD5AQ , accessed 04-19-20 @ 2:49 p.m.

who travelled the street by whatever mode and the infrastructure itself was vulnerable adverse weather events. The pictures below, with the first image from *circa* early 1900s and the second from 2003, however, show how the subsurface PROW practice had not changed in over one hundred years.[69] The more recent picture below, from the roadway reconstruction project on Worth Street, Manhattan, reveal the past as present.[70]





[69] Con Edison, *op. cit.*, slides 4-5.
[70] Terri Matthews, taken some time during academic year 2019-2020.

All categories of tunnels have followed a technological progression from "from hand excavation to excavating with the latest high tech tunneling machinery."[71] Of the three types of tunnel construction—cut-and-cover, bored tunnel and immerse tube tunnel—cut-and-cover is a simple construction method that is appropriate for shallow installations such as utility infrastructure. Of the two types of cut-and-cover—bottom-up method or top-down method—the utility infrastructure method is the bottom-up method involving excavation of a supported trench in which the construction is conducted and at construction completion, back-filling the trench and reinstalling the surface.[72] The public works tunnel category, as distinct from mining and transportation tunnel categories, is generally for subsurface utility infrastructure installation—but not of the transversible utilidor type—and are constructed using the "the tunnel jacking or pipe jacking method," which may be used on by utilities on some roadway reconstruction projects (see **Starts, Misses and Potential—***Earlier Cost Benefit Analyses—* Estimating Social Costs to Support Trenchless Technology Use on the City's Roadway Reconstruction Projects above).[73] While initial costs of "cut and cover" is less than the initial costs of utilidor installation, the long-term costs of "cut and cover," including direct capital costs and indirect social costs, make LCCBA of utilidors a test of the wisdom of continuing the archaic practice (see **Utilidor History and Modelling for Life Cycle Benefit and Cost Sharing** below).

Almost a quarter of the way into the 21st century, however, with modern tunnel technology and the growing use of BIM technology-enabled, off-site robotic prefabricated design and construction in factory settings to control costs and schedules, the City's utilities' practices within a street pit is *now* quite primitive. Anyone holding a cellphone with multiple apps and hearing honks from cars stuck in the single lane beside the open street pit, who peers into the

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[71] Kimoyo Lee Giel-Tucker, Managing Tunneling Construction Risks, A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfillment of the requirements for the degree of Master of Science in Construction Engineering and Management, University of Alberta, Department of Civil and Environmental Engineering, Spring 2012, p. 8 (era.library.ualberta.ca › files accessed 04/29/20 @ 3:56 p.m.)

[72] *Tunnel Construction*, https://en.wikipedia.org/wiki/Tunnel_construction accessed 04/29/20 @ 3:18 p.m. The top-down method, which permits "early reinstatement of roadways, services and other surface features" prior to construction completion, does not seem to have been part of the City's roadway reconstruction project practice, likely due to increased costs. *Idem*

[73] Giel-Tucker, *op. cit.,* pp. 8-9. Tunnel jacking "involves the advancement of a site cast rectangular or other shaped sections using high capacity hydraulic jacks" (https://www.jackedstructures.com/box-jacking.html accessed 04/29/20 @ 4:26 p.m.), and pipe jacking, "generally referred to in the smaller diameters as microtunneling, is a technique for installing underground pipelines, ducts and culverts [using p]owerful hydraulic jacks ... to push specially designed pipes through the ground behind a shield at the same time as excavation is taking place within the shield. (http://www.pipejacking.org/about_pipe_jacking accessed 04/29/20 @ 4:36 p.m.)

pit surrounded by sleek modern high-performance buildings[74] and thinks about it for only a few minutes, might wonder why this primitive practice continues.

In New York City, subsurface utility infrastructure is a combination of city-owned infrastructure—water and sewer distribution and collection—and privately-owned infrastructure occupying the subsurface PROW under various franchise-type agreements—electric, steam, gas and telecom.[75] These physical distribution and transmission systems "deliver the services we expect to rely on [and] contribute public good, even though they are often managed by private entities [, delivering] the critical services that are the essential underpinnings of our increasingly urban society."[76] Images from open street pits all over the City[77] reveal the pervasive and typically hidden spaghetti subsurface problem "across, under and around each other, overcrowding subsurface space."[78] The primitive nature of the situation stems from the generally known corrosive properties of subsurface conditions on the buried infrastructure and the probability of utilities accidentally striking and damaging each other's infrastructure during emergency repair work or routine repair or expansion work, potentially creating dangerous conditions and associated additional repair expenses. Utilities cannot routinely inspect their buried infrastructure to assess repair or replacement needs, much less install computer-assisted sensor technology for remote operational assessments of asset condition and commodity flow and quality, thus increasing the risks of failure, emergency repairs and service disruption.

[74] A high performance building is one with sophisticated CTA-enabled building systems that permit remote monitoring and correction of various building systems so that the entire building is able to perform at high levels to achieve a number of functions, including meeting environmental sustainability targets..

[75] In this précis, the terms utility and utilities will encompass both private and public utilities.

[76] Sterling and Nelson, *op. cit.,* p. 48.

[77] Terri Matthews, taken some time during academic year 2019-2020.

[78] Julian Canto-Perello (C-P) and Jorge Curiel-Esparza (C-E), "An Analysis of Utility Tunnel Viability in Urban Areas" ("Analysis"), *Civil Engineering and Environmental Systems*, Vol. 23, No. 1, March 2006, p. 11.

Utilidors, as an infrastructure locating all utility infrastructure within it and with respect to each other based on the rules of physics and protecting utility infrastructure from the subsurface environmental conditions and from each other, can eliminate negative consequences of direct burial. Utilidors permit easier access to subsurface infrastructure than does the current practice of excavation to find infrastructure for emergency repair, routine 'state of good repair' activities and adding new capacity, eliminating most street cuts and excavations and achieving the street surface design life, collectively saving public and private capital costs over the long term. Utilidors permit electronic sensoring of subsurface infrastructure for remote monitoring of asset condition and commodity quality, with associated long-term capital savings; reduce associated air pollution from construction equipment and delayed vehicles; reduce associated carbon emissions and costs for landfill disposal of construction and demolition waste (CDW) with embedded carbon;[79] and, reduce social costs associated with transportation delays and loss of business income.[80]

Planning and managing subsurface PROW use, including use by critical utilities, increases the resiliency of subsurface PROW infrastructure and reduces their impact on the environment and would help the City to advance significantly Sustainability Development Goal 6—Ensure Availability and Sustainable Management of Water and Sanitation for All—and Goal 11—Make Cities and Human Settlements Inclusive, Safe, Resilient and Sustainable.[81] Initiatives that increase both resiliency and sustainability, two sides of the same coin,[82] are not only more generally understandable by the policy makers and the public, but also "make it easier to include longer-term future considerations into current public discussions, urban planning and facility design decisions even when direct cost-benefit analyses are not available."[83] Resilience

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[79] Re-use of some CDW does occur but it is suspected that most CDW goes to landfills; the URR Working Group in T+G has an NYU/Tandon-CUSP capstone project underway in academic year 2020-2021 to code and computer-read NYS DEC scanned annual reports from transfer stations and landfills to create CDW trip data to import into a data visualization tool to show the magnitude and direction of various CDW flows within the New York City metropolitan area.

[80] See also Y. Luo, A. Alaghbandrad, T.K. George, A. Hammad, "History and Recent Development of Multi-Purpose Utility Tunnels," *Tunneling and Underground Space Technology* 103 (2020) 103511, July 17, 2020, p. 1.

[81] See https://sdgs.un.org/goals accessed 04-18-21 @ 1:21 p.m. In addition, planning and managing subsurface PROW uses such as for underground roadways and parking garages opens up infrastructure design alternatives to reducing surface PROW congestion to complement fee schemes to reduce congestion and provide alternatives when the limits of taxing to reduce congestions become apparent.

[82] "Resiliency . . . is considered, in general terms, as the ability of a community or some aspect of a community to withstand a catastrophic event or, if such an event cannot be withstood, to return the community to effective functioning as quickly as possible after the event. *** In the longer term context, resiliency concerns start to merge with sustainability concerns because it would be hard for a community to be sustainable if it could not cope with irreversible changes in its environment." Sterling and Nelson, *op. cit.*, p. 44.

[83] Sterling and Nelson, *op. cit.*, pp. 43-44.

for critical infrastructure systems includes "both the physical structures that comprise infrastructure elements [and] also the computer, communications and control systems that operate the physical infrastructure and that are a critical component of commercial and social networks."[84]

Studies of structural infrastructure failures reveal that among "the common elements in many of the failures were . . . not paying attention to the early signs of failure . . . lack of redundancy and robustness in design [and] maintenance (and inspection) problems."[85] Translating those findings up to a city-wide systems level in a longer-term resiliency context, "the complexities multiply rapidly [and i]t becomes more difficult to figure out everything that can possibly go wrong and the will to make massive investments against poorly understood threats is often lacking."[86] "Since being initially designed and installed as simple, linear and uncoupled system, [all utility subsurface infrastructure systems] have been added to, repaired and connected in new ways so that the decomposable systems of the past have become tightly coupled, nonlinear and intractable systems of the present, [developing] emergent behaviors that can defy control in an absolute sense, particularly when these systems are asked to perform under conditions of crisis and disasters."[87] Moreover, "[t]he interconnection of aging physical infrastructure systems into larger networks, and the loss of redundancy associated with high efficiency operations has led to reduced reliability and poorly understood interdependencies."[88] The ability to measure the ability of these infrastructure systems to perform and respond under environmental threats in order to "assist decision makers and allocate resources," however, will require engineers and planners "to think about the underground in an integrated way and view investment decisions with social perspectives" and "understand the impacts of scale, aggregation, interactions and interdependencies" at a time when "there are too few trained professionals for future needs in complex system management, and decentralization and new concepts of design and control require recalibration of management judgment."[89]

[84] *Ibid.*, p. 44. The relation of utility systems infrastructure to commercial and social networks underscores a key component of resiliency, which is the resilience of the urban communities themselves as members of society, as discussed in detail in pp. 45-47.
[85] *Ibid.*, pp. 44-45.
[86] *Ibid.*, p. 45.
[87] *Ibid.*, p. 48.
[88] *Idem*
[89] *Ibid*., pp. 47-48, 53; see pp. 50-53 for more detailed analysis of the relationship of underground space use to resiliency, which includes a note that "[decision models for recovery of infrastructure networks that focus on the time and/or cost to repair as much of a network back to normalcy as soon as possible] do not consider the trade-offs inherent in fixing the elements of different infrastructures beneath a particular street in a coordinated fashion so that costs are minimized, [which] is typically not a major issue for aerial infrastructure but it is a very important issues for buried infrastructure except in the case of multi-utility tunnels for which much social disruption of repair would be avoided." p. 51. See also pp. 53-54 for specifics on improving subsurface planning and management.

Improved subsurface planning and management requires “[m]ore extensive monitoring systems [that integrate] data and analysis need . . . in real-time during construction as well as in operation to close the loop between observation, knowledge, design and action. The large lengths of underground utility systems demand inexpensive, wireless sensor systems for effective monitoring,” which would be facilitated by utilidor implementation.[90] As noted above, a city cannot be considered truly "smart" when its utility infrastructure is buried in the dirt, requiring excavation of the surface PROW for its repair and upgrade. An often-cited smart city definition implies utilidors:

> "The vision of "Smart Cities" is the urban center of the future, made safe, secure environmentally green, and efficient because all structures—whether for power, water, transportation, etc. are designed, constructed, and maintained making use of advanced, integrated materials, sensors, electronics, and networks which are interfaced with computerized systems comprised of databases, tracking and decision-making algorithms."[91]

A smart city "monitors and integrates conditions of all its critical infrastructures, including roads, ... communications, water, power ..., [so that it] can better optimize its resources, plan its preventive maintenance activities, and monitor[e] security aspects, while maximizing services to its citizens."[92] To realize the promise for ICT to increase and optimize efficiency and effectiveness in delivery of public and private utility commodities and the public services dependent on such commodities, which is the smart city aspect, it is necessary to focus on the actual infrastructure now located under the PROW that will require utilidor implementation to become smart.

A standard asset management approach consists of an (1) infrastructure assets management strategic approach and (2) service life cycle analysis methodology (collectively, an infrastructure management system), derived from the systems engineering discipline that is intended to work for all infrastructure typologies[93] because it is general in scope yet able to be modified to "incorporate particular models, methods and procedures needed for specific types of infrastructure."[94] Generally, infrastructure management systems begin with "initial information acquisition" to establish a system inventory for purposes of "periodic in-service monitoring and evaluation", followed by "planning, programming, and execution of new

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[90] Sterling and Nelson, *op. cit.,* p. 54.
[91] Hall, op. cit., p. 1.
[92] *Idem*
[93] W. Ronald Hudson, Ralph Haas, Waheed Uddin, *Infrastructure Management* (New York 1997), p. 31; see also pp. 18-20, 25.
[94] *Idem*

construction, maintenance, rehabilitation, and renovation . . .".[95] The nature of the infrastructure object will determine the nature of data acquisition for inventory and condition assessment purposes.

When infrastructure elements fail to provide adequate service—or they reach the end of "service life" because they are structurally unsafe or functionally obsolete—it "causes delay and inconvenience to users due to overuse and overdemand" or it is "costly to maintain and preserve."[96] Service life, defined to be "the period in years from the time of completion of the facility to the time when the complete facility or its components are expected to reach a state where it cannot provide acceptable service because of physical deterioration, poor performance, functional obsolescence or unacceptably high operating costs" . . ."can be estimated from an historical database using" a number of techniques that make computer-based probabilistic modeling a suitable tool.[97] These techniques include the survivor curve method, reference to previous experience, and performance modeling.[98] The performance modeling approach estimates the "physical deterioration rate . . . by condition monitoring and in-service evaluation over a short period of time, [generating] a model to predict future deterioration and failure . . . as a function of age, load/demand and environmental factors."[99]

Above-ground infrastructure, such as power transmission infrastructure and bridges,[100] on the one hand, and subsurface infrastructure, such as water/sewer distribution main infrastructure, on the other, have different methods of data acquisition for inventory purposes as well for in-service monitoring. Unlike subsurface infrastructure, above-ground infrastructure is completely visible. Even when the original design documents for above-ground infrastructure do not exist, it is still possible to reconstruct details, though inventory and asset condition exercises may be more difficult for some above-ground infrastructure than others.[101] In direct contrast, however, subsurface PROW infrastructure requires destructive or advanced non-destructive technology to inventory for location purposes, in the absence of accurate "as built" drawings, to conduct in-service inspection. In the United States, the regulatory environment for bridges imposes inspection standards on owners, but there are no regulatory mandate to inspect subsurface PROW infrastructure; there is only mandated testing of water quality for drinking

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[95] *Idem*
[96] *Ibid.,* p. 42.
[97] *Ibid.,* p. 56.
[98] *Ibid.*, pp. 56-58.
[99] *Ibid*., p. 58.
[100] Vehicle transmission infrastructure.
[101] While non-destructive physical inspection of bridges is the standard for parts of the bridges reachable by people, physical inspection of power transmission infrastructure is more difficult because the nature of electricity and the height of the towers require helicopters and drones for visual inspection and repair.

purposes at the original sources before entering the local distribution center and at the tap and mandated testing of treated wastewater before release into surrounding water bodies.

There are two ways to estimate service life—by computer-based probabilistic modeling or performance-based modeling, which is a deterministic approach.[102] Probabilistic modeling of water/sewer distribution infrastructure has been used in cities outside the United States, such as Paris. Either approach, however, leads to a series of corollary management decisions about whether and in what relative proportions an owner will engage in preventive maintenance, repair/rehabilitation, reconstruction and replacement of infrastructure elements, all within an envelope imposed by the ability to pay for such maintenance, repair/rehabilitation, reconstruction and replacement. The objective of infrastructure management systems is to "serve all management levels in the organization"[103] to coordinate and execute "all activities so that [the utility can make] optimum use . . .of [its available] funds . . . while maximizing the performance and preservation of assets and provision of service"[104] and increase the chances over time that its various infrastructure networks provide "a level of service acceptable to the public or owners" by the "systematic coordination, planning and programming of investments or expenditures [and] design, construction, maintenance, and in-service evaluation of physical facilities."[105]

One can never assume, however, the existence of *sufficient resources* to implement an infrastructure management system's recommended maintenance, repair/rehabilitation or reconstruction and replacement actions. This is not a simple overall constraint issue, but one with two distinct components that operate across infrastructure types and ownership modes (i.e., public or private). The first constraint relates to timing—specifically when deferral (purposeful or not) of operating expense-funded maintenance and repairs turns them into capitalizable projects. On the "maintenance-repair/rehabilitation-reconstruction-and-replacement" continuum, the first stop is maintenance, which public and private accounting rules would likely to consider appropriate to be paid from operating—or expense—revenues. In addition, related activities such as asset inventory and in-service condition inspection activities would also be considered appropriate for current revenues and not capital revenues. Some repairs in the repair/rehabilitation category would also tend toward being treated as an operating expense due to the short useful life of the repair that keeps its cost from being capitalizable. Maintenance and repair activities funded from operating revenues compete with other uses, which includes the personnel costs of people running the business/programs. As a

[102] DOT had been using a deterministic approach for bridges, but as New York State, its regulator, embraces the probabilistic modeling approach, DOT will be adopting probabilistic modeling.
[103] Hudson *et al., op. cit*., p. 58.
[104] *Idem*
[105] *Ibid*., p. 30.

result, maintenance and repairs tend to lose out in this ongoing competition by being deferred during times of constrained annual revenues. This institutional practice is made worse by another practice, which is a preference for waiting until a small problem, fixable at a relatively lower costs, grows over time into a larger, more expensive project, with a longer useful life that *can* be capitalized.

The second type of constraint relates to those projects of rehabilitation, reconstruction and replacement that are clearly capitalizable, which must operate within utility-specific constraints that are limited as to the rates they can charge to support all operations including a state of good repair program. For all utilities, whether public or private, their debt service obligations[106] burden future annual operating revenues with non-discretionary debt service payments, and debt service coverage ratio covenants in their bonds also limit their future ability to issue debt.[107] Non-discretionary debt service burden and limits on debt issuing capacity are joined by further constraints of a political nature on the rates utilities are able to charge customers.

Systemic impediments to state of good repair programs informed by asset management systems—"smart"[108] or not—have been exacerbated by a history of systems that "have evolved in a piecemeal fashion, with new extensions grafted onto existing systems and designs often governed by expediency and low construction costs rather than true life-cycle costs."[109] The nation's inherited "complex network of systems comprised of subsystems with wide variations in age and functionality," is the same systems to which the American Society of Civil Engineers (ASCE), in its periodic Report Card on American infrastructure, keeps assigning poor grades, due to reasons, in addition to those described above, that have recursively compounded the magnitude of problem over the most recent several decades. These reasons include "cutbacks that have slashed public works budgets, . . . failure to replace the infrastructure as fast as it wears out, . . . the tendency by national, state and local officials to

[106] Annual principal and interest payments on the bonds as they come due.

[107] As an aside, with respect to publicly regulated private utilities, the dominant regulatory practice has been to focus on the rate base and the rate of return. There has been great debate in the economic literature about how regulatory bodies handle the "return *of* the money capital invested over the estimated economic life of the investment and the return (interest and net profit) *on* the portion of investment that remains outstanding," which is appropriate for industries with significant capital infrastructure requirements. (Alfred Kahn, The Economics of Regulation: Principles and Institutions (Cambridge 1988), Vol. I, p. 32. There has also been an interesting side debate in the literature about whether this practice encourages utilities to overinvest in capital improvements in order to inflate the rate base beyond what is necessary to satisfy their obligation to serve all as a condition of monopoly status. There is, on the other hand, the possibility that regulatory practices within a jurisdiction that favor conservative capital depreciation allowances may cause reluctance among utility operators to replace obsolete assets with new assets. What does not seem to be mentioned in the literature about regulatory practice is the continuing need to make capital repairs to existing infrastructure to maintain them in a state of good repair.

[108] The use of the term "smart" here means information-technology and/or computer-based and assisted technology, including as applied to statistics and management principles and techniques.

[109] Hudson *et al., op. cit.,* p. 22.

defer the maintenance of public infrastructure, and . . . increased costs to taxpayers to repair and rebuild the obsolescent public infrastructure."[110] Infrastructure management systems as described above operate within a system with "exogenous elements over which little or no control may exist, such as financing, budgets, and agency policies at the network level, and standard and specifications, budget limits and environmental constraints for the project level."[111]

ITC and Remote Monitoring of Infrastructure: Water Systems Case Study.[112] As early as 1970s, researchers in water resource systems began to turn from the standard planning goal of system stability, "which pertains to the variability of species densities over time" toward a planning goal of system resiliency, when it became observable that unstable systems "may be very resilient, for they can persist after severe shocks or during periods of stress because of their capacity to accommodate variability in individual species densities."[113] This change in the focus for planning resulted in "multiobjective planning algorithms" for "multiobjective multiple-decision-maker character of public decisions" using "criteria for evaluating the possible performance of water resource systems" that included criteria and methodology similar to those now in use for asset management systems that include "how likely a system is to fail (reliability), how quickly it recovers from failure (resiliency) and how severe the consequences of failure may be (vulnerability)."[114]

Moving forward, applications of ICT have demonstrated the feasibility of applying historical data to create stochastically-based models to predict failure rates of urban water mains,[115] including the application of artificial neural networks.[116] The continuum of this research demonstrates that multi-condition prediction models that include not only pipe age, but also "soil type and weather conditions" would allow a system owner " to predict the water mains failure and consequently to elaborate an optimized strategy for water mains maintenance and rehabilitation."[117] During this time, moreover, technology has advanced to permit

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110 *Ibid., pp. 22, 25.*
111 *Ibid.,* pp. 25-26.
112 This applies to all utility infrastructure and commodities.
113 Tsuyoshi Hashimoto, Jery Stedinger and Daniel Loucks, "Reliability, Resiliency, and Vulnerability Criteria for Water Resource System Performance Evaluation," *Water Resources Research* (American Geophysical Union), Vol. 18, No. 1, February 1982, p. 14; citing Holling, C.S., "Resilience and Stability of Ecological Systems," *Ann. Rev. Ecol. Systems,* 4, 1-23, 1973.
114 *Idem*
115 A. Vanrenterghem-Raven, P. Eisenbeis, I. Juran and S. Christodoulou, "Statistical Modeling of the Structural Degradation of an Urban Water Distribution System: Case Study of New York City," *World Water and Environmental Resources Congress 2003* (ASCE 2004).
116 Raed Jafar, Isam Shahrour and Ilan Juran, "Application of Artificial Neural Networks (ANN) to Model the Failure of Urban Water Mains," *Mathematical and Computer Modelling* 51, (2010) 1170-1180.
117 *Ibid.,* p. 1170.

instrumented—or "smart"—water pipes that remotely relay received data from pipes located underground, using "off-the-shelf sensors and communication elements."[118] Demonstration projects at test sites, such as the University of Birmingham, UK, campus,[119] and the University of Lille, France, campus[120] suggest the feasibility of implementing these models for leak detection and even water condition in urban settings. In addition, utilization of such technology, in particular remote sensing meters at the consumer site, and such models in water-stressed localities permit a water utility a way to increase distribution system-wide efficiency by repairing post-meter "network leaks and maintain[ing] same volume of water output" as a "lower cost option than constructing capital intensive water supply infrastructure."[121]

Increasing implementation of such technology and models by utility owners, however, runs into operational and financial realities. In Australia, utility owners have been gaining "increased awareness of how digital metering and applying analytics of various data sets in near real-time can benefit utility efficiency," and increased trial use and operational roll outs have been underway at many utility owners' systems,"[122] yet there continue to be impediments to increasing implementation.[123] While survey results indicate that key business drivers such as avoiding "costs by lowering operating costs . . . and/or deferring infrastructure augmentation" are "easier to quantify and justify on water system economics,"[124] and survey-based research reveals that "it is likely that this area will be very 'organic' and rapidly evolving in the next few years as utilities become more aware of the options and applications of 'big data', and gain a more intimate knowledge of the options and processes involved in this quite complex component of the digital water space,"[125] impediments still exist. Among the impediments to implementation, are a "lack of a precedent showing a positive return on investment (ROI),

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118 Nicole Metje, David Chapman, David Cheneler, Michael Ward and Andrew Thomas, "Smart Pipes—Instrumented Water Pipes, Can This Be Made a Reality?" *Sensors,* 2011, 11, 7455-7475, p. 7455.

119 *Idem*

120 Wilmer Cantos, Silvia Tinelli and Ilan Juran, "Risk Assessment for Early Water Leak Detection" (article handed out in class—no citation available) and class presentation by Ms. Tinelli of her Ph.D. dissertation research with respect to bio-contamination.

121 Tracy Britton, Rodney Stewart and Kelvin O'Halloran, "Smart Metering: Enabler for Rapid and Effective Post Meter Leakage Identification and Water Loss Management," *Journal of Cleaner Production* 54, (2013) 166-176, p. 166.

122 See C.D. Beal and J. Flynn, "Toward the Digital Water Age: Survey and Case Studies of Australian Water Utility Smart-Metering Programs," *Utilities Policy* 32 (2015) 29-37, p. 32, for finance considerations. "Many utilities fully funded their projects, with some federal resources being the main source of supplementary funds."

123 *Ibid.*, p. 29.

124 *Idem,* see also p. 32, summarizing results that indicate top three business cost drivers are "reducing non-revenue water, deferring infrastructure and reduced manual meter reads." Later interviews added "reductions in operating costs, network upgrade deferment, increased accuracy and improved customer relations [as] key drivers for pursuing projects." *Ibid.,* p. 34.

125 Beal and Flynn, *op. cit.,* p. 33.

positive outcomes and limited existing industry knowledge from previous smart metering projects"; "[c]osts associated with technology and rollout phases . . . as a limitation;" and "technical issues relating to the wireless communications technology . . . [keeping] project business case drivers not being achieved or not considered as 'on track.'"[126] In addition, subsequent interviews and workshops conducted as part of this research indicated that "a coordinated approach was needed to ensure technology was suitable for the desired outcomes and goals of the project and then work backwards with technology selection [and] that digital water technology is only as smart as the user and the user environment (e.g., communications network, software, storage and analytics)."[127]

Leveraging technology for asset management systems to, among other things, reduce operating costs and possibly mitigate the need for future capital investments, including state of good repair investments, however, is not costless and needs to acknowledge the long-standing impediments posed by the nature of capital programs, which tend to be themselves impediments to state of good repair activities, within a rate envelope. The ASCE's periodic review of infrastructure systems across the nation, which often gives bad grades for infrastructural states of good repair, does not adequately acknowledge the ways in which "[p]ublic owners are challenged by limited and constrained capital sources for acquiring and *sustaining* (emphasis added) infrastructure facilities."[128]

Public capital improvement programs do not explicitly address life cycle issues such as state of good repair, as noted above, and researchers have posited that standard governmental "approaches to municipal infrastructure management [that are] centered upon annual project execution" coupled with segmented project service delivery methodologies do not expressly or meaningfully incorporate life cycle costs, including state of good repair, into any part of the decision-making process.[129] A structured systems perspective model, which facilitates an active approach to "municipal infrastructure management", would permit public owners to consider

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[126] *Ibid.,* p. 34. See also M.P McHenry, "Technical and Governance Consideration for Advanced Metering Infrastructure/Smart Meters: Technology, Security, Uncertainty, Costs, Benefits and Risks," *Energy Policy* 59 (2013) 834-942, accessed through Murdock University Research Repository at http://dx.doi.org/10.1016/j.enpol.2013.04.048.

[127] Beal and Flynn, *op. cit.,* pp. 35-36.

[128] Michael Garvin, Stephen Wooldridge, John Miller and Michael McGlynn, "Capital Planning System Applied to Municipal Infrastructure," *Journal of Management in Engineering*, September/October 2000, p. 41. See ASCE's 2017 Infrastructure Report Card, which has assigned an average grade of D+ to American infrastructure systems. http://www.infrastructurereportcard.org/ accessed 05-07-17 @ 2:57 p.m.

[129] Garvin *et al.*, *op. cit.*, pp. 41-42. In this discussion, whatever applies to municipal infrastructure applies equally to infrastructure owned and/or financed at the state level. In addition, even for municipalities, such as New York, which engages in long-term capital planning, the 10-year horizon in use does not align with infrastructure with capital asset lives in multiples of 10-years.

long-term life cycle issues as part of capital infrastructure planning and management.[130] A model developed within the "emerging discipline [of] engineering systems integration" includes both "choice of project delivery systems and financing methods [to allow] engineers to improve execution of an owner's project *portfolio*."[131] Such an automated decision support model "treats both project delivery and project finance methods as variables for consideration . . . in the course of examining infrastructure alternatives" and would permit utility owners to focus, during the capital planning and budgeting processes, on "corresponding cash flow projection for planning, design, construction *and operations and maintenance* (emphasis added) . . .".[132] Utilizing such a model, at any time during the "planning-to-adoption" continuum of a capital budget, would permit owners to focus explicitly on life cycle state of good repair issues and costs and create a financial and operational space for the integration of technology projects for such infrastructure to make them more operationally efficient.

Utilidor History and Modelling for Life Cycle Benefit and Cost Sharing. The Utilidor Working Group initially focused its attention on cities where utilidors exist and, because most of the group members are from City agencies, the costs and benefits of utilidors. Initial research on European cities with utilidors revealed three cities that stood for implementation typologies.[133]

- Paris: Haussmann's overhaul of the Paris PROW at the end in the 19th century for military purposes created a mirror-image subsurface PROW sewer system into which other utility infrastructure eventually located, making it a *de factor* utilidor. Paris also plans, manages and optimizes its subsurface PROW with an "Underground Town Planning [scheme] which strives to arrange everything in the subsoil and everything which can leave the surface without detriment, such as traffic and car parks; water, gas electricity, drains; town heating, telephone, compressed air; archives, depots of all kinds; commercial shops and stores; convention facilities; swimming pools, gymnasiums, etc."[134] As a typology, Paris stands for a ***lucky*** city, where the master planner/engineer/builder had the foresight and understanding to build galleries large enough to incorporate utilities as they developed, which is not a typology that is replicable in an older dense city like New York City.

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[130] *Idem*
[131] *Idem*, citing Miller, J.B., "Engineering Systems Integration for Civil infrastructure Projects," *Journal of Management in Engineering,* ASCE (1997), 13(5), 61-69.
[132] Garvin *et al.*, *op. cit.*, pp. 42-43.
[133] Matthews, op. cit., p. 29. Tokyo has a "no dig" policy, and "[u]tilidors have been installed in Japan since 1963 under the Law of Development of Common Ducts[, designating s]ome major arterial streets ... where utilidors must be built." R. Bugher, "Utilidor Project 68-2: Preliminary Findings and Observations." *Ekistics*, (1970), Vol. 30, No. 179, p. 299. Available at *JSTOR*, www.jstor.org/stable/43616416. Since the Law of Common Ducts is a national law, including Tokyo as a case study city for purposes of New York City did not make sense at the time.
[134] Bugher, *op. cit.*, p. 299.

- London: Bazalgette, responsible for the construction of London's sewer system, was also involved in related street improvements where he took advantage of opportunities to create "pipe subways" for other subsurface utility infrastructure to reduce future street cuts and excavations, a practice that continues to this day when opportunities present themselves.[135] As a typology, London stands for an ***opportunistic*** city that sees its opportunities to insert utilidors as part of other large construction projects and takes them. This a practice has eluded New York City despite many opportunities, but it is still a replicable typology for New York City to follow, although appropriate transportation projects for pipe subways will likely involve other owners, such as the MTA, so that multi-agency coordination necessary to take advantage of these projects will be difficult.

- Madrid: Cities in Spain have been implementing utilidors for quite some time, with the first modern utilidor in Madrid in 1952.[136] As a typology, Madrid stands for the city that, despite unfavorable economic downturns, ***just does it*** because it understands the long-term economic value of implementing utilidors. With the long-term economic, sustainability and resiliency benefits accruing to utilidor implementation, this could also be a replicable typology for New York City to follow. The long-term implementation of utilidors as part of the City's ongoing roadway reconstruction program implies this typology.

An international survey of utilidors revealed that, overall, utilidors most frequently host "electrical cables, water pipes and communications cables, followed by sewage, district heating and gas pipes," with refuse and district cooling among the least hosted and gravity sewers the most problematic.[137] Life cycle considerations of utilidor implementation point to direct benefits to utilities and the local government in charge of roads consisting of significant long-term construction cost reductions; improved utility inspection and maintenance; minimizing utility damage and corrosion; savings from future utility expansion; reductions in labor accidental injury and death; reduction in local government revenue loss due to reductions in parking meter and fine revenue loss and in business income loss; and better subsurface space planning.[138] Life cycle considerations also point to indirect and long-term social and environmental benefits consisting of traffic congestion/detour reductions; improved health and

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[135] Denis Smith, "Sir Joseph William Bazalgette (1819-1891) Engineer to the Metropolitan Board of Works," *Transactions of the Newcomen Society*, Vol. 58, No. 1 (1986), DOI: 10.1179/tns.1986.006 , p. 99. Available at https://www.tandfonline.com/doi/abs/10.1179/tns.1986.006?journalCode=yhet19; this practice continues as part of the Cross Rail initiative during the Thames Tideway Tunnel Scheme and as opportunities to convert existing disused transit subways into pipe subways. W. McMahon, R. W. Jordan and J. C. Nicholls, Creating the Future of Transport, Interim Report (Transport Research Laboratory (Web Version, March 2012), slides 103-104. [PDF] trl.co.uk, accessed 11/29/19@ 4:55 p.m.

[136] Bugher, *op. cit.*, p. 299.

[137] Luo *et al., op. cit.*, p. 2.

[138] *Ibid.*, pp. 2-4

environment; improved utility service quality; reduction of associated business income loss; and reduction of damage/temporary closure of recreational facilities, which, with biking lanes, the street has become.[139] The benefits that accrue to utilidor implementation also include contributing "to the development of smarter, more sustainable and resilient cities" because utility infrastructure in the utilidors and the utilidors themselves can be equipped with various remote sensors and systems to "serve the functions of smart infrastructure systems of the future."[140]

Utilidor implementation, however, comes with disadvantages that, at first glance, appear as significant impediments, consisting of higher initial investment cost compared to initial direct burial costs; complexity in utilidor financing and allocating construction, operation and maintenance costs across utilidors users appropriately; difficulties related to construction methods; associated disruption of services; compatibility and safety issues; security risks; and coordination issues.[141] In the United States, however, utilidors are "constructed mainly on university campuses, hospitals, private establishments and military installations."[142] "The main reason for the limited growth of [utilidor] projects in Europe and their absence in North America (except in some institutions such as universities) is the high initial cost, especially in matured cities with high traffic congestion and high utility density; although these are the conditions that are used to justify the need for [utilidors]."[143] Disadvantages in addition to "a) high initial cost because of complicated design and construction," include "(b) safety issues related to the incompatibility of some utilities (e.g., proximity of gas and electricity),[144] (c) increased security risks because of integrated and accessible utilities in [the utilidor], (d) complicated coordination of [utilidor] stakeholders, and (e) disruption of utility services during [utilidor] construction."[145] Methods to manage utilidor construction costs include mass off-site prefabricated production of modular sections due to economies of scale and schedule reductions compared to on-site construction due to factory-based production.[146]

In view of the impediments discussed above, especially the high initial cost of utilidors, it is important for policy makers considering implementing a utilidor program to obtain a true economic evaluation of the two options by comparing the direct and indirect life cycle costs

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[139] *Ibid.*, p. 4.
[140] *Ibid.,* p. 29.
[141] *Ibid.*, pp. 9, 27.
[142] Ibid., pp. 2, 21.
[143] *Ibid.*, p. 29.
[144] Which conditions also happen to exist under the PROW under current practice, with no added protection from each other that would be possible in a utilidor.
[145] Ali Alaghbandrad and Amin Hammad, "Framework for Multi-Purpose Utility Tunnel Lifecycle Cost Assessment and Cost Sharing," *Tunnelling and Underground Space Technology*, 104 (2020) 103528, p. 2.
[146] Luo *et al. op. cit.*, p. 29

and benefits associated with high initial cost of utilidors with the direct and indirect life cycle costs and benefits associated with lower initial cost of direct infrastructure burial.[147] This type of “systematic approach” to life cycle evaluation would have an appropriate long pay-back period and be able to (1) assess utilidor project functions on a project basis with the ability to change variables for the project’s local conditions and (2) allocate costs fairly among participants.[148] The first step would generate the life cycle cost (LCC) for a utilidor project as a project, computing a break-even point to determine whether the long-term benefits, which can include social benefits and reductions in social costs, of a utilidor exceeds its costs, and the second step would focus on cost-sharing among utility participants in a way that balances risk, cost-benefit ratios and contributed and gained benefits.[149] This approach would also acknowledge the different roles of the municipality, as owner of the PROW, which benefits from utilidor implementation, and as owner of the public water and sewer utility that shares interests similar to those of the private utilities with respect to appropriate cost allocation.

The first step of the model assumes that utility companies and utility users and citizens benefit from utilidors, with utility company benefits consisting of “(a) major cost savings by reduction of repeated excavation, utility installation, repair of streets and sidewalks, traffic control, and repair of detour road damage bearing extra traffic, (b) reduced damage and corrosion of utilities, (c) facilitated inspection and maintenance of utilities, (d) cost savings related to facilitate future development and upgrade of utilities, (e) reduction of municipal revenue loss from parking meter machines, parking ticket and sales tax, (f) decrease in labor incidental injury and death, and (g) more organized underground space planning.”[150] It also assumes utility users’ benefits and citizen’s social benefits are due to “(a) cost and time savings because of major reduction of traffic congestion, (b) increased quality of utility services and customer satisfaction, (c) improved social health, environment, and safety by preventing problems of construction works such as accidental safety issues, noise, dust, vibration and air, soil and water pollution, (d) reduced negative impact of construction work on local business because of less customers, and (e) decrease in damage/temporary closure of recreational facilities (e.g., parks).”[151]

The first step of the model also considers shared risks, which are those “with more than one responsible company (e.g., fire because of the proximity of gas and electricity or post-completion accidents if due primarily the act of one utility or the conditions of its infrastructure) and shared risk management actions” for the “purposes of sharing cost of risk

[147] Alaghbandrad and Hammad, *op. cit.*, pp. 2-3
[148] *Idem*
[149] *Ibid.*, pp. 2-3, 5.
[150] *Ibid.,* p. 2.
[151] *Idem*

management" and assumes that "risks that are produced by a company and affect only the same company are not a sharable risk and all the costs to manage that risk should be paid by the same company."[152] Examples of shared risk attributable to operation and maintenance of the utilidor, which would be covered by a negotiated management agreement, include various ventilation by extraction or fresh air issues, temperature detection, permanent measurement of gas concentration, access management for security purposes, worker safety protocols, protocols for utility infrastructure repairs and renewal to mitigate chance of damage to other infrastructure or the utilidor itself. Depending on whether the utilidor is financed by a public-private partnership or by a governmental entity (city or state-created authority), various construction risks could be shared between public and private entities involved or be managed by the governmental entity, as sole constructor.[153]

The second step of the model further assumes that the public and private utility companies would be responsible for sharing the financing costs of construction and post-construction operations and maintenance costs.[154] Of two available methods for cost allocation—(a) the proportion of buried costs (PBC) method, in which the utility companies are charged based on the same proportion they were paying in the traditional buried utilities method, and (b) the proportion of utility volume occupancy (PUVO) method, in which utility companies are charged based on the volume of space they occupy—the second step uses PBC for allocating construction costs and PUVO, using Shapely value theorem, for allocating ongoing operation and maintenance costs, and confirming the LCC ratio, derived from the first step, is true for participating utilities.[155]

With the first step having determined a utilidor produces a positive benefit, "defined as the profit or construction and maintenance cost reduction of a utilidor,"[156] the second step assumes that benefit-cost ratios at each utility should not be very different" and confirms, for each utility, that "higher investment should result in higher benefit for a utility company."[157] While the ratios should not different among utilities, there may be certain costs distributed to some utilities that require adjusting the cost allocations and thus ratios, based on the assumption that some costs "to manage safety and security risks should be based on [the]

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[152] *Ibid.,* pp. 2-3.
[153] *Ibid.,* p. 3, Table 1. If a governmental entity is the owner due to financing the entirety of the asset, separate agreements (or amendments to existing franchises) with private utilities would be negotiated to permit occupation of dedicated utilidor space, require payment for share of debt service related to occupied area and share of other operations and maintenance costs and require state of good repair activities for located infrastructure.
[154] *Ibid.,* p. 4.
[155] *Idem*
[156] *Idem*
[157] *Idem*

concept [that] the risk creator [or group of risk creators, if not all of them,] should pay the risk management costs."[158]

The application of game theory, which assumes the decision of each player potentially can affect the costs and benefits of the other involved players," to the balancing process for cost allocation helps deal with "complicated conflicting situations" among the participating public and private utilities that obtain different amounts of benefits.[159] For example, the local government responsible for the surface PROW that will achieve designed life, which also has a utility, will receive more direct benefits than the private utilities and social benefits can be attributed to the entire area for which the local government is responsible, thus increasing its indirect benefits, while among the utilities, the benefit-cost ratio may be lower for some due to their particular regulatory environment. In order to encourage all utilities to participate in a utilidor, it may be useful for the local government to increase utility benefit-cost ratios by adding incentives from areas controlled by the local government, as a contributed benefit, within the framework of "cost-sharing based on balanced benefit distribution."[160]

2019-2020 Columbia/SIPA Lifecycle Cost Benefit Analysis Project—Road to Smart City.
In academic year a team of Columbia/SIPA capstone students[161] performed a LCCBA of implementing utilidor infrastructure in New York City against a baseline of current "cut and cover" direct burial of utility infrastructure practice (current practice) for the Utilidor Working Group. The team was provided with City cost data from five roadway reconstruction projects in Lower Manhattan that were completed as part of the post-9/11 reconstruction and City cost data for subsequent related DOT roadway resurfacing projects as potential case study projects. After applying selection criteria, consisting of cost, subsequent roadway resurfacings, zoning classification, level of vehicle congestion and impacts on residents, to the five projects, the team selected the Beekman Street Project (HWMWTCA6E), which project also did not have a subway tunnel in the public right of way, as the case study project (Case Study Project). The Case Study Project had the second highest city initial cost, the third-largest number of subsequent "street opening" permits issued by DOT and the fourth highest number of 311 complaints, with a high proportion of roadway-related complaints; is located within three Commercial zones (C6-4, C5-5 and C5-3) and a Residential zone (R8); and, has an average of 11.775 vehicles passing through. With respect to "street opening" permits, the team assumed that 1/3 of them resulted in actual street cuts.

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[158] *Idem* Cost sharing and adjustments as well as stakeholder rights and responsibilities with respect to the utilidor will be negotiated in a project agreement as part of project initiation, which will also include financing and operations details. *Idem*

[159] *Idem*

[160] *Idem;* see pp. 5-14 for the model detail.

[161] Mei Butler, Yuya Ikeda, Haeun Kim, Sam Kraus, Jennifer Lee, Daniela Santoyo, Yufei Zhang, Xuanrui Zhou.

The students assumed in the model that there would be no occurrence of street cuts for utility repair purposes after the utilidor was placed in service; a 2.77% increase in the rate in street cuts for current practice; a 50% reduction in real property taxes paid by the private utilities; and, an annual inflation of 4%. Cost estimations in the LCCBA model did not include costs associated with subway tunnels, surrounding businesses, interference with underground uses of public spaces, or costs associated with higher traffic levels. The team estimated the costs of (1) construction of an off-site pre-fabricated utilidor using RSMeans cost data, (2) transportation of the utilidor, (3) relocation of existing utilities while the utilidor is installed, (4) installation of the utilidor, (5) resurfacing and backfilling, and (6) post-construction operation and maintenance, which the team assumed to be 10% of original construction costs. They assumed a utilidor design consisting of a separate access point doors for personnel and for equipment, space from surface to access points for personnel and for equipment, installation of pipes and conduits, smart infrastructure equipment; hangers or shelves to support utilities, ventilation, the main structure, fill material and waterproofing, with a final initial cost of $69,326, 493.[162]

The Case Study Project in 2010 was the counterfactual and the utilidor was the model for the LCCBA model. The time period for the counterfactual in the LCCBA model was 100 years as the utilidor was assumed to have an expected useful life of 100 years, and the students assumed two utilidor rehabilitations during the lifecycle period. The team defined five categories of stakeholders that are thought to be directly impacted by the current practice consisting of NYC government agencies and authorities, private utilities, travelling public (drivers, cyclists, pedestrians and public transportation passengers), residents and businesses. The team defined predicted benefits accruing to NYC government, private utilities, travelling public, residents and the environment.

The results of the team's estimates suggest that implementing utilidors would result in decrease road surface maintenance costs and increased lifecycle of city streets, along with

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[162] Based on ongoing work in the Utilidor Working Group evaluating the LCCBA model that future valued, to 2021, the 2010 city capital construction costs and the recently obtained 2010 associated private capital construction costs, doubling that total future valued cost, which is consistent with the literature, comes close to the team's cost estimate. It has been estimated that "[p]lacing utility lines in a tunnel approximately doubles the initial capital investment" as compared to the trenching method. C-P and C-E, "Assessing," *op. cit.,* p. 5. The trenching method—or the bottom-up method of cut-and-cover tunneling—that is the standard for the City's roadway reconstruction projects has the lowest initial cost by far among all other methods due to, "the ability [of contractors] to use specialized machines for rapid excavation and the low cost of this type of excavation." C-P and C-E, "Analysis," *op. cit.,* p. 13. This apparent initial low cost, however, is increased "in congested areas where large numbers of underground utility lines may already be installed [and] considerable care [with associated increased costs] must be exercised to ensure continuity of service and prevent damage to these utilities during excavation." *Idem*

positive environmental and social externality benefits from reduced roadway construction. Benefits to the City from utilidor implementation accrue to DOT in the form of reduced roadway maintenance costs; to DEP in the form of averted costs from water loss from pipe breaks and emergency repairs for broken pipes as well as increased worker safety and reduction in accidental strikes; to DoITT, as telecom utility franchisor, in the form of reduced damage to telecom infrastructure and increases in reliability; and, to the MTA in the form of reductions in traffic congestion and need to detour bus routes, which would contribute to increases in ridership. Benefits to private utilities accrue from the assumed reduction in real property tax and cost savings from reductions in maintenance costs, reduction in worker accidents, reduction in manhole accident compensation and reduction in major accidents, with attendant headline risks. Benefits to the travelling public accrue to drivers, cyclists, pedestrians and bus riders in the form of elimination of reduced travel time due to roadway construction. Benefits to residents are in the form of indirect benefits and can be categorized as "quality of life" indicators related to noise pollution, air pollution, unimpeded use of public space and reductions in utility disruptions. Environmental benefits accrue from reductions in carbon emissions from delayed traffic and the construction work itself, reductions in construction and demolition waste from the construction work and reductions in lost water.

Overall, the LCCBA model shows, for the Case Study Project, that the estimated net present value (NPV) of the current practice over 100 years is $24 billion, while the NPV of a utilidor is $429 million, with a benefit-cost ratio of 377.2. The team found at least a 90% reduction in costs in all impact categories from a utilidor as compared to current practice, with the decrease in street cuts as the main cause for the cost reductions. Sensitivity analyses, adjusting four factors (increasing the cost of the utilidor; increasing the utilidor maintenance cost; reducing the projected street cuts; and increasing the discount rate), resulted in the utilidor still having a positive NPV. The LCCBA represents an excellent first look, with a directional "order of magnitude" sense, at the long-term cost savings that are possible by moving from current practice and implementing utilidors as part of the City's planned roadway reconstruction program. In reviewing the LCCBA, the Utilidor Working Group observed several aspects of the LCCBA model that will need to be refined. See Appendix B for a list of potential revisions to this LCCBA model.[163]

Subsurface Spaghetti Problem—Poster Child for Recursive Collective Action Problem. Having the LCCBA model that demonstrates the long-term benefits of implementing utilidors over its long-term costs, as compared to the *status quo* direct burial method, is an excellent bit of policy analysis to have in hand to help move the idea in the direction of action. But stakeholder

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[163] T+G will be proposing an experiential learning project to revise this LCCBA, among other things, to the Columbia/SIPA capstone program for the academic year 2021-2022 program.

relationships, mostly of a legal nature, underlie, and may be a root cause of, the spaghetti subsurface condition. The rationality revealed by the best LCCBA may not be able to move the stakeholders toward action. The subsurface spaghetti problem issue area exhibits characteristics amenable to "learning through policy analysis" due to its medium level of conflict, where there is a "mix of policy core and peripheral beliefs and policy positions involved" and coalitions are "willing to alter some beliefs and policy positions on the basis of analytical results," and its professionalized analytical forum that "[e]hances the role of analysis in constraining the scope of plausible claims made in policy debates" because "[p]articipants are admitted on the basis of professional/technical competence and thus *share common bases for assessing analytical claims* (emphasis in original)."[164] Yet, this issue area, despite having these characteristics and various policy analyses performed, has vexatiously avoided resolution, which requires another analytical concept to help understand the impediments and establish a path forward for resolution.

A recursive collective action problem is one "in which the aggregate of multiple stakeholders' individual rational decisions lead to a collectively irrational outcome, with "iterative, self-exacerbating structures that render them particularly destructive," and which require a "particularly robust form of coordination" to solve.[165] The aggregation of individually rational decisions by the City, as owner of the surface and subsurface PROW, and each of the public and private utility stakeholders operating their businesses under the PROW creates "collectively self-defeating or even self-worsening outcomes" that can be resolved by "the presence of a collective agent empowered to act on behalf of all parties to optimize joint outcomes."[166] The spaghetti subsurface problem is a poster child for a problem created by this recursive collective action phenomenon (RCA).[167]

The conditions for RCA consist of "a situation in which (1) multiple decisions that are individually rational in the absence of coordination (2) aggregate into collectively irrational outcomes, the outcomes of which then (3) render it rational for agents to take yet more decisions along the same lines as in (1), thereby compounding the irrationality at work in (2), ad

[164] Hank Jenkins-Smith, *Democratic Politics and Policy* Analysis, (Brooks/Cole Publishing Company: 1990), p. 103.
[165] *Ibid.,* p. 3
[166] Robert C. Hockett, "It Takes a Village: Municipal Condemnation Proceedings and Public/Private Partnerships for Mortgage Loan Modification, Value Preservation and Economic Recovery," Cornell law School, Legal Studies Research Paper Series, No. 12-12 (http://ssm.com/abstract=2038029), p. 2.
[167] Robert Hockett, "Recursive Collection Action Problems: The Structure of Procyclicality in Financial and Monetary Markets, Macroeconomics and Formally Similar Contexts," *Journal of Financial Perspectives*, Vol. 3, No. 2, 2015, p. 3. "[M]any familiar regulatory and policy challenges . . . all constitute instances of the phenomenon under consideration," and other examples, which are variants of the "commons" tragedy, include "asset price bubbles and busts, consumer price inflations and debt deflations, bank runs and financial panics, "paradoxes of thrift" and "liquidity traps" *Ibid.,* pp. 3, 5.

infinitum."[168] The first two conditions make the problem one of collective action, while the last condition makes it recursive, and all three are necessary for a problem to be a RCA problem. The concept of individually rational behavior is based on standard economic theory, which includes freely-made decisions aiming at a maximization of an end result—typically profit while maintaining public service commission standards of user rate affordability in the private utility setting, and maximizing public investment while maintaining affordable rates in the public utility setting.[169] In RCA, however, each of these actors "doing the individually rational thing in isolation can issue in everyone doing the collectively irrational thing in aggregate, in a manner that not only prevents maximization of what each agent individually prefers, but actually can maximize what each individual disprefers."[170]

The concept of collectively irrational behavior "involves subversion of precisely that end which the agents are rationally seeking in their disaggregated, individual capacities."[171] In short, it leads to collective self-defeating outcomes, as shown by user rates being insufficient to maintain system state of good repair and system efficiency due to the avoidable future costs as fiscal waste built into the models for assessing fees and an inability to translate incremental increases in rates to support modern technology that will save money in the long term and improve system efficiency outcomes, as well as increase system sustainability and resiliency with associated indirect environmental and social benefits (see **Planning and Managing Subsurface PROW Utilization: Sustainable, Resilient and Smart** above).

The concept of recursively self-exacerbating focuses on the iterative or "self-amplification characteristics" with impacts akin to waves on a seawall, which, in economic lingo, is "procyclical" or "tending to magnify the fluctuations in an economic cycle."[172] Continuing the 19th century direct burial method, with our feet firmly in the 21st century, for aging infrastructure systems not only continues to cost more over the long term, with diminishing returns in terms of system performance (or fails over the long-term to avoid avoidable costs), which is ultimately wasteful, but also increases the chances of subsurface degradation and accidents and reduces system resiliency when climate impacts in increasingly dense urban environments become as time passes. The continuing failure of individual actors to "adjust their preferences simply repeat[s] their [self-defeating] maximizing actions, since their ends are still unfulfilled and, indeed, less fulfilled than they would have been had not everyone acted

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168 Hocket (2015), *op. cit.,* p. 6; or at least ad suboptimum (*Ibid*., p. 9)
169 *Ibid*, p. 7.
170 *Ibid.,* p. 8.
171 *Idem*
172 *Ibid.,* p. 9; https://www.lexico.com/definition/procyclical accessed 04-19-21 @ 9:25 p.m.

individually rationally and the increasingly ad suboptimum condition moves further from the goals of initial rational actions."[173]

To resolve an RCA problem, it is necessary to address it though its structure, focusing initially on "the collective aspect of their collective irrationality; and second, [on] the rational aspect of their individual rationality" and understanding that "[f]or collectively irrational outcomes to be possible, something has to be missing—some prerequisite to collective rationation and resultant action," which "is a locus or situs at which collective rationation and associated rationality can operate."[174] An entity within the activity sphere that is "able to act in concerted fashion, either directly or via some agent duly authorized to act in the name and on behalf of all in the collectivity" is the last thing to identify.[175] As is the case for the subsurface spaghetti problem issue area, "[w]here the collectivity in question is, or is part of, a polity or some other aggregate of persons in whom the attributes of sovereignty vest—that is, a state—the most common form of agency is a government or government instrumentality."[176] In economics, especially public economics terms, which identifies negative externalities emanating from private arrangements, "government is the collective agent par excellence," as "the collective agent under whose ultimate collectivity-vested authority, and with whose supplemental assistance of various kinds, all individual and other, substate agents will operate."[177] In a market economy that is regulated, such as the subsurface spaghetti subsurface environment, it is the role of government to adjust for negative externalities in the RCA context and "render it no longer individually rational to do that which, when all do it, results in collective, and hence individual, calamity."[178]

Government must "act in the name of all to change the calculus of each, such that certain erstwhile individually rational decisions that aggregate into collectively irrational outcomes cease to be individually rational."[179] It must change the individual actors' calculus so that direct burial of utility infrastructure and failure to share locational data under government permission for them occupy the subsurface PROW for private activities serving a public purpose is no longer individually rational. Only government, in the public interests of utilities' long-term financial and environmental sustainability and long-term infrastructural system efficiency and resilient performance to provide public services, can reform the state regulatory environment for those utilities operating within the City, so that the rate tariffs for these utilities include

[173] *Idem*
[174] *Ibid.*, p. 23.
[175] *Idem*
[176] *Ibid.*, p. 24.
[177] *Idem*
[178] *Idem*
[179] *Idem*

reimbursement for incrementally increased capital costs for financing utilidors and the modern ICT enabled infrastructure installed within, in order to avoid wasteful future costs. These wasteful and avoidable future costs, with associated increased rates, cannot keep aging subsurface infrastructure in a state of good repair at a time when it is necessary to transform the old systems buried in the dirt to be able to function under predicted environmental stress.[180]

The City's Capacity to Act—Primer on Applicable Laws. If economic analysis of utilidor implementation did not already point to the municipality, in this case, New York City, as a municipal corporation with responsibility for the surface and subsurface PROW and with a public water and sewer utility, as a significant beneficiary of utilidor implementation, with the private utilities also benefitting in varying degrees, analysis of the City's capacity to act (CTA) would lead to the conclusion that the City is the appropriate collective agent to solve for the its collective recursive action spaghetti subsurface problem.[181]

Analysis of a city's CTA points to a city's "capability to form and implement policy and programs on different matters" and is a key to evaluating its ability to change the calculus of individual actors with respect to the subsurface PROW, which is a system with "interlinked networks of formal and informal institutions (including energy markets and regulatory systems), technologies, and stakeholders that influence policies, technology decisions and supply and demand choices for different forms of energy within a city or urban region."[182] CTA analysis will also outline how the City's authority's implementation effort can be structured for success because it also assesses "local capacity in relation to other tiers of government and private sector and non-governmental organization stakeholders."[183]

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[180] That all said, for the heavy lift required for government action, see Han Admiraal and Antonia Cornaro "Engaging Decision Makers for an Urban Future," *Tunnelling and Underground Space Technology*, 55 (2016) 221-223, about convincing government for large subsurface construction projects. Government includes elected officials, who are politicians, and public servants, who form the bureaucracy, who respond to the public—private sector businesses and individual people who make up society. Just as engineers are insufficient alone to move government in a rational direction, so too economic-based cost benefit analyses, showing benefits in excess of costs. To move government to look to the subsurface as a solution to surface problems and act, the story of Boston's Big Dig project may be helpful. "Salvucci (2003) says the following about Boston's Big Dig project: 'Only by understanding the extremely high benefits of the project and sheer necessity to the regional economy is it possible to understand how, in the usually fractious political environment of Boston, broad bipartisan political, business, labor, and community support have continued in the face of serious increases in cost, most of which are borne by the City and the State." What Salvucci indicates is that it requires a broad coalition of stakeholders to enable projects. It is not just the politicians that need to be convinced; the real decision makers are those that both formally and informally influence the outcome of projects." At p. 222.

[181] Luo *et al., op. cit*., p. 4.

[182] *Idem*

[183] *Ibid*., p. 3.

While CTA analysis of cities' local energy planning policies and program implementation reveals the articulation of broad climate change action goals, but extremely limited capacity to act in this space,[184] the implementation of utilidors, which has significant environmental sustainability and resiliency impacts, however, is technically more within a city's capacity to act and its span of control as outlined below. Thus, utilidor implementation, which is the *sine qua non* element of a smart city, represents a back door to the City's broader environmental sustainability and resiliency initiatives, and is an efficient way for to achieve elements of these broad initiatives.

The City's paradigm consists of public ownership of the PROW—from the road surface on through to the dirt beneath, in trust for use by the public with various municipal obligations imposed by State and local laws.[185] Below the PROW surface there are multiple public subsurface uses (mass transit and water and sewer facilities) and multiple private subsurface uses, typically by publicly regulated private utilities; State law and local laws establish the authority by which the City grants access to the subsurface PROW for private uses.

In order for the City to plan, manage and optimize the subsurface PROW to solve successfully both subsurface PROW, such as the subsurface spaghetti problem, and other surface PROW problems, it must have "sufficient policy competency, or capacity to take action to deliver on the goals laid out in [its] plans"[186] To be successful in a long-term undertaking of this nature, the City must have the capacity, across all aspects of the effort, to perform with respect to a number of wide-ranging factors such as management and organization, governance and policy, technology, infrastructure and the ability to finance it.[187] A city's CTA to act is established and constrained by superior government laws that create the rights or jurisdiction of cities to act , which can be broad in some areas and narrowly defined in others.[188] Cities do not exist independently, and "key attributes of local authority—its institutional structures, its responsibilities, and its power of taxation—are all derived from state or national government

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[184] *Ibid.,* pp. 6-10; this begs the question of whether climate change initiatives should be really be done, not at a city level, but at a higher level of government, such as the state level in the U.S., which has a larger jurisdictional area and span of control in addition to regulatory powers over the private utilities.

[185] "The City possesses inalienable rights to its streets, highways, avenues . . ."

[186] Stephen Hammer, "Capacity to Act: The Critical Determinant of Local Energy Planning and Program Implementation," Working Paper, Columbia University Center for Energy, Marine Transportation and Public Policy. Presented at the World Bank's 5th Urban Research Symposium (Cities and Climate Change), Marseilles, France, June 28-30, 2009, p. 1.

[187] Hafedh Chourabi, Taewoo Nam, Shawn Walker, J. Ramon Gil-Garcia, Sehl Mellouli, Karine Nahon, Theresa Pardo and Hans Jochen Scholl, "Understanding Smart Cities: An Integrative Framework", *2012 45th Hawaii International Conference on System Sciences*, pp. 2291-2294.

[188] Hammer, *op. cit.,* p. 2.

allocations of authority."[189] What follows is a primer of applicable local law bearing on utilidor implementation for use going forward.

State Law and the Roadway. The City's PROW, consisting of any road, street, alley, public place, public driveway of any other public way, is considered a "public highway,"[190] and the area of a street includes sufficient surface to permit clearance for traffic and the necessary subsurface for a foundation for the surface and for water mans, gas pipes, sewer pipes and other conduits and, by statute, generally includes the sidewalk, from the curbing to the lot lines alongside it that is intended for pedestrians.[191]

Under State law, title or ownership to streets, especially the ancient streets of New York City, is generally in the municipality[192] and is held in trust for the public use, both for the purpose of public travel and as a means of access to and egress from abutting property, and is considered to be inalienable.[193] The City Charter follows this general rule by declaring "[t]he rights of the city in and to its water front, ferries, wharf property, bridges, land under water, public landings, wharves, docks, *streets, avenues, highways*, parks, waters, waterways and all other public places ... to be inalienable," but this inalienable character is not a bar to the City from being able to grant franchises, permits and licenses with respect to this inalienable property.[194] In the United States property ownership of the surface includes the subsurface and whatever of value

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[189] *Idem.* The legal concept of u*ltra vires* or "beyond the powers", a concept in the United States that controlled private corporation authority to act, controls local government action in the United Kingdom. The "Dillon's Rule" doctrine controls in many of the 50 United States and refers to an old case in one state that courts adopted elsewhere in statutory interpretation cases, which holds that, as creatures of the state, the explicit statutory language granting local governments authority to act is hard constraint and the statute cannot imply necessary or convenient powers incidental to what is explicitly in the statute. States are constrained by the concept of pre-emption when federal statutes explicitly state the federal government controls the field of legislation.

[190] New York State Veh. & Traf. Law, §§ 134, 148; New York State High. Law, § 2(4)). The original work on which this and the next three paragraphs are based on a 2012-2013 Town+Gown + Brooklyn Law School legal research and analysis project conducted by Lior Sapir as part of the "Multi-Purpose Utility Corridor Hypothetical: Telecom, Gas and Electric Utility Analysis" research project abstracted in *Building Ideas*, Vol. 4, pp. 15-16, @ https://www1.nyc.gov/assets/ddc/downloads/town-and-gown/building-ideas-4.pdf.

[191] Eugene McQuillan, *The Law of Municipal Corporations, 3rd Ed.*, (Clark Boardman Callaghan: New York, 1971), §§ 30.06, 30.11; although outside of New York City it is held that the fee of the land in the street is presumed to belong to the abutting owner, burdened with a public easement.

[192] *Ibid.,* §30.32.

[193] *Ibid.,* §30.36. New York case law holds that, as the representative of the state, the legislature has the absolute and unrestricted control and authority over the public highways and streets, except as qualified by the constitution. In the United States, the state has the ultimate control of and ability to regulate the streets, which is often delegated to municipalities, and this delegated use of the street is designed for the public at large, as distinguished from the legal entity known as the city, or municipal corporation, and its residents. The management of streets may be characterized as a municipal duty relating to governmental affairs and municipal home-rule provisions of state constitutions do not ordinarily withdraw legislative power to enact general laws or laws relating to municipal streets and affecting their public use. (*Ibid.,* § 30.39)

[194] New York City Charter, § 383.

lies beneath. In the City, to the extent the subsurface PROW soil and mineral rights ever become relevant, the City would own them; in addition, municipal streets are entitled to lateral and vertical support to keep them in place.[195]

State law authorizes the City to "lay out, establish, construct, maintain, operate, alter and discontinue streets, sewers and drainage systems, water supply systems, and lighting systems, for lighting streets, public buildings and public places, … and to cause the necessary explorations, investigations, examinations, surveys, maps, plans, specifications and reports for its proposed water supply systems or extensions thereof to be made for such purposes ..."and to "grant franchises or rights to use the streets, waters, water front, public ways and public places of the city."[196] New York case law holds that a municipality has a non-delegable duty to construct and maintain its streets and highways in a reasonably safe condition.[197] The State confers the power to 'regulate' streets to municipalities, which power is generally limited to maintaining them for the purposes for which they are established, and municipal regulations in this exercise of delegated power can take the form either of prohibiting certain uses of or encroachments on the street, or of granting a right to use the streets in a particular way or for a particular purpose.[198]

State law also requires cities with the power to lay out, adopt and establish streets, highways and parks to establish an official map, in order to conserve and promote public health, safety and general welfare, which map must show such streets, highways and parks, will be deemed to be final and conclusive with respect to the location and width of streets, highways, drainage systems and the location of parks, and must be amended to show changes to the streets, highways and parks.[199] As discussed below, the Charter assigns a lion's share of responsibility with respect to the PROW to DOT, and assigns the responsibility with respect to the map of City street to DCP.

<u>DOT Charter Powers with Respect to PROW.</u> In Section 2903, the Charter enumerates the powers and duties of the DOT Commissioner with respect to transportation and grants the "charge and control of [various] functions relating to the construction, maintenance and repair of public roads, streets, highways, parkways, bridges and tunnels," which functions specifically include:

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195 McQuillan, *op. cit.,* §30.38.
196 New York General City Law, Article 2A, §§ 7, 10.
197 Friedman v. State of New York, 67 NY2d 271, 502 NYS2d 669, 493 NE2d 893 (1986); Highways Law §102, 139.
198 *Ibid.,* §30.40.
199 New York General City Law, Article 3, §§ 26, 29.

> regulation of the use and transmission of gas, electricity, pneumatic power and steam for all purposes in, upon, across, over and under all streets, roads, avenues, parks, public places and public buildings; regulation of the construction of electric mains, conduits, conductors and subways in any streets, roads, avenues, parks and public places and the issuance of permits to builders and others to use or open a street; and to open the same for the purpose of carrying on the business of transmitting, conducting, using and selling gas, electricity or steam or for the service of pneumatic tubes, provided, however, that this subdivision shall not be construed to grant permission to open or use the streets except by persons or corporations otherwise duly authorized to carry on business of the character above specified.[200]

With respect to a Utilidor Working Group's early inquiry about who controls the determination about what infrastructure facilities are to be located above ground and what are to be located underground, old provisions of the City's Administrative Code indicated that the Board of Estimate, which was eliminated by the 1989 Charter Revision Commission process, gave the Board of Estimate the discretion to require undergrounding "whenever practicable" in Manhattan and the Bronx, and whenever "desirable and practicable" in Brooklyn, Queens and Staten Island.[201] This discretion is consistent with DOT's powers described above.

The regulations referred to above are in DOT's Highway Rules (the Rules) and govern current practice with respect to access to the subsurface PROW.[202] The Rules require owners or their contractor to file permits complying with Section 2-02 of the Rules for (i) street openings and excavations and (ii) general construction activity, among other things. The Rules also cover opening underground street access covers, transformer vault covers and gratings and other types of sidewalk, curb and roadway work. All permittees must comply with the most recent version of the Federal Highway Administration's Manual on Uniform Traffic Control Devices for Streets and Highways and the New York State Supplement related to uniform traffic devices.[203] The Rules require permittees and owners of underground facilities to comply with State of New York Industrial Code Rule 753 relating to construction, excavation and demolition operations at or near underground facilities, which is the One-Call Notification Program.[204]

[200] Charter § 2903 (5).
[201] New York City Administrative Code, §§ 24-406 through 24-419.
[202] Rules of the City of New York, Title 34, Chapter 2. https://www1.nyc.gov/html/dot/html/infrastructure/19-152.shtml 04-07-21 5:45 p.m.
[203] Rules, § 2-01.1.
[204] Rules, § 2-11(c)(1)(i); Rules, § 2-02 (g)(1) refers to Rule No. 53.

With respect to street openings and excavations, which is the current practice in the subsurface PROW, the Rules requires a permit[205] for any excavation in any street, and DOT will issue separate permits "for each 300 linear feet of a block segment and for each intersection where work is to be performed." [206] In addition to specific requirements for plumbing work,[207] for street openings and excavations with respect to "any work performed pursuant to a valid contract with a local or state governmental entity requiring a street opening or excavation," DOT will issue a Street Opening Permit only "to the contractor retained by the local or state governmental entity to perform the work requiring the street opening or excavation;" and, contractors working for companies under a franchise or revocable consent must receive permits before any "excavation or street opening pursuant to a franchise or revocable consent."[208]

If there are street closing permits for excavation and restoration activities, the permittees must also notify NYPD, FDNY's Communications Centers and DOT at least 24 hours before non-emergency work commences.[209] Conditions of permits require permittees to take necessary precautions to protect and prevent damage to pipes, mains, conduits, and other underground facilities at their own expense.[210] The Rules also impose mark out requirements on permittees consisting of delineating the proposed area of excavation, ascertaining, to the extent possible, the precise area of excavation and marking the corresponding area 15 feet to the right and to the left with temporary white paint by using a continuous line, dots marking a radius or arc, or dashes outlining the excavation project.[211]

Conditions of permits require permittees to conduct all current practice work in accordance with the most recent version of the standard highway specifications available from DOT and DDC indicating required construction materials (standard specifications), the most recent version of the standard details of construction, available from DOT and DDC, which contains drawings showing required dimensions of items to be constructed (standard detail drawings), and additional provisions of the Rules.[212] The Rules specify: the manner of breaking existing

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[205] Rules, §§ 2-11(b)(1), 2-02.
[206] Rules, §§ 2-11(a)(1), (b)(2).
[207] Rules, § 2-11(a)(1)(i).
[208] Rules, § 2-11(a)(1)(ii), (a)(2).
[209] Rules, § 2-11(e)(1)(i).
[210] Rules, § 2-11(c)(1)(ii).
[211] Rules, § 2-11(c)(1)(iii).
[212] Rules, § 2-11(c)(2). In 2008, DOT released *Sustainable Streets 2008 and Beyond*, DOTs strategic plan to implement the City's PlaNYC program, which sought to transform the City's streets and squares into more people-friendly places with an environmentally sustainable focus, and in 2009, DOT released its Sustainable Streets Design Guidelines, which added various sustainability-related amenities to the standard street design. DOT's Third edition of its Street Design Manual with its emphasis on infrastructure separating pedestrians and cyclists from motorists for public safety purposes, carries forward the sustainability elements, including permitting the use of porous

pavement, including the types of tools that are permitted;[213] requirements for excavation that include a separate permit for tunneling or jacking between two or more street openings and a requirement for full trenching for all waste line repair/connections;[214] requirements to maintain traffic during work;[215] temporary sidewalk closings;[216] work site maintenance;[217] material storage;[218] post-work completion backfill and compaction conducted pursuant to the standard specifications and standard detail drawings requirements, with recycled asphalt millings permitted for backfill and an obligation to re-fill and re-compact if the pavement sinks more than two inches from the surrounding existing surface during the life of the restoration;[219] the nature of temporary asphaltic pavement during the work;[220] the use of plating and decking during the work to make them safe for vehicles and pedestrians;[221] requirements for the concrete and asphalt base materials and base restorations, which must conform to the standard specifications and standard detail drawings requirements, with conduits or pipes installed at the greater of a minimum depth of 18 inches from the roadway surface or below the base;[222] requirements for the wearing course material and related restoration issues conforming to the standard specifications and standard detail drawings requirements, an obligation to install new, properly compacted backfill if the permanent restoration settles more than two inches below the surrounding existing pavement during its existing guarantee period and all trenches to have a minimum opening width of 18 inches;[223] and, requirements with respect for concrete pavements.[224]

The City's quality control program requirements require permittees engaged in street openings to provide smooth riding surfaces throughout the guarantee period on their respective restorations and maintain a documented quality history of the restoration with a record of inspections made at optimum intervals to assure conformance to the guarantee, which DOT is

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asphalt and pervious concrete and permitting a variety of landscape features in the streets, which means that cutting into the streets now means cutting into bike and pedestrian safety infrastructure and sustainable roadway infrastructure, increasing the costs of restoration.

[213] Rules, § 2-11(e)(2).
[214] Rules, § 2-11(e)(3).
[215] Rules, § 2-11(e)(4).
[216] Rules, § 2-11(e)(5).
[217] Rules, § 2-11(e)(6).
[218] Rules, § 2-11(e)(7).
[219] Rules, § 2-11(e)(8).
[220] Rules, § 2-11(e)(9).
[221] Rules, § 2-11(e)(10).
[222] Rules, § 2-11(e)(11).
[223] Rules, § 2-11(e)(12); when a street opening is 12 inches or less from the curb, the entire pavement between the opening and the curb shall be excavated and replaced in kind, in accordance with the applicable Standard Detail Drawing #H-1042, inspected and repaired where necessary, a new wearing course installed from the curb to the street opening, with these areas included in the permittee's guarantee. Rules, § 2-11(e)(12)(v).
[224] Rules, § 2-11(e)(13).

entitled to request.[225] Permittees may propose the use of experimental methods or materials, subject to DOT approval, and may propose an alternative quality control program, which may waive some of the standard quality control program requirements, subject to DOT approval.[226] Additional requirements, during the work, provide DOT with ways to assure ongoing quality control of roadway surfaces and include a street opening location form (cutform), which the permittee must keep on file and which DOT is entitled to request with minor penalties attaching for failure to produce; the cutform includes a sketch showing the exact dimensions and location of the restored area, and a description of the opening or trench defined by distance in feet from the nearest intersection and from the nearest curbline; the street opening permit number; the date of completion of the final restoration; the name of the final pavement restoration contractor; and, a compaction report certified by a New York State licensed professional engineer.[227] When the work is complete, the permittee is required to embed color-coded permanent markers indicating which newly submerged equipment that required cutting and excavation corresponds to what type of infrastructure.[228] The Rules also create two guarantee periods for the permittee's work—three years for work on unprotected streets and five years for work on protected streets—and during that period, the permittee is responsible for permanent restoration and maintenance of street openings and excavations.[229]

In order to protect the integrity of the City's roadway reconstruction projects and DOT's roadway resurfacings that are at risk from frequent cuts and excavations in the absence of utilidors, the Rules create the term "protected street"[230] and restrict the issuance of permits authorizing street opening activity in a protected street for a period of five years from the completion of the street improvement with the exception for emergency work.[231] The concept of a "protected street" is intended to increase the chances that private utilities will coordinate their subsurface work at the same time the City's roadway reconstruction projects have the streets open, but the Rules put the burden on future permittees to contact DDC to determine whether a street is scheduled to be rebuilt under a street reconstruction project.[232]

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[225] Rules, § 2-11(e)(15)(i)-(iii).
[226] Rules, § 2-11(e)(15)(iv)-(v).
[227] Rules, § 2-11(e)(16)(i).
[228] Rules, § 2-11(e)(14)(iv).
[229] Rules, § 2-11(e)(16)(ii)
[230] Rules, § 2-01. A city roadway reconstruction project occurs when DEP has planned for water main and sewer main and catchment infrastructure replacement and DOT has planned for surface roadway reconstruction for those streets and at the same time of DEP's infrastructure replacement, which projects, after being adopted in the City's annual capital budget, become roadway reconstruction design and construction projects that are managed by DDC.
[231] Rules, § 2-11(f).
[232] Rules, § 2-11(f)(2).

While the City's roadway reconstruction projects, which require opening up the streets for long periods of time due to the multiplicity of the utilities' infrastructure, represent opportunities for the private utilities to do more than protect their infrastructure, as minimally required by law and current franchises, and instead upgrade their infrastructure and/or remove old non-functional infrastructure, the City cannot at present require the private utilities to take advantage of these opportunities, which contributes to the multiplicity of street cuts after roadway reconstruction projects are complete. "Operating as a penal provision, New York City Administrative Code § 24-521 requires utility companies to relocate certain facilities when necessary to accommodate public works projects. If a utility does not promptly comply with a removal order from the City, this [provision] subjects the utility to a fine and its executives to possible imprisonment."[233]

To receive a non-emergency permit in a protected street, the permittee must demonstrate to demonstrate that the need for such work could not have reasonably been anticipated before or during earlier road resurfacing or roadway reconstruction project, although the DOT Commissioner may approve a non-emergency permit in a protected street upon finding a necessity for the work.[234] There are additional heightened requirements for restorations for work in protected streets during the five-year period, compared to work in non-protected streets, which include a detailed certification by a State-licensed engineer and an option for DOT to inspect the work.[235] The Rules also provide an expedited permit process for emergency work that requires opening the street and excavation, with restorations to be made with in-kind materials.[236]

With respect to general construction activity, which would also include current practice projects involving street openings and excavation discussed above, Section 2-05 of the Rules requires owners or their contractor[237] to file a separate construction activity permit[238] for each of the following activities, unless otherwise provided by the Rules or by permit stipulations:

(i) Placing construction material on street during working hours
(ii) Placing construction equipment other than cranes or derricks on the street during working hours
(iii) Temporarily closing sidewalk

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[233] *City of New York* v *Verizon N.Y., Inc.*, 2005 NY Slip Op 02360, 4 NY3d 255, March 24, 2005; see Administrative Code §§ 19-149, 19-150.
[234] Rules, § 2-11(f)(1).
[235] Rules, § 2-11(f)(4).
[236] Rules, § 2-11(g).
[237] Only by the general contractor or the construction manage Only by the general contractor or the construction manager r Permits for construction activity involving building operations shall be obtained; Rules, § 2-05(a)(2).
[238] Rules, § 2-02.

(iv) Constructing temporary pedestrian walk in roadway
(v) Temporarily closing roadway
(vi) Placing shanty or trailer on street
(vii) Crossing a sidewalk
(viii) Placing crane or derrick on street during working hours
(ix) Storing construction material on the street during non-working hours
(x) Storing construction equipment on the street during non-working hours[239]

The Office of Construction Mitigation and Coordination (OCMC), a unit within the Department that is responsible for providing traffic stipulations and coordinating construction activity on City streets, may need to approve such permits.[240] The Rules cover the conditions for the placement or storage of construction material and equipment (other than cranes) on the street.[241] Additional permits will be required to close sidewalks temporarily under certain conditions[242] and, under certain conditions, DOT may require permittees to construct temporary pedestrian walkways in the roadway;[243] to close the street if it is necessary to close one or more lanes of the roadway or if the project requires blasting operations or the firing of shots;[244] to place construction shanties or trailers on the street;[245] and, to cross a sidewalk for the delivery or removal of any construction material or equipment on the street by vehicle or motorized equipment where there is no approved drop curb (driveway), with a maximum of two sidewalk crossings per each 300 linear feet.[246] There are specific permit requirements for cranes on street operations.[247]

The Rules cover the opening of underground street access covers, transformer vault covers and gratings in streets and sidewalks to perform work as well as impose maintenance obligations.[248] The Rules cover work on sidewalks (which is the responsibility of abutting property owner), curbs and roadways for uses other than those requiring a Certificate of Occupancy or letter of completion from DOB, with material and design requirements, permitting professional self-certification, and requiring coordination with city, state (including authorities) and federal capital projects.[249] Finally, the Rules permit microtrenching for DoITT's telecommunications franchisees pursuant to DoITT's microtrenching rules, which DOT incorporates by reference as

[239] Rules, § 2-05(a)(1).
[240] Rules, § 2-05(c)(4).
[241] Rules, § 2-05(d)(1)-(19).
[242] Rules, § 2-05(e).
[243] Rules, § 2-05(f).
[244] Rules, § 2-05(g).
[245] Rules, § 2-05(h).
[246] Rules, § 2-05(i)(1)-(2).
[247] Rules, § 2-05(j)(1)(ii), (2)-(7); (k)-(m); Rules, § 2-05(j)(1)(i) cover permit requirements for Building Operations.
[248] Rules, Section 2-07.
[249] Rules, Section 2-09.

its Rules, with DOT issuing a street opening permit and the franchisee complying with the Rules for restoration.[250]

Chicago's Practice for Subsurface PROW Infrastructure Damage Prevention. Chicago's 1992 flood of the Chicago Loop, which "'was caused by sheet pilings being driven into a 'freight tunnel' beneath the Chicago River . . . resulted in nearly to $2 billion in damages and forced people to ask the question, 'How could this accident have been prevented?'"[251] Chicago's civic leaders and utility stakeholders, responded with codifying an innovative "plan to prevent infrastructure damage." Like all American cities, Chicago's historical urban growth resulted in increasingly denser underground infrastructure that was matched by the increasing "risk that utility damage would have severe consequences," but it took the Great Chicago Flood to unleash a comprehensive plan to reduce the risk that is ever present.

The comprehensive plan began creating, within the Division of Infrastructure Management (DIM) of Chicago Department of Transportation (CDOT), of the Office of Underground Coordination (OUC) whose mandate is "to promote efficiency of work in the public way, to reduce the risk of damage to existing underground facilities, and to reduce the inconvenience to the public caused by work in the public way." DIM is "responsible for overseeing any project on or under the public right-of-way in the City of Chicago."[252] CDOT's comprehensive plan takes a damage prevention life cycle approach and is effective because

- all workflows in the life cycle are under the purview of one agency, allowing for standardized rules and encouraging collaboration
- the system operated by DIM relies on technology to control its processes
    - integrated systems at OUC provides reasonable assurance that only approved projects, which are those designed to avoid damage, can move to the next stage and, eventually, to excavation

[250] Rules, Section 2-23.

[251] Jai Kalayil and Matthew Peterson, "Damage Prevention . . . The Chicago Way," *dp-PRO*, Fall 2020, p. 1. All quoted material in this section is from this article.

[252] It is not uncommon for people to assume that DDC has functions akin to those of DIM, but it does not—DDC manages the design and construction of roadway reconstruction projects after they emerge from the City's capital budget each year. See, for example, https://nyc.streetsblog.org/2021/02/10/the-stringer-plan-buses-buses-buses-and-pedestrianized-zones-bike-highways-and-far-fewer-placards/. In the City, DIM's functions are diffused across agencies, with DOT Rules covering permits for street openings and excavations and the One-Call system for agencies that are deemed operators of underground facilities. There is no single agency where DIM's mandate rests, and in many ways DDC's contractors are just one of many permittees and excavators, subject to the same requirements.

- most of the data systems have a public facing view (e.g., ChiStreetsWork, permits and dig tickets), providing an additional layer of oversight
- PROW stakeholders, including all private utility companies, although not required by law to be a member of OUC, participate in the damage prevention life cycle process and participate in reviews related to
    - the Information Retrieval (IR) process that kicks off the life cycle, where the developer requests information about facilities at a site, which information permits the developer to design a project to minimize interference with existing underground facilities
    - the Existing Facility Protection (EFP) process that begins with the developer's submission of drawings for OUC review to ensure the design complies with applicable regulations and is coordinated with other pending projects; if approved by OUC, distribution to utility owners for their review, providing the utility owners, when the proposed excavation and installation interferes with their existing underground facilities, to ask the developer to make changes; and OUC plan approval only after the design is clear of all existing utilities, reducing the likelihood of damage before excavation begins

Through OUM, DIM implements "an oversight life cycle that includes reviewing and approving project plans,[253] issuing work permits and dig tickets and enforcing compliance with CDPT regulations." After OUC approval, the developer's contractor, which must be licensed and previously approved by OUC,[254] applies for a work permit from DIM's permit office, which reviews OUC's earlier comments in the IR and EFP processes part of issuing the permit, which it posts online. Once the contractor receives its permit, it requests a dig ticket from the One-Call Notification Program, operated directly by CDOT and not through the State of Illinois,[255] which direct operation aligns CDOT staff, technology and regulations and closes control gaps.[256] Finally, Chicago's comprehensive plan's damage prevention lifecycle includes a focus on enforcement, with two dedicated inspection units, each with the authority to issue citations[257]—the Public Way inspection unit focuses on permitted work and general

[253] See IF and EFP processes discussed above.
[254] DIM/OUC uses inspection data, including citations, to identify irresponsible contractors and has the ability to deny them future permits.
[255] The City participates in the State's One-Call Notification as an operator and as an excavator.
[256] As an example, CDOT's 811 system will not allow 811 staff to issue a dig ticket in the absence of a permit that went through the IR and EFP processes.
[257] Public Way citations are prosecuted by the City of Chicago's Administrative Hearing division, while 811 citations are review by a panel consisting of representatives from the City and the utility companies.

right-of-way issues and the 811 inspection unit investigates every reported damage to underground facilities and 811 One Call violations.[258]

The results of CDOT's damage prevention lifecycle approach speak to its success. Utility hits decreased during the 2014-2017 period, when construction in Chicago was in the midst of a construction boom across all sectors with increases in excavation activity, and since then, "Chicago experienced a decrease in utility damages, highlighted by a 0.62 damage ratio in 2019."

DCP Charter Powers with Respect to PROW. Chapter 8 of the Charter grants broad authorization to the City Planning Commission and the DCP Director[259] to plan the City's development and it also specifically makes DCP Director responsible for the official City street map. In addition to authorizing the DCP Director to perform assigned functions assigned by the mayor or other provisions of law,[260] the Charter empowers the DCP Director to advise and assist the Mayor, along with the Borough Presidents and City Council, regarding the physical planning and public improvement aspects of all matters related to the development of the City[261] and makes the DCP Director the custodian of the City map, authorizing him to record all legally authorized changes on the city map.[262] The Charter makes City Planning Commission, chaired by the DCP Director, responsible for the conduct of planning for the City's orderly growth, improvement and future development, including adequate and appropriate resources for the housing, business, industry, transportation, distribution, recreation, culture, comfort, convenience, health and welfare of its population. While the practice of the City Planning Commission and the DCP Director has almost exclusively focused on the City's surface, nothing in the Charter language specifically limits their powers to the surface.

The 1989 Charter Revision, which eliminated many powers of the Borough Presidents including those that related to the City map, continued the City map, made the DCP Director its custodian and identified where the City map must be filed and available.[263] The Charter represents the sole authorization to conduct improvements or projects within the City affecting the city map,

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[258] A 2017 law mandates 811 enforcement and mandatory damage reporting.
[259] Who is also the chair and a member of the City Planning Commission, Charter, § 191 (a).
[260] Charter, § 191 (b)(8).
[261] Charter, § 191 (b)(1).
[262] Charter, § 191 (b)(3).
[263] Charter, § 198 (a)-(c). The 1989 Charter Revision continued the maintenance of a topographical bureau and appointment of a bureau director by each Borough President, but greatly diminished the topo bureau's pre-1989 functions to consist of serving as the borough's construction coordinator and consulting engineer, monitoring capital projects in the borough and providing technical assistance on construction projects. Charter, § 82 (3). There are still pre-1989 official and physical Borough maps at each topo bureau. The Charter also requires advance notice of all street closings to the topo bureau director. Charter, § 86.

and additions or changes in the City map, and review of proposed additions to or changes to the City map initiated by or referred to the City Planning Commission, must go through the ULURP process and must be reviewed and approved by the City Council.[264]

The City's uniform land use review procedure (ULURP), which is administered by DCP and subject to final review and approval by the City Council, applies to specifically enumerated categories of applications by any person or agency for changes, approvals, contracts, consents, permits or authorization thereof, related to the use, development or improvement of real property that is subject to City regulation.[265] Among the enumerated categories of relevance to current practice that must go through ULURP includes:

- changes in the City map pursuant to Charter §§ 198 and 199, which govern the City map and projects and changes in the City map[266]
- maps of subdivisions or plattings of land into streets, avenues or public places pursuant to § 202[267]
- requests for proposals and other solicitations for franchises pursuant to § 363[268]
- such other matters involving the use, development or improvement of property as are proposed by the City Planning Commission and enacted by the City Council by local law[269]

While the City's practice with respect to planning and mapping has almost exclusively focused on the City's surface, nothing in the Charter, discussed above, limits DCP's powers to focus only on the surface. Impediments to focusing on the subsurface, however, include the lack of subsurface infrastructure location data for mapping and the absence of any requirement for agencies or private utilities to submit subsurface plans to DCP, which would translate into a process for DCP review and approval.[270]

However, it should be noted that New York City has moved away from what used to be the standard for planning—city-wide planning. The 1975 Charter Revision eliminated the 1936 requirement for a Master Plan and replaced it with flexible requirements for City-wide and local plans for the City's development and improvement of the City.[271] The 1989 Charter Revision

[264] Charter, § 199 (a)-(b).
[265] Charter, §§ 197-c, 197-d.
[266] Charter, § 197-c (1).
[267] Charter, § 197-c (2).
[268] Charter, § 197-c (6).
[269] Charter, § 197-c (12).
[270] At the present time only subsurface project that require easements would go through the zoning process.
[271] 1975 Charter Revision Commission Report, pp. 11, 20-21. The 1975 Commission specifically referred to the Master Plan requirement as "an anachronism" and noted that the Planning Commission had not conducted a Master Plan in the 37 years since it was first required in in the 1936 Charter revisions. It went on: "The Master

introduced strategic planning role for the Commission, requiring it to release, every four years, a comprehensive zoning and planning report stating its planning policy, reporting on its planning efforts and analyzing portions of the zoning resolution that merit reconsideration in light of the planning policy.[272]

> *Where's the Data?* The short answer is that there is precious little accurate digitized subsurface PROW infrastructure location and condition data, and all utility owners are loath to share whatever they have with each other and with the City. And, while applying principles of land economics to the planning, management and optimization of the PROW subsurface space may help initially to overcome the lack of subsurface PROW location and condition data of both public and private utility infrastructure, which can provide an order of magnitude to identify paths for action at both high-level and specific project levels, there is no substitute for actual data.
>
> Surface development directly relates to subsurface development—and both are limited resources. If surface density is an indicator of a City's success in performing its function as a city, subsurface density—a mirror image of the density above--is also an indicator of the City's success as a city. In the absence of meaningful subsurface PROW data, the principles of land economics permit an initial assumption that density distribution of subsurface PROW utility infrastructure mirrors the City's density gradient curve. While subsurface PROW utility density may be the result of historically unplanned and unmanaged activity in the subsurface PROW, it does reflect the economic development of the City reflected on the surface by the density curve. The lack of accurate subsurface PROW data for mapping creates a palpable "chicken and egg" dilemma that impedes action—do we wait for better data and then act or do we act, based on credible estimates and the data will follow? Until there is accurate subsurface PROW mapping data, the City's density gradient provides an economic-based model to estimate subsurface PROW density, providing order of magnitude scales to inform planning governance and action.
>
> Engineering perspectives confirm the application of economic assumptions for the subsurface PROW by noting the relationship between increasing population, increasing

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Plan had its origin in a concept of planning dating back to the 1920s, which envisioned a fixed document with interrelated physical development objectives. The fallacy of a Master Plan—as applied to New York City of the 1970s—is the assumption that the City's constantly changing development process can be frozen in come overall blueprint. The Charter should cast off the Master Plan approach to planning and, instead, mirror the reality of comprehensive planning as a continuing, dynamic process which deals with both City-wide and local issues." 1975 Charter Revision Commission Report, p. 116.

[272] 1989 Charter Revision Report, p. 29

demand for utility services transmitted through subsurface PROW infrastructure, and density within the subsurface PROW that is "a finite and non-renewable resource" and concluding that "we cannot afford a piecemeal type of urban growth, and urban underground space must be considered."[273] Moreover, under the assumption of a finite and non-renewable subsurface PROW, the engineering perspective considers subsurface PROW solutions that eliminate or reduce traditional trenching in favor of utilidor solutions to be environmentally sustainable because they "do not permanently reduce available urban near surface space ... [and] can be used into the indefinite future for any purpose"[274]

While the complex infrastructure network in the subsurface PROW serve the public, as taxpayers and utility rate payers and as general members of the public walking, driving or taking public transportation, these utility infrastructure networks "are independently managed by an array of distinct city agencies, private corporations and public authorities, each operating within its own legal authority, operational framework and business model."[275] Unlike other cities that have either instituted a subsurface PROW planning system that provided the basis for a data system or simply created a data system, New York has no publicly available data for subsurface PROW infrastructure because the state of subsurface utility data is primarily one of imperfection and absence.[276] While there is separated responsibility for each utility network and the each network is functionally unrelated to each other, the networks are "related by location" due to close proximity to each other in the subsurface PROW and each system's "managers share the same need to access information about the locations to manage components of the network infrastructure."[277] The data systems at each utility, especially in historic cities like New York, reflect "long-established traditional methods [that] often impede … efforts to upgrade to new ways of working."[278] For this reason, it

[273] C-P and C-E, "Analysis," *op. cit.,* p. 11.
[274] Jorge Curiel-Esparza, Julian Canto-Perello and Maria Calvo, "Establishing Sustainable Strategies in Urban Underground Engineering," *Science and Engineering Ethics*, Vol. 10, Issue 3 (2004), p. 525. See also Admiraal and Cornaro, *op. cit.,* p. 233. "Further, in order for any development of underground space to be sustainable it must at least meet the following criteria: (1) the development must itself be sustainable; (2) any excavated material must be reused in a sustainable manner; (3) the development must not prevent future use of underground space; and (4) the development must allow for other future uses within the space that has been created."
[275] Kenneth Rozsahegi, MPA, Eric Macfarlane, P.E., M.ASCE, *The Creation and Maintenance of an Infrastructure Inventory Co-op for Public Works and Services in New York City*, 2017, p. 1.
[276] No utility appears to know where *all* of its utility infrastructure—working *and abandoned*—is located. What each utility appears to know is a mix of historical paper-based and electronic data that is imperfectly updated and is definitely not integrated with the imperfect datasets of all the other utilities.
[277] *Idem*
[278] *Idem*

is easier to use modern technology in a new city, which may be more amenable to modern technology, than upgrading systems for new technology in an older system.[279] This lack of mapped data of utility infrastructure in the subsurface PROW contributes to "delays and cost overruns" on the City's roadway reconstruction projects and contributes to utility costs (apart from their own capital projects) to remove, ahead of roadway reconstruction project commencement, the interference their infrastructure causes for the City's projects and move them back before the City closes up the street to prepare for the road resurfacing component.[280] These delays and cost-over runs from the City's perspective and the costs from the private utilities' perspectives occur despite management initiatives,[281] and "the key to successfully minimize delay and costs depend on Pre-Engineering and coordination and sharing of data."[282] The ability to coordinate planning and work that is necessary to reduce delay and costs and increase operational efficiency, also requires locational data translated into map form; maps also translate into increased safety for workers and subsurface infrastructure itself.[283] Mapped location data facilitates long-term planning to increase each system's stability and reliability and avoid catastrophic failure.[284] And, mapping technology "is already in use and can be made ready to receive new data today" at costs that reflect wide-spread use.[285]

The historical reluctance among utilities to share what data exists with each other and with the City, as managers of the subsurface PROW, contributes to this state of insufficient data for subsurface PROW planning and management purposes and especially for mapping the streets for below the surface. There has been insufficient public governance, with a subsurface organizational perspective and purpose, and insufficient funding at all utilities, which has been exacerbated by the historical antagonistic relationship between the City and the private utilities, especially where legacy franchises are still in effect (**Planning and Managing Subsurface PROW Utilization: Sustainable, Resilient and Smart** above), and a lack of trust among all to

[279] *Idem*
[280] Rozsahegi and Macfarlane, *op. cit.*, p. 2. While the City's roadway reconstruction projects provide private utilities the opportunity to upgrade their infrastructure while the road is open, they are not required to do so.
[281] For example, Section U in the City's construction contract manages the interaction of the City's contractors and the private utilities and the joint bidding procurement methodology, permitted since 2014, permits the City to direct the utility interference work at prices obtained under the City's procurement rules, considered to be less than what the private utilities would pay if procured directly by the utilities. *Idem*
[282] *Idem*
[283] *Idem*
[284] *Idem*
[285] Rozsahegi and Macfarlane, *op. cit.*, p. 3.

share what they have, in part due to post-9/11 security fears.[286] In addition, legacy data systems that are primarily text driven, legacy workflows that are difficult to change to incorporate new technology, vertical control management structures that restrict data sharing within the firm and do not support horizontal management workflows, and outdated concepts of proprietary information applied to infrastructure data for what is a public service are additional internal organizational impediments.[287]

The requirements of an Infrastructure Inventory Co-op providing the basis for a subsurface PROW map would include a first level of "basic information to provide basic identification of components, with only general precision," including where the feature is located, what it is, who owns it, when it was installed and other maintenance information, status as operational, active or deactivated, and unique identity tag, which data would permit DCP to map the subsurface PROW.[288] A second level would be for project management purposes with hyperlinks "to a wide variety of resources [such as] schematics, surveys, CAD drawings, repair notes, inspection records, LIDAR repositories and secure folder systems.[289] The participants in this Co-op would include all responsible City agencies—those with subsurface utility infrastructure data (DEP, FDNY, DOT) and those needing data for agency operations, including their own infrastructure projects (e.g., DOT, DEP and DDC) for managing City processes (e.g., DOT for road opening and excavation permits and DCP for mapping the subsurface PROW)—all private utilities and state authorities, such as MTA/NYCTA, with subsurface infrastructure.[290] The public-facing version of this Co-op, in addition to the street map of subsurface PROW infrastructure, would be available to contractors, with a limited view for their purposes.[291] The original data would still be owned by the utilities, but ownership does not preclude sharing consistent with intellectual property rights,[292] and data security would be maintained by segregating the public facing system, based on public's access to public data that is not subject to FOIL and private data that is truly not proprietary for a publicly-regulated private firm that serves the public.

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[286] *Idem* Over a period of time leading up to the events of 9/11, the City and Con Ed had negotiated a jointly-funded underground electric facility data exchange study, with almost-final documents that were never executed. Efforts have resumed during the present city administration to begin developing a governance structure for subsurface data sharing.
[287] Rozsahegi and Macfarlane, *op. cit.*, pp. 3-4.
[288] *Ibid*., p. 5.
[289] *Idem*
[290] *Ibid.* p. 4.
[291] See the publicly viewable version of the ChiStreetWork system, with permit and dig ticket data.
[292] Rozsahegi and Macfarlane, *op. cit.*, p. -4.

Since "the days of the all-powerful municipal engineer have ended ... , the lack of [subsurface utility] coordination is increasing [due to] the large range of public authorities and companies who are separately responsible for urban underground utilities,"[293] which makes governance for subsurface PROW planning and long-term utilidor implementation complex and difficult. For the City's planning function to help solve the subsurface spaghetti problem, "[s]ubsurface conditions [should not be viewed as] an obstruction to the overall urban design process" but rather they should drive this process.[294] In the City, the DCP would have an important role to play in expanding the City map to include subsurface PROW locational data. There cannot be a single "master" for subsurface PROW planning, but engineers, especially those at DEP, DOT and DDC, would play an important role as infrastructure experts and collaborate with DCP to help tackle this part of the solution to the subsurface spaghetti problem.

<u>Franchise Powers.</u> As noted above, the inalienable nature of the City PROW is not a bar to the City from being able to grant franchises, permits and licenses to private utilities to occupy the subsurface PROW with their local transmission infrastructure.[295] Any discussion of the City's franchise law is, however, complicated by the development of franchise law that progressed hand in hand with the historical progression of commodity technology development—first, water and sewer, then gas, electricity and telecommunications, starting with the switch-based telephone system—without effective coordinated planning under a direct burial paradigm as technology and the City developed, with demand for commodities accelerated by the City's growth.

Before the development of state-wide regulation of private utilities, the early methods of government regulation of private utility companies consisted of common law court decisions, state legislative charters and local government franchises.[296] Local or municipal control began "by the enactment of … ordinances, but particularly did local regulation rely on the franchise."[297] Typically, "[i]n order to enter a field, certain businesses had to acquire a franchise from the relevant city council before they could commence services to be rendered, rates to be charged or methods of arriving at the rates, accounting principles to be employed, and in the case of term franchises, the method of renewing the franchise or provision for the locality's taking over the company at expiration of the franchise * * * although many franchises

[293] C-P and C-E, Assessing, *op. cit.,* p. 2.
[294] Fransje Hooimeijer and Linda Maring, "The Significance of the Subsurface in Urban Renewal", *Journal of Urbanism* (2018)*,* p. 20.
[295] New York City Charter, § 383.
[296] Charles F. Phillips, Jr., *The Regulation of Private Utilities* (Arlington, VA: Public Utilities Reports, Inc., 1985), p. 110.
[297] Phillips, pp. 112-113.

were granted in perpetuity."[298] Often, in the early days of new utilities, "it was common for the utility's lawyers to draft the franchise and then present it to the city council for approval."[299]

Weaknesses of the local franchise method, especially for those that were granted in perpetuity, include provisions of exclusivity, the absence of provisions to provide "for administrative machinery to keep check on the company to see that it met the terms of the franchise," and the eventual realization on that local government side, that had "bargained away their rights to allow competition without having retained effective control over rates and service."[300] Even with balanced and complete franchises executed in the early days of new utilities, population growth necessitated changes in rates, terms of service and scope of operations required changes to the initial franchises but *Trustees of Dartmouth College v. Woodward*, a Supreme Court decision, "held that a franchise had the status of a contract which a state could not impair, thus both parties had to approve a change.[301] In the economics of early utilities that were building out their systems, increased terms of service and scope of operations would have exerted an upward pressure on user fees, and for those franchises with terms, it was not uncommon for them to "keep [their capital] investment as small as possible to avoid loss if . . . not renewed."[302]

To the extent the City's early franchisees are still effective due to perpetuity clauses, albeit subject to the PSC's authority over rates and terms of service, they can be considered legacy franchises, which can cover large parts of the City. Other later franchises, especially those executed after the 1898 consolidation but before the more modern franchise law that placed limits on duration may have qualities of legacy franchises. Analyzing the City's franchise environment, under which the City has granted, to all utilities, the right to occupy the subsurface PROW for private purposes, is especially difficult due to the obscure nature of the legacy franchises and the need to analyze separately each utility sector. At some level, analyzing the PSC's rate tariffs for subsurface PROW utilities, which is also difficult, is the initial starting point, but the legacy franchises will add dimensions to the analysis, especially to the ability to change subsurface PROW practices and with respect to location data production.

DOT's Rules, however, require permittees to place color-coded markers in their restored pavement, and the list below provides a good indication of the utilities or categories of utilities holding franchises with the City:

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298 Phillips, p. 113.
299 Phillips, p. 113.
300 Philips, p. 113-114.
301 Phillips, pp. 113-114.
302 Phillips, p. 113.

- Verizon-Cherry red marker
- Empire City Subway (wholly-owned subsidiary of Verizon)-Chrome yellow marker
- Consolidated Edison Co.-Light blue marker
- Keyspan (now National Grid)-White marker
- Plumbers (water or sewer)-Green marker
- Signals and Street Lights-Orange marker
- Long Island Power Authority-Yellow marker
- Metropolitan Transit Authority (MTA)-Purple marker
- Buckeye Pipe Line-Chrome yellow marker
- Fire Department of New York (FDNY)-Purple marker
- Cable T.V.-Regal blue marker[303]

The State authorizes local government franchises and similar types of agreements under the Transportation Corporations Law.[304] Chapter 14 of the Charter, which covers franchises, is the 1989 Charter Commission's amendment of the City's pre-1989 franchise law and primarily re-distributed powers of the Board of Estimate, which had previously been responsible for granting franchises, between the executive and legislature in view of the Commission's abolishing of the Board of Estimate.[305] As part of the redistribution of the Board of Estimate's powers, the 1989 Charter Commission changed the franchise section to require that "no franchise could be executed, without the City Council first adopting a general authorizing resolution" in the form of a local law "to provide the Council with the opportunity to debate whether a particular type of franchise was valuable and under what terms and conditions it should be let."[306] The Council cannot initiate an authorizing resolution for a franchise, but can act only if there is a preceding "determination of need by the responsible agency and the mayor" with the responsible agency as "an agency with the expertise and responsibility for a particular type of franchise."[307] After the Council adopts "a general authorizing resolution, the responsible agency would shape a request for proposals consistent with the terms of that

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[303] Rules, § 2-11 (e) (14).

[304] Transportation Corporations Law, Article 2, § 11 (Gas and Electric Corporations); Article 3, § 27 (Telegraph and Telephone Corporations); Article 7, § 86 (Pipeline Corporations); and Article 9, § 111 (District Steam Corporations). This law also covers private water and waste corporations, which does not apply to the City.

[305] Frederick A. O. Schwarz, Jr. and Eric Lane, "The Policy and Politics of Charter Making: The Story of New York City's 1989 Charter," *New York Law School Law Review*, Volume XLII, Nos. 3 and 4, 1998, pp. 765-774. The Board of Estimate had been found, in *Board of Estimate v. Morris*, 489 U.S. 688 (1989), to be unconstitutional under the "one person-one vote rule". *Ibid.*, p. 719, footnote 26.

[306] Schwarz and Lane, *op. cit.*, p. 876.

[307] *Ibid*., p. 877. The 1989 Charter Revision also "created a new department of telecommunications and charged it with primary responsibility for all aspects of cable franchises", which department was changed in 1994 to become DoITT. *Idem*

resolution."[308] If the request for proposals "had land use implications, it would be subject to the ULURP process," and "[o]nce through the ULURP process, if ULURP was required, a franchisee would be selected, pursuant to any processes set forth in the authorizing resolution."[309] The responsible agency's selection of the franchisee would then be subject to the review by the newly created Franchise and Concession Review Committee," and a franchise requires a vote of five members of this Committee, known as the FCRC.[310]

Under the Charter, franchises can only be awarded pursuant to a City Council authorizing resolution adopted by the City Council pursuant to the provisions of Chapter 14.[311] The head of the agency designated by the Mayor as having the primary expertise and responsibility in the policy area covered by the type of franchise sought (the responsible agency) must first make an initial determination of the need for franchise(s) of a particular type[312] and then prepare and submit, to the Mayor, a proposed authorizing resolution setting forth: the nature of the franchise or franchises to be granted, the public service to be provided, the terms and conditions of the franchise or franchises, including any subsidies that will be given to a franchisee, the method by which proposals will be solicited for the franchise or franchises, and the criteria to be used in evaluating the proposals submitted in response to such a solicitation, which the Mayor submits to the Council.[313] After publication in the submission in the City Record, the Council, within 90 days of receipt, holds a public hearing on the resolution, which is treated exactly as a local law, with Council approval, disapproval or amendment, with a mayoral option to disapprove and council options to override the mayor's disapproval, and Council's authorizing resolution may not include a provision for subsequent Council involvement. [314]

Pursuant to the Council's authorizing resolution adopted by the council, the responsible agency may issue one or more requests for proposals or other solicitations of proposals, including the criteria and procedures to be utilized in evaluating the proposals submitted, subject to corporation counsel's determination that the request for proposals is consistent with the provisions of the authorizing resolution and a determination of land use impacts or implications and, if such exists, completion of the ULUPR process.[315] After selection of the franchisee(s)

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[308] *Idem*; the 1989 Charter Revision Commission was committed to the competitive process. *Idem*
[309] *Ibid.*, pp. 877-878.
[310] *Ibid*., p. 878; consisting of the mayor, the OMB director, corporation counsel, the comptroller, an appointee of the mayor and the borough president for the borough where the franchise located (with a selection by the borough presidents among themselves if a franchise covered more than one borough). *Idem*
[311] Charter, § 363 (a).
[312] The responsible agency may issue one or more requests for information before completing the initial determination. Charter, § 363 (g).
[313] Charter, § 363 (b)-(c).
[314] Charter, § 363 (c)-(d).
[315] Charter, § 363 (e).

pursuant to the authorizing resolution, each selection and each franchise agreement is then subject to the review and approval of the FCRC.[316] Franchise agreements or modification of franchises must be by written agreement, approved by the FCRC and executed by the responsible agency and:

- may not be for longer than 25 years except in the case of a tunnel railroad, which may not be longer than 50 years;
- may provide rights of renewal, at the option of the city, for a period no longer than 25 years in the aggregate on a fair redetermination of the compensation to the City made pursuant to standards and methods specified in the agreement;
- must provide that all the rights or property of the grantee in the City's inalienable property to which the franchise relates ceases without compensation at the agreement's termination;
- may provide that the grantee's property, plant and equipment upon termination, to the extent specified, becomes the City's property, either without compensation to the grantee or on payment to the grantee of the fair value as property to be determined as provided in the contract, but excluding any value derived from the franchise, leaving the City with the option either to take and operate the property, plant and equipment when so acquired or to lease it for a term not longer than 25 years or to require that the City's property be restored to its prior condition; and
- must contain an agreement by the grantee to recognize the right of its employees to bargain collectively.[317]
- must contain adequate forfeiture or other provisions (1) to secure efficiency of public service at reasonable rates, if a public service is to be provided, (2) to assure the maintenance of the City's property in good condition throughout the term of the agreement, and (3) to provide for adequate compensation to the City.[318]
- must contain an agreement by the grantee that it will (1) permit the placement or display of the public health messages required by the City's Administrative Code, on any property subject to such franchise or any facility, plant, equipment or other property used in connection with such franchise and (2) bear any costs associated with the posting of such public health messages and any costs in terms of foregone advertising revenues associated with the placement or display of such public health messages.[319]

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[316] Charter, § 363 (f).
[317] Charter, § 363 (h) (1)-(6). The last requirement does not apply to a contract providing for a modification or amendment of or extension of service under a franchise not containing a similar provision, provided that the term of such franchise is not extended. Charter, § 363 (h) (6).
[318] Charter, § 365 (a).
[319] Charter, § 365 (b).

Executed franchise agreements are not effective until registered by the Comptroller's Office in the same manner as the registration of contracts.[320] The responsible agency is also responsible for monitoring the performance of the grantee and enforce the terms and conditions of any franchise under its jurisdiction.[321] Copies of all franchise agreements are filed with DOT, which compiles and keeps up to date a specific listing of all current franchise agreements and available to the public.[322] The former bureau of franchises was discontinued as of July 1, 1990, and the bureau's records and staff were transferred to DOT, except bureau records and staff relating to telecommunications franchises, which were transferred to DoITT's predecessor agency, and the bureau's records relating to energy, which were transferred to the agency designated by the mayor.[323]

On December 17, 2020, the City Council adopted Resolution 1445-A pursuant to Chapter 14, which authorizes DoITT to solicit franchisees to provide public services consisting of "one or more 'telecommunications services,' defined for the purposes of this resolution as the transmission of voice, data, information service and/or video signals, or any other form of wire communications or radio communications (as such terms are defined in subsections 59 and 40, respectively, of Section 3 of the federal Communications Act of 1934, as amended, or successor provisions thereto)," and excluding telecommunications services authorized under earlier resolutions for cable television services, mobile telecommunications services and public pay telephones.[324] Whether these services will require new subsurface utility infrastructure or are able to tap into existing subsurface utility infrastructure, under the current direct burial method, there will be street cuts and excavation for initial installation and later repairs or expansion activities.

Neither modern franchises nor legacy franchises reflect the reality that the subsurface PROW is a limited resource with value to the City, as owner in trust, in resolving the subsurface spaghetti problem.[325] They also do not reflect the negative externalities imposed on the City and its residents by direct subsurface infrastructure burial. Higher surface density and neighborhood-based road area/person correlate with higher revenues to utilities from residences and commercial enterprises, which can provide a route to mechanisms to support the financing of subsurface PROW elements. Much the same is true of public utilities, though public utilities do not have franchises and their rate setting process is more constrained by local politics than the

[320] Charter, §§ 375, 328.
[321] Charter, § 365 (c).
[322] Charter, § 376.
[323] Charter, § 377; research has been unable to indicate what agency this is.
[324] Resolution 1445-A.
[325] And, surface PROW problems, such as congestion, since advances in subsurface technology create modern infrastructural solutions to solve for surface PROW congestion.

more diffuse state-wide PSC politics.   In addition, neither the modern or legacy franchise nor state law requires disclosure of subsurface infrastructure location data for public safety concerns and subsurface PROW utilization planning and management.

The nature of existing franchises and PSC regulations and the current practice direct burial of subsurface PROW infrastructure impose uncompensated externality costs on the City—its budget, economy and environment—and its residents.[326] Private utility franchises represent a reciprocally beneficial relationship under which private utilities support the economic vitality of the City as a place to work and live, which expands if all goes well, in turn increasing revenues, based on increased customer use, to the utilities. High urban densities—from both firm and household location decisions—translate into more customers for utilities and corresponding higher revenues, compared to smaller and less dense places, which should be captured by either franchise fees charged to utilities or changes to PSC rate tariffs to support utilidor implementation in the City.[327] By treating consumption of inelastic subsurface PROW area is a market issue, which is appropriate for private utility use, in a manner similar to consumption of a city's buildable surface area, planners can evaluate subsurface options that include pricing the use of the subsurface PROW area to account for profits due to densities of firms and households and related negative externalities.[328]

The ability of existing franchises—legacy and modern—to support utilidor implementation with respect to utility payment of their share of utilidor construction costs and operation and maintenance costs and disclosure of subsurface infrastructure location data, would depend on the terms of the existing franchises, subject to the PSC, leaving the City with options, in addition to amending franchises by mutual agreement, including: using the City's franchise powers to initiate new franchises for long-term implementation of utilidors, entering into separate agreements with participating utilities for utilidors; or, seeking State legislation, in conjunction with PSC, to clear up all ambiguities going forward, perhaps in the context of a state-created financing entity for long-term city-wide utilidor implementation (see <u>Finance</u> below).

<u>One-Call (811) Notification Program.</u> Chapter 365 of the Law of New York, enacted in 1994 (One-Call Notification Program or One-Call),[329] requires *excavators*, who are those engaged in

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[326] Alain Bertaud, *Order without Design* (Cambridge: MIT Press, 2018), p. 13. This situation also increases, to some extent, actual costs for each utility from avoidable higher construction costs that flow into user rates.
[327] See, however, *Ibid.*, pp. 35, 41, which does not, however, by itself reduce negative externalities from current practice.
[328] *Ibid.,* p. 82.
[329] 16 NYCRR Part 753 https://www.digsafelynewyork.com/resources/nys-code-rule-753, which may be cited as Industrial Code 53 or Code Rule 53, in addition to its designation as Part 753. 16 NYCRR, § 753-1.2. See also Public Service Law, § 119-b and General Business Law, Article 36; and 16 NYCRR Subpart 753-6 for enforcement procedures.

the business of excavation or demolition,[330] and *operators*, who are those operating an underground facility to furnish electricity, gases, steam, liquid petroleum products, telephone or telegraph communications, cable television, sewage removal, traffic control systems, or water,[331] to participate in the One-Call Notification Program. One-Call is intended to increase safety for utility construction contractor workers and other utilities' infrastructure by reducing accidental damage from excavation activities due to not knowing the location of all nearby subsurface utility infrastructure by creating a clearinghouse database for utilities under City streets. One-Call's requirements for operators and excavators are mirror images of each other, and what follows is a description of requirements for operators; it should be noted that with respect to City agencies that are operators, they hire excavators for their projects as well.

The State's One-Call system requires, the City, as a local governing body that issue excavation and demolition permits, to inform permit applicants about their responsibilities under One-Call to protect underground facilities and details about One-Call.[332] Every operator of an underground facility must participate in the One-Call system within the geographical jurisdiction or boundaries its underground facility is located, which, in the absence of a City-operated One-Call system like Chicago's, is the State's One-Call system.[333] Operators within the City would include DEP for its water and sewer systems, DOT for its traffic control system and FDNY for it communications systems and the private utilities and other entities listed in DOT Rules, § 2-11 (e) (14).[334] One-Call's requirements are intended to minimize construction delay, but an operator's ability to minimize construction delay depends on the operators' ability to access accurate subsurface infrastructure location data in a timely manner. And, each operator that responds to excavator's notices for other operators' projects has its own excavators working on their projects that request information from the other operators.[335]

One-Call requires an operator receiving excavation or demolition work notice to inform the excavator before the stated commencement work date that either the operator has no underground facility in or within 15 feet of the work area or every of its underground facility in or within 15 feet of the work area has been staked, marked or otherwise designated in

[330] 16 NYCRR Part 753, § 753-1.2 9 (10).
[331] 16 NYCRR Part 753, §753-1.2 (17).
[332] 16 NYCRR Part 753, § 753-2.1.
[333] 16 NYCRR Part 753, § 753-4.1 (1) (a); see 16 NYCRR Part 753, § 753-4.1 (1) (b) for grace period to join system after acquisition of underground facilities; 16 NYCRR Part 753, § 753-4.2. for obligations to notify for removal or transfers of ownership of all underground facilities from within the boundaries of any one-call notification system; and, 16 NYCRR Part 753, §§ 753-4.3-4.4 for obligations to provide information and receive notices.
[334] DOT is an excavator when it engages in road resurfacing projects.
[335] See 16 NYCRR Part 753, Subpart 753-3 for duties of excavators, which provide requirements from the excavator perspective that mirror those of the operators as discussed below.

accordance with One-Call.[336] If the operator cannot complete the required staking, marking or designation before the stated commencement work date, it must promptly let the excavator know when such staking, marking or designation will be complete, which should not be more than two working days after the excavator's start date, although both parties can agree to a later date; and, operators must review excavators' request for review of their stakings, markings or designations as soon as possible.[337] When an operator's underground facilities are in or within 15 feet of the work area, One-Call requires accurate location, under a due care standard, with detailed staking or marking requirements,[338] and, as an alternative to staking or marking, One-Call permits the operator to expose the underground facility or its encasement to view within the work area in a manner sufficient to allow the excavator to verify the type, size, direction of run and depth of the facility; provide field representation and instruction to the excavator in the work area; or by any other means as mutually agreed to by the operator and excavator, including but not limited to written descriptions, photographs or verbal instructions, with any agreement to be provided in writing to the excavator upon request.[339]

If an excavator notifies an operator that, after diligent search at a reasonable depth within the tolerance zone as staked, marked or otherwise designated by the operator, that it cannot verify the location of the operator's underground facility, the operator must verify such location as soon as possible or provide the excavator with prompt field assistance or use other means mutually agreed to by the excavator and operator, in writing if requested.[340] If an excavator requests the operator to attend a pre-demolition conference, after the operator notifies the excavator that its underground facilities are in or within 15 feet of a work area, the operator must attend.[341] In addition, when an operator's underground facility will be disturbed or uncovered by excavation or demolition, the operator must indicate to the excavator any preferred means of support or protection required for such facility and any special backfilling requirements or provide any other guidance for protection of an underground facility, before the stated date of commencement of the work, if practical.[342] And, an operator must provide excavators with a means to obtain, within mutually agreed-to time frames, information regarding the location of underground facilities for the excavator's design purposes, including, but are not limited to, provision of maps, meetings, or marking as described above.[343]

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[336] 16 NYCRR Part 753, §753-4.5 (1).
[337] 16 NYCRR Part 753, § 753-4.5 (2) (b)-(c).
[338] 16 NYCRR Part 753, § 753-4.6 (2) (b) (1) – (6).
[339] 16 NYCRR Part 753, § 753-4.6 (3) (c) (1) – (3); see 16 NYCRR Part 753, §753-4.7 for uniform color code of types of commodities flowing through subsurface infrastructure and 16 NYCRR Part 753, §753-4.8 for uniform identification letters of infrastructure types.
[340] 16 NYCRR Part 753, § 753-4.10.
[341] 16 NYCRR Part 753, § 753-4.12
[342] 16 NYCRR Part 753, § 753-4.13.
[343] 16 NYCRR Part 753, § 753-4.14.

An operator receiving notices of contact or damage, facilities in danger of failing and discovery of unknown underground facilities must respond by immediately inspecting the facility and making the necessary repairs or advising the excavator that the excavation work may proceed or performing the repair itself or by others authorized by it, including the excavator.[344] In the case of a receipt of notice of the discovery of an underground facility in danger of failing, the operator must immediately determine whether or not such discovered facility is its by means of records, on-site inspection or otherwise and, as soon as practicable, advise the excavator that the unknown facility is not its facility; and, if such facility does belong to it, advise the excavator on how to proceed and of any special requirements the operator deems necessary.[345] One-Call also requires emergency service and field assistance by operators of underground facilities containing gas or liquid petroleum products and further requires each operator of an underground gas pipeline or hazardous liquid petroleum facility, on its own initiative or through One-Call, to conduct a public education program on the possible hazards associated with damage to these facilities and on the importance of reporting gas odors and leaks.[346]

Finance. Understanding finance options is key for any policy effort that requires capital investment. There are three basic categories of financing available for utilidor implementation: debt issued by the City for the entire utilidor project[347] with an agreement with each participating utility to permit it occupy the space, pay its debt service component (see **Utilidor History and Modelling for Life Cycle Benefit and Cost Sharing** below) and its operating and maintenance expense component; public private partnership (PPP) financing, such as a 63-20 financing issued on behalf of the City, which is not direct City debt, with similar agreements as above; and debt issued by a State-created authority created for the express purpose of a utilidor program in the City, where debt service, operating and maintenance payments by each utility is authorized and required under the State law creating such an authority.

The City's general obligation bond credit is secured by a pledge of its real property taxes authorized by the Constitution and other State laws, and the Transitional Finance Authority (TFA) credit secured by a pledge of the City's personal income tax revenues and sales tax revenues, authorized by State law creating the TFA.[348] State law does not currently authorize true PPPs for itself or its local governments. The 63-20 financing vehicle permitted under

344 16 NYCRR Part 753, § 753-4.9 (1)-(2).
345 16 NYCRR Part 753, § 753-4.9 (3)-(4).
346 16 NYCRR Part 753, §§ 753-4.11, 753-4.15.
347 For a City-only finance option, there would be the ability for the City to issue debt (general obligation and/or Transitional Finance Authority credits) and for NYWFA to issue debt for the portion of the utilidors with water and/or sewer infrastructure as well as the water and/or sewer infrastructure elements.
348 Official Statement of the City of New York dated November 30, 2018, with respect to $1,050,000, 000 General Obligation Bonds, Fiscal 2019 Series D, pp. 7-8, 57-58.

Internal Revenue rules is a financing vehicle that, in the U.S., approximates closely enough the benefits of a true PPP. State law also permits municipalities to create a Local Development Corporation (LDC) under Section 1411 of New York State's Not-for-Profit Corporation Law, to finance off-budget stand-alone projects secured by subject-to-appropriation obligations such as lease payments.[349] It is noted that during the history of the Third Water Tunnel, which serves as the precedent model for this type of long-term program (see ***A Little Bit More about Subsurface Planning for Utilidor Implementation*** below), the effects of the interceding 1975 fiscal crisis led to the creation of the NYWFA, which turned the City's water and sewer system into a revenue-based utility that removed the system from the City's fiscal constraints. Since the utilidor is an infrastructural solution to utility-based problems, the creation of NYWFA provides precedent on the financing side for a State-created financing authority for utilidor implementation, that could also be granted powers of utilidor construction and operation.

Engineers are trained to understand finance and can collaborate with finance teams during the early program and project planning phases to make the tradeoffs between program and project design and finance. While, a policy to implement and finance utilidors will involve project-specific issues (see **Utilidor History and Modelling for Life Cycle Benefit and Cost Sharing** above), since this would be a long-term city-wide effort (see **Planning and Managing Subsurface PROW Utilization: Sustainable, Resilient and Smart** above), an engineering-based structured systems perspective framework that considers an enterprise-wide portfolio of projects and treats both project delivery and project finance methods as variables for consideration . . . in the course of examining infrastructure alternatives" during the capital planning and budgeting processes to focus on "corresponding cash flow projection for planning, design, construction and operations and maintenance" is essential.[350]

A Little Bit More about Subsurface Planning for Utilidor Implementation. In view of the scope, duration and perhaps finance of a plan to implement utilidors as part of the City's roadway reconstruction program,[351] which is based on a combination of the ***opportunistic*** and the ***just does it*** typologies for utilidor implementation (see **Utilidor History and Modelling for Life Cycle Benefit and Cost Sharing** above), the City's history of the Third Water Tunnel is a good precedent for a long-term capital projects spanning decades. Authorized in 1954, construction

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[349] Kenneth Bond, "Local Development Corporations in the Eye of the Comptroller", *New York State Bar Association Municipal Lawyer*, Fall 2015, Vol. 29, No. 3 (https://www.squirepattonboggs.com/~/media/files/insights/publications/2015/12/local-development-corporations-in-the-eye-of-the-comptroller/bond-articlemunilawyerfall15.pdf accessed 04-27-20 @ 9:00 p.m.

[350] Garvin, *et al., op. cit.,* pp. 41-42.

[351] As well as other subsurface PROW uses to address surface PROW congestion.

of the Third Water Tunnel began in 1971 and is nearing completion.[352] It has been a massive tunneling project that has relied on evolving modern tunneling technology, especially at the point where it enters the dense City environment, and it has been expensive but necessary for the future growth of the City. It has been a project beset by financial problems throughout.[353] The currently received story about the Third Water Tunnel project is that it was aimed at solving future repair and maintenance needs of existing water supply Tunnels 1 and 2. But that is only part of the story of the Third Water Tunnel, which started much earlier and had the much broader objective of securing adequate water resources for the City beyond the Croton system, which is of relevance to a utilidor implementation program.[354]

In the early part of the last century, the City's Board of Water Supply[355] began planning for the City's water sources beyond the Croton system with Tunnel No. 1 that brought water into the City leading to the Catskills system, which emerged first, followed by the Delaware system, which includes Tunnel No. 2.[356] Planning for the Delaware system as a new supply source began as early as 1921, quickly following on the heels of the Catskills system planning, and required two Supreme Court decisions to permit New York to tap the Delaware River, leading to the completion of the Neversink (1953), Pepacton (1955) and Cannonsville (1964) Reservoirs.[357] which have significant capacity beyond what Tunnels 1 and 2 can accommodate on their own. The purpose of the Third Water Tunnel, thus, was primarily to bring the water down from the Delaware reservoirs and the redundancy it will create for the system was not its original purpose, although that benefit was helpful in selling its continued financing after the 1975 Fiscal Crisis.[358]

Applied to utilidor implementation, the Third Water Tunnel precedent—its long-term planning horizon, expense, benefits, and implementation to support the City's growth and prosperity—allows the City to see planning for a smart city, with wide-ranging long-term benefits and expenses and implementation and finance issues, as the primary objective, with the benefits to the surface PROW as an important, but not primary, benefit. Where the Third Water Tunnel differs, however, from utilidor implementation is the expansion of the actors necessary to accomplish it. Since utilidor implementation would be in the City, at a level closer to the surface than the Third Water Tunnel, it will involve not only infrastructure systems engineering

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352 From *New York City Water Tunnel No. 3* at https://en.wikipedia.org/wiki/New_York_City_Water_Tunnel_No._3 accessed 04-12-20 @ 4:59 p.m.
353 Jackson, *op. cit.*, p. 1246.
354 *Idem*
355 A State-created entity established in 1905, with planning, construction or execution and finance powers. https://www.nyc.gov/html/nycwater/html/drinking/history.shtml 04-22-21 @ 5:50 p.m.
356 Jackson, *op. cit.,* p. 1246.
357 *Idem*
358 From interview, dated April 14, 2021, with Jeffrey Sommer, former DEP First Deputy Commissioner.

and finance expertise but also urban planning expertise, at a time when not only are there "too few trained professionals for future needs in complex system management" and a "general lack of attention to utility systems in urban planning processes and within the planning profession.[359] While the "current vocabulary of utility companies, municipal departments, and agencies apparently is sufficient for solving most problems encountered, . . . long-range planning may sometime receive inadequate attention."

The subsurface spaghetti problem, which is not unique to New York City, reflects historical *ad hoc* individual utility actor implementation decisions that were intended to rapidly solve surface problems by moving them underground based on best available technology and financial considerations, which largely meant the "cut-and-cover" method.[360] Individual utility actors placed their infrastructure in the dirt in an historical progression as commodity technology developed—first, water and sewer, then gas, electricity and telecommunications starting with the switch-based telephone system—without effective coordinated planning as technology developed and demand for commodities accelerated with the City's growth fueled by success of its earliest plans for the water system (conterminous in a less planned way with what became its sewer system), transportation systems and zoning code for planned building density.[361] While, topics such as "flood prevention, renewable energy [and] infrastructure . . . all imply a claim on using or protecting the subsurface . . . each function or service occupying the subsurface space is governed separately an done on a project-by-project basis" and it necessary to find a method to integrate "the complexity of specific projects with the aim to gain an overarching understanding of the role of the subsurface for urban development and to develop strategies that ensure its sustainable use."[362]

To the extent that subsurface planning does occur, it is "fragmented and sector based and attempts to understand and analyze the subsurface with all the embedded systems as an integrated entity have been repeatedly dropped" which contributes "to a set of problems with regards to data sharing as well as during project planning and implementation that might have been avoided."[363] A systems approach to planning the subsurface is necessary going forward to "facilitate better understanding of the system's elements, their interactions, and the relationship between the system and its environment . . . to prevent conflicts between different stakeholders through early recognition of interactions between the various system elements as well as the interaction between the system looked at and the social, economic and

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[359] Sterling and Nelson, *op. cit.,* 53 and C-P and C-E, Analysis, *op. cit.,* p. 17-18.
[360] C-P and C-E, "Assessing," *op. cit.,* pp. 82-87 [*https://riunet.upv.es*](https://riunet.upv.es) accessed 12/08/19, p. 1; von der Tann *et al., op. cit.*, pp. 144-146.
[361] *Idem*
[362] Von der Tann, *op. cit.*, p. 144.
[363] *Ibid.,* p. 149.

environmental systems it is embedded or nested in [and] to optimize the outcome of unforeseeable system behaviors through continuous learning.”[364] A systems approaches also “requires the decision maker to consider the interest and influence of direct and indirect stakeholders” and “to take the long-term view, acknowledging the time required for feedback to occur, and balancing short-term and long-term perspectives.”[365]

The System Exploration Environment and Subsurface (SEES) methodology, developed to assist all planners engaged in government efforts to eliminate negative externalities from standard urban "land take" development, could be applied to these efforts.[366] The SEES methodology facilitates effective participation, during the early planning phase, of "subsurface specialists" to communicate their knowledge of the "technical space [referred to as] the “engine room of the city” [that consists of] urban infrastructure of water and energy supply, electricity and communication systems, sewers and drainage" and to integrate the right data and "range of new technological options and urban systems."[367] Integrating understanding of the "engine room" and bringing in engineering design options at the earliest possible time during program and project planning—not waiting, as is typical, until the later engineering design phase, where informed technical changes can only be done at the margins at best because change at that point is more costly—increases the overall efficiency of the urban system.[368] Unlike "surface development [that] is controlled by a highly sophisticated planning system, the subsurface amounts to, quite literally, a hidden sphere in which planning is sketchy at best", so that a methodology that "organise[s] and tailor[s] civil constructions to surface development earlier in the planning process, [should] make major improvements in systems efficiency."[369] Modern urban planners "are not used to considering the subsurface in their urban development work" and there is a hard divide between "urban planning or design disciplines from the engineering phases of urban development."[370] This divide is complicated by knowledge of the subsurface that is held by "many different specialists, separated by professional language or outlook, who do not always cooperate."[371]

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[364] *Ibid.*, p. 150.
[365] *Idem*
[366] Hooimeijer and Maring, op. cit., p. 1. This methodology built on prior methodologies and addressed observed weaknesses found in practice. See Fransje Hooimeijer and Lidewij Tummers, "Integrating Subsurface Management into Spatial Planning in the Netherlands, Sweden and Flanders", *Proceeding of the Institution of Civil Engineers-Urban Design and Planning* 170 (4): 161-172 Aug.; Linda Maring and Maaike Blauw, "Asset Management to Support Urban Land and Subsurface Management," *Science of the Total Environment* 615 (2018) 390–397; see also Von der Tann *et al., op. cit.*, p. 159
[367] Hooimeijer and Maring, *op. cit.*, p. 2.
[368] *Idem*
[369] *Ibid.* p. 8
[370] *Idem*
[371] *Idem*

The SEES methodology can make operational "the view that both the surface and subsurface belong to a single [interdependent] space."[372] Integrating the surface and subsurface in practice requires a systems approach, familiar to engineers, that embeds "complexity theory" to "highlight the non-linearity of decision-making given the inherent unexpected behaviour of agents in urban development and the unforeseen consequences of their interactions."[373] In view of the hidden nature of the subsurface contributing to a significant lack of knowledge among planners, the SEES methodology improves on prior layered strategic planning tools by including the relations among the layers, their time dimensions, "links between inspiring ideas and hard financial conditions, ... and functional spatial networks that represent flows of people, goods and information, viewing space as a structure containing related spatial elements and physical networks as made up of physical nodes and connections."[374] The SEES methodology "supports and registers [successive and iterative] knowledge exchange between experts of different fields" on individual projects and on larger scale planning.[375]

In addition to systems planning, however, consideration of utilidors requires other tools specifically focused on this infrastructural type. A multicriteria strategic decision support system for initial planning purposes that helps "achieve a balance between technical, economical, social and environmental sustainability" considerations while including assessment of intangibles" integrates the standard strengths, weaknesses, opportunities, and threats (SWOT) technique with analytical hierarchy process theory in a way that avoids the weaknesses of the SWOT technique by adding a quantitative aspect, all within the utilidor context.[376] This multicriteria decision making method tool involves three surveys. First survey involves a traditional SWOT exercise to determine internal and external origin factors and construct the SWOT matrix.[377] The second survey evaluates the SWOT matrix by applying AHP technique, which identifies linguistic terms and links them together with 9-point scale for pairwise comparison; applies the geometric mean method as aggregation procedure to construct pairwise comparison matrix from experts' judgments; and calculates the inconsistency of the pairwise comparison matrix, creating a consistency threshold that must not be exceeded.[378] The

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[372] *Ibid.,* p. 3.
[373] *Idem*
[374] *Ibid,* pp. 4-6.
[375] *Ibid.,* p. 7. The authors referred to Haussmann's street and sewer project as "The most impressive example of this spatial connection between subsurface infrastructure and the design of urban structures and public space." *Ibid., p. 8.*
[376] Julian Canto-Perello, Jorge Curiel-Esparza and Vicente Calvo "Strategic Decision Support System for Utility Tunnel's Planning Applying the A'WOT Method," Tunnelling and Underground Space Technology 55 (2016), p. 147.
[377] *Idem*
[378] *Ibid.*, p. 149.

last survey measures the priority of SWOT factors, all compared in pairs, with eigenvector method applied to obtain priority vectors and consistency analysis performed for each case.[379]

In the case study application, which demonstrated the feasibility of this tool, the opportunities included "preventing traffic interruption and congestion due to repeated excavation of roads, avoiding travel delays and lost business revenues; improvement of community appearances by elimination of noise and dust pollution due to street cutting and trenching; reduce street maintenance costs by lengthening road pavement life; decrease cost in maintenance of subsurface utilities; reducing of right-of-way space requirements; elimination of leads and ruptures due to traffic and earth movement loads, and possibility of dual use as civil defense shelter" and the threats included "difficulty in allocating and quantifying benefits, and assessing appropriate share of costs to beneficiaries; difficulties in establishing liability in case of damage to tunnel installations or injury to third parties; [utilidors] and transportation network coordination; increased criticality and security concerns, becoming an inviting target due to all major outages of all systems from a single act of sabotage or vandalism as compared to separate systems; difficulties with sewerage connections are result in sanitary and storm sewers being deeper, and adding extra costs due to utility conduits and lines of some services to be longer as a result of being in-tunnel."[380]

[379] *Idem*
[380] *Ibid.,* p. 147.

Appendix A

Abbreviations

Columbia/SIPA: Columbia University, School of International and Public Affairs
DDC: New York City Department of Design and Construction
DEP: New York City Department of Environmental Protection
DOB: New York City Department of Buildings
DoITT: New York City Department of Information Technology and Telecommunications
DOT: New York City Department of Transportation
FDNY: Fire Department of New York
ICT: Integrated computer technology
OMB: New York City Office of Management and Budget
LCCBA: Life cycle cost benefit analysis
MTA: Metropolitan Transportation Authority
NYWFA: New York Water Finance Authority
NYU/Tandon-CUSP: New York University, Tandon School of Engineering, Center for Urban Science and Progress: New York University, Tandon School of Engineering, Urban Systems Engineering and Management
Polytechnic Institute/UCC: Polytechnic Institute of New York University-Urban Utility Center
PSC: New York Public Service Commission
Pratt/Communications Design: Pratt Institute/Graduate Communications Design
PROW: Public right of way
Roadway reconstruction projects or program: A city roadway reconstruction project occurs when DEP has planned for water main and sewer main and catchment infrastructure replacement and DOT has planned for surface roadway reconstruction for those streets and at the same time of DEP's infrastructure replacement, which projects, after being adopted in the City’s annual capital budget, become roadway reconstruction design and construction projects that are managed by DDC.
T+G: Town+Gown:NYC, a citywide action research program in the Built Environment, resident at DDC.

Potential Revisions to LCCBA Assumptions

- *Project Area Length*. Since the Case Study Project length figures into the estimated cost of the utilidor, as the counterfactual in the LCCBA model, it is necessary to confirm the length of the two sections of the Case Study Project, which was assumed to be 1800 linear feet combined; the length of the Case Study Project may be only 1500 linear feet.
- *Interference and Case Study Project.* While the team selected the Case Study Project along several criteria, the absence of a subway under the public right of way for the Case Study Project was dispositive. The City's gravity sewer system poses a potential interference at a significant number of intersection crossings across the city and it will be necessary to consider this ever-present risk of interference, which will impose additional costs, in the next revision to the LCCBA.
- *Annual Utility Cut Number*. The team assumed 481 utility cuts per year along the 5 blocks of the Case Study Project. Review of the actual permits database reveals that 803 permits were issued from January 1, 2010 to present, which comes out to about 73 utility cut permits per year for the Case Study Project.
- *Actual Utility Cuts*. From interviews with DOT, the team assumed 1/3 of permits result in actual cuts. Review of the recent data reveals that over 50% of recent street cut permits were actually renewals of prior permits, so the number of permits resulting in cuts is somewhere below 50%. It is, however, possible to calculate actual utility cuts for the Case Study Project, raising the question of whether to modify the number of utility cuts assumed based on actuals.
- *Percent Increase in Utility Cuts*. The team assumed a 2.77% growth rate in utility cuts based on data from FY16 to FY20. The City actually experienced a spike in utility cut permits during those years, and it has only recently been determined that that spike was actually the result of a huge number of renewals (see above). This spike likely does not reflect a long-term trend, especially for the 100-year period in the LLCBA model. A flat growth rate may be more appropriate.
- *100-Year Utilidor Lifecycle*. The team assumed a 100-year lifecycle for the utilidor, with two rehabilitations/renewals during that period. This assumption should be revisited in view of the City's capital program mechanics and the degree to which the utilidor will be "right" sized for initial construction to account for predicted growth and development, as well as future technologies applicable to utilities and their infrastructure. Once the policy decision to implement utilidors on a long-term basis in conjunction with the City's roadway reconstruction program, the planning and design of utilidors to account for the future is an issue that is only addressed in the literature and not yet in reality.

- *Average Speed Decrease*. The team assumed that vehicle speeds would decrease 3.4% every year in perpetuity, based on the 2010-2017 CBD trend, leading to an average travel speed of 1.0 mph in 2075, which does not seem realistic. It may be better to take the slowest speed from the 2010-2017 trend (7.1 mph) and keep that constant, although the assumption that speeds decrease 20% during construction is consistent with actual experience. Holding the AADT increase flat at 0% may also be more consistent with actual experience.
- *Travel Time Delay and Permits.* The team assumed that travel time delay resulting from each street cut on any block in the Case Study Project will slow travel on the entire corridor (all 5 blocks) by 20%, which seems unlikely, especially since these two streets are not continuous with each other. It is more likely that a street cut on one block will slow down traffic by 20% on that block. In addition, permits only cover one block, not multiple blocks. A possible alternative would be to assume that the entire corridor is slowed by 20% during construction, but that it should take one permit on each block for that to occur.
- *Wage Inflation Rate.* The team's wage inflation rate assumed at 4% may be too high.
- *Noise Complaints.* The team assumed an annual increase of complaints at over 11% per year, which seems too high, especially under the assumption that a utilidor will reduce the need for utilities to make cuts in the street. Since a utilidor assumes a flat level of growth for cuts, it seems reasonable to assume a flat level of growth for noise complaints.
- *Environmental Cost of Annual Water Loss*. The students calculated an annual cost of water loss of $14.8 million per year on the Case Study Project alone. Water loss—or non-revenue water--is a complicated issue and several factors contribute to non-revenue water, only one of which is undetected water loss from damaged water infrastructure. This issue requires further analysis to identify that portion of potential water loss from damaged infrastructure only.
- *Damage to Telecom Infrastructure*. While telecom infrastructure is closest to the road surface, the students assumed the number of damaged telecom connections was would grow at a rate over 10% per year, which seems high. In addition, all utilities have reciprocal risk of accidental strikes, so this damage issue should be applied to each utility in some manner.
- *Removal of Real Property Tax Discount from LCCBA.* The team assumed a 50% discount on private utility real property taxes in the LCCBA. While this 50% discount was allocated to the share represented by the Case Study Model area, it must be backed out at the LCCBA model stage. While it may be appropriate to consider incentives, which can include tax reductions and removal of constraints, among others, to the private utilities to participate in the utilidor, that exercise should not happen at the gross LCCBA model stages, but is more appropriate at the later lifecycle cost-sharing stage of analysis, when balancing costs and benefits, among all participating utility owners, for the proportion of buried costs (PBC) method of allocating utilidor construction costs. Under the PBC method, utility companies

are charged construction costs based on the same proportion they were paying in the traditional buried utilities method, and the balancing exercise takes place after the results are produced.[381]

<u>Potential Revisions to LCCBA Stakeholder Assessment</u>

- *General Comments on Stakeholders Identified by Team*
  - Government—the team assumed government (New York City) would bear the direct costs of installation, which would not be the case if a public-private financing (e.g., 63-20 financing) were to be used. In addition, it is necessary to segregate City agencies on the basis of function and benefit as stakeholders. Benefits to the City would include reductions in street cuts and reductions in post-utilidor road resurfacings financed on the City's credit. DEP, which is the operating agency for the City's water and sewer systems functions as a rate-based utility with a separate credit (New York Municipal Water Authority), and benefits accruing to DEP, as a utility owner, are within the utility rate and financing structure. DEP should be considered a utility owner like the private utilities.
  - Utilities—the team identified Con Edison, which is responsible for electricity across the city, gas in Manhattan and the Bronx, and steam (as a by-product of remaining electricity generation) in Manhattan, and Empire City Subway, which is a wholly-owned subsidiary of Verizon, as the incumbent local exchange carrier in the City providing telecommunications services under a franchise with the City. There are, however, all categories of private utility companies that become part of the utility stakeholder group. Franchise agreements are publicly available pursuant to Charter Sections 376 and 377. The team considered DoITT, a City agency, as accruing benefits, but DoITT is only the counterparty to various telecommunications franchise agreements and would not directly receive any benefits from utilidors that would accrue to their franchisees.

    Before researching all franchises, DOT's Rules require permittees to place color-coded markers in their restored pavement, and the list of colors provides a good indication of the utilities holding franchises with the City:

    - *Verizon-Cherry red marker*

[381] Ali Alaghbandrad and Amin Hammad, "Framework for Multi-Purpose Utility Tunnel Lifecycle Cost Assessment and Cost Sharing," *Tunnelling and Underground Space Technology*, 104 (2020) 103528. As an aside, however ,the City's statutory classified assessment system, in place since 1981, consists of four classes of property that are assessed at different ratios of market value, some with a cap on annual assessed value growth and/or a phase-in period of such growth. Class 3, consisting of utility real property other than land and buildings (i.e., subsurface utility infrastructure under franchises), has neither a cap on annual assessed value growth nor a phase-in period.31

- *Empire City Subway (wholly-owned subsidiary of Verizon)-Chrome yellow marker*
- *Consolidated Edison Co.-Light blue marker*
- *Keyspan (now National Grid)-White marker*
- *Plumbers (water or sewer)-Green marker*
- *Signals and Street Lights-Orange marker*
- *Long Island Power Authority-Yellow marker*
- *Metropolitan Transit Authority (MTA)-Purple marker*
- *Buckeye Pipe Line-Chrome yellow marker*
- *Fire Department of New York (FDNY)-Purple marker*
- *Cable T.V.-Regal blue marker*[382]

Additional information related to the utility stakeholder group is below:

Above and Below Ground Utility Infrastructure

Water, sewer, gas underground.
Electricity and telecommunications:

- Manhattan is all underground. The other boroughs have mostly overhead except for the downtown sections and the newer developments.
- As a general rule, utilities are buried in Manhattan and the South Bronx. Almost everywhere else above ground (except for Long Island City, Downtown Brooklyn and Jamaica, Queens).
- Schist exists in Manhattan, parts of Bronx, little in Brooklyn and perhaps Queens.
- Steam mains exists in Manhattan and Brooklyn.
- LIPA facilities have been taken over by PSE&G (Far Rockaway)
- Overhead lines for telecom and electricity exist in Queens, Bronx, Brooklyn and Staten Island

Utilities and Boroughs

Commodity	Provider	Borough(s)
Electricity	ConEd	All except per below
Electricity	Long Island Power Authority	Far Rockaway/Queens
Steam heat (byproduct of electricity generation)	ConEd	Manhattan

[382] Rules, § 2-11 (e) (14).

Gas	ConEd	Manhattan, Bronx
Gas	National Grid	Brooklyn, Queens, Staten Island
Water and Sewer	New York City Department of Environmental Protection	All boroughs
Telecommunications		
Voice, broadband, cable TV via fiber optic cable (copper wire and co-axial cable in process of being eliminated)	Empire City Subway (wholly-owned subsidiary of Verizon_	All boroughs Occupies "under the roadway" • in Manhattan and portions of the South Bronx pursuant to Empire City Subway (ECS) agreement + state law • rest of other boroughs under interpretations of state law
Voice, broadband, cable TV	Various cable companies	Use Verizon's ESC conduit infrastructure where available; lay own conduit in remainder • RCN: All boroughs • Altice: Bronx, South Brooklyn • Charter: Manhattan, North Brooklyn, Queens and SI
Mobile communications industry and data transmission services to businesses via fiber optic cables	Various companies	Use Verizon's ESC conduit infrastructure where available; lay own conduit in remainder

Alternate View

Gas Infrastructure

Bronx	Brooklyn	Manhattan	N. Queens*	S. Queens	Far Rockaway	Staten Island
100% ConEdison	100% Nat. Grid	100% ConEdison	100% ConEdison	75% Nat. Grid	100% Nat. Grid	100% Nat. Grid

Electric Infrastructure

Bronx	Brooklyn	Manhattan	N. Queens	S. Queens	Far Rockaway	Staten Island
100% ConEdison	100% ConEdison	100% ConEdison	100% ConEdison	100% ConEdison	100% PSE&G	100% ConEdison

*N. Queens: For Gas infrastructure, generally areas North of Northern Blvd.

- Long-term cost benefits from the ability to deploy integrated computer technology for remote monitoring of asset condition (break detection) and quality of commodities flowing through infrastructure, which utilidors make possible, are significant for all utilities; in addition to gains from digital information that can be shared to reduce accidental strikes, other cost benefits accruing to utilities include gains from the ability to coordinate sub-surface planning, design and construction, especially for expansion of systems.
- Businesses—the team mentioned them in the narrative but then excluded costs and benefit attributable to them. Street level retail businesses could be considered to suffer more than the travelling public and residents and the costs, which are quantifiable, include loss of business income due to the construction activity and they need to be included in the revision to the LCBBA.
- The team's report refers to MTA and surface bus issues, but the MTA is not an explicit stakeholder. Reductions in travel time do have an impact on ridership and revenues; local roadway conditions affect the conditions of their bus equipment, necessitating more frequent repairs and shorter equipment life span; and subway tunnels posing interference issues for utilidors.
- Other stakeholders, such as rate payers and the Public Service Commission, are included in the chart below that also reflects comments above.

Stakeholders	Costs	Benefits
Public and Private Utility Owners		
• Water and sewer transmission (DEP)	Initial upfront incremental capital costs for construction and installation of tunnels with issue of public-private finance Initial upfront cost of installing remote sensor and creating a monitoring system and associated predictive data modelling system	Long-term capital savings from ability to repair and upgrade transmission infrastructure without needing to do roadway cuts and meeting design life of reconstructed streets Increased safety from lack of degradation of buried water and sewer pipes Reduction of construction materials with associated construction and demolition material waste used by current system, which reduces long-term city-wide capital costs (and improves environmental sustainability considerations) Ability to install remote sensors to detect potential emergencies and engage in systemic predictive state of good repair analysis will reduce long-term capital costs by avoiding "avoidable" costs

• Electric transmission (Con Edison and LIPA)	Same as above—also see Utility Regulator below for utility transaction costs to make special case for utilidor implementation capital costs	Same as above—also see Utility Regulator below Plus, increased safety from natural degradation from soil conditions, elimination of crossing of other utility infrastructure and increased resiliency from storms and rising water levels
• Gas transmission (Con Edison and National Grid)	Same as above—also see Utility Regulator below for utility transaction costs to make special case utilidor implementation capital costs	Same as above—also see Utility Regulator below Plus, increased safety from natural degradation from soil conditions, elimination of crossing of other utility infrastructure and increased resiliency from storms and rising water levels
• Telecommunication transmission (Verizon and various telecommunications providers)	Same as above—also see Utility Regulator below for utility transaction costs to make special case utilidor implementation capital costs	Same as above—also see Utility Regulator below Plus, increased resiliency from storms and rising water levels
NYC Department of Transportation (DOT)		
	DOT portion of incremental city-wide capital costs attributable to DOT portion	Increases the time between road surfacing due to reduction in street cuts creates long-term capital savings Improves street condition between road resurfacing needs reducing capital costs and permits other sustainable road uses such as bike lanes, general vegetation and bioswales to reduce CSO event to be free from street cuts May also incrementally reduce pothole repair needs associated with improper road cuts reducing capital costs Reduces private road repair quality enforcement activity (annual expense budget) Will facilitate connected autonomous vehicles' ability to communicate with the roadway infrastructure, reducing congestion
MTA/NYCTA Bus		
	Interference of utilidor with subway tubes	Lack of ridership loss due to roadway reconstruction delays; reductions in capital bus costs due to improved roadway conditions

Utility Customers		
• Water and sewer transmission	Incremental capital costs will be reflected in rates, which include capital component	Long-term capital cost savings (all else equal) from not needing to do cuts and ability to do predictive state of good repair efforts
• Electric transmission	Same—see also Utility Regulator below	Same—also see Utility Regulator below
• Gas transmission	Same—also see Utility Regulator below	Same—also see Utility Regulator below
• Telecommunication transmission	Same—also see Utility Regulator below	Same—also see Utility Regulator below
Members of Public		
• Pedestrians	More disruption for initial installation, which can be mitigated by off-site construction of tunnel to be installed in perhaps deeper trenches to accommodate tunnel	Less long-term disruption, including noise, due to cuts for emergencies and state of good repair, increasing quality of life and environmental sustainability
• Car drivers	Same	Same; plus, better roadway conditions will reduce damage to cars and associated private car repair costs Will facilitate connected autonomous vehicles' ability to communicate with the roadway infrastructure, reducing congestion
• Adjacent property owners	Same	Same
• Business owners	Same	Long-term reduction of loss of business income due to repeated construction activity due to utility cuts

Utility Regulator for Private Utilities (New York State Public Service Commission)		
	Transaction costs for evaluating private utility requests for special consideration of tunnel infrastructure needs and financing for rate base applicable in the city only	Long-term capital cost savings at private utilities will exert less pressure on future rate increases (all else equal) for city customers

Potential Revisions to Case Study Project Cost Data

- *Private Utility Cost Data*. Construction cost data for the Case Study Project incurred by the private utilities under the joint bidding agreement for the Lower Manhattan reconstruction projects has been identified, which can provide a complete cost of construction for the Case Study Project; with this complete cost, under the rule of thumb method for utilidor cost estimation discussed below, there would be an additional magnitude of cost for the utilidor.

Potential Revisions to LCCBA Cost Estimates

- *Rule of Thumb Utilidor Cost Estimate.*
    - Doubling the "cut and cover" cost. The literature suggests that the initial cost of a utilidor is twice the cost of current practice.[383] Now that the private utilities' cost for the Case Study Project is available, a revised LCCBA should future value, to 2021, the 2010 city capital construction costs and the 2010 associated private capital construction costs, based on construction-related indices. Doubling that future valued 2021 cost of the Case Study Project, which is consistent with the literature, can serve as a check on the revisions made to the utilidor costs suggested below.
    - Factoring Approach. If 100% is the total cost of the utilidor (after the doubling above), moving and maintaining services during construction probably represents 40-50%, and reinstalling or moving utilities into the utilidor could be 30-40%, with the cost of the utilidor in the order of 10-20%.
    - Ancillary Costs for Subsurface Work. These costs, which are included in the cost of the Case Study Project, and could be assumed to be at the same level in the utilidor project

[383] Julian Canto-Perello and Jorge Curiel-Esparza, "Assessing Governance Issues of Urban Utility Tunnels" (Assessing), Tunneling and Underground Space Technology, Vol. 33 (2013), pp. 82-87 @ https://riunet.upv.es accessed 12/08/19 @ 10:12 p.m., p. 5.

as double the Case Study Project, include traffic agents/ traffic control, noise and dust mitigation, impact/support cost to other utilities at the cross streets that not part of the utilidor, and, utilities' cost of moving their infrastructure out of the way of utilidor installation while maintaining services.

- *Addition of Allowance for Standard Design and Construction Processes*. There should be an allowance for standard design and construction activities, such as surveying, agency filings and inspections, protection, site work, scaffolding and other protections or traffic management, which typically adds costs in the order of 15% to the construction cost.
- *Addition of Allowance for Excavation-Related Activities*. There should be an allowance for removal and disposal of existing utilities and pavement, which could be in the order of $2 million.
- *Re-estimate Utilities Installation within Utilidor.* The cost of installation of utilities within the utilidor appears to be under-estimated and should be on the order of $250/LF.
- *Contingency Percentage due to Lack of Conceptual Design.* Since there is no conceptual design for the utilidor, while the team made assumptions for design contingency, general conditions, overhead and profit, permit costs, bonds and insurance and escalation adjustment, it would be appropriate to add an explicit contingency percentage line to the construction estimate, which contingency percentage can be adjusted, but 25% may be a good estimate in view of no actual conceptual design at this point.
- *Addition of Allowance to Excavate for the Utilidor.* While water and sewer lines are deep, it may be necessary to excavate below them for the utilidor structure, depending on its eventual design. And, excavation for a utilidor is likely greater than what is excavated under current practice. An excavation allowance would include the possibility of expanded excavation, in addition to backfill and disposal, which the team calculated; environmental remediation may also be required.
    - <u>Other considerations.</u> The utilidor must be sized based on what utilities are going in and how much room needed for future maintenance (equipment and personnel), ventilation, lighting, drainage, system monitoring, security monitoring (with the analogy to a subway tunnel, but smaller in size); surrounding soil considerations are also critical—if the soil underneath the utilidor poor, it will need to be supported by piles, but if it is rock, if excavation below current infrastructure is necessary, the cost of excavation of rock will be more expensive
- *Add Cost of Fill Material.* The team's calculation of fill costs appears to assume that it is free, which is not valid. If soil from construction and demolition of other City capital projects is available for a utilidor project, it may be closer to free, but that will require advancement of the City's current efforts with its Clean Soil Bank and other City re-use of CDW efforts (e.g., recycled concrete aggregate and glass).

- *Re-estimate the Cost of Waterproofing.* The team's cost of waterproofing appears to be under-estimated; a rate of $30/SF is more appropriate.
- *Specifically Estimate the Costs of Utilidor Operation.* While the team assumed an annual cost of operation and maintenance of 10% of construction costs, it might be good to specifically estimate an allowance for lighting of the utilidor during operation and revise the allowance for the supply of power and communications services for the smart infrastructure, which seems to be under-estimated.
- *Estimate Debt Service in Line with Practice.* While the team's report does make reference to debt service in the LCCBA model, the team assumes that construction will happen over a 24-month period, but the construction costs are all shown to occur in the first year. Now that cost data from private utilities' use of Lower Manhattan Joint Bidding Contract is available, it will be necessary to re-estimate total debt service for the Case Study Project and the counterfactual utilidor project in line with practice.
  - <u>Future Valuing Construction Projects.</u> Since the Case Study Project cost data is from 2010, it will be necessary to future value the Case Study Project to the current time. Identifying the right percentage for future valuing construction projects is a complicated process and requires understanding how the construction industry prices projects. As an example, construction literature anticipates 3% to 4% inflation for 2020 with the potential to go higher in specific Infrastructure markets, such as pipeline or highway; local roads are not highways with bridges, so perhaps 4% is a possible future value percentage.[384]
  - <u>City Financing Practice—Reimbursement of General Fund Payments to Contractors.</u> The City funds its committed construction costs initially out of general fund and then reimburses general fund from bond proceeds. While it is probably not possible to lag debt issuance precisely, debt service should not begin immediately in view of the fact that the bonds will be issued sometime after construction costs are paid to the contractor.
  - <u>City Financing Practice—DOT Component and DEP Component.</u> The City's roadway reconstruction projects are funded from (1) DOT's capital budget, which is the City's credit (general obligation (GO) or Transitional Finance Authority (TFA) debt) and (2) DEP's capital budget, which is the New York Municipal Water Authority (NYMWA) credit. It is possible to assume that the Case Study Project is 10% DOT work and the rest, 90%, DEP work.
  - <u>City Financing Practice—Periods of Probable Usefulness.</u> The State's Local Finance Law assigns a Period of Probably Usefulness (PPU) for each item of capital work, which provides an outer limit for associated debt maturity. The PPUs for DEP sewers and water mains are 15, 20 and 40 years for sewers and 15 to 50 years for water mains. Since each

[384] See https://edzarenski.com/2020/01/28/construction-inflation-2020/ 03-22-21 @ 8:10 p.m.

roadway reconstruction project involves replacing both sewers and water mains, it is appropriate to assume a 50-50 split between sewers and water mains for the Case Study Project. The PPU for DOT street reconstruction is 15 years. Research into the official statements for recent City GO and TFA issues and for recent NYMWA issues can help identify appropriate interest rates for estimation, with the caveat that current low interest rates may change in the future.[385]

- Issues for Estimating Private Utility Debt Service. Public utility companies are required to make regular disclosures under the federal Securities Exchange Act and they are also subject to tariffs under the State's Public Service Commission. It may be possible to assume a single interest rate for private utility debt for the total private utility costs for the Case Study Project.[386]
- Issues for DOT Road Resurfacing Debt Service. The PPU for DOT street resurfacing is 5 years. See above for calculating debt service.
- Issues for Private Utility Work—Costs and Debt Service. Using assumptions the team made for the nature of road cut work to the extent present and/or supplementing assumptions to create a standard utility cut project, it would be possible to apply a rate for this type of work and schedule debt service for that using the utility interest rate above.[387]
- Discount Rate for Present Valuing Debt Service. After estimating all debt service components as suggested above, research into the appropriate discount rate for a heavily regulated industry should be done to identify the right one to use.

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[385] See https://www.finra.org/sites/default/files/2016_FI_EMMA.pdf for access to public issuer official statements.

[386] See https://investor.conedison.com/financial-information/annual-reports for Con Edison's debt interest rates.

[387] See https://www.coned.com/en/rates-tariffs/rates for Con Edison's Statement of Average Cost per Trench Foot of Installed Underground Facilities.