

Advancing New York City's Public Subway Business Model

DIGITAL ENTERPRISE TRANSFORMATION COURSE ESSAY

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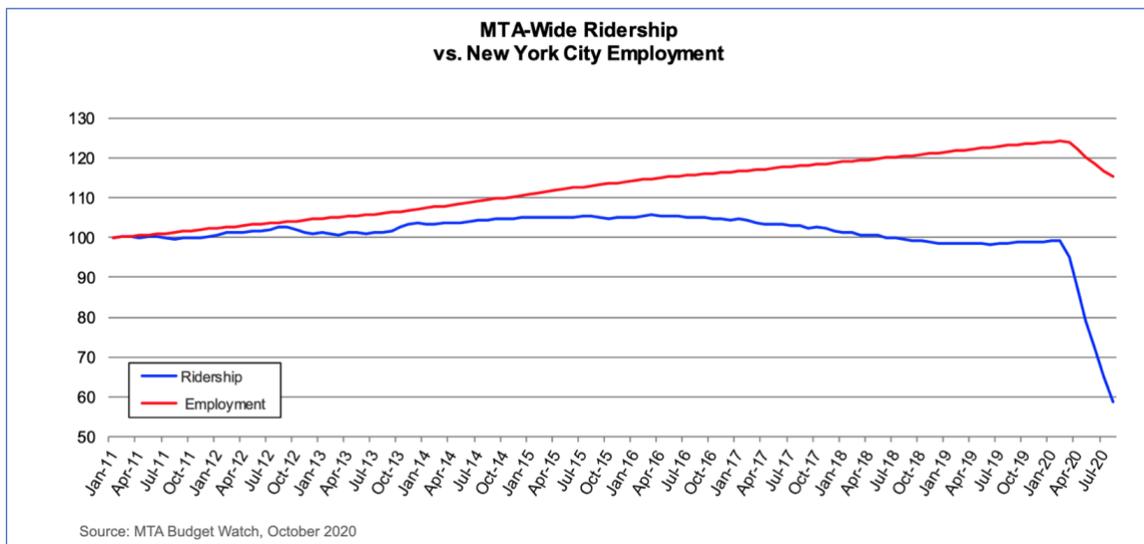
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Introduction

With vaccinations commencing last month, the world has witnessed the beginning of the end of the Coronavirus pandemic. Hopefully, we will soon be able to return to the freedom of movement we all cherish. The global landscape as we knew it, however, has changed significantly.

The pandemic has impacted every aspect of our lives, considerably influencing how we think, behave, and engage in the world. According to a McKinsey study, pandemic stay-at-home orders resulted in public transit ridership falling "70 to 90 percent in major cities across the world". (Hausler, et al., n.d.) This overnight contraction in economies also resulted in significant business failures and job loss.

In New York City, the Metropolitan Transit Authority (MTA) saw subway ridership, and thus revenue, plunge 60 percent from pre-pandemic levels. Similar drops took place on the other two MTA rail properties: 67 percent for the Long Island Rail Road and a staggering 90 percent for Metro-North Railroad. (Goldbaum, 2020) While the PATH, the New Jersey subway line that links adjacent New Jersey communities to New York City (NYC), suffered a 94 percent drop in ridership (Port Authority of New York and New Jersey, 2020).

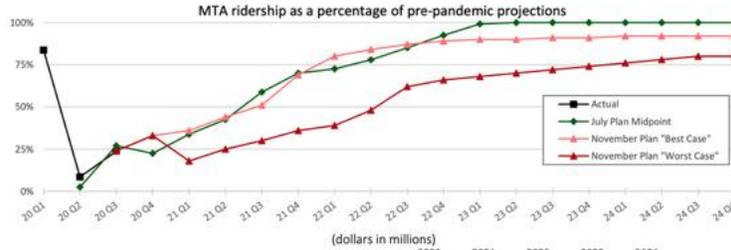


A May 2020 McKinsey analysis determined that even post-vaccine, MTA ridership would only rebound to 92 percent of pre-pandemic levels by 2024 (Metropolitan Transportation Authority, 2020). According to the New York Post report, this assessment was supported by research firm Euclid, which found that 44 percent of NYC residents plan to avoid public transit entirely. In comparison, only 18 percent will return to their pre-pandemic riding habits (Barone & Meyer, 2020). The number is even direr for New York City Transit Subways (NYCT Subways). Conservative estimates place 2024 ridership at half of the 2019 level (Metropolitan Transportation Authority, 2020).

Ridership projection



The May 1 McKinsey analysis is being updated, and preliminary results are more pessimistic ¹

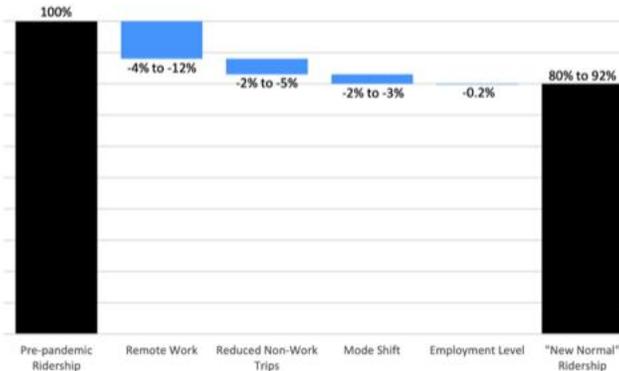


	2020	2021	2022	2023	2024
Change from July Plan Midpoint to November Plan Midpoint	\$0	(\$849)	(\$849)	(\$1,329)	(\$1,043)
Change from July Plan Midpoint to November Plan "Worst Case"	\$0	(\$1,613)	(\$1,899)	(\$2,009)	(\$1,519)
Preliminary November Financial Plan [see Slide 5]	\$1,785	(\$2,858)	(\$2,993)	(\$1,348)	(\$1,587)
"Worst Case" Adjustment to Farebox Revenue Forecasts ²	0	(1,613)	(1,899)	(\$2,009)	(\$1,519)
Preliminary November Financial Plan ("Worst Case")	\$1,785	(\$4,471)	(\$4,892)	(\$3,357)	(\$3,106)

¹ Tolls and Subsidy/Dedicated Taxes are still to be determined but are not expected to have a material adverse impact on MTA revenues.
² Reflects ridership recovery rates of 27% for 2021, 54% for 2022, 71% for 2023, and 79% for 2024 (average of four quarters in each year).



Looking beyond 2020, McKinsey estimates ridership may remain at 80% to 92% of pre-pandemic levels through the mid-2020s

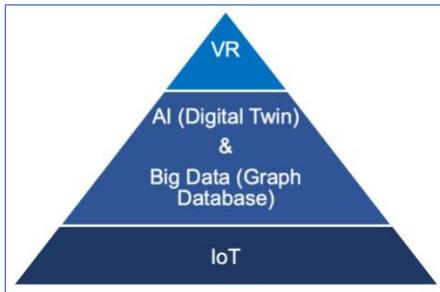


Source: Metropolitan Transportation Authority

The result is that NYCT Subways is in a self-energizing negative spiral. Health concerns plus job losses reduce ridership, which lowers revenue (fare collection + business taxes), forcing cuts in services (trains, maintenance, and staff), further driving the public's reluctance to use the system. This situation is untenable. NYCT Subways needs to leverage technology to help it transform into an entity suited for the new reality.

Before diving into the specifics, we should review the key technologies and trends that are, or will, impact transportation's future.

Key Technologies



Transportation agencies need to put into place technology-based solutions to not only drive greater operational efficiencies but, more importantly, meet the service experience levels customers now demand (Tan, 2020). The key technologies that underpin such a transformation are the Internet of Things, Big Data & Artificial Intelligence, and Virtual Reality.

Internet of Things (IoT)

IoT made the top of the technology list because it transforms how entities gather and use their data. The wide range of IoT devices (load and location sensors on train cars, motion sensors, video cameras, and the like), as well as the IoT networks on which they reside, means that agencies will be able to gather more information at a much higher frequency. IoT devices also furnish either implicit or explicit location information (metadata). Knowing the specific placement of a sensor gives the rest of the transmitted data contextual structure to the activity.

For example, in the subway systems that service NYC, agencies can currently only gather turnstile information. However, because entrances feed multiple platforms and more than one train line uses a station, the provided information is not enough to monitor platform loads or determine directional demand. A rich IoT network can provide the right data in the needed format to better monitor, adjust, and take actions that improve a rider's experience and build confidence in the system.

Big Data & Artificial Intelligence (AI)

Data's value isn't determined by the volume captured but by its use to achieve a mission. Data has to be transformed into information and disseminated in ways that help data-driven decision making. Big Data & AI help organizations execute this three-step process of store, transform, and inform.

Big Data refers to the act of managing datasets for analytics. As presented in CXO's Digital Enterprise Transformation course, Big Data's key attributes are the ability to (Uhl, 2020):

- Manage large volumes of data collected from various sources - IoT devices, video, smart meters, etc.
- Handle the velocity at which the information hits and is pulled from the system in near-real time.
- Deal with the variety of data formats - structured, numeric, video, etc.

Where Big Data is all about speed and efficiency, AI is about immediately analyzing the data and making informed recommendations based on past lessons. Transit systems enabled with (AI) can harness the power of real-time

data and the codified tacit knowledge of experienced dispatchers to enable dynamic congestion management, potential integrations with other modes of transportation, and power advanced modeling.

It is not uncommon for both of these applications to run in unison on a cloud computing platform such as Amazon Web Services (AWS) or Microsoft Azure. The ease and speed at which cloud-based service scale makes it ideal to:

- Handle the torrent of data from IoT; petabytes of storage.
- Connect legacy systems through application program interfaces (APIs).
- Replace large upfront capital investments with pay for what you need, when you need it, monthly operating expenses.

Performance "Digital Twins"

Digital Twins are at the forefront of the Industry 4.0 revolution (Fuller, Fan, Day, & Barlow, 2020). These virtual replicas of an environment use the volumes of stored and real-time data feeds along with sophisticated computational power to design and execute complex what-if simulations based on real-world conditions. For transportation agencies, this means that dispatchers and the computer can evaluate the impact of new alternatives or policies faster in a safe environment.

Big Data & AI opens up opportunities in several areas—from alternate route optimization to congestion mitigation (Cuddihy, English, Desmurs, Bacalhau, & Forbath, 2019).

Virtual Reality (VR)

The natural continuation of the above technologies for transportation agencies is VR for planning and training purposes.

VR provides many of the same learning benefits through real-world experience—but without the accompanying safety risks. What's more, because the experiences are planned, trainees are exposed to a wider variety of scenarios in a shorter timeframe. A 1991 study by James M. Clark and Allan Paivio showed that VR training participants experienced higher memory retention due to the experience being anchored in multi-sensory and emotional input (Clark & Paivio, 1991). On its own, the training benefit justifies the development of a VR component for industries like transportation. A Digital Twin is perfectly suited to produce simulations based on real conditions found in the system - infrastructure issues, crowding conditions, and emergency assistance requests (Fishman, Kelkar, Schwartz, Nicol, & Sen, 2020). VR places the trainee into the physical environment of the RCC during an emergency with all the noise, multiple communication streams, and distractions they have to deal with in reality.

Challenges

Despite all of the accrued benefits, there are universal concerns.

IoT:

- *Integration*: The size of a network can make it impractical to manage all of the endpoints manually. Platforms must be configured to automatically recognize devices, assign them correctly, and enable visibility.
- *Security*: as the number of connected devices increase, security policies must adjust to protect both data and the IoT network
- *Network complexity*: agencies must have personnel with the skills to manage a complex IoT infrastructure

Cloud Computing:

- *Data security*: Security protocols for data transmission and storage, plus access privileges, must be addressed.

Key Trends

Enabling digital forces:

The two technology trends that most positively impact an agency's transformation are Automation and Mobilization. As is typical, these trends do not operate independently but rather reinforce each other.

1. Automation & digitization

- Programmable intelligence enabling device-based networks that learn, reason, and process not just data but also information. With the increase in AI and IoT seamless integration, many use cases are being introduced where AI interacts with real-time data to automate processes at scale. For example, these predictive analytic based systems are autonomously taking action on the data it monitors to redirect traffic, oil distribution in Nigeria, and control self-driving vehicles (Matellio Inc., 2019).

2. Mobilization

- The mobility ecosystem is in the first wave of a transformational step. With the launch of the near-zero latency fifth-generation (5G) networks, mobile connectivity is virtually instantaneous. The stage is set for productivity-enhancing opportunities like low-power boundless edge computing and instant cloud applications and storage.
- Soon to be rolled out, private 5G networks will address commercial use security concerns. Operators will physically or virtually isolate these commercial networks from public networks by utilizing different hardware, network-slices, or virtual servers (Capgemini, 2020).

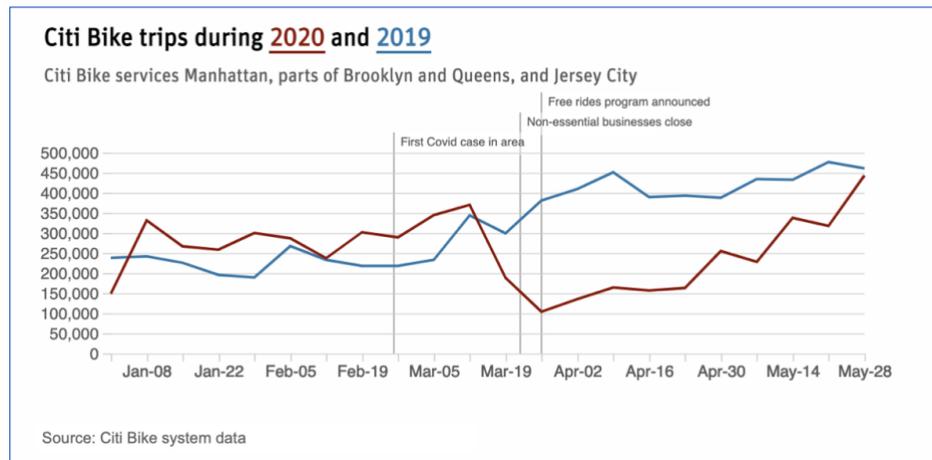
Disruptive digital forces:

The two most impactful technology-driven disruptors impacting transportation agencies are the mobility-powered Sharing Economy and cloud & big data-enabled Work-From-Home (WFH) movement.

1. Mobile technology: powering the shared economy

Access to shared mobility via apps has provided the public with easy access to transportation options on an 'as-needed' basis. Included are services, such as car-sharing services like Zipcar, microtransit providers like Via, and shared micromobility (e.g., bike-sharing).

In NYC, the local government advised avoiding public transit during the pandemic and encouraged more personal forms of transit such as bicycles. At first, the use of all transit forms took a steep dive. According to City Monitor, even when stay-at-home orders lifted at the end of May 2020, public transit, in particular, subway ridership, was still off 70 percent, while bike-sharing was down only 4 percent (Kanik, 2020).

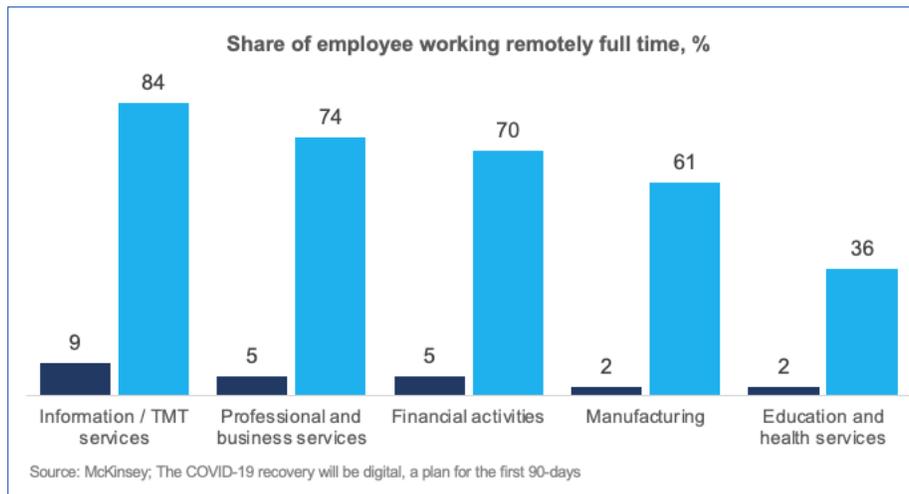


2. Cloud & Big Data: the normalization of remote work

Before the pandemic, the technology structures that provided the means for remote working were in place. Many businesses were utilizing virtualized technology services like cloud storage and hosted applications such as Microsoft 365. Telecommunication companies had fiber optic backbones and robust consumer offerings such as broadband to the home to meet the consumer demand for time-shifted entertainment and immediate connectivity (Loozen & Baschnonga, 2020). Regardless, at the end of 2019, nearly 92 percent of workers commuted daily to their place of employment (Loozen & Baschnonga, 2020).

But the pandemic changed that. With stay-at-home orders, quarantines, and physical distancing requirements that required complete workplace design overhauls at a significant cost, businesses were forced to embrace work-for-home. The short-term impact was evident. More importantly, a McKinsey sentiment survey showed

that the change is solidifying, citing that digital adoption "vaulted forward five years in a matter of months" (Baig, Hall, Jenkins, Lamarre, & McCarthy, 2020).



Given the above, along with the fact that the NY Metro area has an unusually high percentage of its workforce employed in positions ideally suited for remote working (high-skilled low collaboration), the ridership return forecasts are likely too optimistic in the number of riders and when they will return.

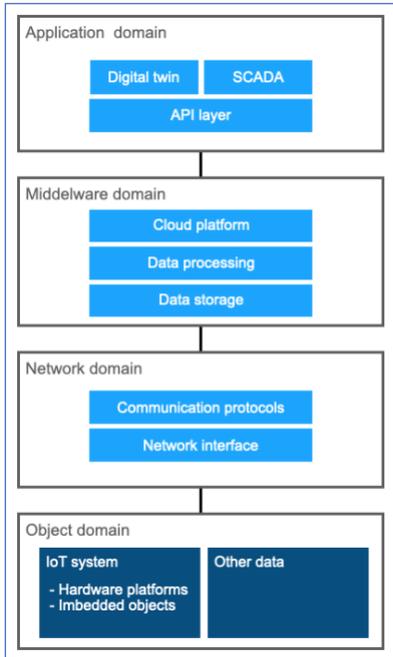
Proposed Solution

Pat Foye, the MTA Chairman, was quoted as saying, "Everything is on the table. That includes taking reservations for subway seats or "metering" to limit the number of people on a bus or in a rail station" (Tanya Snyder, 2020).

Mobility-as-a-Service (MaaS)

Transition from transport operator to mobility manager. Establish a MaaS paradigm that puts into place a region-wide platform focused is on rider-centric outcomes.

A large number of commuters in the New York City area cross artificially imposed transportation agency boundaries. Regional operations need to come together to deliver a transformative solution that at a minimum focuses on quickly counteracting - or avoiding - crowding across the full ecosystem while being more economically efficient.

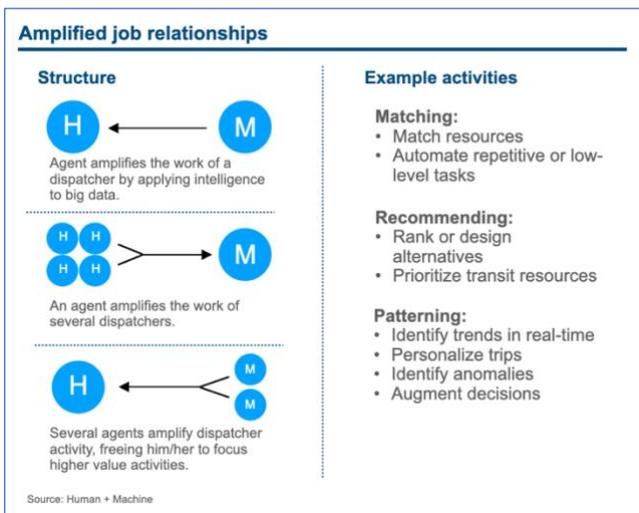


From an operational perspective, the purpose of the system is to support human-made decisions by gathering and making sensible connections between the vast amount of information generated by the transportation system and the other elements that influence service demand (Wilson & Daugherty, 2018). The core of the proposed digital platform will leverage technology and data to connect five distinct public rail systems – NYCT Subway, PATH, NJ Transit, MNR, and the LIRR – to improve efficiency and accessibility for people throughout the region.

This means rethinking the interconnection between technology, people, and processes to create enough slack in the system to balance passenger loads, so there is an opportunity to physically distance. This requires gathering real-time rider movement and other IoT data and unifying them in a digital model (digital twin) representing "customer journey" stories.

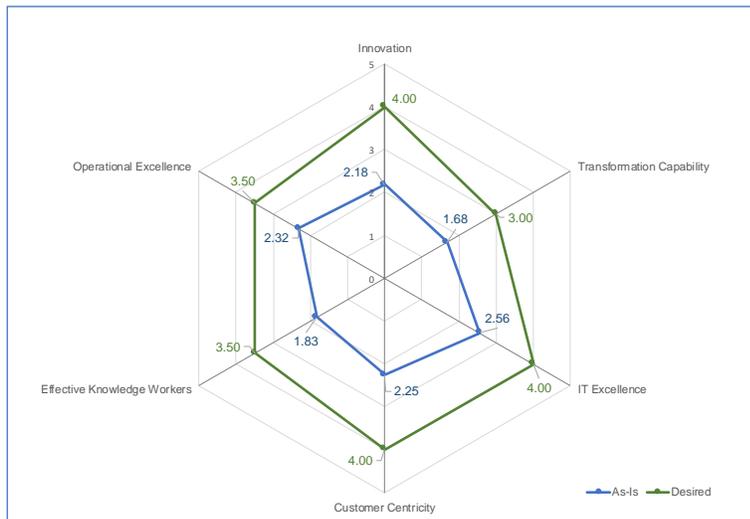
Using its AI capability, the Digital Twin will provide congestion alleviation suggestions, in the intermediate-term match projected mobility demand with transportation supply, and in the long-run pair with VR to improve training (Greg Lindsey, 2016).

Potential benefits



- *Enhanced customer experience* - ability to plan and pay for trips across multiple transportation modes at one touchpoint, making travel more transparent and predictable.
- *Better visibility*: seamless responses to changing conditions.
- *Operational efficiencies*: a clearer perspective on how well the regional system meets user demand and lays the foundation for future integration on items like regional buses and infrastructure planning.

Gap analysis: does NYCT have the ability to ignite this movement?



The figure to the left shows the result of a digital capability assessment survey that looked at the "as-is" state of the RCC and its direct-support services. As shown, the RCC's current capabilities are lacking across the board. Hence, what follows are the necessary actions to close the gaps, increasing the likelihood of a successful digital transformation.

Digital Capability Assessment

Digital Use Cases

Innovation Capability:

"What-if" simulations that use the combination of artificial intelligence and predictive analytics to continuously rethinking service offerings to match and take advantage of mobility patterns and behaviors picked up by an IoT network. The result will be faster and more accurate decisions that better match rider needs and identifying untapped demands.

Innovation Capability	
Description	Standup an artificial intelligence (AI) platform - AI linked to predictive analytics - to generate actionable advanced analytics insights such as conducting "what-if" simulations to rethink service offerings to match and take advantage of mobility patterns and behavior data fed directly into the system through the IoT network.
Current Situation	Service levels are set by each entity without regard to the other entities. Schedulers utilize month old turnstile and Traffic Counter reports (physical rider tally surveys) plus customer survey data to determine proposed service changes.
Value Proposition	Enable faster and more accurate planning by leveraging the predictive analytics capabilities of a Digital Twin to conduct "what-if" simulations to better match service levels and inter-system transfers based on collected mobility pattern and ridership behavior data. (IoT sensors, video, asset movement records, etc.)
Benefits	<ul style="list-style-type: none"> • Incorporates both system and outside factors on a region-wide basis to produce richer, more accurate demand patterns and dynamics. • Transform data into real-time actionable insights that enhance decision making. • Identification of untapped demands.
Consequences of not changing	Inflexibility/limited ability to coordinate cross-entity scheduling.

Transformation Capability:

A Cloud-based core technology platform that facilitates interoperability of legacy systems and allows for the exploration of compatible technology at a lower cost with increased ease. The shift from large upfront capital investments in hardware to a pay-as-you-go structure plus the decreased need for expensive, highly skilled IT professionals is a substantial financial incentive.

Transformation Capability	
Description	Cloud-based core technology platform that facilitates interoperability of currently incompatible legacy systems as well as provides an affordable upgrade path as the MaaS concept for the NYC region matures.
Current Situation	Multiple on and off-premises applications and hardware that uses multiple standards. The results in the inability to "see" the entire ecosystem due to a lack of data sharing. When coordination happens it is executed via phone and email between control centers.
Value Proposition	A technology platform that allows exploration of compatible technology at a lower cost with increased ease.
Benefits	<ul style="list-style-type: none">• System interoperability.• Flexibility and scalability.• Shifts expenditures to pay-as-you-go model from high upfront capital investment paradigm.• Operating cost reduction; decreases need for expensive highly skilled IT professionals.• Reduction/elimination of data silos.
Consequences of not changing	<ul style="list-style-type: none">• Fragmentation of data (data silos persist).• Incompatible data formats.• Continued struggles to retain top IT talent.

IT Excellence:

Universally accessible data repository whose data architecture allows for advanced analysis. Amongst other benefits, this facilitates the consolidation of information in one accessible location eliminating data silos and providing the ability to see the entire ecosystem.

IT Excellence	
Description	Common big data storage architecture (Data Lake) that merges separate data sources and supports tools for quick exploration and analysis.
Current Situation	Data sets primarily sit in three distinct database architectures. interoperability is limited because it requires the coding of custom interfaces.
Value Proposition	Universally accessible data repository whose data architecture allows for advanced analysis.
Benefits	<ul style="list-style-type: none">• Ability to store raw data in a common pool.• Seamless data movement.• Provides quality data for real-time analysis.• Low data storage costs.
Consequences of not changing	

Customer Centricity:

End-to-end trip planning that takes into consideration system conditions, disruptions, and accessibility requirements. The benefits include one fare payment capability, real-time alerts, and alternative travel options powered by the unified data collection and analysis system (Digital Twin).

Customer Centricity	
Description	End-to-end trip planning that takes into consideration system conditions, disruptions, and accessibility requirements.
Current Situation	Data sets primarily sit in three distinct database architectures. interoperability is limited because it requires the coding of custom interfaces.
Value Proposition	Give riders one place to go for their trip planning and fare payment needs.
Benefits	<ul style="list-style-type: none"> • Accurate display of tailor-made travel options. • One fare payment capability. • Automatic route adjustments during trip based on rider needs and system considerations.
Consequences of not changing	<ul style="list-style-type: none"> • Riders do not perceive the ecosystem as "one system". • Hampers ability to relieve congestion by influencing rider trip decision.

Effective Knowledge Worker:

Dynamic train rerouting (operational decision-making) based on Digital Twin suggestions as it monitors demands and supply conditions. Assisted decision making will result in better minute-by-minute choices, reduced human error, and free dispatchers to focus on higher-value customer experience adjustments, such as congestion monitoring and travel time.

Effective Knowledge Worker	
Description	Dynamic train rerouting (operational decision-making) based on suggestions from the Digital Twin as it actively monitors demands and supply conditions.
Current Situation	Dispatchers visibly monitor a large system schematic board mounted at the front of their control center with LED lights that represent train positions. Supplementary information such as diversions are distributed as emails, while active emergencies are communicated by radio if in the Dispatchers area of responsibility or verbally communicated by another Dispatcher at the RCC if an adjoining sector is experiencing a disruption.
Value Proposition	AI-assisted decision-making helps Dispatchers make better minute-by-minute decisions by incorporates both structures (IoT data), unstructured data (email, video, etc.), and previous outcomes (episodic memory) into its analysis.
Benefits	<ul style="list-style-type: none"> • The system can handle routine tasks freeing up dispatchers to focus their attention to higher-value customer experience adjustments, such as congestion monitoring and travel time. • Active monitoring of demand and system conditions to identify what riders need and address unexpected circumstances faster. • Reduce the number of human errors • Improved Dispatcher retention resulting in better overall performance and lower orientation costs due to reduced stress
Consequences of not changing	Dispatcher left to focus on asset movement and availability versus customer experience.

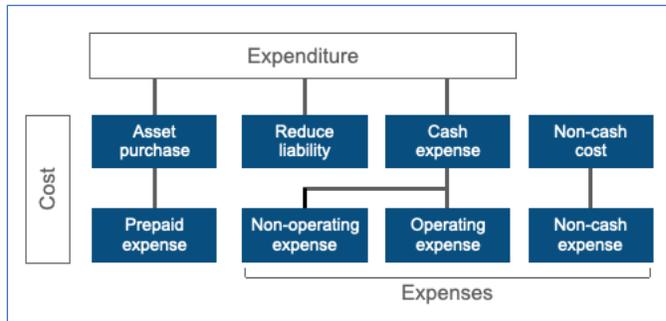
Operational Excellence:

Traffic flow mapping using IoT sensors, computer vision, and special sensors to understand how riders move within the larger transfer stations and map previously invisible service connections.

Operational Excellence	
Description	Traffic flow mapping using IoT sensors, computer vision, and special sensors.
Current Situation	Only able to measure station entry via turnstile reporting.
Value Proposition	Gaining a better understand and how riders move both with in stations and across the system. This information can be fed into the AI platform to help train its ability to assist with dynamic train scheduling.
Benefits	<ul style="list-style-type: none"> • Understand rider intent; transfer point, final stop, etc. • Travers pattern mapping to facilitate design and scheduling adjustments to provide better physical distancing opportunity.
Consequences of not changing	Not have a clear understanding of how riders utilize the system, thus a less effective AI platform.

Key Benefits

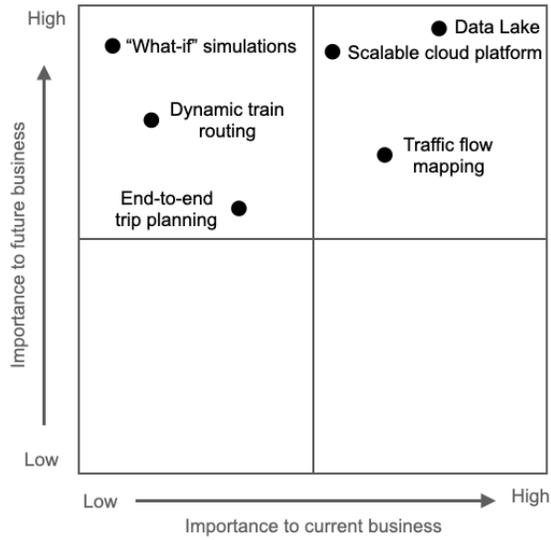
Because the proposed solution is a public good entity, the proposal's benefits are measured in terms of value contributed to the business objective.



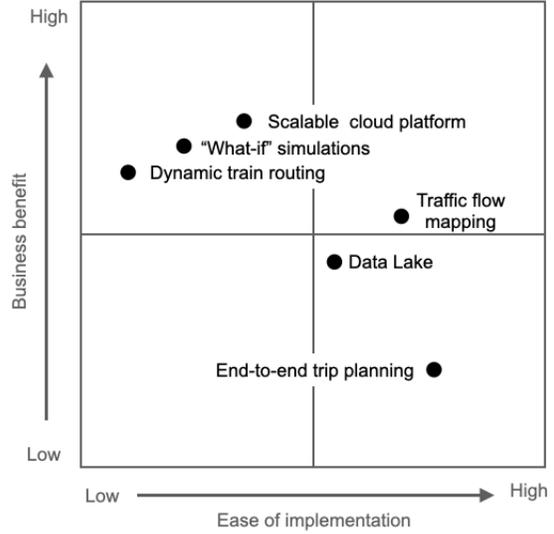
- *Financial objectives:* minimize the capital investment burden and decrease associated personnel expenses.
- *Non-financial objectives:* reliability (reduce human error), agility (respond to changes in real-time such as congestion) and improve customer satisfaction scores.

The benefit and priority assessment summary for each key use case is pictured below along with their individual scores. Appendix B includes the specific control measures framework (Dulce & Flawell, 1998) (Boyle, 2020).

Benefit Analysis



Business Priority Assessment



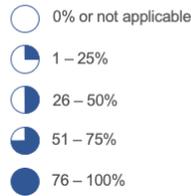
"What-if" simulations

Benefit		
Risk Reduction		
Return on Investment		
Reliability		

Effort		
Investment		
Annual Cost		

Time Horizon	
0y	5y

Benefit



Effort



Scalable cloud platform

Benefit		
Risk Reduction		
Return on Investment		
Reliability		

Effort		
Investment		
Annual Cost		

Time Horizon	
0y	5y

Data Lake

Benefit		
Risk Reduction		
Return on Investment		
Reliability		

Effort		
Investment		
Annual Cost		

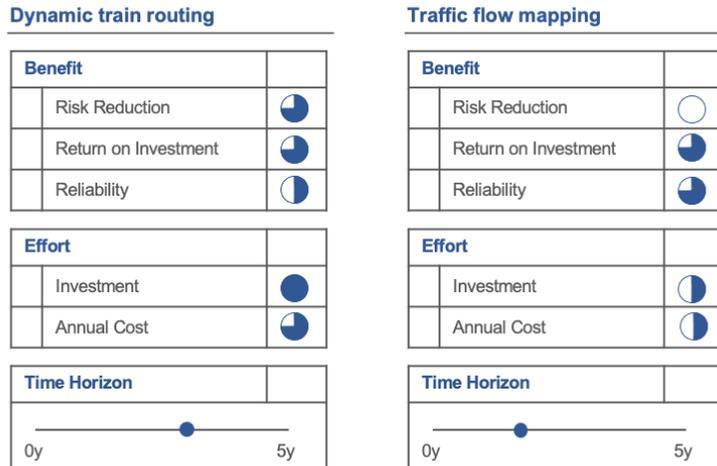
Time Horizon	
0y	5y

End-to-end trip planning

Benefit		
Risk Reduction		
Return on Investment		
Reliability		

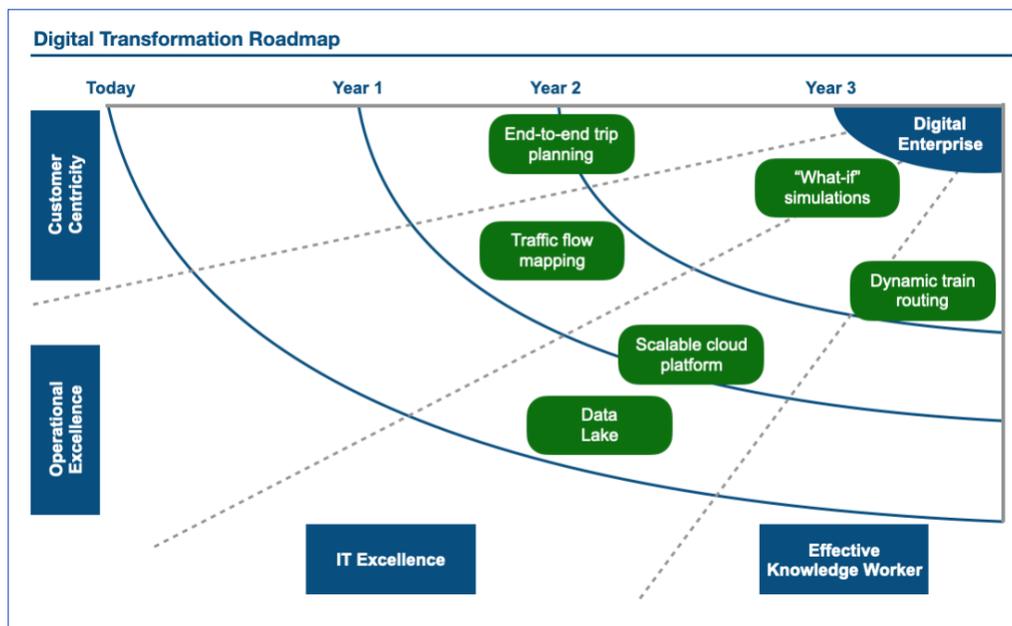
Effort		
Investment		
Annual Cost		

Time Horizon	
0y	5y



So how do we get there?

Most crisis events are short, sharp shocks—over in days. But this pandemic is a long-term challenge, and the immediate actions must be the foundations for long-term survival. The graphic below lays out the timeline for the activation of the key use case projects.



Given the historical challenges of aligning all of the stakeholders required to effect change, it is worth breaking this transformation into easily understood initiatives.

Initiative 1: Digital Business Platform

- Finish what was started; fully digitize the RCC's processes and services.
- Free data and information from silos:
 - Identify currently available data and what can be done with it; create a centralized repository.
 - Adopt open data standards.

- Leverage past investments in data feeds, devices, and IT infrastructure.
- Invest in elements required to establish the digital platform (cloud storage, IoT network, etc.).

Initiative 2: Alignment

- Secure political agreement that it is in the region's best interest to unify rail control centers.
- Incorporate the Controls Center operations of the other existing MTA rail agencies.

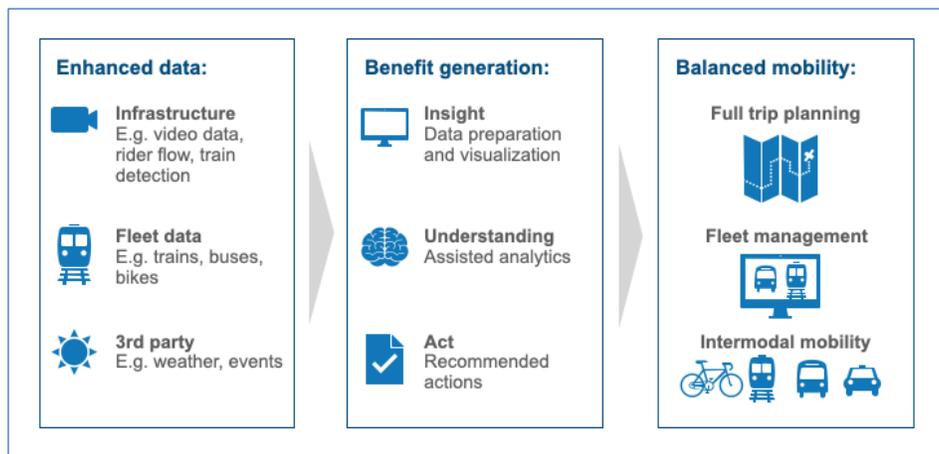
Initiative 3: Service Re-imagination

- Rethink operations from the rider's point of view and make changes that improve their experience.
- Bring in regional bus and water taxi services plus integrate private mode information to achieve a true regional mobility system.

Conclusion

This paper presented tangible benefits to the New York City Metropolitan area. Even more importantly, it can be leveraged to build a more valuable regional transportation platform that incorporates:

- Subways (NYCT Subways and PATH)
- Heavy rail (LIRR, MNR, Amtrack)
- Bus network (MTA Bus, NYCT Bus, regional commuter bus providers)
- Alternate transportation (taxi, car service, bike share)



Appendix

Appendix A: Digital Capability Assessment

Innovation Capability at NY Transit Subway

INNOVATION	DIRECTION			ENABLEMENT				
	STRATEGY	VALUE	RISK	PROCESSES	IT	CHANGE	TRAINING	PROGRAM
Culture	Vision & Goals	Value Identification	Risk Identification	Governance	Information & Analytics	Change Impact Analysis	Training Need Analysis	Framework
Leadership	Business Model	Value Realization Planning	Risk Management Planning	Methods & Tools	Business Applications	Change Management Planning	Curriculum Development	Organization
Values	Execution	Value Realization	Risk Mitigation	Process Optimization	Communication Technology	Change Management Execution	Training Education	Execution

n = 35 Information missing Scale: Initial Reactive Defined Manged Excellence

Transformation Capability at NY Transit Subway

INNOVATION	DIRECTION			ENABLEMENT				
	STRATEGY	VALUE	RISK	PROCESSES	IT	CHANGE	TRAINING	PROGRAM
Culture	Vision & Goals	Value Identification	Risk Identification	Governance	Information & Analytics	Change Impact Analysis	Training Need Analysis	Framework
Leadership	Business Model	Value Realization Planning	Risk Management Planning	Methods & Tools	Business Applications	Change Management Planning	Curriculum Development	Organization
Values	Execution	Value Realization	Risk Mitigation	Process Optimization	Communication Technology	Change Management Execution	Training Education	Execution

n = 35 Information missing Scale: Initial Reactive Defined Manged Excellence

IT Excellence at NY Transit Subway

INNOVATION	DIRECTION			ENABLEMENT				
	STRATEGY	VALUE	RISK	PROCESSES	IT	CHANGE	TRAINING	PROGRAM
Culture	Vision & Goals	Value Identification	Risk Identification	Governance	Information & Analytics	Change Impact Analysis	Training Need Analysis	Framework
Leadership	Business Model	Value Realization Planning	Risk Management Planning	Methods & Tools	Business Applications	Change Management Planning	Curriculum Development	Organization
Values	Execution	Value Realization	Risk Mitigation	Process Optimization	Communication Technology	Change Management Execution	Training Education	Execution

n = 35 Information missing Scale: Initial Reactive Defined Manged Excellence

Customer Centricity at NY Transit Subway

INNOVATION	DIRECTION			ENABLEMENT				
	META	STRATEGY	VALUE	RISK	PROCESSES	IT	CHANGE	TRAINING
Culture	Vision & Goals	Value Identification	Risk Identification	Governance	Information & Analytics	Change Impact Analysis	Training Need Analysis	Framework
Leadership	Business Model	Value Realization Planning	Risk Management Planning	Methods & Tools	Business Applications	Change Management Planning	Curriculum Development	Organization
Values	Execution	Value Realization	Risk Mitigation	Process Optimization	Communication Technology	Change Management Execution	Training Education	Execution

n = 35

Information missing

Scale: Initial Reactive Defined Manged Excellence

Effective Knowledge Worker at NY Transit Subway

INNOVATION	DIRECTION			ENABLEMENT				
	META	STRATEGY	VALUE	RISK	PROCESSES	IT	CHANGE	TRAINING
Culture	Vision & Goals	Value Identification	Risk Identification	Governance	Information & Analytics	Change Impact Analysis	Training Need Analysis	Framework
Leadership	Business Model	Value Realization Planning	Risk Management Planning	Methods & Tools	Business Applications	Change Management Planning	Curriculum Development	Organization
Values	Execution	Value Realization	Risk Mitigation	Process Optimization	Communication Technology	Change Management Execution	Training Education	Execution

n = 35

Information missing

Scale: Initial Reactive Defined Manged Excellence

Operational Excellence at NY Transit Subway

INNOVATION	DIRECTION			ENABLEMENT				
	META	STRATEGY	VALUE	RISK	PROCESSES	IT	CHANGE	TRAINING
Culture	Vision & Goals	Value Identification	Risk Identification	Governance	Information & Analytics	Change Impact Analysis	Training Need Analysis	Framework
Leadership	Business Model	Value Realization Planning	Risk Management Planning	Methods & Tools	Business Applications	Change Management Planning	Curriculum Development	Organization
Values	Execution	Value Realization	Risk Mitigation	Process Optimization	Communication Technology	Change Management Execution	Training Education	Execution

n = 35

Information missing

Scale: Initial Reactive Defined Manged Excellence

Appendix B: Three-dimension proposal benefit framework

1. Risk reduction

- Confidentiality - reduces the risk of unauthorized disclosure or access to critical information.
- Trustworthiness - strengthens confidence in the overall capability of the systems or processes.
- Authorization paradigm - ensures organizational assets are only used for approved purposes.
- Business Continuity - increases the ability to continue critical business functions after a disaster.

2. Return on investment.

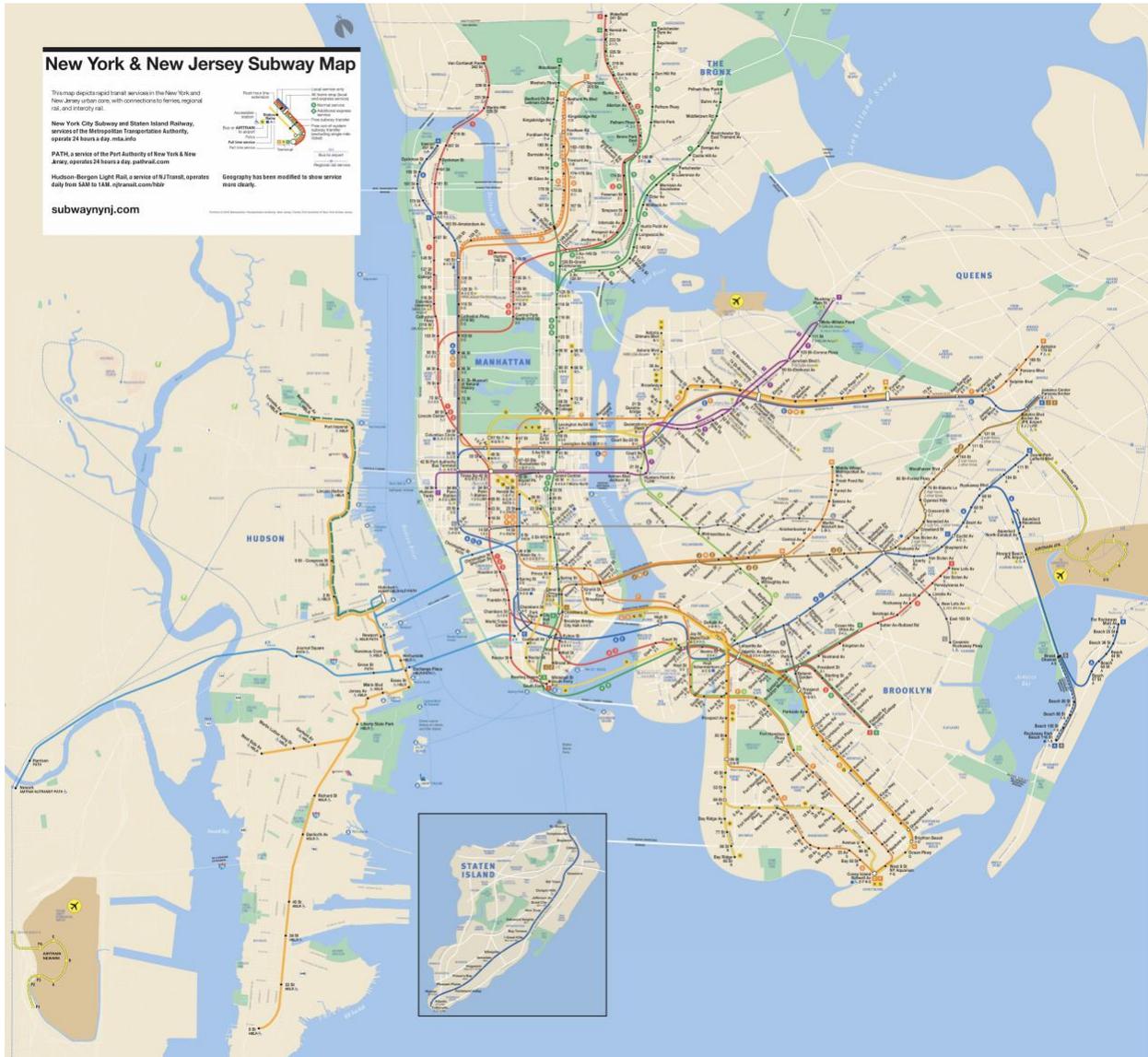
- Cost Savings or Revenue Gain - measurable, hard dollar savings or increases revenue.
- Productivity - increase in efficiencies by reducing headcount related expenses, improving staff utilization, or improving service.
- Decision Enablement - improves the quality of the information provided to managers allowing them to make better decisions.
- Economic Value - lowers the costs per employee, per unit sold, or per revenue dollar.

3. Reliability.

- Strategic Linkage - keeps the organization on a supported version of a critical system or enables the linking of legacy systems extending their useful life.
- Architectural Value - improves technology scalability, performance, or disaster readiness
- Maintenance Value - preserves current capabilities or makes an improvement.
- Integrity - preserves confidence in data by ensuring accuracy or guarding against data corruption.

The proposal is evaluated against each dimension and award points for each delivered benefit. Each benefit can receive a maximum of 8.33 points. One adds all of the points to get a total business value score for the proposal. A maximum of 100 points is possible.

Appendix C: NYC Metropolitan Area subway map



Annotated Bibliography

Kanik, A. (2020a, July 21). Cities' coronavirus decisions had big impacts on bike-sharing. *City Monitor*.
<https://citymonitor.ai/transport/the-decisions-cities-made-about-coronavirus-had-a-big-impact-on-bike-share-ridership>

This article (post) investigated how the pandemic impacted the way people moved around cities. In the first months after cities in the United States issued stay-at-home orders, their transportation systems witnessed declines of 70 plus percent. Simultaneously, other modes like bike-sharing initially dipped but quickly rebounded to the 2019 level when the economy started opening. Not surprisingly, the heaviest usage centered around critical workforce sites like hospitals. The source is credible because it is from the "City Monitor," whose focus is on data-led analysis and insights from leading urban policy journalists and experts. The author is a seasoned journalist and data analyst. This article was used to pull the statistics on the impact of the pandemic and New York City's advisory to find more "personal" means of transportation had on bike-sharing (alternative transit) versus traditional public transportation modes.

APTAAAdmin. (n.d.). Public transportation fact book. *American Public Transportation Association*. Retrieved January 31, 2021, from <https://www.apta.com/research-technical-resources/transit-statistics/public-transportation-fact-book/>

The fact boom contains both aggregate and regional statistical data covering all aspects of the United States' transit industry. This includes ridership facts, transit finances, and operating statistics by modes of transit. The source is credible because it is based on data from the US Federal transportation Authority's (FTA) Database. It supports the ridership level of public transportation figures in the New York City Metropolitan area before the pandemic.

Automation and our lives, pre- and post-covid-19. (n.d.). Retrieved January 30, 2021, from <https://www.fuqua.duke.edu/duke-fuqua-insights/victor-m-bennett-automation-and-our-lives-pre-and-post-covid-19>

This video discusses what automation means for our lives and how the pandemic has impacted the artificial intelligence (AI) adoption curve. The first section of the video reviews how automation has historically freed human capital to do higher-value tasks with classic examples such as ATMs. ATMs became the focal point for simple transactions such as deposits and cash withdraws. This freed bankers to work on loans, personal services, and other more complex operations. The economic impact on the banking business was that marginal costs were reduced. This made it possible to open more bank locations, but with fewer bankers per branch. Today we see the same dematerialization in retail positions due to self-serve checkout. The pandemic has suppressed the demand for anything that is done in person (e.g., dining, transportation, live events, etc.) while boosting the demand for things that help avoid people (e.g., home delivery, on-demand entertainment, internet, etc.). It is theorized that in shrinking markets, automation helps the smaller business catch-up, while in growing markets, it will help the leaders expand their lead. One of the most considerable challenges is re-skilling people to do new jobs. Most likely, those that are doing the displaced jobs are not currently capable of moving forward. This could result in a shortage of qualified people, which in turn increases demand raising a business' wage costs. The video lecture was produced by Victor Bennett a professor in the Strategy area of Duke University's Fuqua School of Business. His work has been published in the likes of Management Science, the Strategic Management Journal and Organizational Behavior and Human Decision Processes. The information provided insights on how the pandemic may change the uses of automation, including artificial intelligence. It was incorporated in the essay's introduction and problem definition.

Baig, A., Hall, B., Jenkins, P., Lamarre, E., & McCarthy, B. (2020, May 4). Digital adoption through COVID-19 and beyond | McKinsey. *McKinsey - Our Insights*. <https://www.mckinsey.com/business-functions/mckinsey-digital/our-insights/the-covid-19-recovery-will-be-digital-a-plan-for-the-first-90-days>

The focus of this article is to provide business leaders with a roadmap to recovering from the pandemic. A critical component of any business recovery plan is to address both customer and workforce expectations. Given that the last several months have verified the value created by digital technologies, the article argues that management should selectively modernize its technology capabilities. It then discusses why one of the top priorities should be to inventory core models that support business operations and push that data to analytic teams. Teams that should then craft or feed the data into artificial intelligence (AI) applications ultimately positioning themselves to be better suited for the anticipated fast-changing environment. This blog post (article) is credible because it was written collaboratively by McKinsey & Company's members and published on their thought leadership blog Our Insights. Additionally, the author is a senior partner in the North American technology practice. This source was used to provide insights on business leaders' digital adoption level, attitude about remote workforces, and willingness to continue adoption trends post-pandemic.

Barone, V., & Meyer, D. (2020, May 14). Nearly half of New Yorkers plan to avoid mass transit post-lockdown: Poll. *New York Post*. <https://nypost.com/2020/05/14/nearly-half-of-nyc-plans-to-avoid-transit-post-lockdown-poll/>

This is a short newspaper article that succinctly puts forward the findings of a sentiment poll of public transit riders conducted by the research firm Elucd. The poll was completed in May 2020, about two months after local governments issued stay-at-home orders. The findings showed that almost half of residents planned to avoid public transit. Forty-four percent said they would avoid public transportation entirely, while just eighteen and a half percent planned to return to their pre-pandemic ridership habits. This article was published by the New York Post, a credible local New York newspaper. This article's insights were used in the section describing the ridership impact of the pandemic.

Boyle, K. (n.d.) Estimate benefits - Implementing an information security program video tutorial. LinkedIn; Microsoft. Retrieved November 20, 2020, from <https://www.linkedin.com/learning/implementing-an-information-security-program/estimate-benefits>

This section of the educational course focuses on developing an evaluation framework that effectively communicates the business benefit of investing an organization's people, time, and money. The model's four components are risk reduction, protection against a financial loss (indemnity), return on investment, and reliability. Each of which has four subcomponents. The lecturer then discusses each area in more detail. Points are awarded for each proposed benefit, a total of 100 divided evenly across each sub-component. Experience has shown that viable proposals typically earn between 50 and 80 points. An anonymized example is then reviewed to reinforce the lesson. This source is credible because LinkedIn Learning, a Microsoft entity, backs it. For decades Microsoft has demonstrated commitment to providing quality IT-based education content. Additionally, the course was designed and delivered by the Founder of Cyber Risk Opportunities, and those that complete the course receive Continuing Professional Education Credit. This source guided the construction of the benefit (value) framework used to evaluate the selected use cases.

Clark, J. M., & Paivio, A. (1991). Dual coding theory and education. *Educational Psychology Review*, 3(3), 149–210. <https://doi.org/10.1007/BF01320076>

Dual coding theory (DCT) explains human behavior and experience in learning using multiple senses to more efficiently store information in stable memory. Research has shown that the most effective combination is verbal and nonverbal (or imagery) representations. This work describes the underlying premises and then shows how to use the method in educational environments. The piece then demonstrates how imagery and verbal associative processes play a significant role in various educational activities: the comprehension of school material, practical instruction, and the learning of motor skills. Jim Clark is a Psychology professor at the University of Winnipeg, and Allan Paivio is the same at the University of Western Ontario. The *Educational Psychology Review* is a publication of peer-reviewed articles, interviews, and research-based advice for psychology practitioners. This work helped clarify and

enhance the section on the benefit of leveraging the capabilities of the Digital Twin as an engine to drive virtual reality (VR) as a training tool.

Competing in the age of AI. (2020, January 1). *Harvard Business Review*. <https://hbr.org/2020/01/competing-in-the-age-of-ai>

The article looks at how today's markets are being reshaped by organizations that have embraced artificial intelligence (AI). It discusses how companies like Google, Wayfair, and Ocado obtain most of their value from running algorithms rather than employees. Doing so frees them from traditional operating constraints, which allow AI-driven processes to be the core of their operations. The authors termed this configuration the "AI-Factory." There is then a discussion on how these AI-driven companies outstrip traditional firms. There is little to no limit on the ability to scale, breadth of their scope, and speed at which learning can be folded into operations. The article concludes with insights on the leadership challenges associated with guiding such entities. This article was published by Harvard Business Review, a well-respected professional publication. The author is the Harvard Business School professor who heads the school's Technology and Operations Management Unit and their Digital Initiative. This article was used to understand how to design strategies that provide concrete guidance during an AI-driven transformation.

Connecting urban environments with IoT and Digital Twins. (n.d.). Retrieved January 31, 2021, from <https://azure.microsoft.com/en-us/blog/connecting-urban-environments-with-iot-and-digital-twins/>

This article is an overview of how Microsoft's Azure cloud computing platform is being used as the connector between IoT networks (the edge) and artificial intelligence (AI) applications. It then explains what a Digital Twins is, the value proposition of constructing a Digital Twin, how the power of cloud computing has made this possible. Several real-world case studies are used to support the article's claims. This source is credible because it was published by Microsoft, which has demonstrated a commitment to providing quality IT-based content. This source guided the integration of Digital Twin technology within the Big Data trend discussion.

Cuddihey, A., English, M., Desmurs, P.-O., Bacalhau, C., & Forbath, T. (2019). *Transit in transition: Transportation technology vision 2019*. Accenture; December 20, 2020. https://www.accenture.com/_acnmedia/PDF-105/Accenture-Transportation-Technology-Vision-2019.pdf

This presentation (pdf) is focused on helping transportation entities leverage technology to improve rider's full journey by personalizing the experience. The benefits of Mobility as a Service (MaaS) is also investigated utilizing a case study of the system that services Charlotte, NC, USA. The Accenture Technology vision team produced this work. It is part of Accenture, a global consulting firm that provides a range of strategy, operations and technology services to a list of international clients. Their specialty is project execution (delivery). This document is relevant to this essay because it shows how artificial intelligence (AI) can help transport agencies with real-time route optimization, congestion mitigation and provide riders with a personalized experience.

Datta, S. (2017). Emergence of Digital Twins - Is this the march of reason? *Journal of Innovation Management*, 5(3), 14–33. https://doi.org/10.24840/2183-0606_005.003_0003

This research paper delves into the rationale for digital twins, how they are configured - within the program and to the IoT network, and the quantification of their benefit. A benefit that is primarily derived from the ability to offer real-time transparency. The key adoption hurdles are the lack of interoperability between architectures, standards, and ontologies. This article was published in the *Journal of Innovation Management*; a multidisciplinary peer-reviewed journal focused on innovation. This source guided the integration of Digital Twin technology within the Big Data trend discussion.

Digital platform as a growth lever | Deloitte Insights. (n.d.). Retrieved January 31, 2021, from <https://www2.deloitte.com/us/en/insights/focus/industry-4-0/digital-platform-strategy.html>

The article's focus is to show how to best leverage technology to simultaneously drive growth and operational efficiencies through the adoption of a digital platform strategy. The introduction describes the four most common platforms; aggregation, social, mobilization, and learning. The reader is then warned that it is not easy to monetize existing services and capabilities in a new way. Building a platform demands an enterprise-level shift; for most, a large-scale digital transformation. A transformation program that links strategy, a business model, capabilities, operating model, people, processes, and technology. The article then focuses in detail on how to develop a viable strategy and the associated business model. This is a credible source because it was published in Deloitte's thought-leader blog "Our Insights," and the author is a managing director in Deloitte's Technology, Media, and Telecommunications practice. This article provided insights on how a platform strategy could help a public transportation agency, or any organization, transition from an individual provider to a network orchestrator.

Digital transformations in the public sector. (n.d.). ICF. Retrieved January 30, 2021, from <https://www.icf.com/insights/technology/public-sector-digital-transformation-trends>

This article starts by exploring how the rapidly changing digital evolution has many organizations struggling to determine when—and to what extent—they should adopt new technology. With more consumers expecting seamless experiences and personalized engagement, organizations are under more pressure than ever to meet these expectations. Public service entities are not an exception. Unfortunately, due to decades of under-investment, most face a steep uphill battle, one that includes a full-fledged digital transformation. Given that public service entities are subject to more regulation than private companies, they don't have the same latitude to iterate, reorganize the workforce, or change offerings at will. Additionally, they also have constrained, often inflexible, budgets. To fuel one's thinking about what is possible, the article delves into use cases from the aviation, transportation, federal IT, and energy sectors. The conclusion puts forward that digital transformation in the public sector is moving towards independent technology platforms that would result in modernization and improved cybersecurity. This article was written by ICF is a global advisory and digital services provider recognized for their skill in public sector IT transformation. This work provided insights into how Amazon, Google, and Netflix have conditioned the public to expect seamless experiences and how digital transformation can be used by public service entities to reach this expectation.

Digital twin technology: A guide for innovative technology. (2020, December 7). Intellias. <https://www.intellias.com/digital-twin-technology-a-guide-for-2019/>

The article starts by reviewing all the key elements that comprise Industry 4.0. Although digital twins' concept is not new - the most cited initial usage was in 1970 with the Apollo 11 mission - the article explains how a combination of IoT, big data, artificial intelligence, and machine learning solutions have finally allowed it to reach its full potential. The business value of and the cons associated with digital twins are explored. The article concludes by citing use cases for digital twins. The author is the IoT Practice Leader for Intellias, a global technology consultancy specializing in the development and deployment of Industry 4.0 driven solutions. Provided insights on understanding the different types of digital twins models - reliability, life-cycle, and performance - best suit the proposed transformation of NYCT Subway.

Digital twins – the secret to safe training? (2019, February 7). Mass Transit. <https://www.masstransitmag.com/technology/intelligent-transportation-systems/article/13000009/digital-twins-the-secret-to-safe-training>

This article reviews four cases in different transportation industry segments where digital twins have been established for employee training. The benefits derived from each scenario is described. Industry insiders regard Mass Transit as one of the most credible periodicals dedicated to public transportation by producing first-hand, in-depth profiles of transit agencies, transit operations, and transit systems managers and management. Understand the scope and current uses of digital twins for employee training. This article informed the proposed solution and supported a use case for public transit agencies.

Fuller, A., Fan, Z., Day, C., & Barlow, C. (2020). Digital twin: Enabling technologies, challenges and open research. *IEEE Access*, 8, 108952–108971. <https://doi.org/10.1109/ACCESS.2020.2998358>

This is the technical professional journal for the IEEE, whose mission is to advance technology for the benefit of humanity. The paper's focus is on the emerging Digital Twin technology and real-world applications. First, it explores how Industry 4.0 has facilitated the expanding use of Digital Twins, particularly in the manufacturing industry. This paper was published in IEEE's official technical journal. The IEEE has highly cited for its publications, conferences, and professional and educational activities. It is considered one of the world's most trusted voices for engineering, computing, and technology information. The primary author is a post-doctorate researcher with the School of Computing and Mathematics, Keele University. His co-authors are Doctors of Philosophy (Ph.D.), who focus on IoT, neural networks, or machine learning applications. This paper was essential to further my work, covering the application, and associated challenges, stitching together Artificial Intelligence (AI), Internet of Things (IoT), and Big Data into a predictive platform. These insights were used to help tie together the Key Technology Trends section of the essay.

Gartner top 10 trends in data and analytics for 2020. (n.d.). Retrieved January 30, 2021, from [//www.gartner.com/smarterwithgartner/gartner-top-10-trends-in-data-and-analytics-for-2020/](http://www.gartner.com/smarterwithgartner/gartner-top-10-trends-in-data-and-analytics-for-2020/)

This article looks at what Gartner believes are the top technology trends that analytic leaders should focus on as their organizations prepare for the post-pandemic reset. Most of the trends are around leveraging the cloud to deliver augmented management and what they have termed "X analytics." X represents the variable input, which can consist of different structured and unstructured content such as text, video, and IoT sensor data. Each trend includes an overview of a current use case. The conclusion is that data and analytics in combination with artificial intelligence (AI) will be important in the organization's effort to predict, prepare and respond to the pandemic's aftermath. This article is credible because Gartner published a leading global research and advisory company that has built its business on providing the best technology insights. To understand how leaders can leverage data and analytics to navigate their COVID-19 response and recovery and prepare for a post-pandemic world.

Goldbaum, C. (2020, March 17). M. T. A., citing huge drop in riders, seeks \$4 billion virus bailout. *The New York Times*. <https://www.nytimes.com/2020/03/17/nyregion/coronavirus-nyc-subway-federal-aid-.html>

This newspaper article looks at the steep drops in ridership one month after stay-at-home directives were issued in the New York City Metropolitan area. And the lobbying efforts were undertaken by agency officials to secure emergency financial relief for both New York State and the United States federal government. This source is credible because it was published in the "New York Times" (newspaper). Goldman's work is relevant to this analysis because it provides in the moment insights on how the MTA leadership has to balance service availability, primarily for essential works, with the financial impact of severe ridership drops. I've used this work to set the context of why the NYC Subway is amid both an economic and ridership shock, which drives the need to transform its business model.

Hausler, S., Heineke, K., Moller, T., Hensley, R., Schwedhelm, D., & Shen, P. (n.d.). *The new normal: Impact of COVID-19 on mobility solutions*. Our Insights; McKinsey & Co. Retrieved November 28, 2020, from <https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/the-impact-of-covid-19-on-future-mobility-solutions>

Ijaz, R. (2020, September 16). Predictive analytics: 4 primary aspects of predictive analytics. *SmartData Collective*. <https://www.smartdatacollective.com/predictive-analytics-4-primary-aspects-of-predictive-analytics/>

The article is a primer on predictive analytics and the four key components to maintaining effectiveness; data sourcing, data utility, deep learning/automation, and the business objective(s). The Smart Collective is a blog for recognized subject matter experts to share their insights through peer contributions and custom content. This information was utilized in the Key Technology Trends section to enrich the discussion around big data analytics' impact on decision-making.

IoT in Transportation: Benefits, Challenges, and Uses (n.d.). Retrieved November 29, 2020, from <https://mobility.here.com/learn/smart-transportation/iot-transportation-benefits-challenges-and-uses>

The article discusses how IoT can change the transport industry by transforming how transportation systems, private and public, gather and use data. It discusses benefits such as enhanced rider safety and operational performance from sensors that detect station loads and train position. It balances this perspective by going into three key challenges associated with IoT deployment; security, extending network infrastructure and installing and maintaining the thousands of needed sensors and devices. The work also discusses use cases of IoT in public transit. This source is credible, HERE Technologies is a location technology company whose legacy is built upon building mapping platforms to help optimize operations and simplify journey planning. This article informed my thinking on the use of IoT in transportation scenarios.

Kanik, A. (2020a, July 21). Cities' coronavirus decisions had big impacts on bike-sharing. *City Monitor*. <https://citymonitor.ai/transport/the-decisions-cities-made-about-coronavirus-had-a-big-impact-on-bike-share-ridership>

This article (post) investigated how the pandemic impacted the way people moved around cities. In the first months after stay-at-home orders were issued in the United States, major cities witness mass transit declines of 70 plus percent. At the same time, other modes like bike-sharing initially dipped but quickly rebounded to the 2019 level when the economy started opening. Not surprisingly, the heaviest usage centered around critical workforce sites like hospitals. The source is credible because it is from the "City Monitor" whose focus is on data-led analysis and insights from leading urban policy journalists and experts. The author is a seasoned journalist and data analyst. This article was used to pull the statistics on the impact of the pandemic and New York City's advisory to find more "personal" means of transportation had on bike-sharing (alternative transit) versus traditional public transportation modes.

Loozen, T., & Baschnonga, A. (2020, May 12). *COVID-19: How the telecoms industry is pursuing a renewed purpose*. https://www.ey.com/en_us/tmt/covid-19-how-the-telecoms-industry-is-pursuing-a-renewed-purpose

This article (post) explores US consumers' attitudes toward technology, particularly telecommunications, during the early stages of the pandemic versus their counterparts in the UK, given the sudden urgency for reliable high-capacity service in support of remote education and work. It then compares country average network performance metrics, customer service, and network maintenance with suggestions on how automation in many areas could help current performance ratings. Finally, they use cases on how telecom leaders can make their business more innovative, better positioning them for the future. Although Ernst & Young is one of the top accounting consultancies, it also has a strong business and technology practice, and the author is Ernst & Young's Global telecommunications Leader. The Technology, Media & Entertainment, and Telecommunications (TMT) group focuses on these three industries' technology-centric convergence point. The source was used to review how well the linkage between remote works cloud-based corporate data stores had performed and what role they may play in sustaining a heightened level of remote working post-pandemic.

Lopes, D., & Flavell, R. (1998). Project appraisal—A framework to assess non-financial aspects of projects during the project life cycle. *International Journal of Project Management*, 16(4), 223–233. [https://doi.org/10.1016/S0263-7863\(97\)00055-0](https://doi.org/10.1016/S0263-7863(97)00055-0)

This article proposes a valuation methodology to assess the overall viability of a project on non-financial terms. The report puts forward the case that such frames are uncommon because there is little guidance on incorporating them in the overall appraisal. The paper constructs such a framework by extending published guidance through interviews with several project-oriented organizations in the UK and a detailed examination of one extensive and complex project. The text analyses the non-financial aspects of projects, how they can be assessed, their relative importance to the project's success, and how they can be incorporated into the appraisal procedure. The mentioned non-financial aspects include strategic and synergistic effects, political and technical links, and organizational issues. This is a credible source. The

article was published in the International Journal of Project Management. The author was a professor at the University of Porto at the time of publishing. The item was used to help structure the benefit (value) framework used to evaluate the selected use cases.

Matellio. (2019, November 29). How AI and IoT are emerging as the future of the industry? *Matellio Inc.*
<https://www.matellio.com/blog/how-ai-and-iot-are-emerging-as-the-future-of-the-industry/>

This article discusses how transportation firms can use artificial intelligence (AI) and the internet of things (IoT) to proactively respond to maintenance issues, alert maintenance staff, and keep passengers and freight safe. It first discusses the role of AI and IoT through real-world examples and then discusses the combination's possibilities. Finally, AI-enabled IoT applications in various industries are discussed. Matellio is an international software engineering studio who focus on helping their clients capitalize on the digital revolution. Their experience includes delivering projects that leverage AI, IoT & IIOT, cloud integration, machine learning, and mobile solutions. This article was used to understand and convey the benefit of the emerging trend of building predictive engines by bundling artificial intelligence (AI) with real-time data.

McAllister, J. (2017, December 22). 4 ways to use big data in employee training. *InsideBIGDATA.*
<https://insidebigdata.com/2017/12/22/4-ways-use-big-data-employee-training/>

This article discusses how the demand for better big data tools has been on the rise because of the expanding number of business functions that see it's potential. One of these is employee training. The data produced in skills development can be analyzed to increase training efficiency. The article references data creditable data sources and reports. The insights were used to understand the benefits associated with existing big data-driven training programs.

Means of transportation to work. (n.d.). U.S. Census Bureau. Retrieved December 20, 2020, from
https://data.census.gov/cedsci/table?q=K200801&g=02000C0US1_310M500US35620&tid=ACSSE2019.K200801&hidePreview=true

The tables show a worker's travel from home to work. The US Census collected the data by asking questions about travel time, means of transportation, time of departure for work, vehicles available, and expenses associated with the commute. The data is creditable because it is part of the United States Census Bureau's official census. The survey information was used to understand public transportation ridership levels in the New York City Metropolitan area before the pandemic.

Nine-Month financial results through September 30, 2020. (2020). Port Authority of New York and New Jersey.
<https://corpinfo.panynj.gov/documents/Nine-Month-Financial-Results/>

Monthly financial performance report presented in the public board meeting to review the agency's financial results, ridership activity, and the state of its financial obligations. This is a creditable source because it is the official report on the public entity's financial performance. The numbers were prepared in accordance with the U.S. generally accepted accounting principles and signed-off as accurate by the agency's leadership. This presentation was used to put into context the need for regional collaboration by showing that the PATH also had a significant ridership drop.

November 2020 MTA board meeting report. (2020, December 12). Metropolitan Transportation Agency; December 12, 2020. https://www.youtube.com/watch?v=qAE68PGYU48&feature=emb_logo

This video provides information about both financial and ridership projections and historical trends. You hear directly from the MTA's leadership on how they see the pandemic unfolding in the coming months. The forecast was developed by McKinsey & Company precisely for the MTA based on the information on hand. What was not included in the assumptions made in May 2020 was a second wave of the pandemic during the late Fall of 2020 and the Winter of 2021. When this report was presented in November of 2020, this deficiency was recognized, and the MTA had secured McKinsey to revise the forecast. The

presentation is used to understand the estimate and estimation process utilized to determine the pandemic-driven ridership estimates.

October 2020 MTA board meeting report. (2020). Metropolitan Transportation Agency; December 12, 2020. <https://new.mta.info/document/21416>

The MTA BudgetWatch report reflects preliminary operating results and NYC economic data through September and including subsidies received in October, with results measured against the Mid-Year Forecast. An MTA constructed a budget report to understand the business employment situation and the correlation with public transportation ridership. The report provides factual information because it is based on internal MTA ridership data and employment data from the city of New York. The report was used to understand the direct correlation between business closures and the stay-in-place orders in the New York City Metropolitan area on ridership on the public transportation sources controlled by the MTA (includes NYCT Subway).

Opportunity insights: Economic tracker. (2020). Opportunity Insights; Opportunity Insights - Harvard University. <https://opportunityinsights.org/>

Opportunity Insights' work provides comprehensive, up-to-date quantifiable information on the business impact of the pandemic. The research institute translates raw digital data on millions of customers, workers, taxpayers, and businesses into insights utilizing scientific research that helps local stakeholders to make more informed economic-based decisions. In addition to publicly available data sources, several companies are convinced to feed it information like credit card spending, employment data (Earnin, Paychex, and Intuit), and data on small-business revenue from (Womply). Opportunity Insights is a Harvard University co-venture that also receives funds from the Bill & Melinda Gates Foundation and the Chan Zuckerberg Initiative. The organization is staffed by Harvard professors and post-doctorate researchers, and policy analysts. I used this information in the section where I wrote about the pandemic's impact on business viability, employment loss, and the long-term outlook for employment levels in the New York City Metropolitan area.

Pierre, P., Mindala-Freeman, M., Bagnon, P., Tignon, M., Larsson, T., Buvat, J., Puttur, R., & Ghosh, A. (n.d.). *5G in industrial operations*. Capgemini Research Institute. Retrieved October 18, 2020, from <https://www.capgemini.com/gb-en/wp-content/uploads/sites/3/2019/06/Report-5G-in-industrial-operations.pdf>

This report explores how 5G and Edge computing will impact businesses. It provides insight into how all edge computing devices can take advantage of this higher bandwidth, lower latency, transmission protocol. Next, it reviews 5G's advantages over existing systems and why some businesses consider purchasing their own 5G licenses for security reasons. Additionally, time is spent on informing the reader of how to build a 5G use case. The Capgemini Research Institute is an in-house think tank focused on all things digital. The Institute is highly regarded for its thought leadership content. In addition to its staff, the Institute engages with the firm's network of experts and works closely with academic and technology partners. This report was used to understand and convey the emerging trend of 5G, its advantages, hurdles, and possible timeframe.

Rossmann, M., Hein, A., Thieullent, A., Brosset, P., Chemin, M., Buvat, J., Kar, K., & Khemka, Y. (n.d.). *Unlocking the business value of industrial IoT*. Capgemini. Retrieved October 22, 2020, from https://www.capgemini.com/wp-content/uploads/2018/03/IoT-in-Ops-Research_Digital.pdf

This article delved into Capgemini's research finding that more than six out of ten organizations failed to take Industrial Internet-of-Things (IIoT) initiatives beyond proof-of-concept. It reviewed the top four technical or business impediments; unclear business case, analytical capability gap, security concerns, and lack of IIoT standards. The authors then utilized the rest of the article to educate the reader on choosing optimal use cases. The impediment that Capgemini sees as the most important hurdle that keeps entities from positioning themselves to drive greater value from their IIoT investments. This report is creditable

because it is a published work of Capgemini Research Institute. Additionally, the lead author is the global head of Capgemini's Digital Manufacturing Services. The report was used to enrich the section on technology trends, in particular the advancement of IoT. Elements also lent themselves to the identification and development of the essay's use cases.

Schwartz, A., Fishman, T., Kelkar, M., Nicol, J. B., & Sen, R. (2020, April 18). Transportation trends in 2020. *Deloitte Insights*. <https://www2.deloitte.com/us/en/insights/industry/public-sector/transportation-trends.html>

The article discusses public and private transportation entities' convergence to provide riders a personalized and seamless experience. First, it examines how five transformative trends - frictionless travel, digital identity, customer experience, digital accelerators, and artificial intelligence - are reshaping aspects of how people and goods traverse transportation networks. It then discusses the rise of mobility hubs and the technology that underpins them. Finally, it provides advice on how government leaders can navigate the fast-changing mobility landscape. Deloitte is a global consulting firm that includes a practice dedicated to exploring how emerging technologies could transform their business model. The primary author, Avi Schwartz, is a principal at Deloitte Transactions and Business Analytics, leading the infrastructure and capital projects team for the government and public services division. This information source was used to understand the required supporting technology (technology stack) and the challenges one would face implementing a network-connected artificial intelligence (AI) platform.

Snyder, T. (n.d.). *From goody-two-shoes to pariah: How coronavirus is changing public transportation*. POLITICO. Retrieved January 31, 2021, from <https://www.politico.com/news/2020/05/19/transit-commute-coronavirus-267920>

The article (post) documents how the pandemic has changed the transportation habit of millions and even has officials in cities across the United States who had to spend decades trying to move constituents onto mass transit urging the opposite. It then documents the ridership losses and the associate financial bind for agencies who are lobbying the national government for billions in relief funding. Funding will have to be in place for years as systems redefine their process and, more importantly, their role in society. The online publication Politico is a creditable source for political insight from across the globe. The author is a seasoned journalist who covers transportation for Politico with special interests in driverless cars and safety issues. Pulled a quote for the Metropolitan Transportation Agency (MTA) to attest to the state of ridership and leadership mentality three months after the New York City metropolitan area had issued a stay-at-home order.

Tan, V. (2020, November 17). Smart cities in a post COVID-19 world. *Capgemini UK*. <https://www.capgemini.com/gb-en/2020/11/smart-cities-in-a-post-covid-19-world/>

This article (post) goes beyond "smart cities" as a policy research area to explore how the pandemic has brought about the opportunity to advance digital transformation projects focused on overcoming the unprecedented challenges posed by this health crisis. In particular, the value of smart technologies to combat the spread of the virus. The article also touches on the aspects of data governance, privacy, and security that need to be defined before the full deployment of an initiative. Vivian Tan is a Senior Business Analyst in Capgemini's Singapore office, and the content is presented on Capgemini's blog (website). Although not very long, the article does discuss Singapore's smart facility management application and how it utilizes the internet of things (IoT) and surveillance, and security are becoming the hallmarks of Smart Cities. This articles provided information and insight on which technology is central to the deployment of public managed digital monitoring platforms.

The future of transportation agencies | Deloitte Insights. (n.d.). Retrieved January 31, 2021, from <https://www2.deloitte.com/us/en/insights/focus/future-of-mobility/future-of-transportation-agencies.html>

This article explains how most transportation agencies' processes have remained rooted in mid-20th century paradigms. Evidence is presented that the normal decades-long planning cycles and antiquated

workforce systems are typically the largest capability gap any US agency needs to close on their modernization journey. The authors then put forward what they believe will be the most impactful disruptors that will affect the industry. Each future disruptor is then grouped and explained in the context of one of five categories; technological, environmental, societal, economic, and governmental. The article then argues that the best path forward for the industry is to anchor their actions in the vision of being an integrated, frictionless transportation system. Something only possible is they let data guide their decision-making. To help readers actualize this recommendation, a mobility maturity curve is introduced as a stage-by-stage guide for the transformation journey. This is a creditable source because it was published in Deloitte's thought-leader blog "Our Insights". Additionally, the author is the Managing Director of Deloitte Transactions and Business Analytics. This source broadened my perspective on modern transit management and the gap between the typical transport agency processes and modern technology-enabled systems.

Types of internet connections. (n.d.). Retrieved December 20, 2020, from <https://data.census.gov/cedsci/table?q=200801&g=400C100US63217&tid=ACSST1Y2019.S2801&hidePreview=false>

Contains computer usage and internet access levels for households in the New York Metropolitan area, which includes populations in Southeastern New York, Northeastern New Jersey, and Southern Connecticut. In addition to the types of activity, the data is bucketed by household income. The data is creditable because it is part of the United States Census Bureau's official census. Survey information was used to support insights about households' ability to conduct work-from-home activities before the pandemic.

Uhl, A. (n.d.). *Digital enterprise transformation course* [Online course]. CXO Transformation. Retrieved September 5, 2020, from <https://cxotransformtion.com>

The course explains the models, procedures, methods, and tools that allow organizations to transform their current business model into a digitally based, data-driven business model. First, the course explores the megatrends, like artificial intelligence, robotics, and individualization, that are both forcing and allowing organizations to modify their operations. Course participants are then introduced to the digital maturity models and how to use them to develop a digital strategy. Finally, there is a review of the risk and challenge organizations, workers, and society must face. Along the way, case studies are used to reinforce the learning and provide a comprehensive overview of innovative digital models. Dr. Axel Uhl is a Senior Lecturer at Lucerne University, and author of four (4) titles focused on helping business people understand business transformation. Before his professorship, Dr. Uhl worked as a consultant to help organizations develop and implement their digital strategies. Additionally, the course includes monthly live case studies that allow participants to practice newly learned skills. This course is directly relevant because it provides the foundational information and framework upon which the essay was developed. It gives a detailed explanation of how to use the DCF to craft a tailored digital strategy, the key technology megatrends, and imparts practice-relevant knowledge.

Uhl, A., & Gollenia, L. A. (2016). *Digital enterprise transformation: A business-driven approach to leveraging innovative IT* (A. Uhl & L. A. Gollenia, Eds.; 1st ed.). Routledge. <https://doi.org/10.4324/9781315577166>

This book contains a considerable amount of information about successful organizations' processes to implement a digital business transformation. The authors introduce the Digital Capability Framework (DCF), a step-by-step approach to integrating digital technology into all areas of an organization, fundamentally changing how it operates and delivers value. First, the authors explore how to leverage technology trends and summarizes the characteristics of a digital enterprise. Then, they introduce the DCF explain how it integrates with the Business Transformation Management Methodology (BTM) to provide a holistic analysis. Finally, the reader is systematically taught how to implement each section of the framework through instruction and examples. Dr. Axel Uhl is a Senior Lecturer at Lucerne University, and author of four (4) titles focused on helping business people understand business transformation. Before

his professorship, Dr. Uhl worked as a consultant to help organizations develop and implement their digital strategies. This book's insights provide an understanding of, and the ability to apply, the Digital Capability Framework (DCF); Section 2.3. Chapter 9 on valuing a transformation's benefits were also utilized to help find and apply a measurement framework to the identified use cases. The additional chapters of the book helped to reinforce the overall thinking about how to connect

Wilson, H. J., & Daugherty, P. R. (2018). *Human + machine: Reimagining work in the age of AI*. Harvard Business Review Press.

This book gives insights into the different ways artificial intelligence (AI) is being leveraged to innovate and grow faster by better meeting market needs. This book reviews the history of AI's progression from powering single-focused automation machines to today's myriad of uses. Much has been written about both human-only activity and machine-only activity, but what has been overlooked is the large area of convergence between these two extremes - this is what the authors refer to as the "missing middle." A discussion then ensues on how human competencies, cognitive knowledge, complement machines, and how AI gives humans superpowers. The section referenced in this essay centers on how AI is providing humans augmented capabilities. Augmentation comes from augmented reality, robot arms, to analytical engines. The chapter presents arguments and supporting cases that show how AI goes beyond automation to creating symbiotic relationships that upend traditional workflows. The book then evaluates how machine learning and other machine-only activities will likely lead to a variety of new jobs. A workforce composition change that will require different management and leadership paradigms. Finally, the book explores how work itself will change since the key skills will be associated with collaborating with intelligent agents. This is a creditable source because Harvard Business Press published it, and the author is the Managing Director of Information Technology and Business Research at Accenture Research. This source was used to understand and determine the different ways artificial intelligence (AI) is being used in business to increase productivity.

Yelp: *Local economic impact report*. (n.d.). Yelp Economic Average. Retrieved January 31, 2021, from <https://www.yelpeconomicaverage.com/business-closures-update-sep-2020>

Yelp used its internally collected data on its site's usage plus data collected from its targeted business user base to determine the immediate impact on business in several geographic regions. This particular report looks at how the business economic environment had endured after the first six months of the pandemic. Numerous charts indicated which industries and regions were hardest hit and provided closures per 1,000 residents to facilitate city by city comparisons. This is a reliable source because it used numbers from business owners marking their business as closed (permanent or temporary), including hour changes or through a COVID-19 banner, on its Yelp page. Closure data was aggregated by state, metro area, and category. This economic report was useful to provide quantitative values on the number of businesses closed and likely not to reopen after the pandemic.