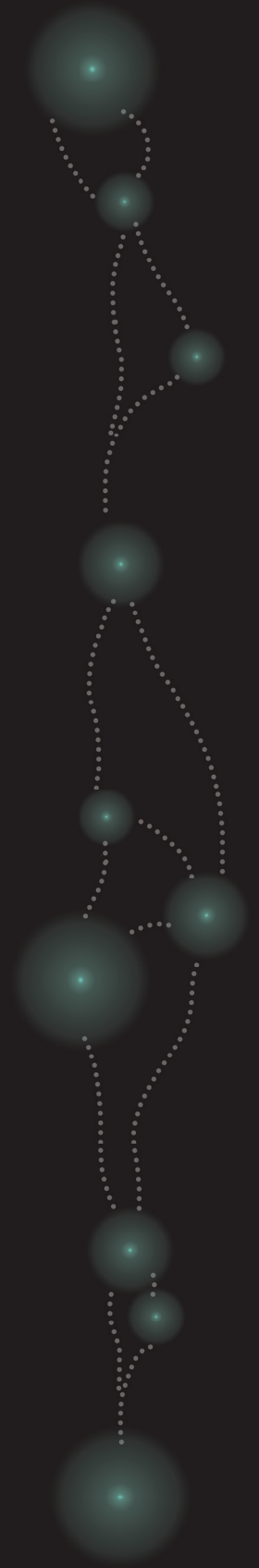


The Physical Presence of the Digital World

Bryan Shishakly



To Claire Bear - Coming home to your smiling
face gave me the strength to complete this
book. Without you I am nothing. I love you.

-Daddy

The Physical Presence of the Digital World

During the course of this thesis
I have created...

61.3 GB

of data

in 2,556

files

stored in

3

locations

183.9 GB

of data

in 7,668

files

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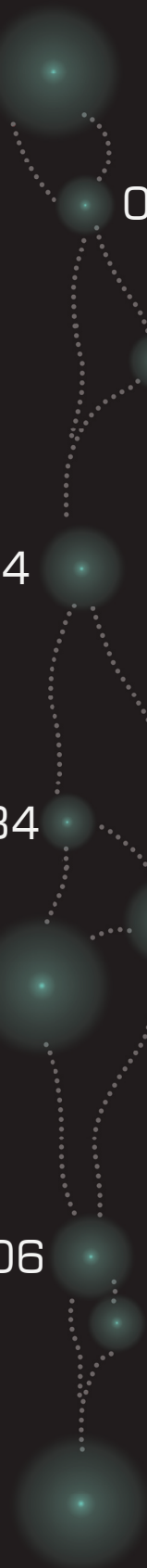
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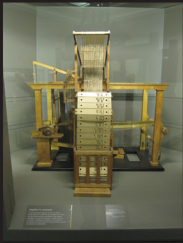
Abstract

The apparent lines between the digital and physical worlds are becoming increasingly blurred. What we perceive happening is an integration of both worlds in which a faster, smarter and more efficient society is born out of. Our ever-growing digital world is being marketed as sexy and sleek and the products that are created to connect you to that world as status symbols. The emphasis placed upon the importance of our digital lives and digital world ensures that the ugly truths about how it operates and the ramifications it creates are kept veiled from view. The view is so well hidden behind the mask of evocative and enticing marketing campaigns that even the physical architecture of the digital world goes virtually unnoticed. Most people don't perceive anything of the infrastructural requirements or environmental impacts of completing even the most mundane tasks within the digital world.

The grim reality is that during a period of time in which sustainability and technology have become dominant pieces of public discourse we have created a new and rapidly expanding world that functions as the antithesis of sustainability. The physical manifestations of this digital world are hidden in plain sight within our built environment, yet many do not recognize their presence. While the environmental impacts of the digital world increase, so too does the divide between the physical and digital worlds. The user is only connected to the digital world through the screen of a device, but is completely disconnected from the physical reality of digital space. With the digital world expanding at exponential rates we have reached a point at which a critical analysis of the digital world and how it intersects with the physical is warranted. This thesis aims to understand the ramifications of the digital world on the physical and seeks to develop a means to architecturally question the physical manifestations of the digital to both inform and draw connections for the user between both worlds in which we live.

A Brief History of Data Storage

[1725-2012]



1725
Bouchon creates first semi-automated loom

1728
Falcon alters process to handle punched cards



1805
Jacquard fully automates the loom

1890
Hollerith automates the U.S. Census



1900
Hollerith's machines are used globally to sort and tally information

1911
Hollerith creates the Computing-Tabulating-Recording Company

The origins of modern computing date back to the early 18th century and are rooted in the textile industry. Though very different from the ways in which we understand, compute and automate information, the developments made in the textile industry during the period of time between the early 18th and 19th centuries. Obviously we have made monumental technological advances, but we owe much to the achievements of French textile workers and their ingenuity for many of our modern technologies.

Textile Automation

In 1725, Basile Bouchon, the son of an organ maker in Lyon, France, created the first semi-automated machine for industrial application.¹ His concept was derived from the way in which cylinders for musical automata were created. Bouchon understood that the templates for the very expensive cylinders were first laid out on paper and recognized that all of the information for the automated cylinders was present within the paper templates. He utilized this concept to adapt a means for beginning the automation of the looms used in the textile industry. Bouchon created rolls of paper with perforated patterns that would allow for the hooks that grabbed the warp threads to hit either solid paper or a hole in the paper. This automated the tedious process of determining which threads were raised and which were not during the weaving process.^{1,2} Though incredibly innovative, Bouchon's process was flawed in that it could not be

utilized for large designs and using a roll of paper was not practical considering any rip would force a whole roll to be reproduced. However, three years later, in 1728, Bouchon's assistant, Jean-Baptiste Falcon greatly improved the machine. He increased the size of the design that the machine could handle and replaced the paper rolls with punched cards that were attached to form a continuous loop. This made it possible to both replace damaged sections of the paper pattern and allowed for rapid changing of the program.³ Despite Bouchon and Falcon's advancements in automating looms and reducing the number of mistakes made when raising threads, their machine was only modestly successful. It wasn't until 1805 when Joseph Marie Jacquard created a fully automated loom that these machines began to rapidly alter the textile industry and the way we understood information.⁴

Hollerith's Punched Card

It wasn't until the 1890 census that the world saw the first successful means of information processing. The automated textile looms of the early 18th and 19th centuries created a method for utilizing patterns of information to expedite production processes, but no one had yet developed a means to process and tabulate data sets. However, after working on

¹ Usher, Abbot Payson. *A History of Mechanical Inventions*. Revised edition. (Mineola, N.Y.: Dover Publications, Inc., 1988), pages 289-291. (Originally published in 1929 by Harvard University Press in Cambridge, Mass.)

² Morrison, Philip and Emily (1961). *Charles Babbage and his Calculating Machines*. Dover Publications, Inc, New York. xxxiv.

³ Randell, Brian ed. *The Origins of Digital Computers: Selected Papers*, 3rd ed. (N.Y., N.Y.: Springer-Verlag, 1982), page 5.

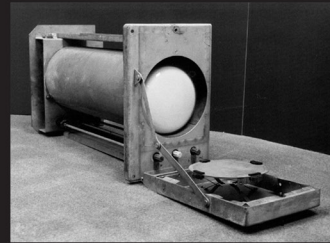
⁴ Essinger, James (2004). *Jacquard's Web: How a hand-loom led to the birth of the information age*. Oxford: Oxford University Press.



1924
CTRC becomes International
Business Machines or IBM

1932
Tauschek develops
drum memory

1946
The ENIAC computer
is used for the first time



1946
The Williams Tube
is invented

1948
The Williams Tube
executes the first electronically
stored memory program

the 1880 census, a young Columbia University graduate named Herman Hollerith saw the need to develop a more efficient and accurate method for tabulating census results. He saw that the tabulation of census data sets by hand was sluggish and prone to error and began a venture to reinvent this process.

Hollerith built upon the achievements of Bouchon and Falcon by developing a system of punched cards that could hold information and developed two machines, a tabulator and a sorter, to tally the results. This model allowed for a substantial increase in efficiency in calculating the results of census information. The job had previously taken ten years to complete, but with Hollerith's machines the job took approximately three months (although various sources cite results ranging from six weeks to three years).⁵ Hollerith's machines were once again utilized for the 1900 census and in various countries around the world including Russia, Austria, Canada, Norway, France, Puerto Rico, Cuba and the Philippines. In 1911, the company that Hollerith founded merged with several others to create the Computing Tabulating Recording Company (later becoming IBM in 1924) and began to usher in the age of modern computing.⁶ The punch card, though now an antiquated method of data processing, was a major part in data processing throughout most of the 20th century. The major shift from punch cards to other data storage medium began in the 1970's and was essentially

completed industry wide by the 1990's. The punch card did still have one major use that carried through to the new millennium and that was voting. Though a transition had already begun to modernize voting technology, it wasn't until the "hanging chads" debacle of the 2000 U.S. presidential election that punch cards were put to rest.⁷ Though now virtually non-existent in voting or any other applications, the punch card which was the first form of real data processing maintained its usefulness in one form or another until almost present day.

The Williams Tube

It wasn't until the Williams tube was developed in 1946 and 1947 by Freddie Williams and Tom Kilburn that the world saw the first random-access storage device.⁸ Random-access storage allows for any information housed on a device to be accessed in virtually the same amount of time despite its location on the device. The Williams tube was created at the University of Manchester in England and was the first medium on which an electronically stored-memory program was executed on June 21, 1948.^{8,9} The Williams tube was never extremely reliable as every time information was read it would be erased. This forced every read operation of data to be followed by a write operation to ensure that the information was still in place. It also became increasingly unreliable as the tube aged, but despite this it still saw some commercial

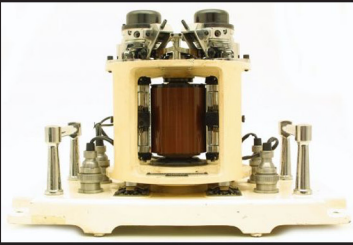
⁷ Jones, Douglas W. "Punched Cards." *Douglas W. Jones's Punched Card Index*. University of Iowa., 2000. Web. Sept.-Oct. 2012

⁸ "Early Computers at Manchester University" (<http://cs.man.ac.uk/CCS/res/res04.htm#g>), *Resurrection* (The Computer Conservation Society) 1 (4), Summer 1992, ISSN 0958-7403 (<http://worldcat.org/issn/0958-7403>), retrieved Oct. 2012.

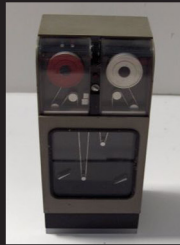
⁹ Napper, Brian, *Computer 50: The University of Manchester Celebrates the Birth of the Modern Computer* (<http://www.computer50.org/>), retrieved Oct. 2012.

⁵ Austrian, Geoffrey, *Herman Hollerith: Forgotten Giant of Information Processing*, Columbia University Press (1982).

⁶ Bashe, Charles J.; Lyle R. Johnson; John H. Palmer; Emerson W. Pugh, *IBM's Early Computers*, MIT Press (1985).



1950's
Drum memory begins to see widespread computing use



1950
Magnetic tape is used to store information in the UNISERVO I

1951
Using the UNISERVO the UNIVAC I uses magnetic tape to record census data



1956
IBM 350 is developed becoming the precursor to the modern hard drive

success. The Williams tube could hold roughly 512-1024 bits of data (up to 1 kilobyte).¹⁰ Though only able to house the most rudimentary forms of information the Williams tube revolutionized the way in which we housed digital information.

Drum Memory

In 1932, Gustav Tauschek developed drum memory in Austria, but his invention did not see widespread use as computer memory until the 1950's and 60's.¹¹ The drum was the precursor to the platters of modern hard drives, the only difference being that the memory was held in the form of a drum rather than a flat disk. The drum is itself a large cylinder that is coated on the outside with magnetic recording material. It operated by rotating the drum around until the information that an operator is trying to access falls under a head that performed read/write operations. In most cases the drum was the main working memory of a computer system, but was sometimes utilized at secondary storage.¹² The data or programs were loaded onto, and off-loaded from, the drums using punched cards or paper tape. The original drum memory that Tauschek invented had a capacity of about 62.5 kilobytes which is significantly larger than the Williams Tube that came later, but it did not see commercial use until the IBM 650 computer was introduced.¹¹ This model had a drum with approximately 8.5 KB of memory, but even with the clear loss of storage capacity it made drum memory the

working memory standard until core memory and other systems were introduced.

Magnetic Tape: UNISERVO

Magnetic Tape is the oldest form of computer memory still in use today, being first used to record data in the UNIVAC I computer in 1951 for the US Census Bureau.¹³ Though magnetic tape had been developed years earlier it was utilized in the UNISERVO I in 1950 and implemented in the UNIVAC I computer a year later. The UNISERVO was a large tape recorder developed by Eckert-Mauchly Co., and stored information on a ½ inch wide tape of nickel-plated phosphor bronze. The tape itself was 1200 feet long and could hold 128 bits of information per inch on eight separate tracks.¹⁴ This meant that the total capacity was just over 14 megabytes of information, a massive leap forward in terms of sheer storage volumes. The UNISERVO also had other advantages other than simply the ability to hold more data. The UNISERVO could buffer information allowing execution of operator instructions in tandem with the movement of the tape and transfers. It also supported forward and backward operation making it easier to sort and merge applications.¹⁴ Though the technology is old and for personal use it is outdated, magnetic tape is still being used in computers today. The tape is even

¹⁰ Napper, R. B. E. (2000), "The Manchester Mark 1 Computers", in Rojas, Raúl; Hashagen, Ulf, *The First Computers: History and Architectures*, MIT Press, p. 366

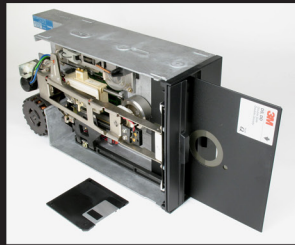
¹¹ Universität Klagenfurt, ed. "Magnetic drum" (<http://cs-exhibitions.uni-klu.ac.at/index.php?id=222>). *Virtual Exhibitions in Informatics*. Retrieved Oct. 2012.

¹² e.g., IBM 2301 Drum Storage (<http://columbia.edu/cu/computinghistory/drum.html>). Retrieved Oct. 2012.

¹³ Osborn, R. (1954). "GE and UNIVAC: Harnessing the High Speed Computer." *Harvard Business Review* 32(4): 99-107.

¹⁴ Phillips, W., "The Uniservo 1 - The First Digital Tape Recorder," in Daniel, E., et. al., *Magnetic Recording - The First 100 Years*, IEEE Press, 1999, Chapter 17, pp. 294-5

1960's
Removable storage begins
being developed



1971
The first floppy disk is introduced
with an 8 inch format and a capacity of 75.75KB



1977
The Apple II is introduced
becoming the first mass produced
personal computer

1976
The 5.25" Floppy is introduced
with a capacity of 87.5KB

being used as a storage medium in the CERN large hadron collider.¹⁵ The capacity and reusability of magnetic tape storage devices make them still today incredibly important for housing and accessing information.

it was withdrawn by IBM in August 1969.¹⁶ The whole unit weighed more than a ton and had to be moved via cargo plane and forklift making it inaccessible for the everyday user¹⁷, but it was the development of the disk drive that makes the IBM 350 one of the most important advances in data storage history.

IBM 350: The First Modern Hard Drive

What has been recognized as the first modern hard drive is the IBM 350 disk storage unit. Developed by IBM, the IBM 350 was released in September 1956 as the storage component of the IBM 305 RAMAC (Random Access Memory Accounting) system. IBM developed the 350 out of a need for real time accounting in the business world. When coupled with the 305 RAMAC it allowed for businesses to maintain up-to-date accounts as transactions occurred by recording them on the hard drives of the 350. The IBM 350 was the first disk drive storage device containing fifty 24-inch diameter disks creating a total of 100 recordable surfaces. The disks spun at 1200 RPM, a far cry from the standard of 7200 RPM today with some drives running even faster, but this allowed for a rapid transfer rate for the time. The total storage capacity was 4.4 megabytes with the 305 RAMAC allowing connectivity to two 350 disk drives. The IBM 350 was used for storage until

The Floppy Disk

Though developed in the late 1960's, it was in 1971 that the world saw the beginning of removable computer storage in the form of the floppy disk.^{18,19} The floppy disk became such a ubiquitous means for storing information over its lifetime that the symbol created for it is still in use in many software programs as the icon for saving information including the newest releases of Microsoft Word.²⁰ Though the floppy disk is most widely known in its final format, and to some extent its second format, in 1971 it was developed as an 8 inch disk.¹⁹ The 8 inch disk, though revolutionary, quickly fell out of favor for being too large. The problem was that the 8 inch disk was not all that convenient and within 5 years the standard became a 5 ¼ inch disk. The first 5 ¼ inch floppy disks were created in 1976²¹ and could hold the same amount of information as the 8 inch format

¹⁵ "Everything You Wanted to Know about the Large Hadron Collider." CanWest MediaWorks Publications Inc., 28 July 2008. Web. Oct. 2012. <<http://www.canada.com/montrealgazette/news/arts/story.html?id=f8b84761-ef5a-45c0-ab3e-9b5ce6497088>>.

¹⁶ "IBM Archives: IBM 350 disk storage unit" (http://www-03.ibm.com/ibm/history/exhibits/storage/storage_350.html). ibm.com. Retrieved Oct. 2012.

¹⁷ Lee Gomes, "Talking Tech" *The Wall Street Journal*, Aug. 22, 2006.

¹⁸ Fletcher, Richard (2007-01-30). "PC World announces the end of the floppy disk" (<http://www.telegraph.co.uk/finance/2803487/PC-World-announces-the-end-of-the-floppy-disk.html>). Telegraph.co.uk. Retrieved Oct. 2012.

¹⁹ "20th century disk storage chronology" (<http://www-03.ibm.com/ibm/history/exhibits/storage/storage-chrono20.html>). IBM Archives. Retrieved Oct. 2012.

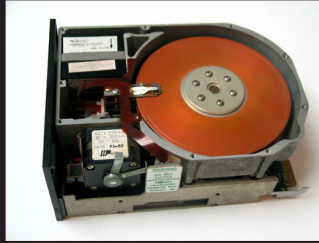
²⁰ Landphair, Ted (10 March 2007). "So Long, Faithful Floppies" (<http://voanews.com/english/archive/2007-03/2007-03-10-voa3.cfm>). VOA News (Voice of America). Retrieved Oct. 2012.

²¹ Sollman, George (July 1978). "Evolution of the Minifloppy (TM) Product Family". *Magnetics, IEEE Transactions on* **14** (4): 160-166. doi:10.1109/TMAG.1978.1059748 (<http://dx.doi.org/10.1109/FTMAG.1978.1059748>). ISSN 0018-9464 (<http://www.worldcat.org/issn/0018-9464>).



1980

The IBM 3380 is released
ushering in the era of the gigabyte



1980

Shugart (Seagate) released
the first 5.25" hard drive at 5MB



1982

The ubiquitous 1.44MB 3-1/2"
floppy disk is introduced

1983

The first version of Windows
is announced by Microsoft

at its peak of 1.2 megabytes (the first 8 inch models held 79.75 kilobytes and the first 5 1/4 inch models 87.5)^{22,23} highlighting the ability for information to be held on an increasingly smaller area. However, during the early 1980's the problem of size became an issue for the 5 1/4 inch format as well.²⁴ Various solutions to the problem of size were developed, with drives being created for 2, 2 1/2, 3 and 3 1/2 inch disks.²⁵ All of these variations were developed with a rigid outer case (the 8 and 5 1/4 inch formats actually being "floppy") making them far less susceptible to damage. Ultimately, in 1982, the 3 1/2 inch design was adopted as the new standard by 23 different manufacturers.²⁶

By 1988 the 3 1/2 inch floppy disk was outselling the 5 1/4 inch format and it would make it the format of choice for the remainder of its existence. The first versions of the 3 1/2 inch format held 720 kilobytes, but ultimately in 1987 the standard model held 1.44 megabytes.²⁷ Given that hard drives at the time could hold very little comparatively to today (10-20 megabytes), the floppy disks capacity and durability made it extremely popular as an external storage device. The floppy disk remained in use in the 3 1/2 inch format well into the first decade of the 21st century, but high capacity storage devices like the CD-R and the flash drive would ultimately render the floppy disk obsolete despite attempts to make its storage capacity larger.

²² <http://www.research.ibm.com/journal/rd/255/ibmrd2505ZB.pdf>

²³ "Shugart SA 400 Datasheet" (http://www.swtpc.com/mholley/SA400/SA400_Index.htm). Swtpc.com. 2007-06-25. Retrieved Oct. 2012.

²⁴ "The Microfloppy-One Key to Portability," Thomas R. Jarrett, Computer Technology Review, Winter 1983 (Jan. 1984), pp 245-7

²⁵ Ibid, 245-7

²⁶ Ibid, 245-7

²⁷ Infoworld Media Group, Inc. (November 1, 1982). "Tandon announces tiny but powerful 3 1/2 inch disk drive" (<http://books.google.com/?id=EzAEAAAAMBAJ&pg=PA11>). Infoworld (InfoWorld Media Group, Inc.) 4 (43): p.11. ISSN 0199-6649 (<http://worldcat.org/issn/0199-6649>).

That's Gigabyte with a G

In 1980, IBM introduced the first storage device to reach gigabyte capacity, the IBM 3380.²⁸ It was unveiled in June 1980 and allowed people to store almost four times as much information as previous devices. The total capacity reached was 2.52 gigabytes, a massive amount for the time.²⁹ The 3380 also increased access, writing and transfer speeds more than twice any other model introduced prior. The price range for the various models that IBM released was \$81,000 to \$142,200 to purchase or \$1,800 to \$3,713 a month to lease.³⁰ The 3380 was a long way away from the development of a high capacity storage device available to average consumers, but brought the world into the gigabyte realm.

The Modern Hard Drive

In the same year that the IBM 3380 was released introducing gigabyte capacity to the world, Seagate Technology (then Shugart Technology) released the first 5.25 inch hard drive.³¹ The way in which the controller and drive interfaced was derived from the floppy disk drive interface making it a relatively simple design.³² The total storage capacity was 5 megabytes, which is a long

²⁸ "IBM Archives: IBM 3380 direct access storage device" (http://www-03.ibm.com/ibm/history/exhibits/storage/storage_3380.html). 03.ibm.com. Retrieved Oct. 2012.

²⁹ Ibid.

³⁰ Ibid.³¹ "Disc-storage innovations keep coming while manufacturers ponder user needs". *EDN Magazine*: p. 59. May 20, 1980.

³² "Simplify system design with a single controller for Winchester/floppy combo," *Electronic Design*, October 25, 1979, pg 76-80.

1988
3-1/2" Floppy gains market dominance over 5.25"



1988
The Compact Disc is published in Sony's Orange Book



1992
Sony debuts the MiniDisc exciting dozens of people

1993
Windows NT is released bringing 32-bit operating systems to home and business computers

way off from the 2.52 gigabyte capacity of the IBM 3380, but while the 3380 weighed in at 500 lb. the ST-506 could fit in your hand.³³ The price was still high for the average consumer at \$1,500, but it was clear that digital storage was quickly becoming increasingly important for personal users.

Goodbye Floppy, Hello CD

While the floppy disk dominated the removable storage market from during the 1980's and early 90's the CD-R became the removable storage device of choice during the remainder of the 90's and the better part of the first decade of the new millennium. The CD-R (Compact Disc Recordable) was invented by Philips and Sony as a variation of the Compact Disc and first published in the Philips and Sony Orange Book in 1988.³⁴ Though at first the medium was not readily available to the average consumer the cost for a recording device had dropped from \$35,000 in 1990 to just under \$1,000 in 1995.³⁵ The accessibility of CD-R discs and their recorders continued from there and now a recording device is included as a standard feature in nearly every computer that is manufactured today. The CD-R became dominant because it could hold upwards of 700 MB of information

making the floppy disks 1.44 MB seem intolerably small. The CD-R has been shown to be unreliable after some aging, with tests showing that some can degrade quickly even if stored normally.³⁶ The average life span of CD-Rs is expected to be approximately 10 years.³⁷ While the CD is still in use as a medium for created and distributing recorded music they have tended to fall out of favor as a removable storage device being replaced by DVD-Rs, and more recently flash memory in its various forms.

MiniDisc: A Short Lived Medium

The MiniDisc, invented by Sony, was first released for sale in 1992 in Japan, the USA and Europe as a storage device intended for audio recordings.³⁸ The format became extremely popular in Japan, but made little impact in any other major markets.³⁹ In reality, the MiniDisc was actually better than alternative formats that were already in use, but the significant cost differences made it difficult for the MiniDisc to catch on. Though eventually music labels began to utilize the MiniDisc as a format choice it was too little too late. The release of the iPod and the inexpensive alternative of the CD made the MiniDisc fall even further out of favor.⁴⁰ The format did have a solely data driven format that held 140 MB of information, but it was slow and caught on even less than the music driven MiniDiscs. Sony pushed on, selling MiniDisc players

³³ Seagate ships one billionth hard drive (http://www.computerworld.com/s/article/9079718/Seagate_ships_one_billionth_hard_drive), *Computerworld*, April 22, 2008.

³⁴ "The Great Books." *ThinkQuest*. Oracle Foundation, n.d. Web. Oct. 2012. <http://library.thinkquest.org/C0112823/greatbooks_cd.htm>.

³⁵ Roxio history of CD-R (<http://web.archive.org/web/20030202233907/http://www.roxio.com/en/support/cdr/historycdr.html>) from Roxio Newsletter 17 January 2000. Retrieved Oct. 2012.

³⁶ "CD-R Unreadable in Less Than Two Years" (<http://www.myce.com/news/cd-recordable-discs-unreadable-in-less-than-two-years-6450>). *myce.com*. Retrieved Oct. 2012.

³⁷ "Journal de 20 Heures" (<http://www.ina.fr/video/3571726001/20-heures-emission-du-3-mars-2008.fr.html>) Retrieved Oct. 2012.

³⁸ Sony history (<http://www.sony.net/Fun/SH/1-21/h5.html>) Retrieved Oct. 2012.

³⁹ Music On The Move: MiniDisc (<http://www.trustedreviews.com/mp3/review/2008/04/08/Music-On-The-Move/p4>) Retrieved Oct. 2012.

⁴⁰ "MiniDisc, The Forgotten Format" (<http://www.guardian.co.uk/music/musicblog/2012/sep/24/sony-minidisc-20-years>). *The Guardian UK*. September 24, 2012. Retrieved Oct. 2012.



1994

Iomega releases the Zip Drive as a response to floppy disks storage limits



1997

Pioneer releases the DVD-R with a capacity of 4.9GB

1998
Iomega sued over Zip Drive
"Click of Death"



1999

M-Systems and IBM
develop the Microdrive

until September 2011 when they pull the last models out of the market rendering the MiniDisc an obsolete medium of the past.⁴¹

Zip Drives: The Click of Death

In 1994, Iomega launched the Zip Drive and Zip disk to tackle the need for larger storage capacities than the floppy disk. While it never saw mass popularity like the floppy it did find its way into some niche markets including graphic design as a means to transfer larger file types.⁴² Initially the storage capacity was 100 MB, but later versions increased this capacity first to 250 MB to 750 MB.⁴³ The disks were ideal for large file transfer as they were rewritable where CD-Rs were not and although CD-RWs were rewritable they were not compatible with most CD drives. The Zip drive had seemingly found a solid position in the removable storage market until 1998 when a class action lawsuit was brought against Iomega for the drive failure that came to be known as the "Click of Death".⁴⁴ Essentially, the click of death was a result of the drive heads becoming misaligned and hitting the edges of the discs, resulting in any data on discs inserted into the drives permanently lost.⁴⁵ The fallout from the lawsuit as well as the higher cost per megabyte compared to CD-R and CD-RW discs caused sales of Zip drives to fall steadily from 1999 to 2003.⁴⁶

⁴¹ Ibid.

⁴² "The Freelance Graphic Designer's Resource" (<http://www.freelancegraphicdesigner.info/90s-graphic-design-marketing.php>) *Taking a look back at late 90's graphic design and marketing styles*. Retrieved Oct. 2012.

⁴³ "Zip Drives: Size and Geometry and Partition Table of ZIP Drives." University of Technology Eindhoven, n.d. Retrieved Oct. 2012. <<http://www.win.tue.nl/~aeb/linux/zip/zip-1.html>>.

⁴⁴ Festa, Paul. "Click of Death" Strikes Iomega - CNET News." *CNET News*. CBS Interactive, 30 Jan. 1998. Retrieved Oct. 2012. <<http://news.cnet.com/2100-1001-207628.html>>.

⁴⁵ Ibid.

⁴⁶ op cit.

In 2006, the Zip drive was named the 15th worst technology product of all time by PC World citing the "Click of Death"⁴⁷, but the next year they also named it the 23rd best technology product of all time citing its ability to deal with larger file sizes than any other medium when it was released.⁴⁸

DVD-R

In 1997, Pioneer introduced the DVD-R format as a response to the need to store and backup data.⁴⁹ While other variations on the DVD-R format have been developed it is still the most popular and holds approximately 4.9GB of information.⁵⁰ The format far exceeds the capacity of the CD-R that came before it, but is now facing new more reliable removable storage devices like SD cards, USB drives, etc., taking over its market share. However, in 2011, JVC announced the introduction of an archival quality DVD recording media with the intent on making DVDs a viable alternative for long-term data storage.⁵¹ Still the larger disc formats have greatly fallen out of favor in recent years, being replaced by flash memory devices that are far less susceptible to damage and also quite a bit smaller than DVDs or CDs.

⁴⁷ PC World: The 25 Worst Tech Products of All Time (http://www.pcworld.com/article/125772-4/the_25_worst_tech_products_of_all_time.html). Retrieved Oct. 2012

⁴⁸ PC World: The 50 Best Tech Products of All Time (http://www.pcworld.com/article/130207-6/the_50_best_tech_products_of_all_time.html) Retrieved Oct. 2012.

⁴⁹ "History - Pioneer Europe" (<http://www.pioneer.eu/eur/content/company/company/history.html>). Retrieved Oct. 2012.

⁵⁰ "What is DVD?" (<http://www.videohelp.com/dvd/>). Retrieved Oct. 2012.

⁵¹ JVC introduces archival grade DVD-R media (http://broadcastengineering.com/products/jvc_dvd_archive_media_11242011/?YM_MID=1274908&YM_RID=crs003@airmail.net), November 23, 2011, broadcastengineering.com. Retrieved Oct. 2012.



1999
The first SD card is introduced
ushering in the era of flash storage

1999
Salesforce.com becomes the
first major cloud based service



2000
M-Systems announces the release
of the first USB Drive: DiskOnKey

Microdrives

In 1999, IBM and M-Systems developed the Microdrive as a removable storage device that could fit into CompactFlash II slots. The original capacity of Microdrives was 170 MB and was expanded to its peak of 8 GB by 2006.⁵² The Microdrive was very popular in the field of professional photography and still has a following within that field due to Microdrives ability to handle loss of power better than flash making the data they house more secure.⁵³ The other advantage was for the Microdrive was its ability to store more information than CompactFlash cards. On the other hand because the Microdrive is a miniature hard disk with the same moving parts as a traditional hard disk drive it does not handle shock very well whereas flash memory can much better. The advantages and disadvantages between CompactFlash drives and Microdrives became irrelevant when, in 2006, the capacity advantage of Microdrives was lost to CompactFlash cards and USB based flash drives.^{54,55} These products were around, but weren't able to outpace the Microdrive as a high capacity storage device for 6 years. Though relatively short lived the Microdrive shows how far we have come since the first spinning hard drive disks.

⁵² McIntyre, Michelle. "IBM Ships the World's Smallest Hard Drive." IBM News Room. IBM, 17 June 1999. Web. Oct. 2012. <<http://www-03.ibm.com/press/us/en/pressrelease/2145.wss>>.

⁵³ Nguyen, Kim. "IBM Microdrive Is out of This World." IBM.com. IBM, 30 Apr. 2001. Web. Oct. 2012. <<http://www-03.ibm.com/press/us/en/pressrelease/1285.wss>>.

⁵⁴ SanDisk introduces the world's highest capacity card for professional photographers - the 16-gigabyte SanDisk Extreme III CompactFlash (http://www.dpreview.com/news/0609/06092603_sandiskextremelll.asp). Retrieved Oct. 2012.

⁵⁵ Corsair launches 16GB Flash Voyager drive (<http://www.engadget.com/2006/12/12/corsair-launches-16gb-flash-voyager-drive/>). Retrieved Oct. 2012.

USB Flash Drives

In September 2000, M-Systems announced the development of the first USB Flash Drive and later that year IBM began marketing the product as the DiskOnKey.^{56,57} The first product was attached to a keychain and had a capacity of 8MB.⁵⁸ Now 8MB is seemingly insignificant, but at the time it was more than 5 times the capacity of the popular floppy disk and had a performance speed almost 10 times that of the floppy disk.⁵⁹ The growth in size and availability of USB flash devices along with the rapid decrease in the cost to size ratio has made them what is now seen as the most popular form of removable personal storage device. Like all data storage devices they have a finite life span, but the life span of the average shelf stored USB device is 10 years.⁶⁰ While the capacity problem for many removable devices has made them fall out of favor, currently there are USB flash drives available that can hold upwards of 256 GB of data.⁶¹ This massive growth in capacity is allowing USB flash drives to become viable long term storage devices for the increasingly large file formats of today in place of portable hard drives. Like the floppy disk before it, the USB flash drive has become the ubiquitous removable storage device of choice for computer users of today.

⁵⁶ "History of USB" (http://www.usbmemorydirect.com/news/overview_of_usb_flash_drives.htm). Retrieved Oct. 2012.

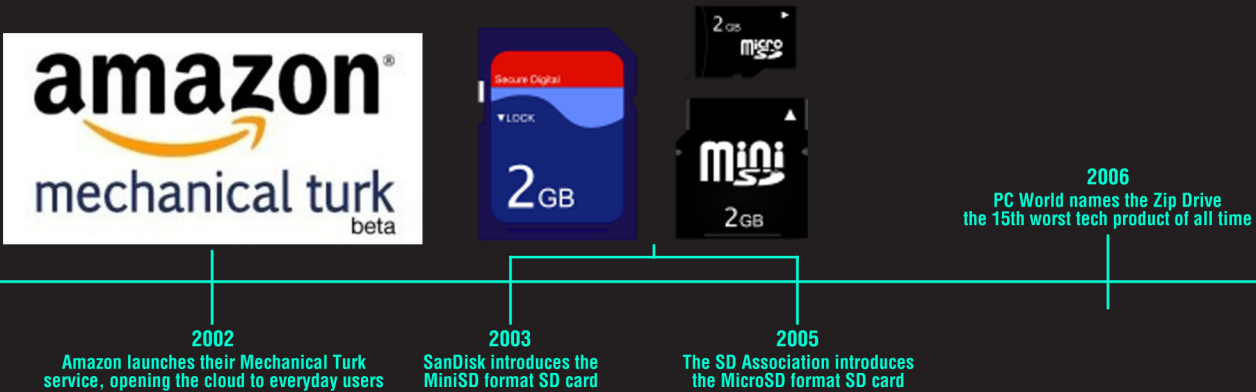
⁵⁷ "All-Time 100 Gadgets" (http://www.time.com/time/specials/packages/article/0,28804,2023689_2023703_2023613,00.html). Time. 2010-10-25. Retrieved Oct. 2012.

⁵⁸ "8MB USB Memory Key - Overview" (<http://www-307.ibm.com/pc/support/site.wss/document.do?sitestyle=lenovo&docid=MIGR-4R3GWN>). www.ibm.com. Retrieved Oct. 2012.

⁵⁹ Ibid.

⁶⁰ "Memory Card Reliability" (<http://www.allmemorycards.com/glossary/reliability.htm>). www.allmemorycards.com. Retrieved Oct. 2012.

⁶¹ Baker, Jeff (July 20, 2009) "Kingston unveils 256GB thumb" (<http://www.mobilewhack.com/kingston-unveils-256gb-thumb/>). MobileWhack.com. Retrieved Oct. 2012.



Secure Digital Cards

In 1999, the Secure Digital (SD) card was released as a removable storage device and has since been made by more than 400 brands with over 8,000 different models.⁶² The devices are standardized by the SD Card Association in three different capacity formats within three different size formats.⁶³ The sizes are the standard SD card, the miniSD, and the microSD which is currently the smallest memory card format available.⁶⁴ The different capacities are the original Standard-Capacity (SDSC), High-Capacity (SDHC) and eXtended-Capacity (SDXC). The ranges of capacity are as follows; SDSC – 1 MB to 4 GB, SDHC – 4 GB to 32 GB, and SDXC – 32 GB to 2 TB.⁶² The standardization of all of these cards by the SD Card Association is meant to ensure compatibility,⁶⁵ but there are some issues that can arise when using the less popular SDXC cards with older devices. The incredible 2 TB capacity limit of the SDXC is also not readily available to the average consumer, but rather several manufacturers sell SDXC cards with capacities up to 128 GB commercially with the size increasingly rapidly.⁶⁶ The SD card has the ability to outpace the USB drive in terms of capacity in commercially available storage devices, but have largely been relegated to use in cameras, phones, tablets, etc. as a means to quickly transfer data from these mobile devices to personal

computers. Nonetheless, SD cards have made a significant impact on the removable storage market and highlight just how far we have been able to take flash memory devices since they were first introduced.

Solid-State Drives

While their roots begin in the 1950's,⁶⁷ the first modern solid-state drives were developed by StorageTek in 1979.⁶⁸ Though revolutionary in terms of reliability and data access speeds they do have their flaws the most notable being that when failure does occur it tends to be catastrophic, resulting in complete loss of data.⁶⁹ Solid-state drives are, however, much less susceptible to physical damage as there are no moving parts making them an ideal solution for mobile computer systems like laptops.⁷⁰ Many companies have started to issue SSDs as standard on some of their laptop models,^{71,72} but while the prices of SSD drives continue to drop over time they are still significantly

⁶² "About" (<http://www.sdcard.org/developers/about/>). SD Card Association. Retrieved Oct. 2012.
⁶³ "Capacity" (<http://www.sdcard.org/developers/overview/capacity/>). SD Card Association. Retrieved Oct. 2012.

⁶⁴ "About" (<http://www.sdcard.org/consumers/choices/>). SD Card Association. Retrieved Oct. 2012.

⁶⁵ About Compatibility with Host Devices (<https://www.sdcard.org/consumers/compatibility/>) SD Card Association. Retrieved Oct. 2012.

⁶⁶ "SD Card, Memory Stick formats to reach 2 terabytes, but when? - Betanews" (http://www.betanews.com/article/SD_Card_Memory_Stick_formats_to_reach_2_terabytes_but_when/1231453659). 09-01-08. betanews.com. Retrieved Oct. 2012.

⁶⁷ Rent, Thomas M. (2010-03-20). "Origin of Solid State Drives" (http://www.stoagereview.com/origin_solid_state_drives). storagereview.com. Retrieved Oct. 2012.

⁶⁸ Moore, Fred. "Enterprise Storage Report for the 1990s" (http://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/19930003944_1993003944.pdf). Storage Technology Corporation. Retrieved Oct. 2012.

⁶⁹ Ku, Andrew (29 July 2011). "Tom's Hardware, Data center feedback." (<http://www.tomshardware.com/reviews/ssd-reliability-failure-rate.2923-4.html>). Tom's Hardware. Retrieved Oct. 2012.

⁷⁰ Vamsee, Kasavajhala (May 2011). "SSD vs HDD Price and Performance Study, a Dell technical white paper" (http://www.dell.com/us/business/p/d/shared-content-data-sheets-en/Documents-SSD_vs_HDD_Price_and_Performance_Study.pdf.aspx). Dell PowerVault Marketing. Retrieved Oct. 2012.

⁷¹ "MacBook Air" (<http://www.apple.com/macbookair/>). Apple, Inc. 2010-10-20. Retrieved Oct. 2012.

⁷² "Toshiba Ships First Laptop With a 512 GB SSD" (<http://www.tomshardware.com/news/Toshiba-Portege-R600-ssd-notebook>). Tom's Hardware. 2009-04-14. Retrieved Oct. 2012.

2007
PC World names the Zip Drive the 23rd best tech product of all time baffling their readership



2009
Solid state drives become standard in certain laptop models and replace HDDs



Present
Major cloud based services begin to see mass marketing, the world enters the cloud

Future
As cloud based services gain popularity the world will be forced to address the ramifications of cloud infrastructure

more expensive than traditional hard drives.⁷³ On average, an SSD drive costs approximately \$0.65 per GB versus traditional hard drives at \$0.05-0.10 per GB.⁷⁴ In 2009 Toshiba introduced a 512 GB model that was the first SSD to become truly competitive with traditional hard drives in terms of capacity.⁷⁵ While SSDs are far from becoming the dominant form of in computer storage, they are certainly being looked at as the best option for the future.

Moving into the Cloud

While we are still making strides in personal removable and in-computer storage we have also mounted a large push to develop something that we refer to as “The Cloud”. What we understand today can be traced back to the ideas of Joseph Carl Robnett Licklider in the 1960’s. Licklider introduced the idea of an “intergalactic computer network” which could be accessed anywhere by anyone.⁷⁶ While at the time his ideas may have seemed far off, the way in which we store information remotely and access it via the internet is closer than ever before to

Licklider’s “intergalactic” network. Others during his time had other ideas that may have predicted what we would become including John McCarthy who proposed computation as being delivered as a public service.⁷⁷

It wasn’t until the late 1990’s, when significant amounts of internet bandwidth became readily available for the masses that we truly began to see what was possible for what we would come to call “The Cloud”. In 1999, the first major cloud based service was introduced with the inception of Salesforce.com.⁷⁸ The idea was to develop an access point for enterprise based applications via a simple website. Three years later Amazon.com developed the “Mechanical Turk” which opened the doors for users to have access to cloud storage, computing and artificial human intelligence.⁷⁹ While these early developments set the tone for the cloud, Amazon, Google, Microsoft and others have made the cloud something that is becoming an everyday part of the average person’s life, though we may not readily notice. If you have used Google Docs, checked your weather, checked last night’s sports scores on your phone, or posted something on Facebook you have accessed the cloud. Most people have no perception of what the cloud is exactly or what it does, and even fewer people understand what the physical ramifications of the cloud are. What is happening, however, is happening rapidly whether we perceive it or not and the growth of the cloud and its physical manifestations will continue warranting a critical analysis of the architecture of the cloud.

⁷³ Gasior, Geoff (21 June 2012). “SSD prices in steady, substantial decline: A look at the cost of the current generation” (<http://techreport.com/articles.x/23149>). The Tech Report. Retrieved Oct. 2012.

⁷⁴ “As Latest SSD Prices Hit \$0.65 per Gigabyte, OCZ Forecasts Further Drop of Costs” (http://www.xbitlabs.com/news/storage/display/20120502220953_As_Latest_SSD_Prices_Hit_0_65_per_Gigabyte_OCZ_Forecasts_Further_Drop_of_Costs.html). X-bit Labs. 2012-02-29. Retrieved Oct. 2012.

⁷⁵ “Toshiba announces world’s first 512GB SSD laptop” (http://news.cnet.com/8301-17938_105-10241140-1.html). CNET News. 2009-04-14. Retrieved Oct. 2012.

⁷⁶ Computer Weekly Article: A History of Cloud Computing (<http://www.computer-weekly.com/articles/2009/06/10/235429/A-history-of-cloud-computing.htm>). Retrieved Oct. 2012.

⁷⁷ Ibid.

⁷⁸ Ibid.

⁷⁹ Ibid.





Enter the Data Center

[The Physical Impacts of our Digital World]

The creation of the cloud and its silent infiltration of daily life have placed the user in a position where they have little to no perception of the ramifications of their digital actions. The cloud is a concept based entirely around redundancy, from file storage to energy consumption the nature of the facility is to ensure near perfect security for digital information and near perfect ability to access the world's massive bank of digital information.

Data centers that store our digital information do so in a manner in which every file tends to be at least 4 times redundant (two copies in two different facilities each). This is meant to ensure that if a server with one copy stored on it has a catastrophic failure at one data center that the second at that location would then go online. The other data center has two copies of that same file so that if the entire first data center had either a full power outage or was destroyed in some way the file could then remain online.

Digital Energy Hogs

This level of redundancy has implications beyond the simple storage of the information and defines the data centers thirst for electricity. The simple act of sending an e-mail or requesting a search on Google sets involves significantly larger amounts of infrastructure than is apparent through the lens of a computer screen. The "cloud" requires vast amounts of infrastructure to operate properly and alleviate the concerns of individuals utilizing it the physical manifestation of which is the data center. Data centers are "the cloud", they are buildings dedicated to the secure storage of digital information so that it can be readily accessed and broadcasted throughout the world to users when they need it. While cloud technologies are being marketed as sleek, sexy and oftentimes eco-friendly, the physical reality is that they are big, often ugly, and downright dirty for the environment. As of mid-2012 there are 2,489 large scale data centers (those over 10,000 sq. ft.) worldwide located within 88 countries. The United States has by far the most with over 1,000 located within its borders with the next closest country, the United Kingdom, having

approximately 170. On average these facilities are approximately 115,000 sq. ft. with an estimated total footprint of 285,831,541 sq. ft.¹ To put that footprint into perspective it would be equivalent to 190,554 single family homes at an average size of 1,500 sq. ft. the major difference being that data centers require significantly more energy to operate than a home.

The computing power needs and ultimately the necessary cooling involved in keeping the buildings operational require vast amounts of energy which can be understood through the average ratio of megawatts to square footage. Currently the typical required energy needs are approximately 10 megawatts for every 100,000 sq. ft.² The current expected energy needs for the current data center infrastructure (approximately 285 million sq. ft.) is roughly 28.5 gigawatts or 1.2% of global energy production.³ This comes from a report by Jonathan Koomey and also mentions that because it is difficult to accurately predict the final numbers this could have reached 2.2% in 2010. Given that there are a total of only 2,489 large scale data centers globally the power hungry needs of our digital information begin to show themselves.

We Create Too Much

This seemingly large amount of storage space is also woefully inadequate to meet our needs. Throughout the past 120 years we have seen massive strides taken in our ability to house and store information and yet only now are we beginning to face a time when it is critical to rapidly increase the amount of global data storage.

Today's hard drives tend to average between 500GB and 1TB making them over 234,000 times more efficient than their ancestor the IBM 350, but even with these leaps in storage

¹ "State of the Data Center 2011." Emerson Network Power. Emerson, 2011. Web. Oct. 2012.

² Kanellios, Michael. "Data Center Power Consumption: By the Numbers" *Greentech Media*. 26 June 2008. (<http://www.greentechmedia.com/green-light/post/data-center-power-consumption-by-the-numbers-341/>). Retrieved Oct. 2012.

³ Jonathan Koomey. August 1, 2011. Growth in Data center electricity use 2005 to 2010. Oakland, CA: Analytics Press. (<http://www.analyticspress.com/datacenters.html>). Retrieved Oct. 2012.

there are **2489** DATA CENTERS
WORLDWIDE

located in
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285,831,541 sq. ft.

which is equivalent to
190,554     single family homes

@50mw_{per} 500k^{sq.} ft.

they require
28.5gw

or **1%** of global energy production

avg. single DC consumption **2.5%**
of plants needed to power all DCs **14.5**



NUCLEAR

avg. single DC consumption **11%**
of plants needed to power all DCs **62.8**



GOAL

avg. single DC consumption **33%**
of plants needed to power all DCs **187**



GAS

avg. single DC consumption **128%**
of plants needed to power all DCs **733**



HYDRO

avg. single DC consumption **500%**
of plants needed to power all DCs **2858**



-AR

avg. single DC consumption **44%**
of plants needed to power all DCs **253**

WIN

avg. single DC consumption **227%**
of plants needed to power all DCs **1299**

GEO

avg. single DC consumption **909%**
of plants needed to power all DCs **5197**



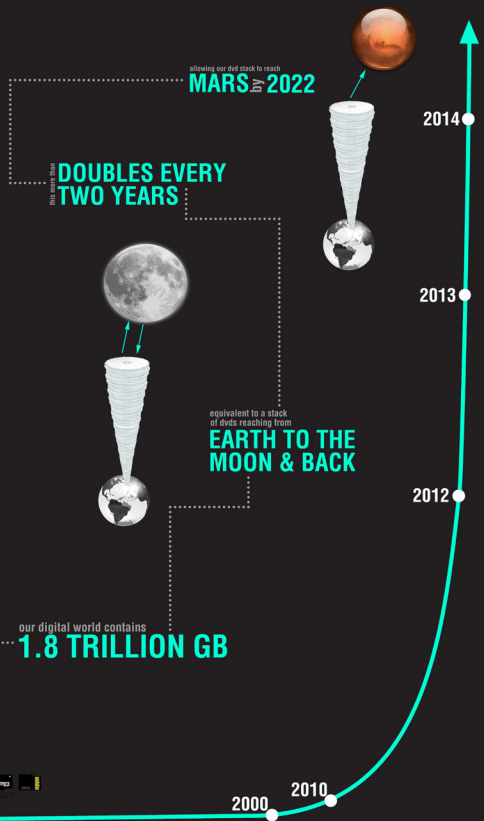
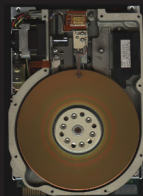
BIOMASS



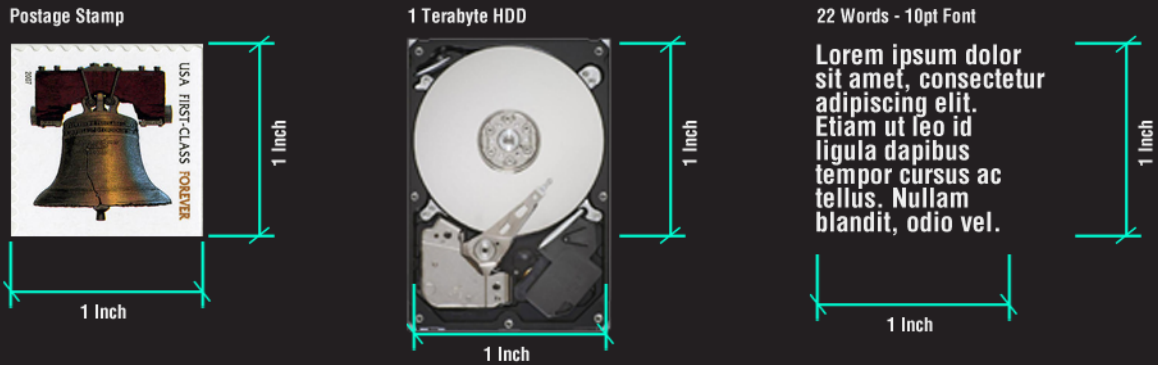
**WE CREATE
2.5 QUINTILLION
(2,500,000,000,000,000,000)
BYTES OF DATA
DAILY**

**6FT. WALL
OF IPADS**

**ANCHORAGE
TO MIAMI**



Data creation infographic [Image 02]



How much information can 1 inch hold? [Image 03]

capacity we can't keep pace with global data production and consumption. We are beginning to see the spiking upward of an exponential growth in the amount of digital information that we both create and store. Throughout history the amount of information that was required to be stored in various locations remained negligible compared to what we have seen in just the past 4 years. Currently, we are creating data at a rate of 2.5 quintillion bytes (2,500,000,000,000,000,000) of information daily.⁴ This is so much information that we have created 90% of the data stored in the world in the past two years.⁵ If you were to store that on the popular 32GB iPads you could build a wall containing 57.5 billion of them six feet high spanning from Anchorage, AK to Miami, FL.⁶ and that is every day. We can only choose to store less than half of that information over the long term due to storage capacity limitations, but as new data centers are built every day we will likely see larger and more power hungry buildings grow out of our desire to store everything.

Our total digital world, currently, is comprised of about 1.8 trillion gigabytes of information stored within 500 quadrillion files.⁷ This total amount of stored information is doubling every two years and is not expected to slow at any time during the foreseeable future. Currently, if you took the 1.8 trillion GB of data and were to place it on DVDs you could build two stacks that could reach from the Earth to the Moon.

⁴ "Bringing Smarter Computing to Big Data." *Ibm.com*. IBM, 2011. Retrieved Oct. 2012.

⁵ Ibid.

⁶ "Data Storage - In the Era of Big Data." *Viawest.com*. Viawest, 2012. Retrieved Oct. 2012.

⁷ Extracting Value From Chaos. *IDC*. June 2011. (<http://www.emc.com/collateral/analyst-reports/idc-extracting-value-from-chaos-ar.pdf>). Retrieved Oct. 2012.

Based upon the projections that this number will double every two years we can expect our hypothetical DVD stack to reach the planet Mars by 2022.⁸

The general assumption is that we are also shrinking the amount of physical space required on a given medium at such a rapid pace that we will eventually have no concerns about the physical space required to store this information. However, what we are beginning to see occur is a reverse exponential curve occurring in regards to data storage size and capacity. We have reached a point at which essentially 1 terabyte of information can fit within a single square inch. This seems minute, but when factored into our stored digital universe is quite the contrary today as we have over 285 million square feet dedicated to the storage of information and the amount of information is expected to nearly double by the end of 2014 and every two years after that.⁹

The need to cool data centers accounts for half of the energy consumption of the facilities and even after cooling the off put of waste heat is significant when compared to almost any other type of building. The overall consumption of energy by data centers is staggering, an average data center consumes more than 100 times the amount of energy than that of an office building of the same size consumes and the electricity used to power an average data center is equivalent to the amount used in the powering of 25,000 single family homes. This begs the question, how can we do better?

Firstly, the byproduct of heat that results from the constant operating of servers can be seen as a

⁸ The Digital Universe Decade - Are You Ready?. *IDC*. May 2010. (<http://www.emc.com/collateral/analyst-reports/idc-digital-universe-are-you-ready.pdf>). Retrieved Oct. 2012.

⁹ Ibid.



Uspenski Cathedral sits above Academica data center [Image 04]

benefit rather than a negative. It can be syphoned off and distributed to adjacent programmatic functions rather than being wasted and released out of roof vents. This would allow any type of function attached to or within close proximity to the data center to utilize this heat in the warming of their facilities, thereby alleviating the cost of heating in the winter months. This will create incentives that can help spur development based on cost savings derived from being adjacent to a data center vs. a comparable space in another location or the same space with the absence of a data center. The waste heat byproduct of the data center can also be utilized in a more socially aware manner if we consider some of the needs of urban centers. For example, this concept of heat recovery and distribution is being utilized in Finland at Eaton's Academica data center. The facility is housed underground and generates enough heat to successfully warm both the cathedral it sits beneath and upwards of 500 large nearby homes. Heat recovery should then be considered an irreplaceable programmatic element.¹⁰

Thinking Passive

There also have been some technological advancements and changing in thinking within the past few years that have come about as a response to the growing concerns by data center operators over the problem of cooling and energy consumption. The first advancement is less about the advancements of technologies and instead the product of

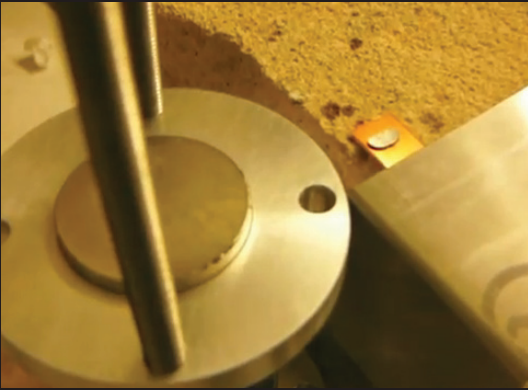
questioning whether certain technologies are necessary. Intel recently did a study to investigate whether it was necessary to constantly cool the server rooms in their data centers.¹¹ What they found was that by simply using outside air drawn in by fans rather than chilled air from air conditioning units they could sufficiently cool data center server rooms when ambient temperatures outside were at levels up to 92°F. This is not necessarily ideal for a person who has to maintain and replace servers, but this work does not require an individual to spend their entire shift inside of the server rooms and could be a potential for change.

Another advancement is purely technological and is the result of a University of Minnesota research team studying the effects of pseudo magnetic alloys.¹² Initially, the research stemmed from neodymium magnets that are nonmagnetic when static and only create a magnetic field when in motion. The alloys were then reworked so that a magnetic field and ultimately an electrical charge could be created when the alloy was heated. The research culminated in the creation of a multiferroic alloy that when heated even a small amount creates a small, but powerful, electromagnetic field. This electricity can then be harnessed much in the same way that we collect and utilize geothermal heat. Currently the team that created this alloy is working on a means to implement it as a film. The film could then be applied to computer equipment such as

¹⁰ Heimbuch, Jaymi. "Data Center Housed Under Cathedral Heats Homes in Finland." TreeHugger. N.p., 01 Dec. 2009. Web. Oct. 2012.

¹¹ "Reducing Data Center Cost with an Air Economizer." *Intel.com*. Intel, Aug. 2008. Retrieved Oct. 2012.

¹² Zurn, Rhonda. "University of Minnesota Engineering Researchers Discover New Source for Generating 'green' Electricity." *UMNews : University of Minnesota*. University of Minnesota, 21 June 2011. Retrieved Nov. 2012.



Multiferroic Alloy developed by the University of Minnesota [Image 05]

servers to regenerate electricity from the heat created during use. While the technology is a long way off from creating enough electricity to meet all of a servers electrical needs it is a huge step forward in offsetting the energy consumption of data centers. As it stands, if the film is created and works as projected it can reduce the operational energy costs of a server by upwards of 15%.

Considering where digital computer storage began we have made massive strides in the ability to store data efficiently, but we are not able to shrink storage medium sizes fast enough to keep pace with our thirst for more information. We now are seeing the implementation of “cloud” technologies to help allow for vast amounts of information to be stored, made redundant and easily transferred from user to user over the internet. In an age where the internet and the digital world are beginning to pervade nearly every aspect of our lives it is strange that we rarely conceive of the ramifications of the things that we do within that digital world. What we tend to understand is that information is sent out from one device to another allow the world to stay connected. We don't see is the massive level of infrastructure necessary to accomplish the most mundane of digital tasks. Simply sending an e-mail with a 10MB attachment requires a sender to store the initial file on their device along with the recipient to have a copy stored on their device of the file. It is also then stored on 2 separate

servers at a data center and then mirrored at another data center facility for each user. That single attachment and email end up being stored in at least 10 different locations making the initial 10MB file that was created now fill at least 100MB of storage space (more if the number of recipients was larger or the user personally backs up their information).

It's Not All Bad

All of these things are interesting and somewhat shocking, but when we understand that our rate of production of digital information and the total amount of stored information will double every two years we can begin to also grasp the economic potential of the creation of data centers. Beyond the simple construction, operation and maintenance of these facilities, they offer growth in other sectors including energy production and technology research and development as well as offering opportunities for ancillary functions with potentially invaluable beneficial outcomes for the community at large. Many cities and towns of varying sizes have recognized the benefits of bringing data centers to their backyards. Today many data center operators have recognized the benefits of utilizing heat recovery systems. However, none have integrated outside programmatic functions through means other than heat recovery.

Cities like New York, Chicago, Seattle, Los Angeles, San Francisco and many more have built data centers



350 E. Cermak Fiber Optic Risers [Image 06]

in and around the heart of the city which results in the laying of massive amounts of fiberoptic infrastructure. This infrastructure becomes the draw for many tech related startups when they are choosing where to open their businesses. The financial cost of the development of fiber optic lines in urban centers is large and therefore smaller entrepreneurial tech businesses seek out the connectivity offered when a large data center is nearby. Other small towns have seen great benefits from the development of data centers such as Prineville, Oregon, Forest City, North Carolina and Quincy, Washington. None of these towns have historically held a population of over 10,000, yet they have suddenly been thrust onto the map of the digital world. Companies like Facebook, IBM, Yahoo and Google are setting up shop in smaller towns because of the need for cheap, reliable energy, but ultimately these companies still retain the need to have their facilities located within urban centers. This is due to the desire to be within close proximity to those whose data is being stored as well as the need for massive fiberoptic infrastructural requirements based on population density. There are obvious benefits to constructing data centers in areas where you are close to your clientele. Being close to a potential customer base and the benefits of being in an urban setting are amplified when we look at the number of tech startups who desire offsite storage. The relationship between the large data center and the tech startup is symbiotic in nature with the startup coming into a particular area to piggyback off of the fiber optic infrastructure and the data center gaining a potential client.

Another major benefit of having data centers in areas with dense populations is that there is a time savings that occurs in connection speeds that is of the most benefit to research communities that require significant amounts of computing power. The benefits to the average internet user in terms of access speeds are negligible when comparing an urban data center to a rural data center, but for the companies this can have a major impact as their profits are driven by a timescale based on milliseconds and nanoseconds. For instance, an hour of downtime due to equipment failure or power outages cost roughly \$300,000 for the average data center. That means that for every minute down they lose \$5,000, for every second \$83.33, and 8 cents for every millisecond they are shut down.¹³ That means that any seemingly insignificant increase in connectivity speeds means a potentially lucrative profit when spanned over the course of a fiscal year. On average, data centers globally are losing 426 billion dollars every year due to these power failures, equipment failures, etc. making saving time and ensuring connectivity speed and reliability top on the priority lists of the companies that operate these facilities.¹⁴ It is without a doubt that there is a proven impact upon the communities that have had these facilities built and developed. The first impact comes when the construction of the facilities is undertaken and tends to have an effect on construction and construction related jobs for approximately 2 years after planning and

¹³ Understanding the Cost of Data Center Downtime - An Analysis of the Financial Impact on Infrastructure Vulnerability. *Emerson Network Power*. Emerson Network Power and Liebert Corporation, 2011. Retrieved Oct. 2012.

¹⁴ Ibid.



DuPont Fabros data center under construction [Image 07]



Microsoft's Chicago data center entrance [Image 08]

groundbreaking occurs. These jobs have a finite lifespan, but in the construction industry a two-year commitment is a fairly good opportunity. The other benefit that has been seen for the construction industry is that when one is initially constructed that the trend has been that others will follow in or around the same location. With the exponentially increasing need for these types of facilities it is becoming critical for major city centers to begin incentivizing and developing data centers now to stake their role in the digital world before they are left without the ability to be a major player and reap the benefits of the expansive development that these facilities can offer. The facilities themselves hold little opportunity internally to create any significant impact on job growth in an area because it requires very little man power to actually operate a data center. For instance Microsoft's 750,000 square foot data center in Chicago, IL requires only 45 people to operate.¹⁵ The flip side to this is that the data centers infrastructural requirements entice startups to come to a given area and ultimately stimulate more outside job growth than they could ever hope to create on their own. The tech research, tech manufacturing, educational and other functions that are born out of the development of data centers will create a much more significant amount of economic growth than the creation of the data centers themselves. While the growth in the tech sector is probably the most beneficial to the average person in economic terms these

facilities could, if designed and developed properly, become a much greater catalyst for long-term growth and development. Data centers and the industry that surrounds also have a significant impact on the global economy. Since 2005, the amount of financial investment from companies involved in the creation, storage and management of data to seek revenues from the digital world grew to 4 trillion dollars.¹⁶ That is more money spent than the entire GDP of Germany during the year 2011.

Our thirst for digital information and our desire to access that information rapidly and remotely has forced us to create this new building typology. The ramifications of the data center range from their vast amounts of energy consumption to their inability to store all that we create. While we are being forced to address these issues we have yet to address the typology architecturally outside of technical design considerations. We live in an age with two realities, one physical, the other digital, yet they are intrinsically linked at the intersection of the two worlds. The physical informs and restricts the digital, while the digital demands and imposes change on the physical. Given that our lives are changing and becoming ever more influenced by the growth and development of digital media we must investigate what effects, for better or worse, that these developments have on our physical environments. It will be a paramount concern, as time progresses, to determine and be aware of the impacts of our digital lives. Therefore there is a need for a critical analysis of the digital world and the architecture that arises from it.

¹⁵ Burns, Greg. Microsoft's Chicago Datacenter Shows Huge Investment in Cloud Computing. *Burns on Business*. Chicago Tribune, 12 Oct. 2009. Retrieved Oct. 2012.

¹⁶ IDC, *Extracting Value*.

The Digital Disconnect

[The Rift Between the Physical and Digital Worlds]

The explosion of off-site data storage and access and its ability to connect us remotely to our information and to others has changed the way in which individuals interact with each other and not always for the betterment of society at large. Our digital lives are creating a greater impact that we can readily perceive. For the most part the facilities that house our digital world are rarely far from us physically, yet we seldom recognized that they are there. With some exceptions in recent years, the majority of data centers are located within dense urban centers to maintain proximity to those who require access to the information that they house. The building typology of the data center has created an interesting contradiction; while the data centers sole purpose is to securely house and broadcast personal and business information digitally, they actively disengage the user physically. This contradiction is most evident when the data center is placed within an urban context. For instance, both the Sabey Data Center and one of AT&T's data centers are located within Manhattan and both buildings front the street with a foreboding presence. The structures themselves are monolithic and neither informs the user of its functionality nor engages the user in any active way. Each of these buildings, though massive and physically filling entire

buildings sites, ironically create urban voids. The Sabey and AT&T data centers in Manhattan are not atypical of the formal reaction to urban contexts by data centers, whether they are of new construction or adaptively reused buildings.

Data centers across the country are built in plain sight and the lack of recognition of their presence pervades nearly every instance. For example, in 2012, the Minnesota Vikings were planning the construction of a new football stadium and were considering a site that they thought was ideal. The site was across the street from the current stadium and contained a nondescript building that the team's management felt could easily be demolished to make way for their new stadium and to them it was seemingly unimportant. The team's management felt that the use could be relocated elsewhere in the city without much issue. It wasn't until the team was confronted with a lawsuit by the building's owner, Timeshare Systems, that the true functionality of the building was made public. The Vikings organization quickly dropped any plans to relocate the buildings use elsewhere.



Sabey Data Center Manhattan [Image 01]



AT&T Data Center Manhattan [Image 02]



AT&T Data Center Manhattan [Image 03]



View of Metrodome from 511 Building Rooftop Minneapolis [Image 04]

The Timeshare Systems building, at 270,000 sq. ft. contains Minneapolis' most important hub of technological infrastructure, and is the point of convergence of approximately 70 different data networks.¹ It is located directly adjacent to the site of the current Vikings stadium the Metrodome making it clear how easily data centers can be hidden in plain sight. Not even the Minnesota Vikings who had been next to this building for years had any idea what purpose the building served, yet they likely utilize the buildings networks every single day. The construction of these hidden in plain sight data centers is extremely common, and for good reason. There is an inherent need when designing them to create buildings that are hyper-secure. One of the best ways to do this is to become nearly invisible. This can be illustrated through the development of other data centers globally, all of which are hidden in plain sight.

Through the investigation of five different cases studies, the innate physical disconnection with users and the intentional design of hidden structures, in one way or another, is shown. Each highlights how users either have no idea that a structure is in their midst as in the case with those that were constructed underground (a growing trend in data center construction) or that despite a large physical presence the user rarely recognizes what the functionality of the structure is. Each has unique features that range from things that help offset energy inefficiencies, highlight the inefficiencies inherent in data center design or otherwise exemplify the disconnection between the physical and digital worlds.

¹ Miller, Rich. "If You Like the Internet, Don't Knock Down That Building." *Data Center Knowledge*. Data Center Knowledge, 26 Dec. 2012. (<http://www.datacenterknowledge.com/archives/2012/12/26/511-building/>). Retrieved Dec. 30, 2012.

The first example is 350 E. Cermak in Chicago. This is the largest data center in North America at approximately 1.1 million square feet and was originally designed to house the printing presses for Yellow Book and Sears catalog.² It is currently Commonwealth Edison's 2nd largest customer next only to O'Hare Intl. Airport.³ It requires 100mw of power which is backed up by 50 constantly running diesel generators to maintain a guaranteed uninterrupted power source.⁴ Its cooling requirements are incredible and account for approximately half of the buildings operating costs. The traditional HVAC cooling system is aided by an 8.5 million gallon tank of refrigerated liquid that can be circulated throughout the facility to aid in cooling server racks.⁵ This facility is also a great example of the ability of data centers to become the backbone of fiberoptic infrastructure networks within urban centers. Like the Timeshare Systems data center in Minneapolis, 350 E. Cermak is the epicenter of Chicago's fiberoptic networks. The facility, though much more ornate than other newly constructed data centers, is intentionally left without signage and does not engage the urban context around it. It is monumental in size and without any conception of activities taking place inside the user is left with no desire to investigate.

The second example is also a data center that utilized adaptive reuse design, Google's Hamina data center in Finland. While this was originally a paper mill designed by Alvar Aalto it utilizes

² Miller, Rich. "World's Largest Data Center: 350 E. Cermak". *Data Center Knowledge*. *Data Center Knowledge*. 13 Apr. 2010. Retrieved Oct. 2012.

³ Ibid.

⁴ Ibid.

⁵ Ibid.



Google Hamina Sea Water Cooling Infrastructure [Image 05]

new technologies to help with the constant battle of cooling server racks inside the data center.⁶ The structure utilizes sea water from the Gulf of Finland as a cooling device in an attempt to lower the carbon footprint of the building.⁷ However, the image of the sea water cooling rooms highlights just how intensive a process that this becomes. This facility, like 350 E. Cermak, also is monumental in scale and leaves passers-by either wondering what the facility might be.

A third example is one that has already been mentioned, the Sabey data center in Manhattan. This monumental structure has little fenestration and a monolithic base and tower, creating no desire for a user to engage the building. The building was developed in 1975 as a switching hub for New York Telephone Company.⁸ The building, like 350 E Cermak, is now a hub for national and international fiber optics in New York City.⁹ The structure was clearly chosen for its foreboding appearance and unassuming frontage, but it leaves users without any sense of activity or the impact that the building likely has on their daily lives.

The last three cases studies have all found their way underground in pursuit of becoming almost completely invisible. The first is Bahnhof's Pionen White Mountain facility in Stockholm. It was located within a former military bunker 100 feet under Stockholm, Sweden by the service provider Bahnhof.¹⁰ The decision to use

the shelter was to allow the naturally low ambient temperatures of the underground shelter to offset cooling loads as well as maintain high security levels. The design also highlights the differences between the physical and digital and the natural and man-made in the way it treats its intervention within the space.

The second underground case study is the Green Mountain Facility located in Norway in a former NATO ammunition cache.¹¹ The structure was built for essentially the same reasons that the Pionen data center was and in the same way is nearly invisible save for its mountainside entry way. Both facilities have no visible structures with the exception of entryways into the structures leaving anyone who passes by wondering what might be contained within.

The last and probably most interesting underground case study is the Academica data center in Helsinki, Finland. This facility is housed in an underground cave, but in this case it is located directly under Uspenski Cathedral.¹² This is likely one of the most invisible data center facilities in the world. Though housed under the cathedral, it does engage other surrounding buildings through a heat recovery and distribution system. The system allows the facility to warm upwards of 500 homes year round.

All of these case studies can be analyzed better through the diagrammatic image studies and more detailed written examinations on the following pages. Each showcases a series of images of the facilities as well as a simple diagram showing the user-building relationship.

⁶ "Hamina Data Center." *Google Data Centers*. Google, n.d. Retrieved Oct. 2012.

⁷ Ibid.

⁸ Miller, Rich. "Sabey Acquires Huge Verizon Building in NYC." *Data Center Knowledge*. N.p., 07 June 2011. Web. Oct. 2012.

⁹ Ibid.

¹⁰ Miller, Rich. "The Data Bunker Boomlet." *Data Center Knowledge*. N.p., 14 July 2009. Web. Oct. 2012.

¹¹ *Green Mountain Data Centre*. Smedvig, n.d. Web. Nov. 2012. <<http://greenmountain.no/>>.

¹² "Academica." *Eaton - Powering Business Worldwide*. Eaton, n.d. Web. Nov. 2012. <<http://www.eaton.com/Eaton/OurCompany/SuccessStories/DataCenters/Academica/index.htm>>.

¹³ Heimbuch, Jaymi. "Data Center Housed Under Cathedral Heats Homes in Finland." *TreeHugger*. N.p., 01 Dec. 2009. Web. Nov. 2012.

350 E. Cermak



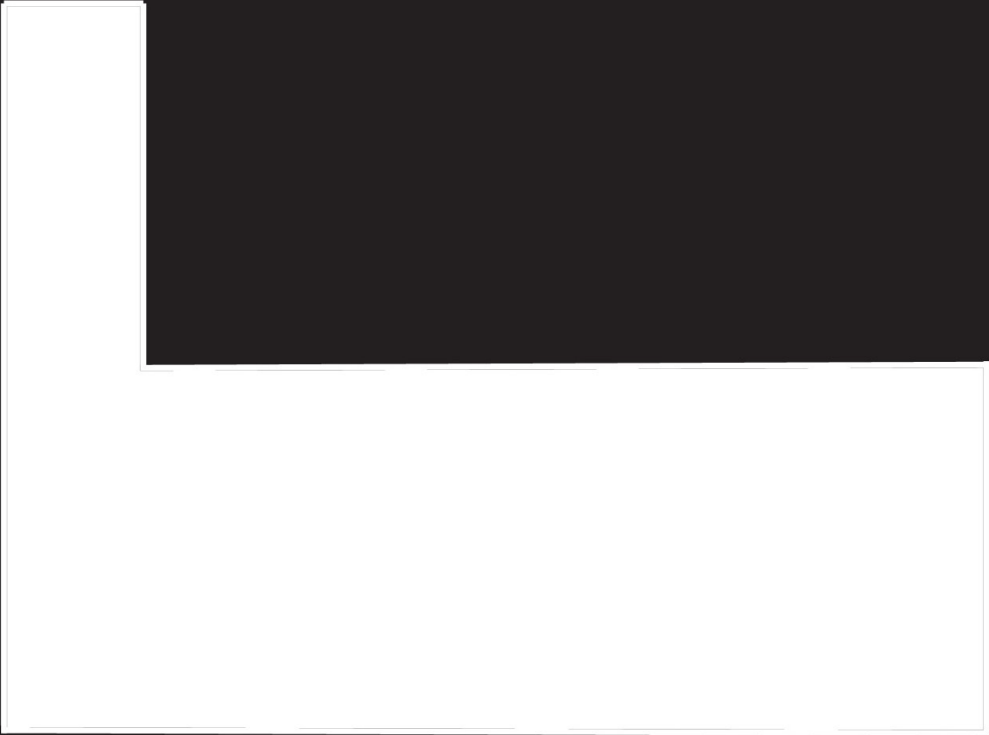
Satellite Image of 350 E. Cermak [Image 06]

Designed as a Gothic revival icon for the industrial age, 350 E Cermak [otherwise known as Lakeside Technology Center], was modified to become the crux of Chicago's information technology infrastructure. The building itself took 17 years to complete spanning from 1912-1929. The buildings original purpose was to house the printing presses for RR Donnelley Printing Company, who printed the Sears Roebuck catalog and the Yellow Pages phonebook. The National Park Service designated the building a historic landmark in 1983 as a testament to the importance of the building to Chicago's storied history.¹⁴ The English Gothic style architecture is comprised of red brick and limestone exterior walls with details of terra-cotta depicting printing history. Its construction is comprised of fireproofed reinforced concrete, a major design decision for the era of construction.¹⁵ Much of the original interior character remains intact with only the former manufacturing portions of the structure being converted over to server space. The conversion from printing press facility to data center made perfect sense given the open and expansive structural grid and heavily constructed and fireproofed structural system.

A parallel can be drawn between the buildings former use and new use, in that it has always been a facility dedicated to the transmission of information to people. Though the building was built during a time when computing was based around a rudimentary punch card system, its purpose was to create media that could be distributed en masse. As technology has advanced and printed media is falling out of favor, the building has found new life as a distributor of digital media. In this regard the building itself has evolved and advanced, reaching far more people digitally than it ever could have during its years housing a printing press. Though the building is connecting with people in large numbers, it is a safe assumption that virtually none of them recognize it. This is because they are only being engaged in the digital world, the building itself has nearly ever door secured with keycards or biometric security. This lack of physical engagement is puzzling simply because of the buildings prominence within city history. It is currently one of the largest data centers in the world and yet very few people know what exists within its walls.

¹⁴ "Calumet Plant, R.R. Donnelley & Sons Company." *National Register of Historic Places*. National Park Service, 17 Feb. 1983. Web. Oct. 2012.

¹⁵ "The Most Powerful Building". *The Chief Engineer*. April 2006. Retrieved 2011-09-28.





Preserved Interiors - 350 E Cermak [Image 08]



Fiber optic Risers - 350 E Cermak [Image 09]



Street View of 350 E. Cermak [Image 10]



Satellite Image of Google Hamina [Image 11]

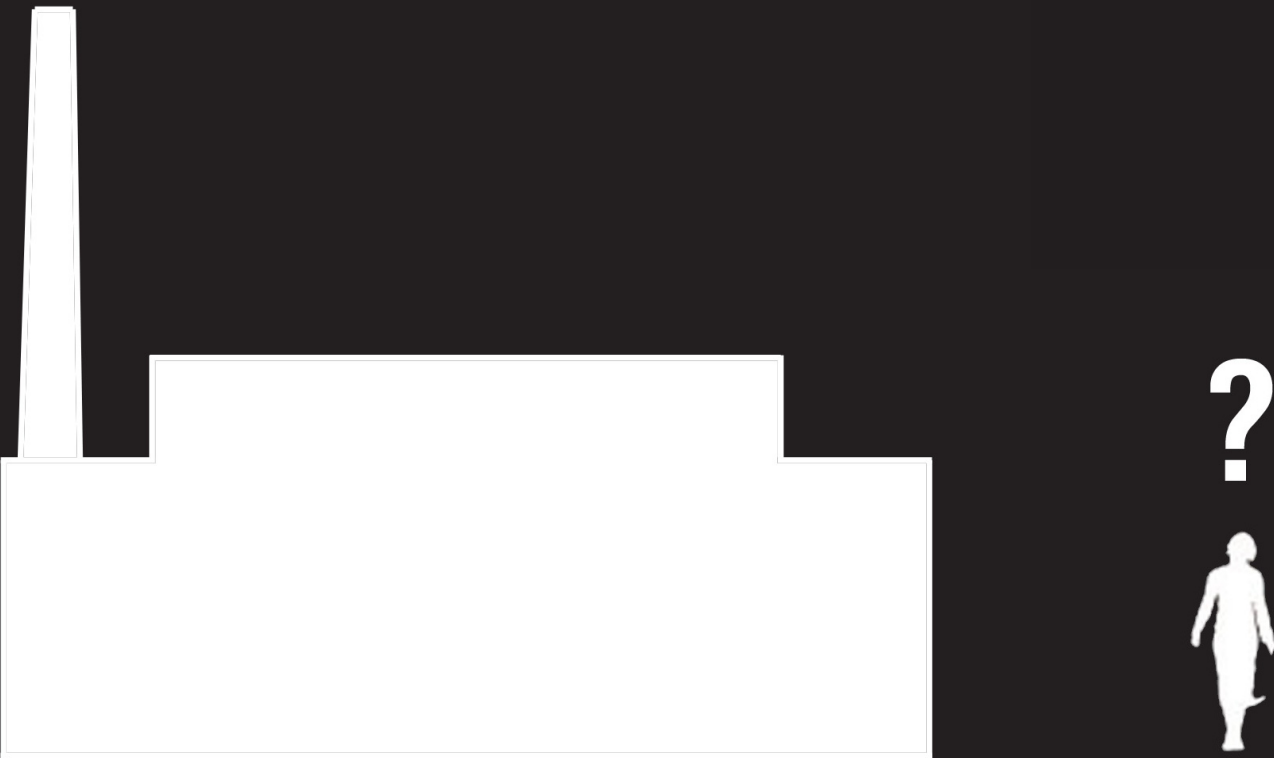
Like many other data centers, Google opted to adaptively reuse a structure for their Hamina, Finland based operation. The building was a former paper mill on the coast of the Gulf of Finland which was designed by famed Finnish architect Alvar Aalto. Much like 350 E Cermak, the Google Hamina's former building functions created spaces that were ideal for data center operations. The buildings open industrial design created easy to manage areas for server racks and the floor to ceiling heights allow for easier cooling. Though the building itself was helpful, the location in Finland helped with natural cooling and the adjacency to the Gulf of Finland facilitated the use of sea water cooling. The building had already used tunnels under the bedrock to draw water from the gulf to cool a steam generator plant on site, but Google is now utilizing the tunnels to cool server racks. This is an intensive process, but significantly more efficient than traditional cooling.¹⁶

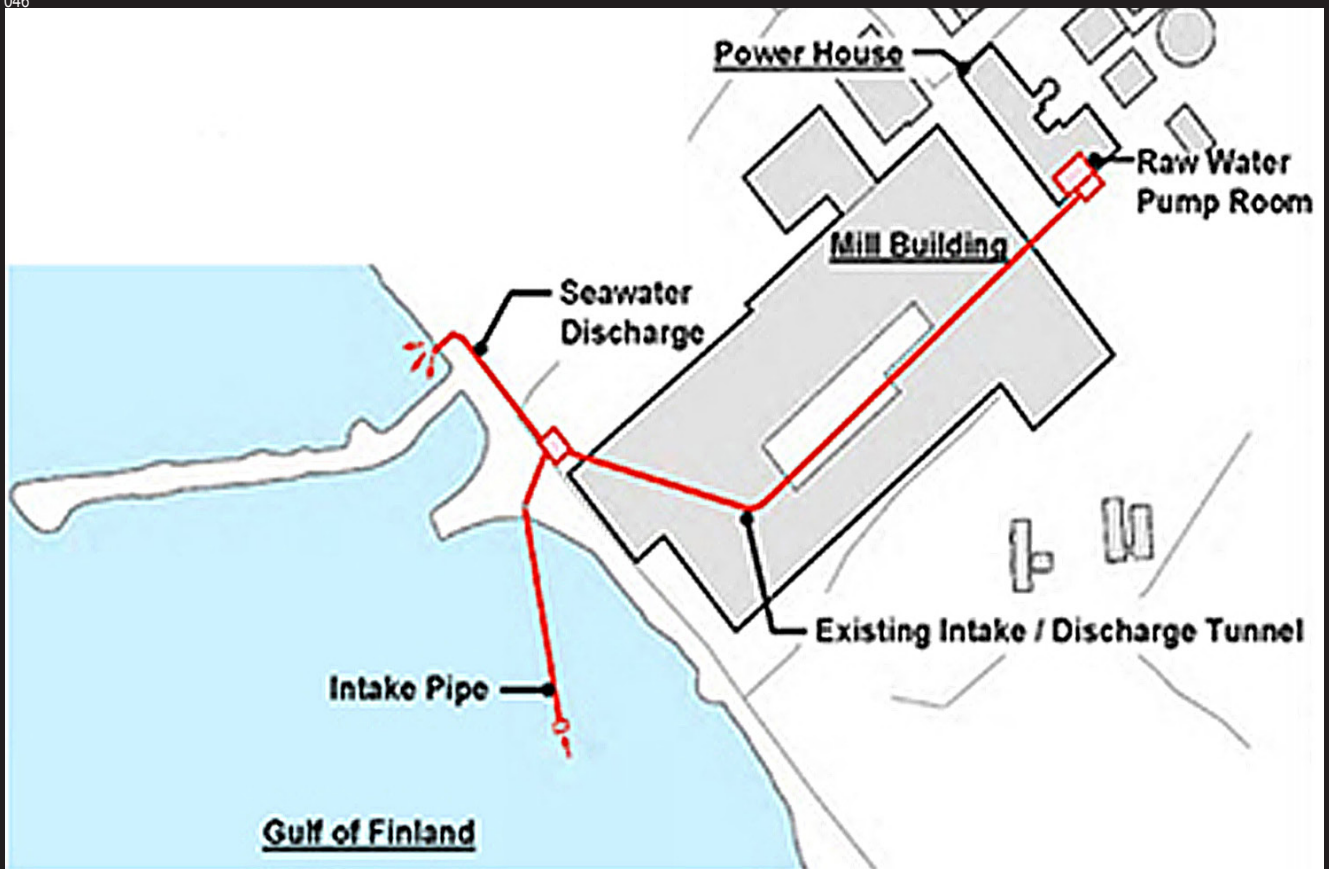
In the same way that 350 E Cermak leapt forward from analog media distribution to digital media distribution, so to did the mill at Hamina. The former use created paper to be printed on and distributed as necessary to the public. Now, with the paper production gone, the facility is just one more pass through for the plethora of information that the world creates and desires access to. This monumental transformation and connection is largely lost on the general public as the building sits with its unassuming appearance on the Gulf of Finland. It's industrial design makes it visually seem like another workplace along the gulf rather than an international data hub. To the casual passerby it would likely garner no more than a glance, but in reality that passerby is very likely to have accessed this facility digitally on hundreds of occasions. As one of only 9 completed Google data centers worldwide [4 under construction]¹⁷ Google Hamina has become an invisible staple in our everyday lives. The average person's computer likely travels to Hamina on a frequent basis when utilizing Google's search engine or e-mail services. In a brutally poetic way, both Google Hamina and 350 E Cermak speak volumes about the death of analog media formats and the rise of digital media to replace it. There is some bizarre romanticism in major IT companies developing and maintaining their operations of transmitting digital media in the buildings that stand as monuments to a bygone era of printed media.

¹⁶ Metz, Cade. "Google Reincarnates Dead Paper Mill as Data Center of Future."

Wired.com. Condé Nast Digital, 26 Jan. 2012. Web. Oct. 2012.

¹⁷ Levy, Steven. "Where Servers Meet Saunas: A Visit to Google's Finland Data Center." *Wired.com*. Condé Nast Digital, 22 Oct. 2012. Web. Nov. 2012.





Site Diagram - Google Hamina [Image 13]



View of Google Hamina from Gulf of Finland [Image 14]



Google Hamina Server Room [Image 15]



Google Hamina Sea Water Cooling Infrastructure [Image 16]



Satellite Image of Sabey Data Center [Image 17]

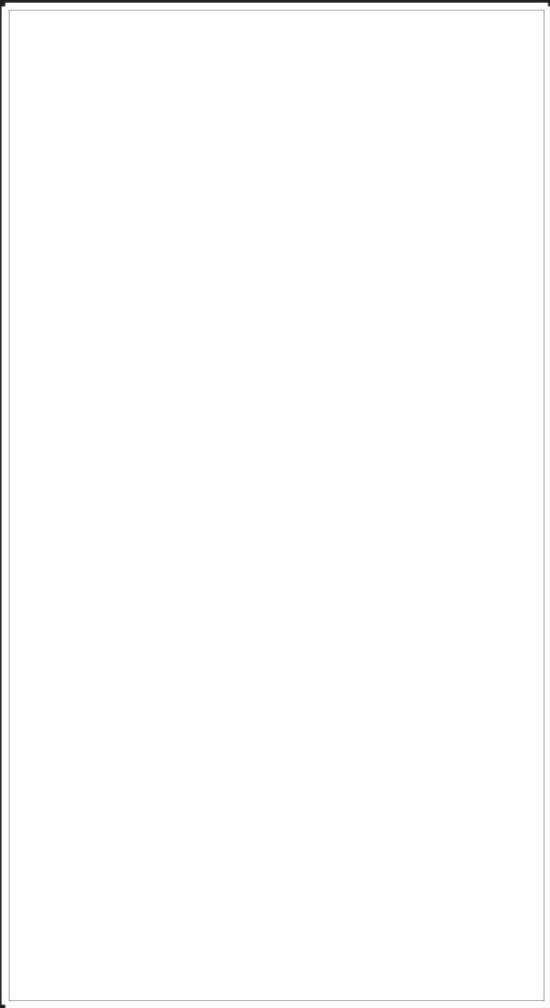
Standing at the base of the Brooklyn Bridge in Lower Manhattan is the Sabey Data Center also known as Intergrate.Manhattan. The building was originally constructed in 1975 as a telecommunications switching hub for the New York Telephone Company. When it was built New York Times architectural critic Paul Goldberger claimed it was the “most disturbing” of New York Telephone’s new switching hubs and said that it “overwhelms the Brooklyn Bridge towers, thrusts a residential neighborhood into shadow and sets a tone of utter banality.”¹⁸ When Verizon Communications [who had become the owners of New York Telephone] decided to sell the building in 2007, that sentiment was not lost on the new owners. Taconic Investment purchased the building and had plans to alter the façade to give the building a more appealing appearance.¹⁹ Though it likely would largely improve the building’s perceptions within the neighborhood it never came to pass. The building was purchased by Sabey in 2011 while Taconic was facing foreclosure on the property. While it has become an international data hub, the distaste for the structure itself has remained, with the Daily Telegraph naming it one of the ugliest buildings in the world.²⁰

The same poetry about the sacrifice of one industry for the sake of another is apparent at Sabey as it is at Hamina and 350 E Cermak, but in Sabey’s case the printed media industry is replaced by the traditional telecommunications industry. In reality, the telecommunications industry is not dying, but rather adapting. The change from hard lined telephones to cellular phones and internet communications has forced the industry to alter its structure for a new age. This new age of communication has yet to find an architectural language and in Sabey’s case has found its way into a building that exemplifies the faceless nature of telecommunications infrastructure. Though the building is monumental and is seen by millions of people regularly its foreboding and monolithic appearance make it a strange testament to the anti-humanistic tendencies of the digital world. The building is well suited for a uses like data center operations which require minimal physical interaction with humans, but its setting within a residential area of Lower Manhattan has made it a void in the urban fabric of New York City. In physically disengaging the community around it Sabey disrupts both the visual and social composition of its context.

¹⁸ Dunlap, David W. “Open a New Window: A Tower With a View.” *The New York Times*. The New York Times, 15 Jan. 2008. Web. Oct. 2012.

¹⁹ Weiss, Lois. “DOWNTOWN TOWER DEAL: Verizon Sells Cheap to Taconic.” *New York Post*. NYP Holdings, 26 Sept. 2007. Web. Oct. 2012.

²⁰ “Are These the Ugliest Buildings in the World?” *The Telegraph*. Telegraph Media Group, 10 Apr. 2012. Web. Oct. 2012.





Sabey Data Center - Former Verizon Longlines Building [Image 19]



Sabey Data Center [Image 20]



View of 275 Pearl St. from Brooklyn Bridge [Image 21]



Satellite Image of Bahnhof Pionen [Image 22]

Designed for Sweden's largest internet service provider, Bahnhof, the Pionen facility (full name Pionen White Mountain) is one of the most interesting data center facilities in the world. It was constructed within the shell of a cold war era nuclear bunker for the Swedish government buried under 100 feet of solid granite bedrock. The facility is capable of withstanding a near direct hit from a hydrogen bomb, and its two entrances are sealed with 16 inch thick steel doors.²¹ It is perfectly suited for capitalizing on the low ambient temperatures of the bunker. The facility, though hyper-secure, is one of the most advertised and well documented data center facilities in the world. It is the site of the famed Wikileaks servers and it publicized as a hyper-secure colocation facility, allowing tours to prospective tenants.²² The bunker was converted to data center use in 2008 and the owners wanted to focus on the humanistic side of data center operations. Though the facility only requires approximately 15 staff members to operate, it does boast some very unique design details. The overall design concept was derived from movies ranging from Logan's Run to Star Wars to early James Bond movies.²³ The bunker walls were left bare to expose the granite bedrock, and the office work areas sit among greenhouses, artificial waterfalls and a massive salt water fish tank.²⁴ The entire facility also uses artificial daylighting for the benefit of its employees, but despite Bahnhof's attempts to be more humane in their design they have still forgotten the context that surrounds them.

That context is the heart of Stockholm, a major urban center, which is only connected to the Bahnhof facility, located right under the city's feet, by two entrance doors. The interesting part is that located directly above Pionen is a group of residences and the Vitasbergparken [a major park within Stockholm]. The facility's entrance is situated into a rock face opposite a series of mid-rise apartment complexes. Bahnhof touts that it believes in the freedom and transparency of information while the general public is shunned and denied access visual or physical to the facility located in its midst.²⁵ Though Pionen is physically removed from the general public it is the only facility in the world that has taken such strides to ensure comfort for its workers within the data center. For this reason Pionen seems to have desterilized the interior while forcing the exterior to remain virtually invisible.

²¹ "The World's Most Super-Designed Data Center - Fit for a James Bond Villain."

Royal Pingdom RSS. Pingdom AB, 14 Nov. 2008. Web. Oct. 2012.

²² Ibid.

²³ Ibid.

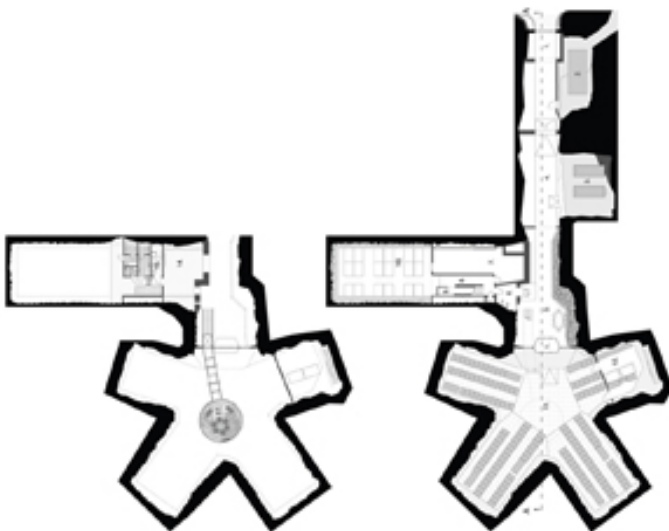
²⁴ Ibid.

²⁵ "Privacy." *Bahnhof.net*. Bahnhof, n.d. Web. Oct. 2012.

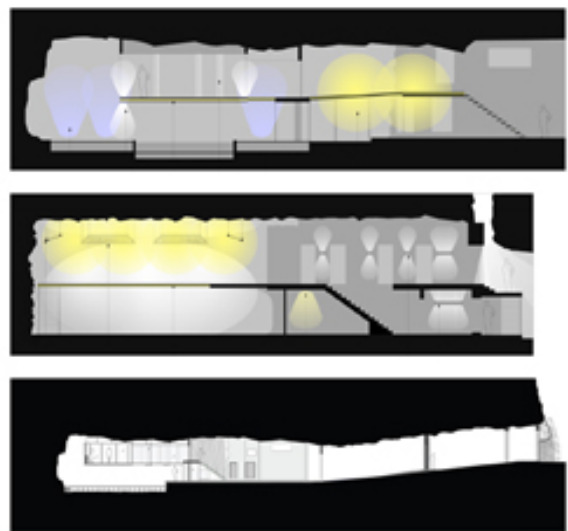




Bahnhof Pionen Street Entrance [Image 24]



Bahnhof Pionen Floor Plans [Image 25]



Bahnhof Pionen Sections [Image 26]



Bahnhof Pionen Interior [Image 27]



Bahnhof Pionen Server Rooms [Image 28]

Green Mountain



Satellite Image of Green Mountain [Image 29]

Located within a recently abandoned NATO ammunition cache in Norway the Green Mountain Data Center is, like Bahnhof's Pionen, hyper-secure. The structure was adapted for essentially the same practical reasons as Pionen was before it, but in this case much of the humanistic concerns were forgotten. Green Mountain's interiors do not tout any major features geared towards those who would spend their workday within the underground facility. Instead it is designed to maintain the bare cave walls and utilize the utilitarian spaces put in place by NATO. The facility utilizes the significantly lower ambient temperatures of the underground facility along with a closed loop heat exchange system that draws water in from the fjord adjacent to its site to cool its servers.²⁶ The owners also boast that the carbon footprint of the facility is negligible as all of the power input is coming from a 100% hydroelectric power station located nearby.²⁷ In the case of Green Mountain the facility is even more hidden from the public in that it does not reside within a dense urban context, nor does it even allow street front access to its entry doors. This facility is virtually invisible, save for the views of the entrance one might gain while out on the water in the fjord and the two nondescript buildings behind the sites gates. The facility has even gone so far as to filter the views of the two above ground buildings and the main underground entrance with foliage. The facility then only becomes accessible by driving along the single road that dead ends at the gates preventing virtually all chance of a passerby ever stumbling upon the complex to even begin to ponder what might be there.

The facility is another example of how data centers are avoiding physical engagement with the general public, even simply visual engagement. Green Mountain, though addressing the environmental issues in some ways, is ignoring the social implications of its facility. It and all other data centers function as one of the main conduits by which information is disseminated throughout society. In this instance, however, the social issues and issues related to context are minimized due to the facility's isolated location. Being located on the Island of Rennesøy located in the North Sea allows the facility to remain anonymous with minimal impact to its surround context. In such a rural and isolated location the facility can blend in and present the hyper-security that certain clients desire.

²⁶ "Cooling System." Green Mountain Data Centre. *SMEDVIG*, n.d. Web. Oct. 2012.

²⁷ "100% Clean." Green Mountain Data Centre. *SMEDVIG*, n.d. Web. Oct. 2012.





Green Mountain Entrance [Image 31]



Green Mountain Orthographic Diagram [Image 32]



Green Mountain Interior [Image 33]



Satellite Image of Academia [Image 34]

Located in the heart of Helsinki, Finland sits the Academia data center, a state of the art facility that is also completely hidden from plain view. This time rather than a war time military bunker the data center is hidden directly under Uspenski Cathedral. Eaton, the company operating Academia, adapted a former underground electrical substation for use as their data center.²⁸ This, like several other case studies before it utilizes the cool sea water afforded to it directly adjacent to the site, this time again from the Gulf of Finland.²⁹ The system allows for cool water to be brought it to offset traditional cooling loads while the waste heat is sent out into the local district heating network to aid in the heating of homes and hot water for those homes.³⁰ Estimates of how many homes that this approximately 21,000 sq. ft. facility can heat ranges from 500-2000, but regardless of what the real total is, Academia is having a truly positive impact upon Helsinki as a whole.³¹ For this reason Academia received a Green Enterprise IT award in 2010 from the Uptime Institute for their facility.³²

It is the simple exchange of heat for the benefit of the collective, the benefit of the physical world, that becomes intriguing. Academia is the only facility in the world that is engaging in an activity that both acknowledges the context around it and attempts to be a benefit to that context. Despite this positive influence that Academia has upon the surrounding area, it is entirely invisible to the passerby. Buried under the cathedral the digital user, and in Academia's case the beneficiary of its waste heat, remain unaware that the facility is in existence. A worshiper would have no idea that the basement of the house of God rests a chamber of technology. What does it mean to have physical users of a worship space directly above the physical manifestation of the internet? While the Academia facility is a positive influence upon Helsinki, it still retracts itself from the physicality of the urban fabric. Removed from the surface, it has removed itself from the users perceptions. Like other underground data centers it invisibility creates an ignorance to the amount of space, power and complexity is involved in allowing individuals to access their digital worlds. Without an urban face these facilities cannot begin to thoughtfully shape our urban centers as other building typologies have in the past. Academia is, however, a great leap forward in data center design thought.

²⁸ Miller, Rich. "Sea-Cooled Data Center Heats Homes in Helsinki." *Data Center Knowledge RSS*. Data Center Knowledge, 06 Sept. 2011. Web. Oct. 2012.

²⁹ Ibid.

³⁰ Ibid.

³¹ Ibid.

³² Ibid.





Academica Server Room [Image 36]



Academica Data Center Interior [Image 37]



Uspenski Cathedral [Image 38]

The disconnect between the physical and digital goes deeper than the way in which the physical infrastructure of the digital world interacts with users. The digital world has pervaded our society to such an extent and connected us to information so closely that we are interacting with the physical world and each other less and less often. We are seeing great shifts in societal norms and the way in which things have been done traditionally. From the lower amount of face to face interaction in the wake of cell phones and social media, to the movement away from storefront shopping in favor of online shopping we are creating a strange culture of socially insulated individuals spending much of their time within a digital reality. We have created a culture that seeks immediate gratification within practically every aspect of life. The vast production of devices that incorporate digital imaging options, whether still or video, coupled with social media have allowed for nearly anyone to create "art". The thought of any non-digital art forms have been removed from the minds of many. Even food has left necessity in common culture to embrace its new form as an immediate commodity. The art of cooking has long since been sent to the wayside by fast-food and frozen dinners.

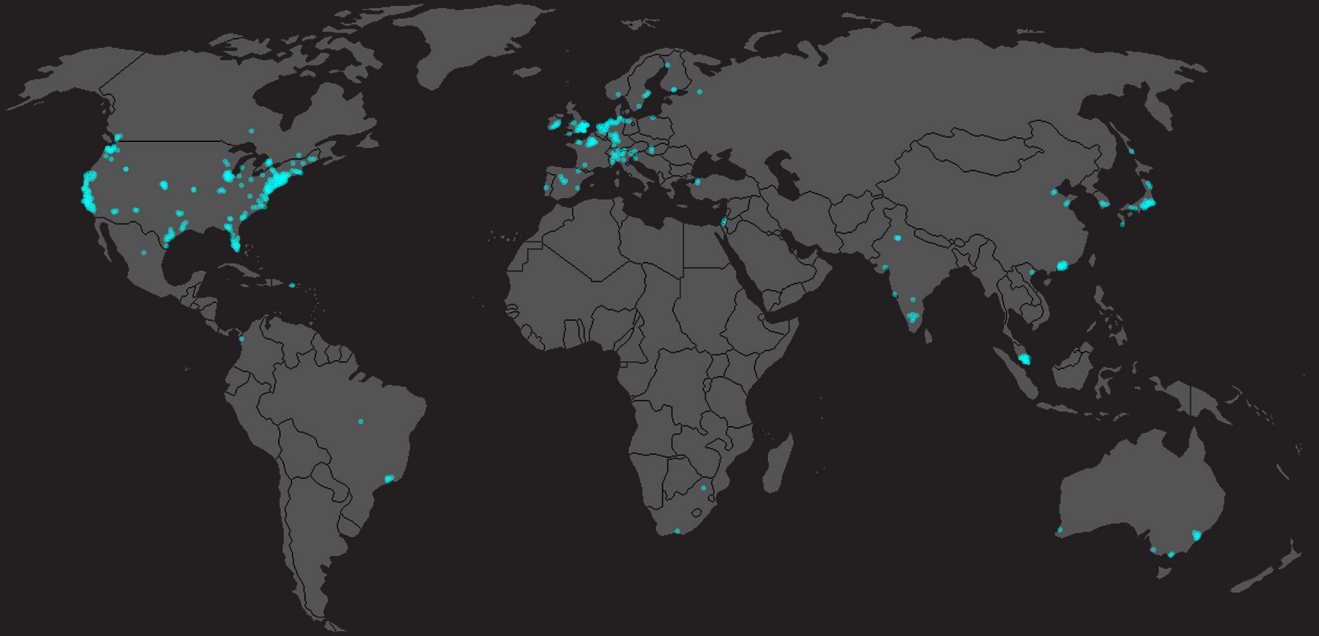
The loss of face to face interaction and the degradation of storefront shopping are arguably in their second phases. The first began with the automobile becoming available to nearly everyone after the second world war along with the creation of the interstate highway system. The urban core and all of the amenities that had been located there began to struggle as suburbs sprang up with shopping centers designed around the automobile placed within them. Now, however, the expansion within telecommunications has pushed this degradation of the city to a higher plane and is doing more than simply degrading the physical aspects of the city. The advent of round-the-clock news coverage as well as the rapid implementation of the computer into the business world as well at home has created a loss of place. The individual can be anywhere and everywhere in an instant within the screen-viewed venue of the internet. The individual has quickly, much like the business world had earlier, become globalized.

The most recent wave of technological advancement has, at least in the developed world, degraded the

individual's ability to engage with the world around them in various ways. The advancement of the cellular phone coupled with the prolific use of social networking websites has "connected" people together like never before. In reality these things have created a growing trend to physically disconnect from face to face social interaction, between individual and individual, and between individual and business. The machine is now the face of a vast amount of social interaction almost everywhere in the world. The developed world's social interaction and culture have suffered from the use of these technologies and their growth is exponential.

It should be noted, however, that this proliferation of technology has become an incredible benefit to the individual in many developing nations. Individuals in many developing countries have faced great social and political injustice without the ability to speak out. The massive implementation of cellular phones and probably more importantly social networking have allowed the exchange of ideas between people to occur rapidly and openly. This exchange has allowed people of different backgrounds to work together towards social and political change by bridging previous cultural gaps and uniting them under one common cause. The uprisings in the Middle East during the "Arab Spring" are a testament to the ability of technology to benefit society and allow for positive growth.

So while in many ways we have created something that can benefit us in innumerable ways, we have also created something that can in many ways destroy traditional face to face interactions with the world around us. With the faces of data centers so hidden from view, even when they are right in front of us, what can we do architecturally to reengage the user of the digital world physically? What if we could maintain necessary security measures and remove the desire for anonymity? If architects can design events and moments within data center facilities that create intersections between the digital and physical we might yet change the patterns of social interaction within our cities.



Major Global Data Center Locations [Image 39]

Rethinking the Paradigm

[Project Objectives and Theories]

While we begin to understand the implications of our digital world upon our physical and vice versa it is imperative to develop moments at which the two worlds can intersect. As explained in the previous sections, the major physical manifestation of the digital world within our built environment is the data center. They are the homes in which the digital information that we interact with resides. Data centers are also the point of departure and arrival for information as it travels throughout the world from user to user, server to server, user to server and server to user. The data center is at all times, digital residence, archive and transportation hub.

The predominant design philosophy guiding data center development has been to isolate the facilities from the rest of the physical environment systematically. Traditionally, various building typologies and infrastructural developments have affected the built environment and the urban landscape through their integration with the human component of cities. The manufacturing complexes that were built during the industrial revolution played a major role in the development of housing, neighborhoods and transit infrastructure. This was a pattern that is seen throughout the United States and is poignantly displayed in the development and decay of Detroit during its boom and bust years. A parallel can be drawn between the development and removal of manufacturing complexes and the effect upon neighborhood development and health of nearly every post-industrial city in the United States. The construction of urban manufacturing facilities, and later suburban manufacturing facilities, brought with them a boom in housing,

commercial and transit developments that permanently altered the landscape of cities. When the facilities left the city for the suburbs and in some cases left inner ring suburbs for fringe communities, the consequences began to occur almost immediately. Neighborhoods that once thrived off of the economic input of manufacturing complexes now began to see widespread vacancy as the workforce left with the work. While this is an over simplification of a much more complex issue with other variables at play, the reality is that when the core manufacturing bases of cities left, there was only a void in the urban fabric that remained.

A perfect example of this is located within Detroit which formally hosted one of the largest industrial complexes in the world, the Packard Plant. Now synonymous with urban decay in the Detroit area it has stood entirely vacant, save for one small chemical business, for a decade. The original Packard factory stopped operation in 1958 the facility served various uses until it began to see widespread internal vacancy during the 1990's. During the period of the Packard's decline and abandonment the neighborhood also saw extensive population loss and abandonment. During the period of the Packard Plant's decline [1960-1990] the population of the Detroit dropped from 1.67 million to just over 1 million people, a loss in population of 40%. Between 1990 and 2010, while the Packard has sat virtually entirely vacant, the 48211 zip code [within which the Packard resides] saw their population

drop from 13,100 to 6,685, a loss of 51%. These declines are indicative of the impact of a job base for a local urban neighborhood.

Why is it then that the data center, as a new building typology with significant economic impacts is developed in a way that prevents it from becoming a part of a neighborhood or community? Even in the densest urban areas data centers are developed to avoid becoming visible or even recognized by the populous of the area. The inherent need for security and privacy at these facilities drives these tendencies, but the negation of participation within the greater context in which a data center sits creates social voids within the urban fabric of cities.

This willful disengagement with context must be combated through the design language of a data center along with the architectural programming that is inserted into the structure. Like any other building program, the expression of the use should be implied or even displayed through the architectural language. Thus, in the case of the data center the architectural language must inform users of its connection with the digital world. The fiberoptic connections that data centers rely upon to stay connected with one another and with users are hidden underground and only breach the surface at "POP" [point of presence] rooms inside data centers. The architecture should express this breaching of the surface to highlight the underground nature of the

digital world. This could occur in various ways and it does not necessarily mean that fiberoptic lines must be exposed, but rather the acknowledgement of the digital world meeting the physical should be celebrated. The data center could be showcased by transparent elements of the façade when security measures are less stringent, i.e Tier I and II data center capabilities.

The potential user of a data center could allow for the direct showcasing of the functionality at the ground plane where users could visually engage the facility. For example, municipal servers that house information that is considered public record could be housed in an area that displays the server room to the public without fear of losing sensitive materials. In other situations in which the public would not be granted direct access of the information digitally, the material palette could be chosen to acknowledge the data centers presence yet still not allow direct visibility. The visibility of the working data center can be determined based upon the nature of the information being stored through interplay of transparent, translucent or opaque materials depending on the circumstances.

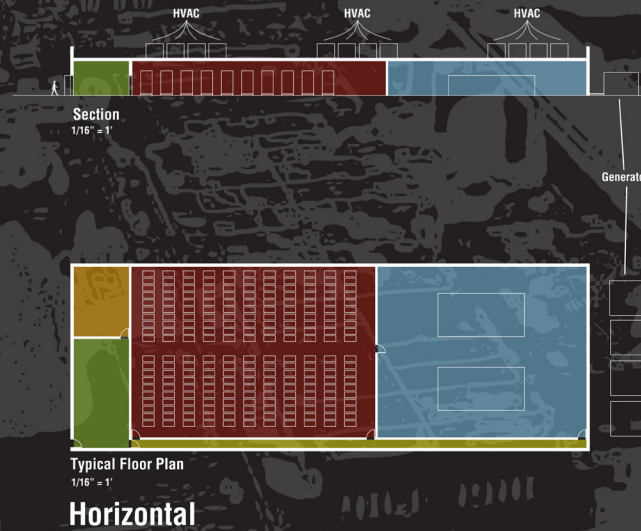
Other factors that can help determine the level of visibility can be based upon whether or not the server space being displayed is direct adjacent to areas in which the public might have access. For instance, if the data center is on the ground plane the level of visibility may be greatly different than one on dedicated floors several levels above grade. That data center could also become visible through the lens of a transitional space, for example an office

setting. This could become a situation in which the data center office rings the data center itself, but both are contained within glazed walls. This allows the data center to have a buffer space between the public and direct physical access to server rooms.

In all cases the visibility of the functionality of the data center should be expressed. With society dreaming of a digital cloud that seemingly couples well with our new fascination with sustainability, it seems irresponsible, if not negligent, to not highlight the misconceptions about how the digital world actually functions. We live in a world in which the internet, the cloud and all other facets of our digital lives is seen as sleek, sexy and environmentally friendly. The fact is that we have created an ethereal reality in which the material is no longer present and apparent and individuals can disconnect themselves from the ramifications of their lifestyle. The digital world poses a growing concern towards our environmental, social and economic sustainability and this concern must be addressed globally.

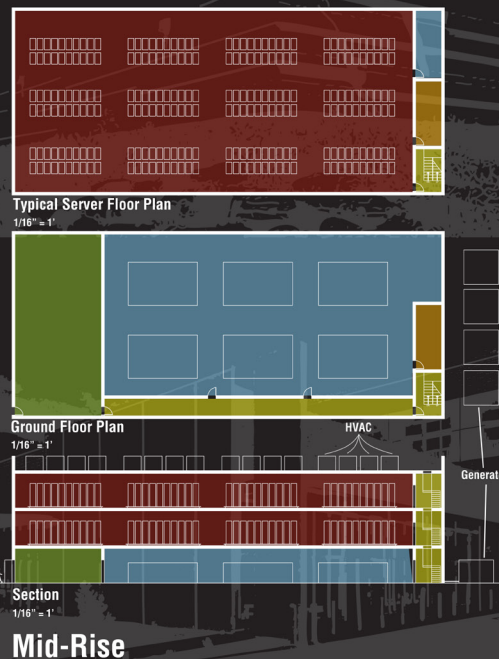
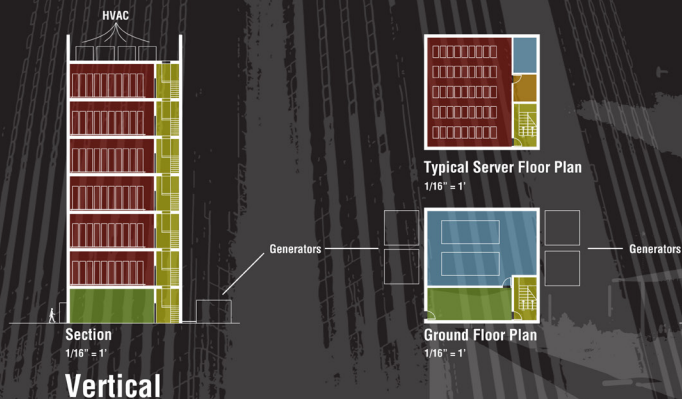
The study showing the typical spatial arrangements of data centers expresses the simplicity of their concept. Yet a diagram like this cannot express the complexities that make up their inner workings. The diagrams show the spatial relationships as they relate to low, mid and high rise data centers. In all cases the server rooms and mechanical functions are the dominant pieces of programmatic function.

Typical Data Center Spatial Plans



In the typical low rise arrangement the floor plans are broken apart approximately 50/50 between HVAC and power components and server room components with storage, circulation and office space minimized and added as an afterthought. These facilities for are well suited for rural areas where land and energy are cheap and easy to come by, but are poorly suited at a large scale for urban development.

The mid-rise diagram shows how the proportions of HVAC and server rooms change with the scale. In this case the ratio is about two-thirds server rooms and one-third HVAC and power infrastructure. Again with office, storage and circulation being minimized and created as an afterthought. This arrangement



is suited for certain urban developments, however, it once again disengages the user. Mid-rise adaptive reuse of existing buildings has been a relatively frequent means of developing data centers in urban centers.

The typical high-rise diagram shows that this arrangement is the most efficient in terms of HVAC and power requirements by reducing the ratio necessary to cool significantly. The exact numbers vary depending on the height, but it is rare to find spaces available to create these types of developments. In urban centers though this would be an ideal method of developing tech infrastructure in the heart of downtown business districts.

How then do begin to best examine what the digital world is and what its ramifications are? We must first determine the scale of the project and what type of context it will sit within. The physicality of our digital world should inform the user of the ramifications of engaging the digital and create environments that foster tangible engagement with our world. This is especially important in urban centers which have begun to decline in recent years creating further urban sprawl and growing economic disparities. We need to learn to allow our digital world to coincide with our physical and blur the lines that are creating a stark divide between the two. How then does this occur? The next sections investigate what it would mean if we were to develop a comprehensive plan for tech infrastructure through an entire urban area.

Networking the City

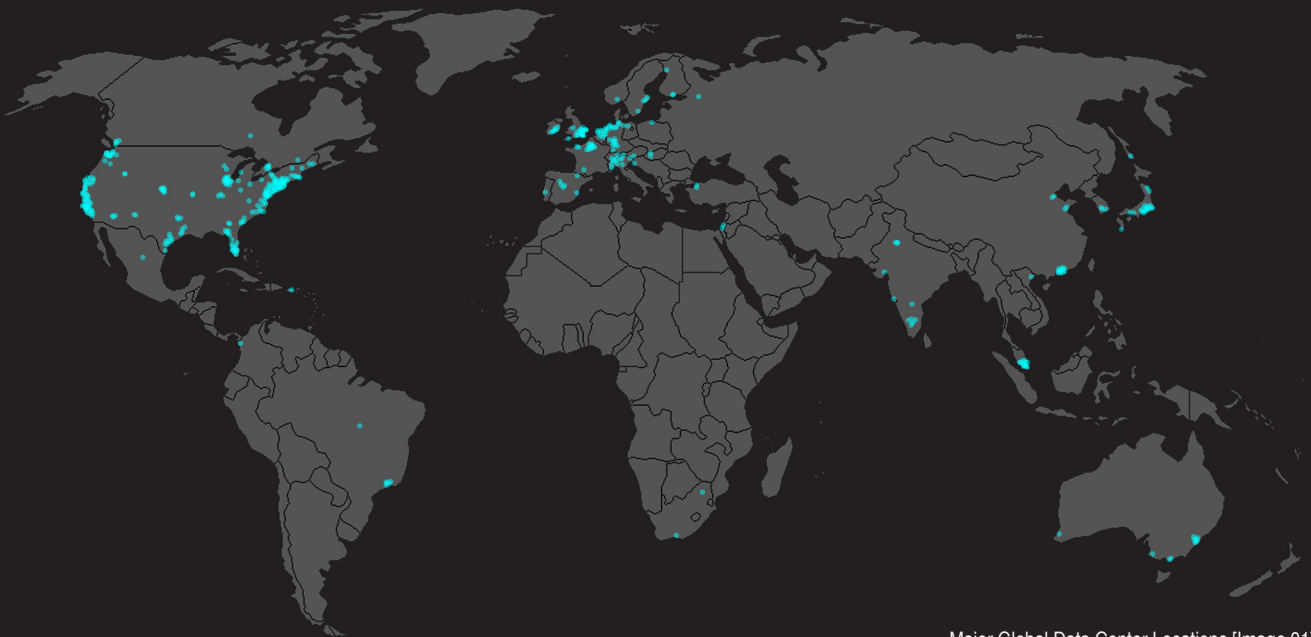
[An Urban Scale Intervention]

If we were to begin to view data centers as independent facilities we would again be creating a gross misconception about how our digital world functions. Every data center facility is part of a much larger infrastructural network that can only be fully understood on a global scale. The image below represents every current major data center globally with a small blue dot. The most recent estimates show that there are approximately 2500 major data centers worldwide, although that number is increasing rapidly.

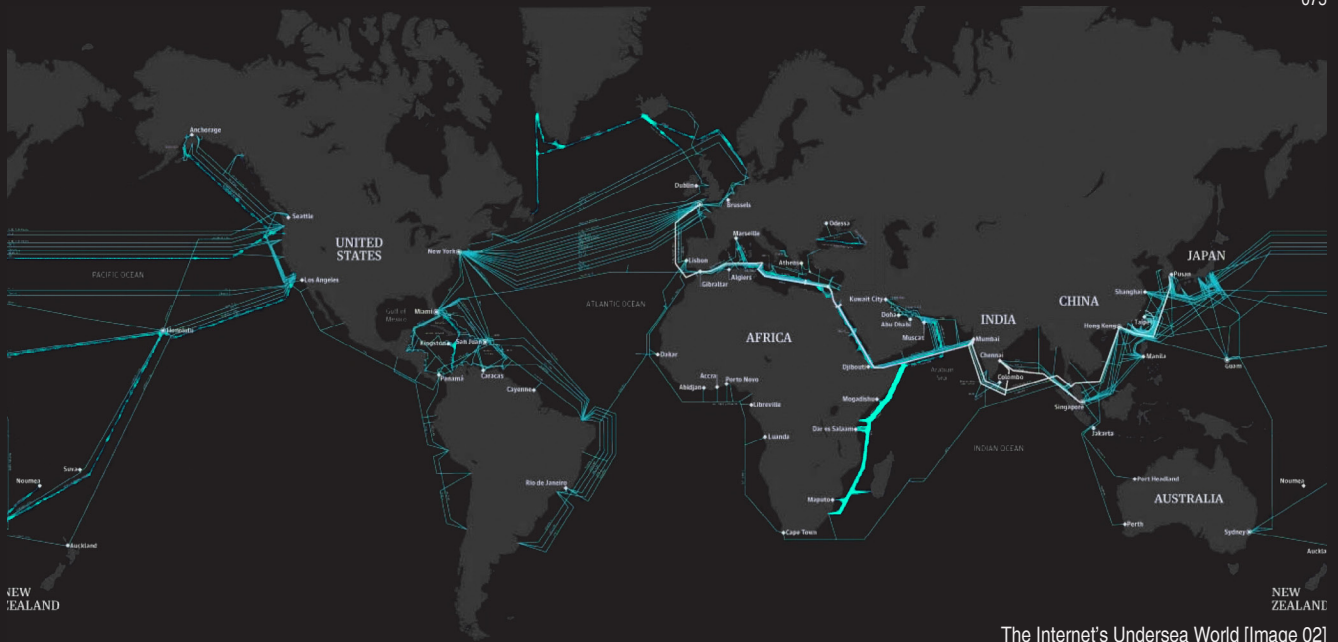
None of these facilities are disconnected from another, they all operate along the same major fiberoptic lines that traverse the globe. Even the fiberoptic lines that link this network of facilities together are hidden from view. When on land they remain underground and

only surface at data center locations in what are known as P.O.P. (point of presence) rooms. When fiberoptic lines have to traverse across oceans to stitch continents together within the digital world thousands upon thousands of miles of cable are laid across the ocean floor. The image on the opposite page displays this deep ocean network and together with the map showing data center locations highlights the monumental scale of our digital world.

This global network is one of the worlds most significant achievements and significant pieces of infrastructure, yet we keep it hidden which disallows the world from celebrating this achievement let alone understanding its ramifications. This global network highlights how in many respects the digital world



Major Global Data Center Locations [Image 01]

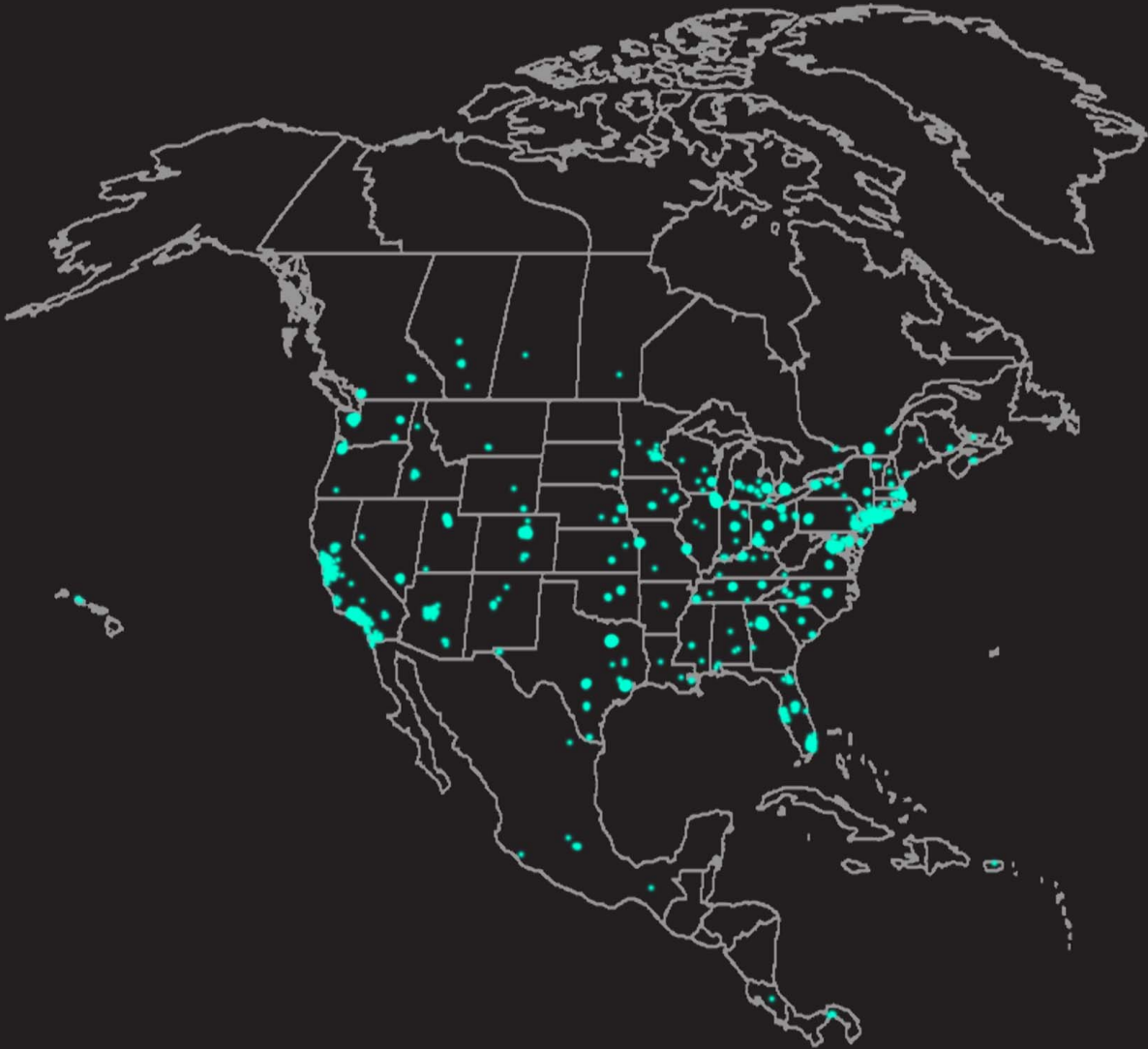


has brought us ever closer together, sometimes for better, others for worse.

A brief look at the locations of these facilities along with the areas with large numbers of transoceanic fiberoptic meeting land shows that they are built and developed almost exclusively in major urban centers. This is despite the lack of any functional need for them to be located near heavily populated areas or engage digital users in a physical way. The rationale is that they be located in urban centers for the sake of efficiency. Not necessarily efficiency in terms of speed, but rather being close to potential clients and maintaining a more efficient HVAC system. This tendency towards developing in urban areas is what poses the challenge and need to address

The Internet's Undersea World [Image 02] the data center as a building typology and its development patterns as well as critically analyze ways of rethinking how they can be created in a more socially, ecologically and economically equitable manner. Considering data centers tend to create voids in urban centers, and with major cities everywhere finding them already in vast numbers it would be difficult to allow the public to visualize and understand them as a greater network rather than single buildings.

By investigating various urban centers it became clear that almost every major or minor city in the United States had the majority of its tech infrastructure not only within the city proper, but within the downtown business district. Standing out from the crowd was Detroit, MI with 19 colocation data centers operating the entirety of the



• Data Center Location

city's tech infrastructure, but all of them are located outside of the city proper. When compared to cities like Chicago (a major data hub), or Portland and Atlanta which the city and the Detroit Collaborative Design Center has begun to compare Detroit to, the tendency to locate data centers in downtown districts is apparent. All of these cities, with the exception of a few outliers, has all of their colocation facilities in the heart of their downtown districts. This creates a unique situation for the Detroit. Not only is there no design precedent for a data center within their borders, the city is undergoing a major transition. With various plans in place to alter Detroit's long tarnished image and transform the local and global perception of the city, Detroit stands poised to take

North America

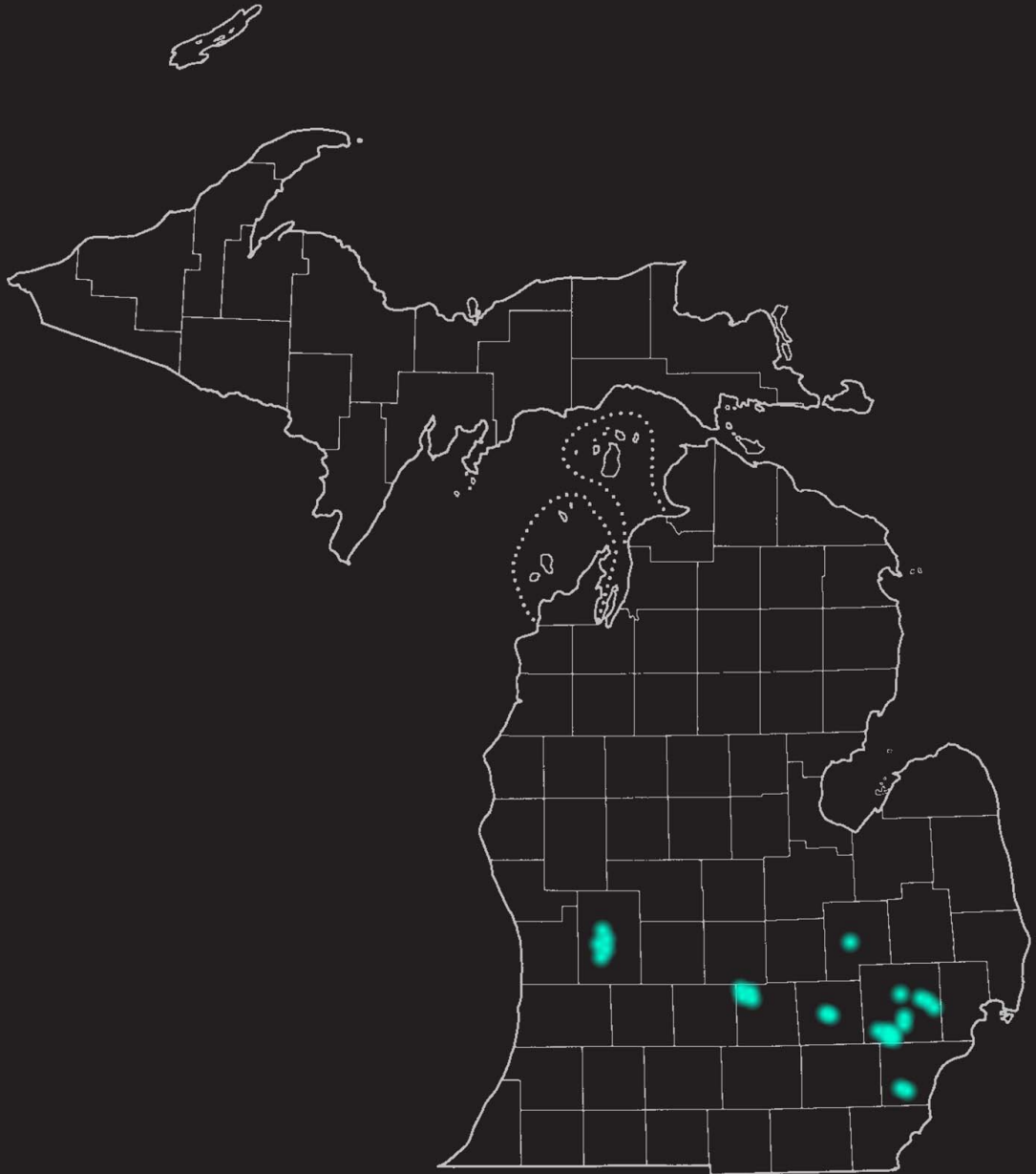
Major North American Data Center Locations [Image 03]

on the role of a leader in creative development of the tech infrastructure of our digital world.

The city is interested in various methods and means to revitalized currently blighted areas of the city. This includes urban agriculture, infilling of certain areas, creating a new transit system, developing entertainment, fostering research and industry among other things. However, despite previous efforts to bring a data center into the city of Detroit they lack one entirely. The common misconception is that the TechTown organization based in Detroit's Midtown district is pursuing both data center and tech related development within the city. This until recently was true,

but due to various financial issues related to the recent economic recession the organization lost its potential data center developer. Within the last year the group has also shifted away from being a solely tech related business incubator to become a more generalized organization to avoid going under financially. Now without any group pushing the development of inner-city tech infrastructure the city needs to find creative ways to incentivize colocation facilities to move to Detroit.

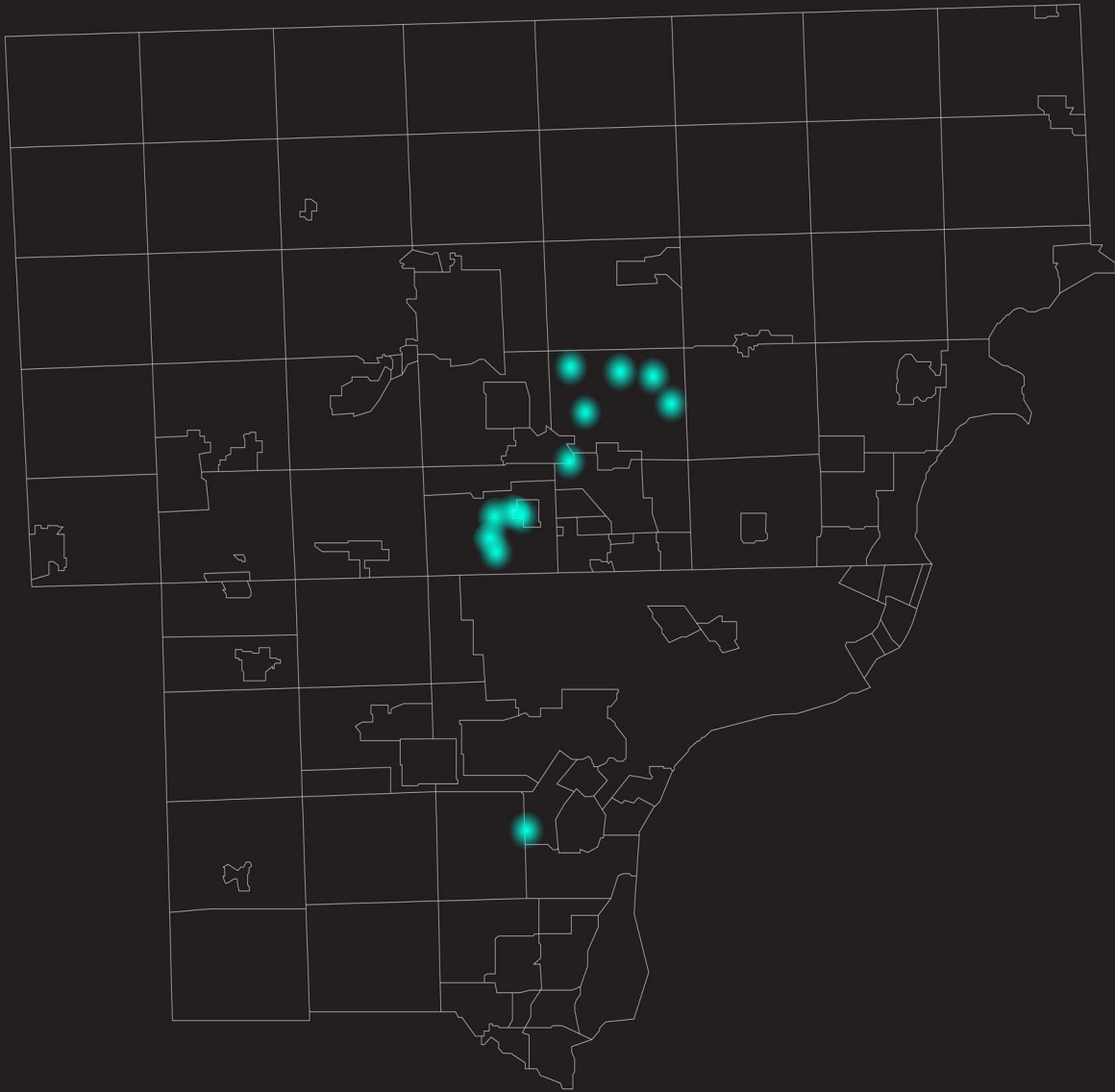
The other major reason that Detroit proper has not been seen as a viable location for a data center to be developed in is painful, but far too often true, stigma that it is not a safe and secure city. On the flip side, the hyper-secure nature of much of the data which is stored is something of a farce. Individuals who aim to steal digital information from others rarely seek out the physical medium that stores the information, rather they are hackers who steal it through the digital world itself. The physical walls of the data center do little to nothing to protect it from would be thieves, but rather give



• Data Center Location

Michigan

Major Michigan Based Data Center Locations [Image 04]



• Data Center Location

a physical sense of security to potential clients looking to lease space within a data center. This allows one to think of the data center as something that can be open, engaging and contribute positively to the urban context within which it sits.

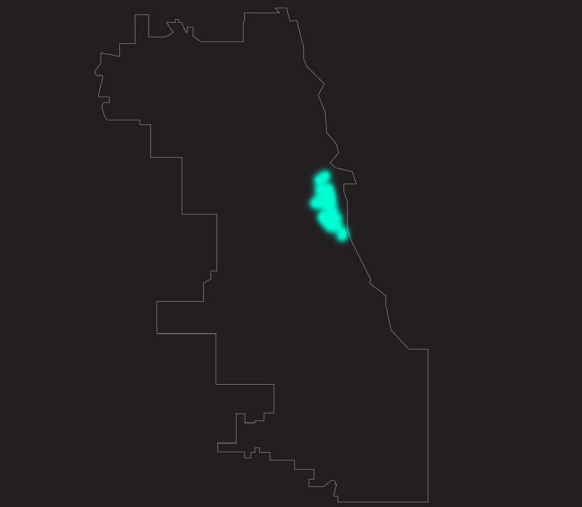
The combination of having a clean slate for digital infrastructure along with the need for a nearly city-wide revitalization effort creates a unique situation. The city can become the first to find a means to merge the physical and digital into world in which we can occupy and understand the two worlds as they relate to each other more clearly.

With a need to more efficiently move its populous as well as the need to incentivize staying within the

Metro Detroit

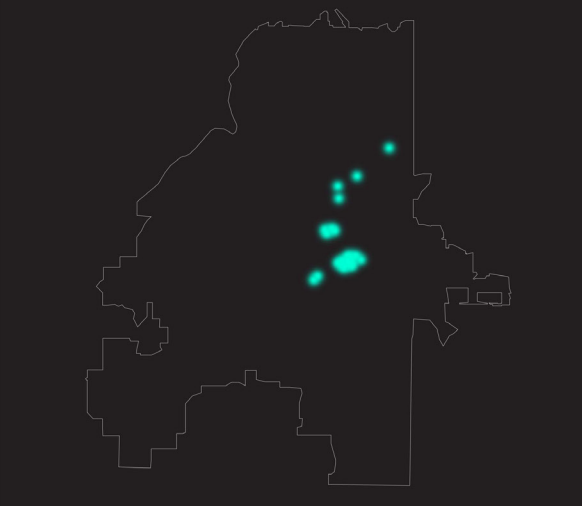
Major Metro Detroit Based Data Center Locations [Image 05]

city rather than leaving, Detroit has various plans to create a new and more efficient transit system. With two major potential infrastructural improvements to accomplish, the first the movement of people and the second the movement of information, the first means to allow the visualization of the digital world could occur through the union of Detroit's fiberoptic lines and transit lines. Because fiberoptic lines need to be maintained underground, it would then make sense to develop an underground rail system in Detroit. This system could then be utilized as a basis for general site selection purposes by data center operators.



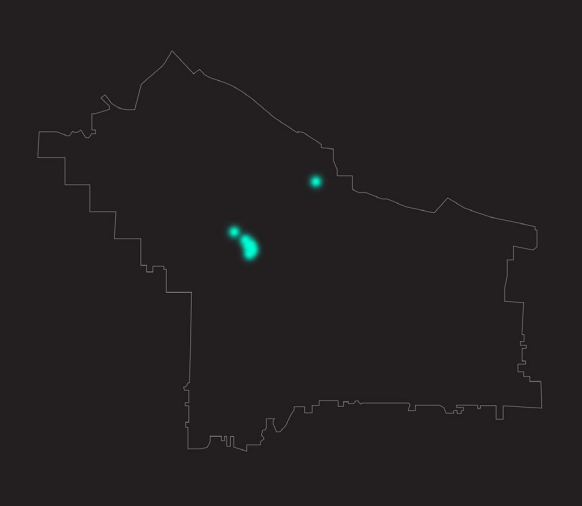
• Data Center Location

Chicago



• Data Center Location

Atlanta



• Data Center Location

Portland

Various Cities Data Center Locations [Image 06]



Recently, the Detroit Works Program along with the Detroit Collaborative Design Center created a master plan for the city entitled Detroit Future City. This plan called for the development of a comprehensive city-wide transit network that the city desperately needs. The plan calls for transit lines running along the 5 major radial arteries of the city, along with two crosstown routes, a north/south route on the west side of the city and a major ring line. The plan was adopted as the basis for creating a network of nodes throughout the city that could become both the basis for transit stations and data centers. The only two changes that have been made that break from what is already being proposed is the addition of an inner ring line that is closer to the downtown core and the assumption that this network would be placed underground to coincide with the development of fiberoptic lines. Along each line transit/data stations have been mapped and a key unique site located that would be the iconic station along that line. The following pages will give a brief about each individual line and its key site, concluding with the line that was studied in the most detail and ultimately became the basis for the remainder of the project.

The first site that was analyzed was the Southfield Fwy. Line. It is the only direct north/south line that is proposed and services the west side of the city of Detroit. It is unique in that it connects various suburbs, including Southfield and Dearborn to the city proper in a much more direct way and traverses an area of the city that is largely left out of most planning efforts. Its key site is the Grandale Station, which is located at the corner of W Chicago St. and the Southfield Fwy. It is at this intersection that a major active rail line intersects with the Southfield line. While Detroit certainly needs and local transit system, it also needs a regional transit system due to its history of urban sprawl. This station could serve as the west side's transportation hub for both local and regional transit. A station could be constructed along the railroad easements leading up to the Chicago-Southfield intersection that would allow for underground local passengers to transfer to regional trains and be a meeting point for local and regional fiber optic lines.

Southfield Fwy Line

Fairline Town Center - 8 Mile

Key User Areas

Greenfield Hospital
Wayne County Community College
Grand River / Southfield Commercial
Fullerton St Industrial Zone
Chicago St Industrial Zone
Ford Southfield Commercial

Key Site - Grandale



Proposed Inner City Transit
Existing Rail
Data Stops

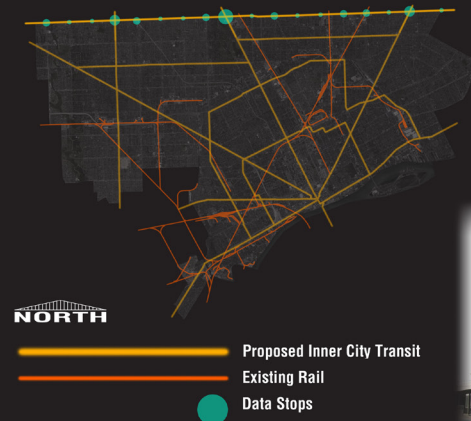
8 Mile Crosstown

Five Points - Eastland Center

Key User Areas

Lahser YWCA
Northland Center
Inner Ring Industrial
Detroit Recycling Center
Chrysler Truck Assembly
Eastland Mall
General Commercial

Key Site - Woodward / 8 Mile



The 8 mile Crosstown route connects the entire north end of the city as it traverses along the full length of the northern border. It is a line that will serve and connect both the residents of the city that live along the 8 Mile Road corridor to the south and the residents of the suburbs that line the corridor to the north, with connections to 3 other proposed local transit lines. The line's key site is the Woodward/8 Mile station which is the connection point with the Woodward Ave. Line. The Woodward line serves as the most significant artery along the entire system running from the northern border to the city center. This station would serve as a gateway into the city from the north and could be designed to celebrate the reuniting of the suburbs with the city. The site also is adjacent to the former state fair grounds which boast various vacant historic structures. That site is currently seeing redevelopment as a shopping center, but the integration of a major transit link might spur further development that aims at engaging community members more actively. The station's design would be iconic in nature and seek to welcome both residents and visitors into the city of Detroit through the integration of our digital and physical worlds.

The 7 Mile/W McNichols Crosstown route is the second major east-west connection for the city. It serves the northern end of the city running along the length of W McNichols on the west side of Woodward Ave. and the length of 7 Mile Road on the east side of Woodward. The route connects various major districts and facilities and has links to four other proposed transit lines. The key site for this line is the University District Station which is located on the grounds of the University of Detroit Mercy. It sits on the corner of W McNichols and Livernois Avenue on a portion of the university's campus that is currently not being used. The site formally housed a transit station for the city's street car system until its removal. The station served both the students of the University of Detroit, but also the patrons of the many businesses along Livernois Ave. The area is currently seeing a major effort to revitalize and bolster the business community and the ability to have transit access would only expedite the efforts that are already ongoing. The design would be developed to be subtle and mesh with the surrounding neighborhood and the university's campus.

E 7 Mile / W McNichols Crosstown

Riverdale - Gratiot

Key User Areas

Wayne County Community College
 Cornerstone Schools
 Marygrove College
 University of Detroit Mercy
 7 Mile / I-75 Industrial Zone
 Sherwood / Mt Elliott Industrial Zone
Key Site - University District



NORTH

- Proposed Inner City Transit
- Existing Rail
- Data Stops





Key User Areas

Jefferson North
 City Airport
 Conner Industrial Zone
 GM Hamtramck
 Detroit Water and Sewerage Dept.
 Sherwood / Mt Elliott Industrial Zone
 Highland Park Industry
 West Riverfront Industry
Key Stop - Delray



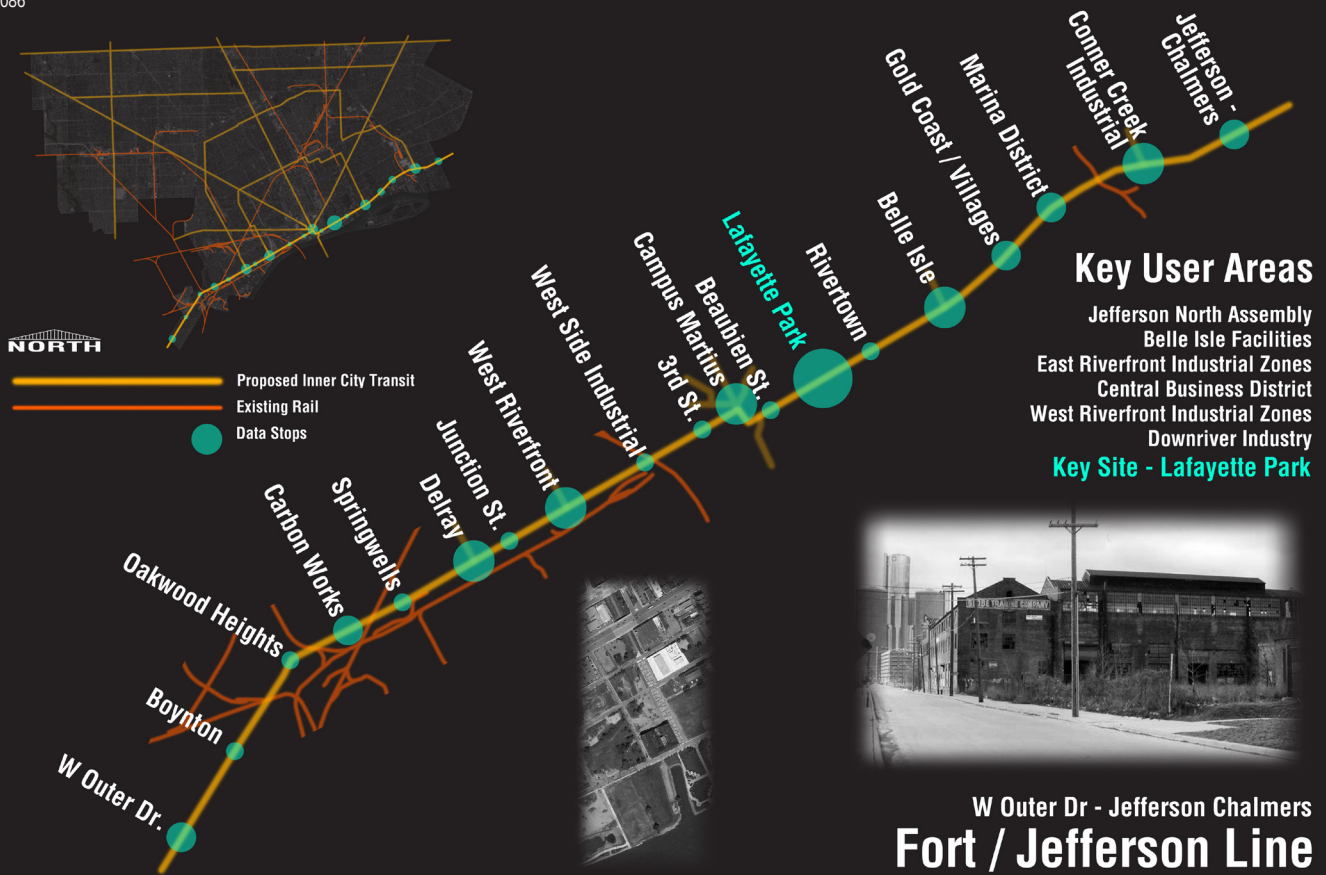
Delray - Conner Creek Industrial
Outer Ring Line

The Outer Ring Line is the proposed ring line from the Detroit Future City plan that navigates through various different types of neighborhoods throughout Detroit. These areas range from industrial, to residential to commercial. This ring line would meet and connect with all five of the radial lines at various points while also intersecting with numerous rail lines that could serve a more regionalized train system. The site location for the data center station would be the former headquarters for Roberts Brass Works on Fort St. The building is located within the Delray neighborhood on the southwest side of Detroit and has historically been an industrial area. The building would serve as a potential influence on the ability of the nearby thriving Mexicantown districts ability to expand outward. This facility would be particularly suited for the development of a data center component as most industrial buildings are well built and have a simple easily adaptable and dividable layout.

The Inner Ring Line is the only line of the proposed network that is not outlined within the Detroit Future City plan. This line was created to connect various thriving areas that are closer in proximity to the downtown core of Detroit. This line again links up with all five of the radial lines that are proposed as well as various rail lines that could serve regional transit needs. The ring follows the path of Grand Boulevard which already serves as a ring road around the city. It connects to various points of interest including Belle Isle, Mexicantown, Corktown, New Center and the former site of the Packard Plant. The Packard Plant was selected as an adaptive reuse project that would serve as the major transit station for the Inner Ring Line. This facility is over 3 million square feet and could serve as a major data hub along with creating an extremely dynamic mixed use development. Though the Packard Plant needs significant work due to years of neglect it stands as an icon and testament to the history of the city of Detroit. This facility sits within a neighborhood with little to no investment occurring currently, however the implementation of a major transit and data center to serve the nearby GM assembly plant and the plan to daylight the Bloody Run Creek which will have a headwaters at the site could spur development in the area.



West Riverfront - Belle Isle
Inner Ring Line



The Fort/Jefferson Line is the major connection on the lower east and west sides of the city to the downtown core. Its general path runs along the riverfront with Jefferson Avenue on the east side of the city and along Fort Street on the west side of the city through several major southwest side neighborhoods. This will also connect with the Woodward Avenue line and the ends of both ring lines. The eastern portion is served by a single rail line that could be adapted for regional transit, but the leg to the west on Fort Street is served by various rail lines that all feed off of the former Michigan Central Station. The key site for this line would be just to the east of downtown at Lafayette Park. This was a project that was designed by Mies Van der Rohe as a development that was part of the urban revitalization efforts at the time. For some time the complex was not viewed as a success, but as the landscaping that it sits in has matured the intended design have begun to show through and create a very unique and interesting place. The particular building nearby building that would be adapted as the transit and data center would be the former Globe Trading Building that is currently slated to become a condo development, but do to its former use would be easily adapted to create spaces for a data center component.

W Outer Dr - Jefferson Chalmers
Fort / Jefferson Line

The Grand River Line is one of the five major radial lines and serves the west side allowing direct access to downtown. The line crosses paths with both ring lines along their western portions, the Southfield Fwy Line, the 7 Mile/McNichols Line, the 8 Mile Crosstown Line and its terminus is at Campus Martius where it meets all other radial lines. The line serves various industrial areas and is also connected with numerous rail lines that would connect it to a more regionalized transit network. The key site location for this line is the Grandmont Rosedale stop at the corner of Grand River Avenue and Greenfield Road. This intersection boasts a historic shopping center called the Mammoth Shopping Center that currently sits vacant. With Grandmont Rosedale being a fairly successful neighborhood the redevelopment of the Mammoth Center into a mixed use retail, data center and transit center could spur further development on the west side of the city. The facility is both iconic and historic having formerly housed a large scale retailer is perfectly suited for implementation of a data center within the structure.

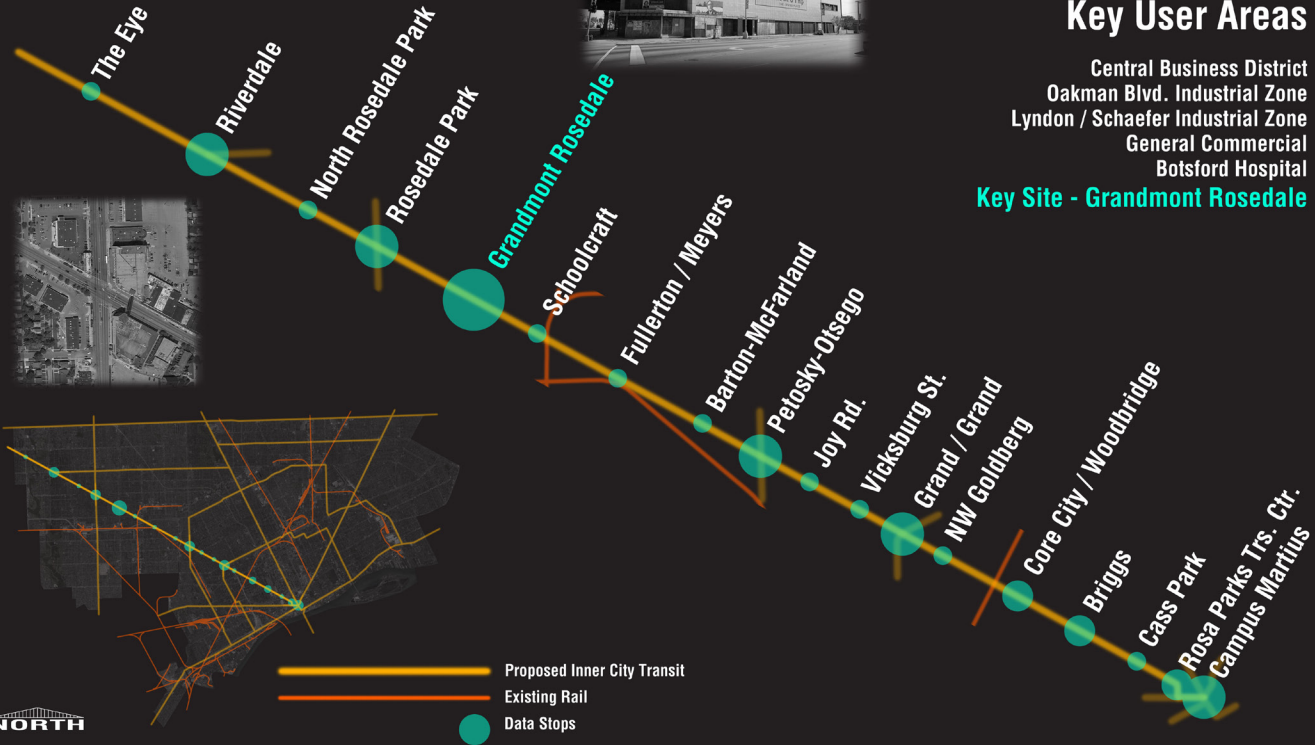
Grand River Line

Campus Martius - The Eye

Key User Areas

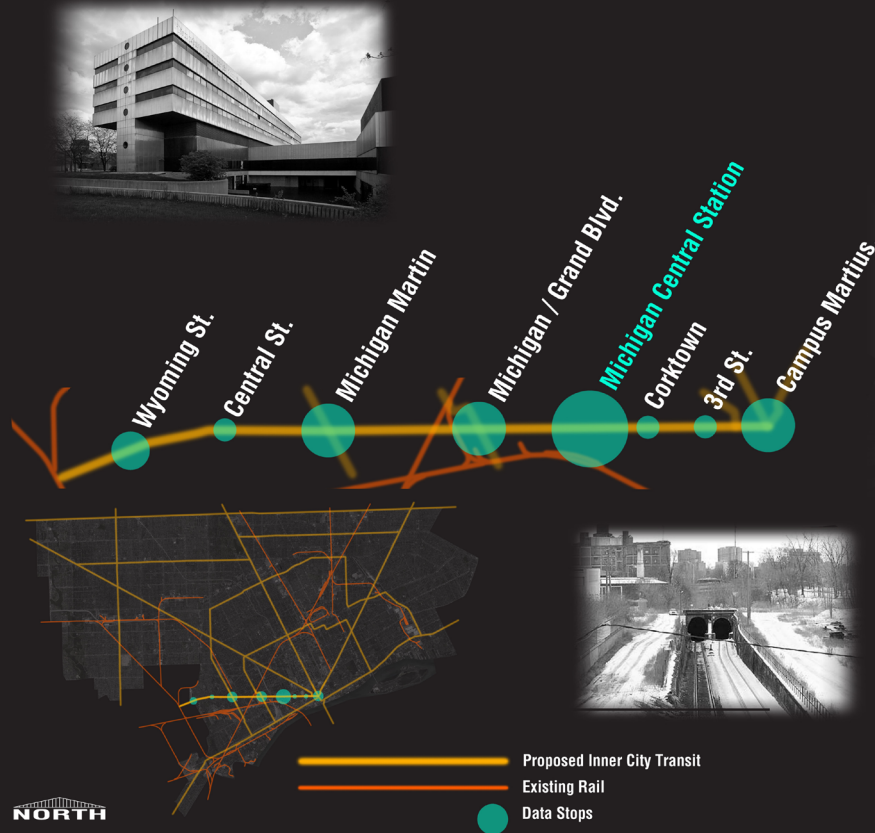
- Central Business District
- Oakman Blvd. Industrial Zone
- Lyndon / Schaefer Industrial Zone
- General Commercial
- Botsford Hospital

Key Site - Grandmont Rosedale



Michigan Ave. Line

Campus Martius - Wyoming



Key User Areas

Michigan Central (Regional Transit)
 Central Business District
 Michigan Ave. Industrial
 City of Detroit Public Works
 General Commercial
 Southwest Detroit Industrial

Key Site - Michigan Central Station

The Michigan Avenue Line is the major artery that will serve the west side and would be the most significant connection with regional and national rail transit networks. The line runs from Wyoming St. on the west side (continuing into Dearborn) to its terminus with all other radial lines at Campus Martius in the heart of downtown Detroit. The line also connects with both ring lines on their western sections, but most importantly runs directly past the site of the former Michigan Central Station. Michigan Central has stood vacant for decades, but once served as the hub for regional and national transit coming into and out of Detroit. The station sits at the foot of Roosevelt Park which has recently undergone a transformation, and the buildings owner is currently working on improvements to the building. The area also contains various other major vacant structures such as the former Detroit Public Schools Book Depository, the Accountants Building and the former United Community Hospital. The rail lines that run through the station also connect internationally through a rail tunnel with Canada creating a potential linkage for rail travelers heading to and from major points across our borders. This area creates a unique opportunity to not only create a data driven transit center, but also a data driven district that is supported by what would be the most important regional, national and international connection.

The Gratiot Line serves the east side of the city of Detroit running from Campus Martius to the northern border at 8 Mile Road. The line connects with both ring lines along their eastern portions, the 7 Mile/McNichols Line, the 8 Mile Crosstown Line and all other radial lines at its terminus in Campus Martius in downtown Detroit. The key location for the development is a site on the east side of Gratiot Avenue at the southern end of Eastern Market. Eastern Market is a thriving market based community that also currently has various development plans in the works including the Bloody Run Creek Daylighting Project, the extension of the Dequindre Cut Greenway and plans to revitalize some of the vacant warehouse spaces in the district. The site that was selected for the development of the major transit node for this line is a large vacant lot that could house a mid-sized development that could support the Eastern Market community while serving as a gateway to it from the south.

Gratiot Line

Campus Martius - Regent Park

Key User Areas

- Central Business District
- Eastern Market
- Faygo Beverages
- General Industry
- General Commercial
- City Airport
- Key Site - Eastern Market



Woodward Line

[Campus Martius - 8 Mile Rd.]

Key User Areas

Highland Park Industrial Zones
 New Center / Henry Ford Hospital
 TechTown
 Cultural Center
 WSU / CCS Campuses
 Medical Center
 Downtown Business District
Key Site - Campus Martius

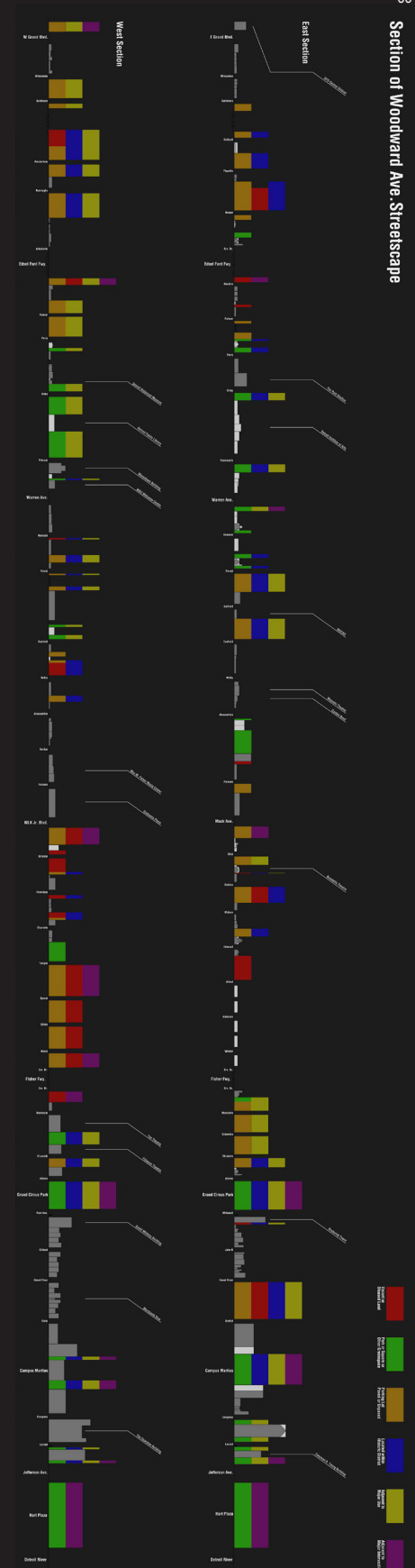


Proposed Inner City Transit
 Existing Rail
 Data Stops



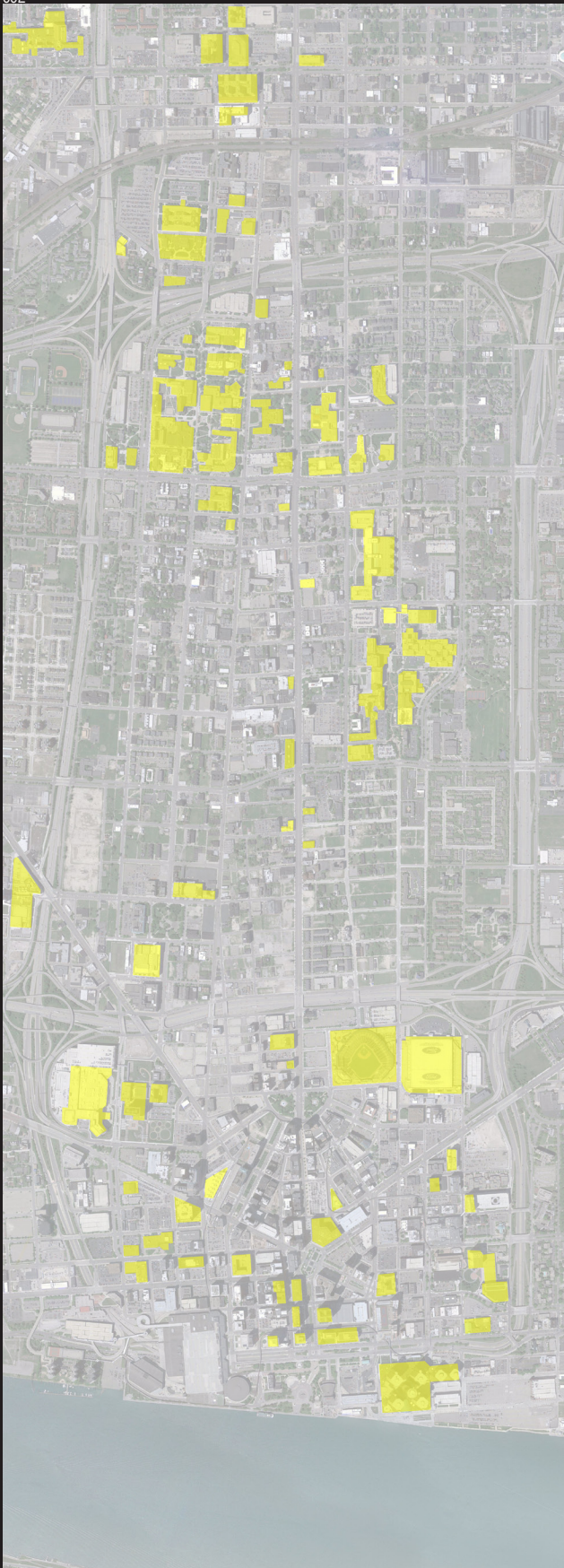
The Woodward Avenue Line serves as the backbone for the entire proposed transit network. The line is the most significant north/south artery for the entire city. It runs through the downtown, midtown and New Center districts as well as through many other major communities including the land island city of Highland Park. The line connects with both all other transit lines with the exception of the Southfield Fwy. Line. It's local terminus is in the heart of the downtown district at Campus Martius Park, but it has a spur that continues south to cross the river into Canada which allows for a physical connection between downtown Detroit and downtown Windsor. The line connects almost every major point of interest currently in the city and therefore was critical to study further. The selection of the key site at Campus Martius occurred as a result of both the need to address the coming together of five major transit lines as well as the desire to have a major data/transit hub along the most active section of the Woodward corridor. This section, which is located between Hart Plaza (which is at the base of Woodward Avenue along the Detroit River) and the New Center area which is located in the at the point where the Woodward Avenue Line would meet the Inner Ring Line. To analyze this area further a 3.5 mile long section was cut along the street to establish where voids were left in the street frontages along Woodward Avenue.

Section of Woodward Ave Streetscape



Woodward Streetscape Section Showing Void Spaces [Image 07]

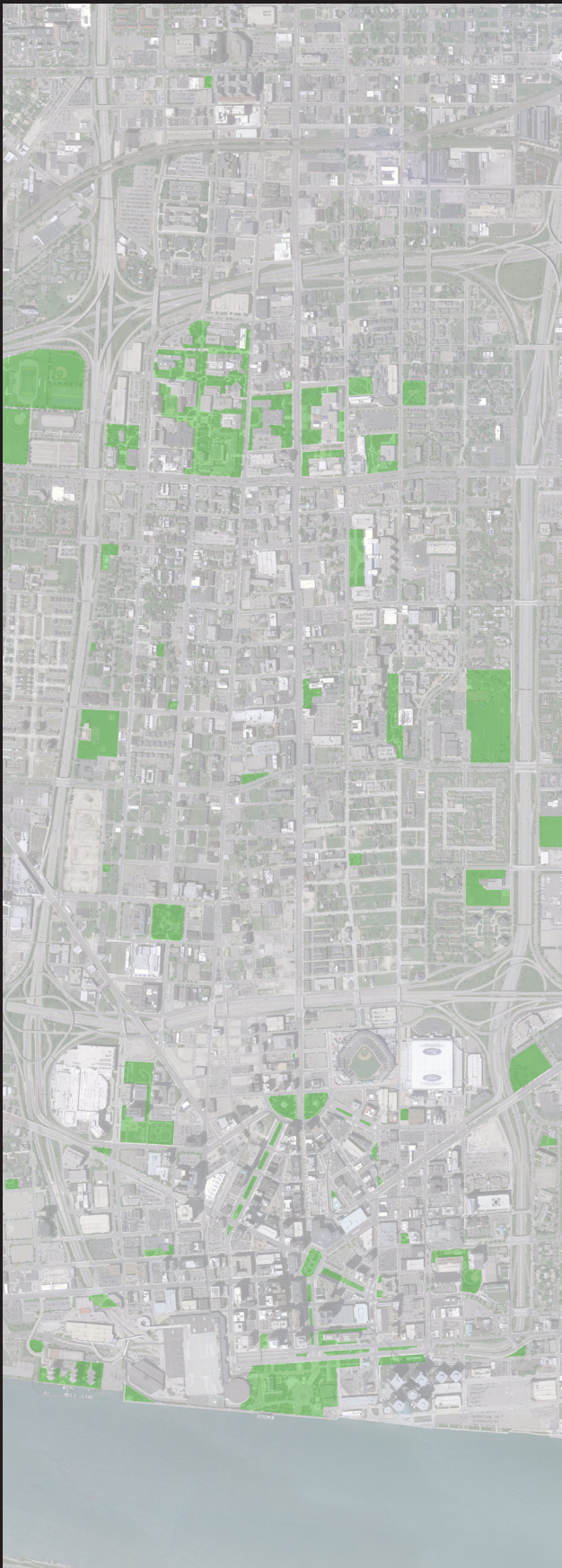
The results of this study of void spaces along the most significant artery in the city couple with various studies of the surrounding area on the following pages allowed for the selection of various potential sites that could be used to infill the downtown areas street frontages. The study showed that the most significant use for these vacant sites is parking which in a city rife with parking lots they stand nearly empty a vast majority of the time. The analysis of the void spaces and surrounding areas was moved forward into another study that showcased the same section of Woodward with potential site locations denoted as a network of nodes.



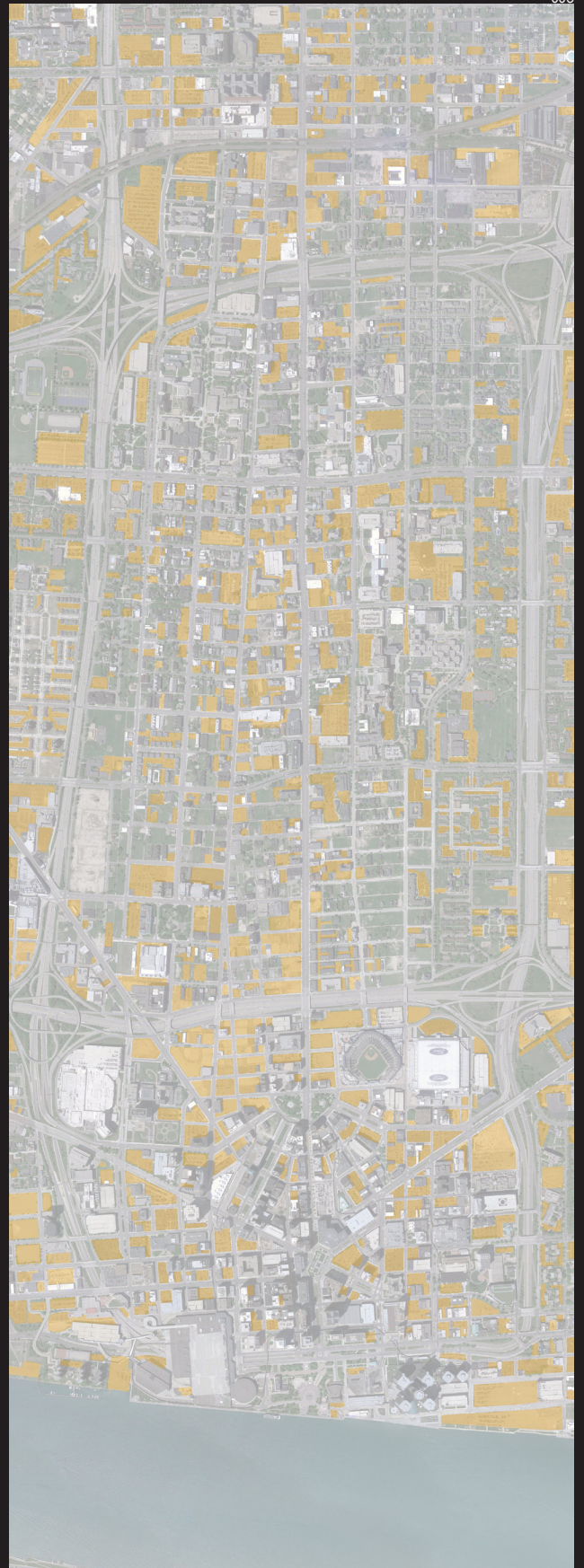
Map of Woodward Corridor Assets [Image 08]



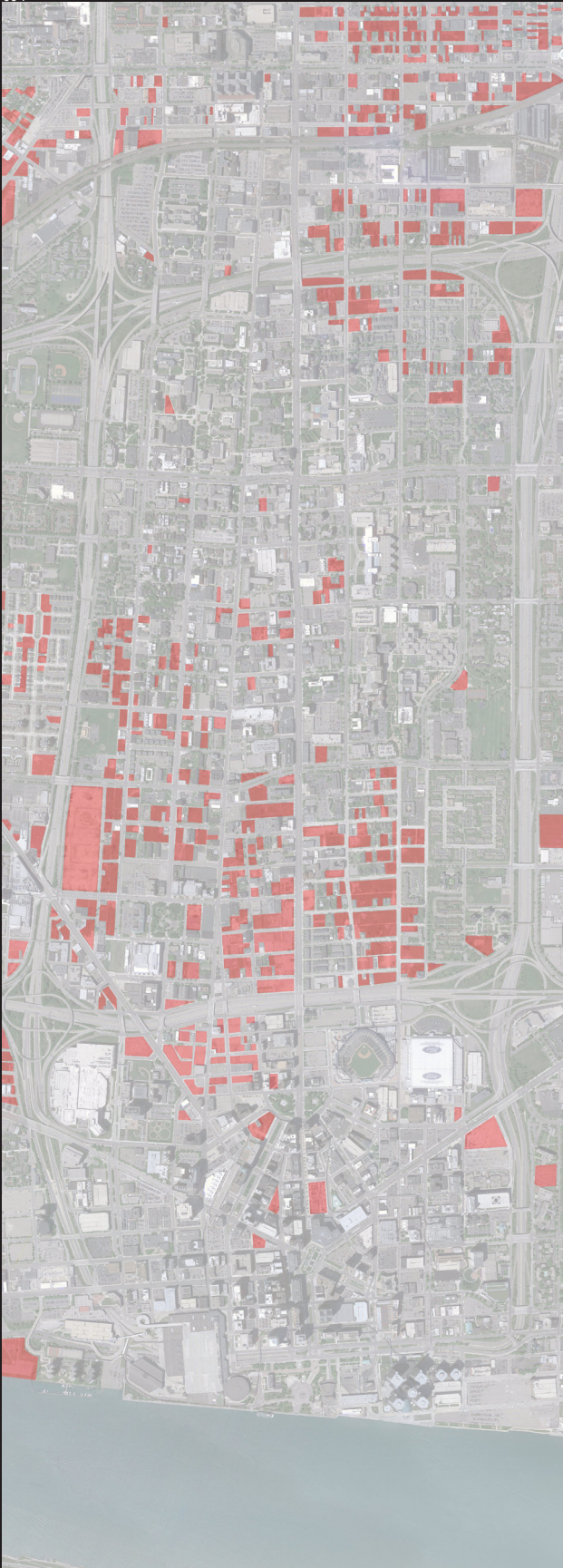
Map of Woodward Corridor Historic Districts [Image 09]



Map of Woodward Corridor Greenspaces [Image 10]



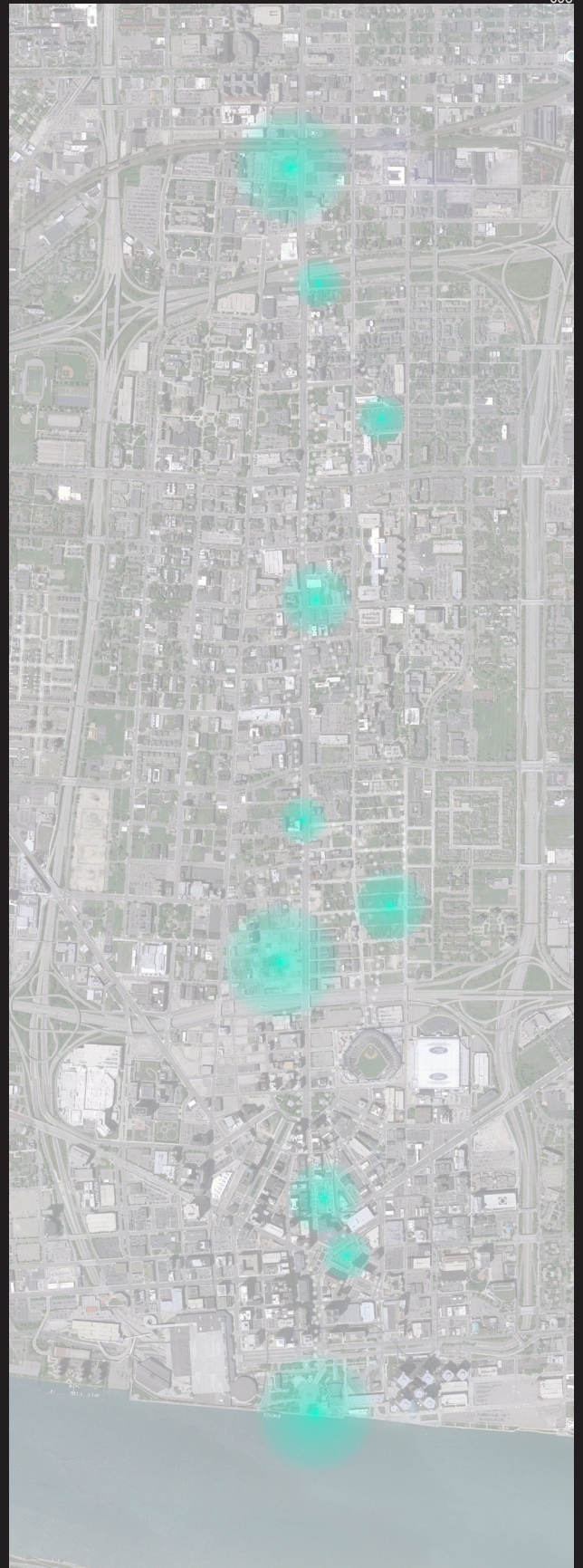
Map of Woodward Corridor Parking Lots [Image 11]



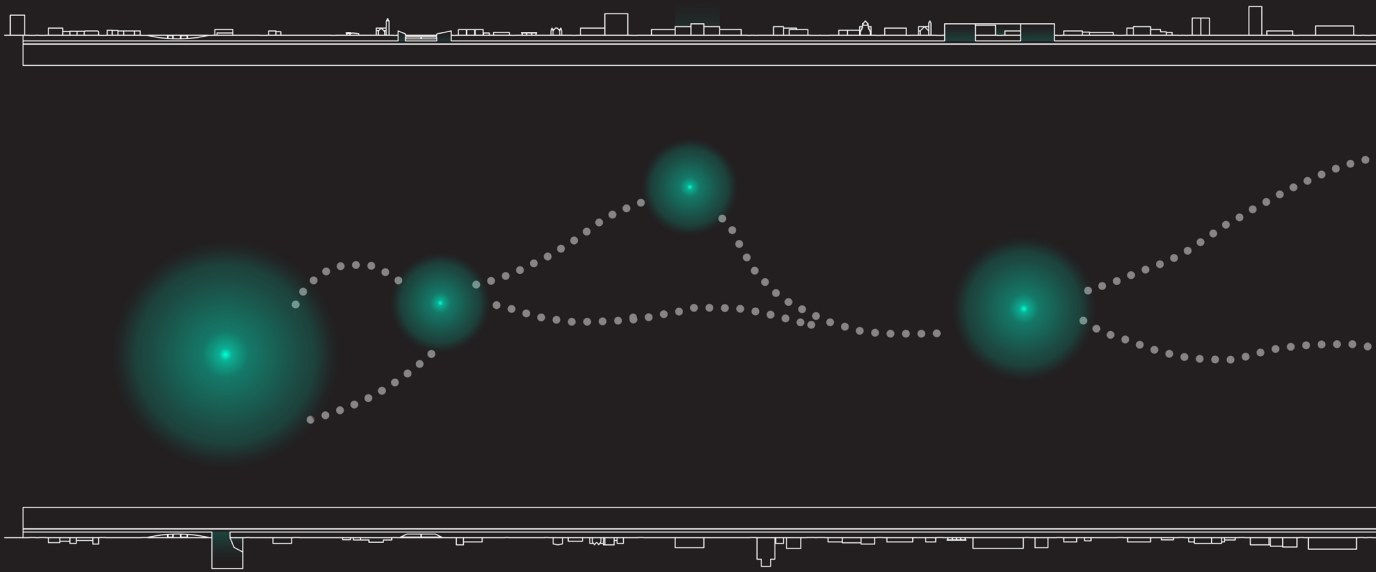
Map of Woodward Corridor Vacancy [Image 12]

This series of mapping exercises allowed the visualization of the severity of the Woodward Corridors vacancy and voided streetscape issues. However, it was also meant to highlight the significant number of assets that were available to one that was seeking to develop the area. For instance, there is a high density of vacancy in the area north of the central business district and south of the Midtown area. This vacancy creates a dead zone along Woodward, but there are numerous assets, historic districts and green spaces that surround the area creating the potential for developments to begin to bleed into the area. This is especially likely if the two thriving centers of downtown and midtown were connected via a comprehensive transit network.

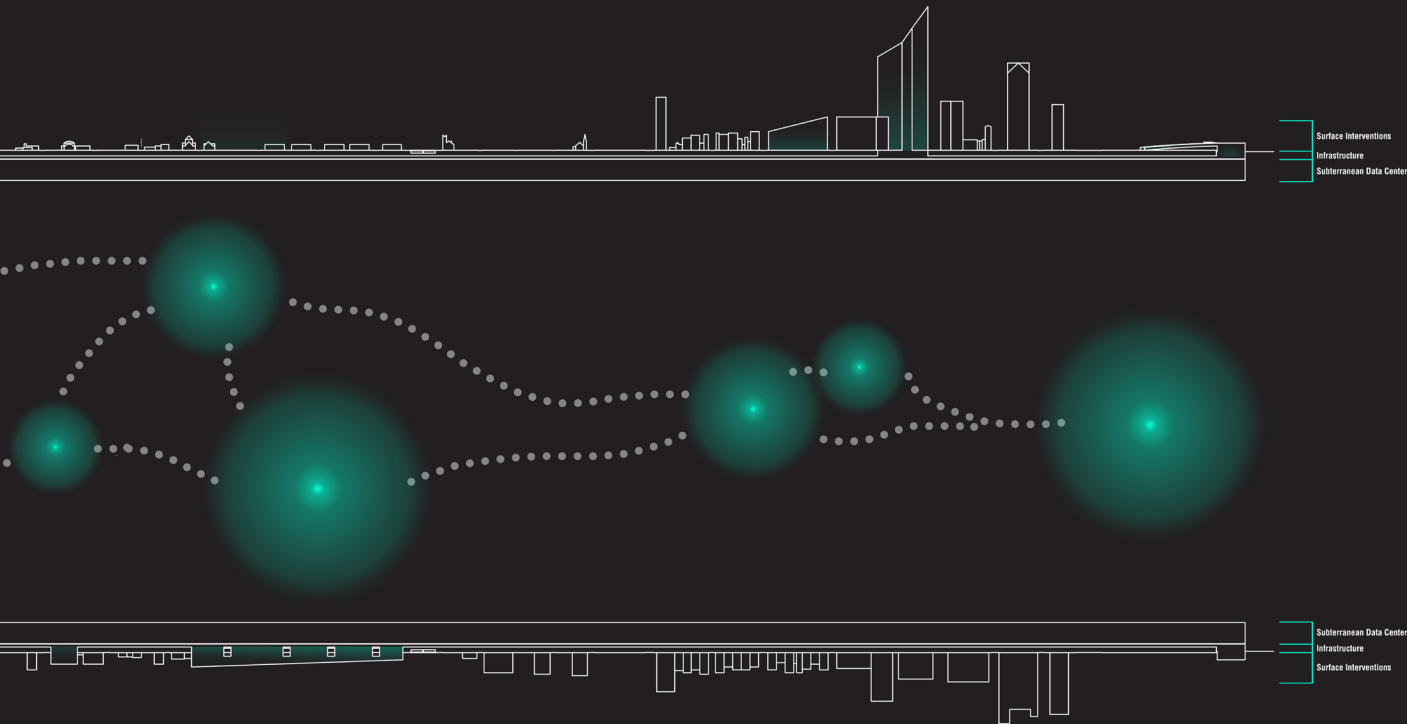
The resulting nodes were derived by finding sites that were ideally located for redeveloping formerly key locations along the Woodward corridor that now sat as vacant sites. The nodes were also all located in areas that were either in severe need of new programmatic functions to spur activity or in areas that were already begin to see growth and development.



Map of Woodward Corridor Potential Data Nodes [Image 13]



The nodal network that was generated as a result of studying the voids, vacancy, assets, etc. along the Woodward corridor was meant to begin to visualize and create vignettes that could ultimately help determine what potential ancillary programmatic functions would be best suited for development alongside data center components. The various ancillary functions that were established were meant to create situations in which the data center could become a benefit not only for the urban context in which it was created, but also as a means of creating socially sustainable and visually engaging spaces that would inform the individual of the ramifications of their digital world. Some of the initial concepts that were derived were created as a series of icons meant as a guiding set of programmatic functions that could be coupled with specific sites based upon their needs. The listing of these various functions is located on the opposite page, but broke down into six main groups of functionality; Research and Development, Production, Housing, Relief, Community, and Commercial. It was with these that the various conceptual vignettes that will follow were born from.



Woodward Streetscape Section Showing Data Nodes [Image 14]

Ancillary Programs

R&D



Technology Research



Biotech/Med Research



Alternative Energy Research



Office Space

Production



Light/Adv Manufacturing



Alternative Energy Production

Relief



Warming Center/Shelter

Housing



Live/Work Spaces



Housing

Commercial



Commercial/Retail Spaces



Hotel

Community



Urban Public Spaces



Community Functions

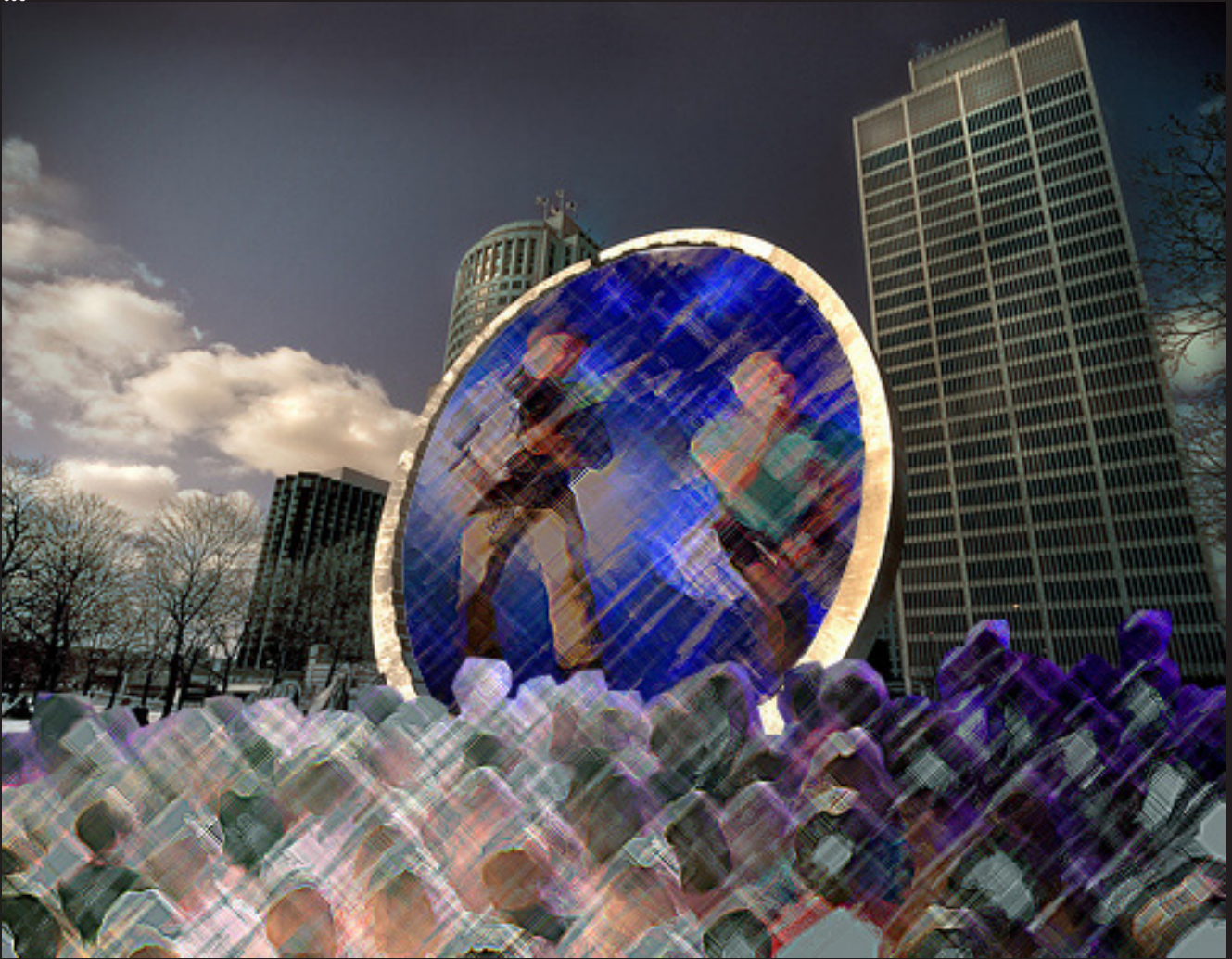


Civic Functions



Transit

Potential Ancillary Programmatic Function Icons [Image 15]



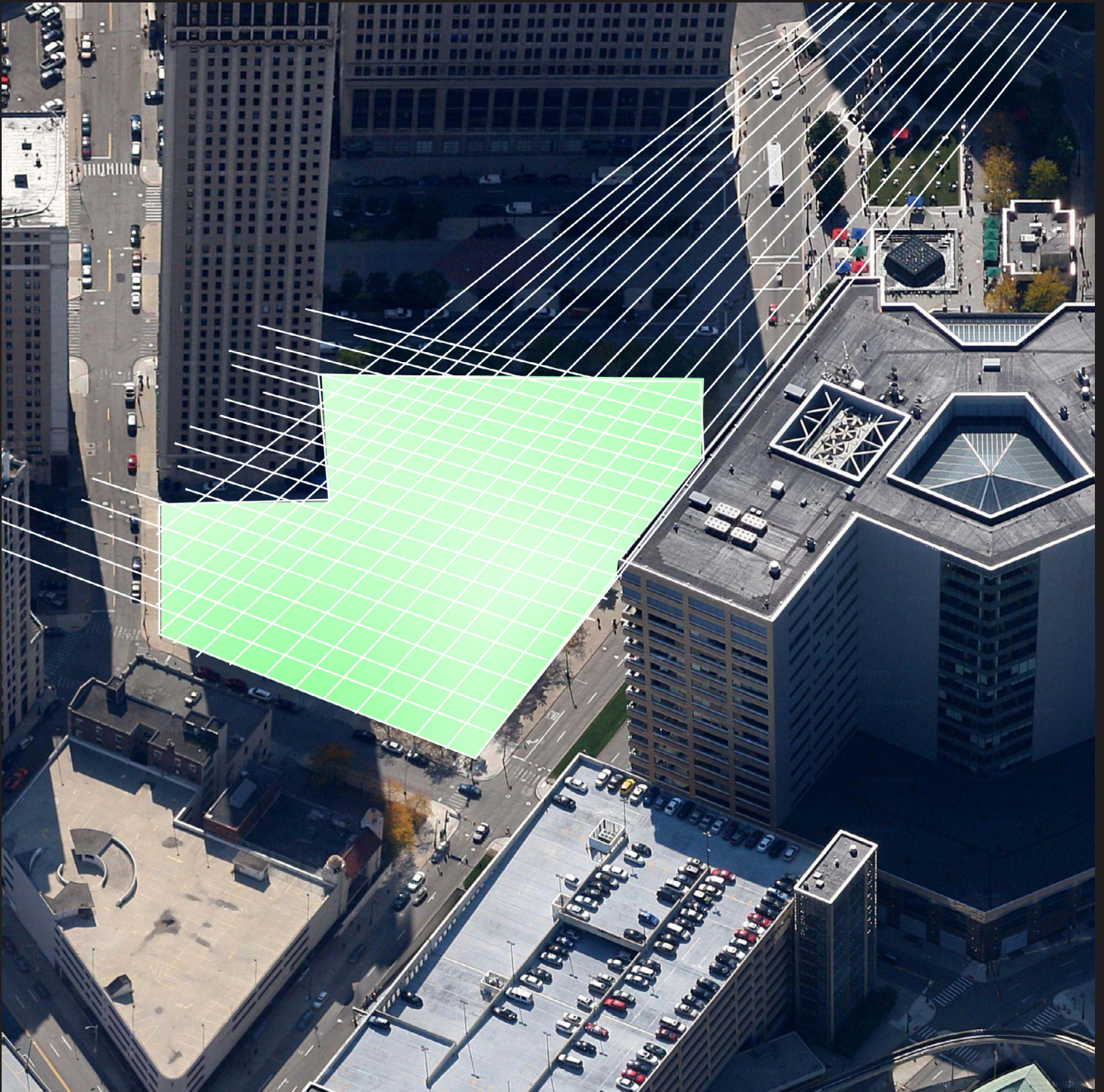
Data Center as Digital Venue [Image 16]

Data Center as Digital Venue

As data hungry websites like YouTube and Qello begin to stream live events directly to our internet connected devices we allow users to experience an increasing amount of live entertainment from within the comfort of their homes. This disengages the user from the goal of the event, but if we allow for the data center to become the point of projection for the data which it houses we can reengage the user with others by creating digital event spaces that seek to remotely emulate the event itself.

Data Center as Urban Square

With the advent of social media has come the degradation of social interaction. A growing amount of our social activities occur digitally where historically they took place in town squares. This poses a question about what it will mean in a digital age to engage with urban squares. The square can become a venue where physical interaction and chance meetings collide with social media, i.e. FourSquare, to encourage the interaction of the physical and digital.





Data Center as Retail Space [Image 18]

Data Center as Retail Space

Online shopping has become one of the central functions of our digital world. It has also, in the form of Craigslist, reintroduced the historical concept of bartering within a digital forum. What happens if storefronts begin to connect with web outlets like Craigslist to create ad hoc, temporary, retail spaces?

Data Center as Neighborhood

As many urban centers face steep declines in population and rapid increases in vacancy there are a growing number of voids occurring within traditionally built neighborhoods. While data centers create vast quantities of waste heat, could they become the infrastructural network for entire neighborhoods? What form does a home take in a digital era? And ultimately how does this begin to shape the way in which we live?



Data Center as Neighborhood [Image 19]



Data Center as Graveyard [Image 20]

Data Center as Graveyard

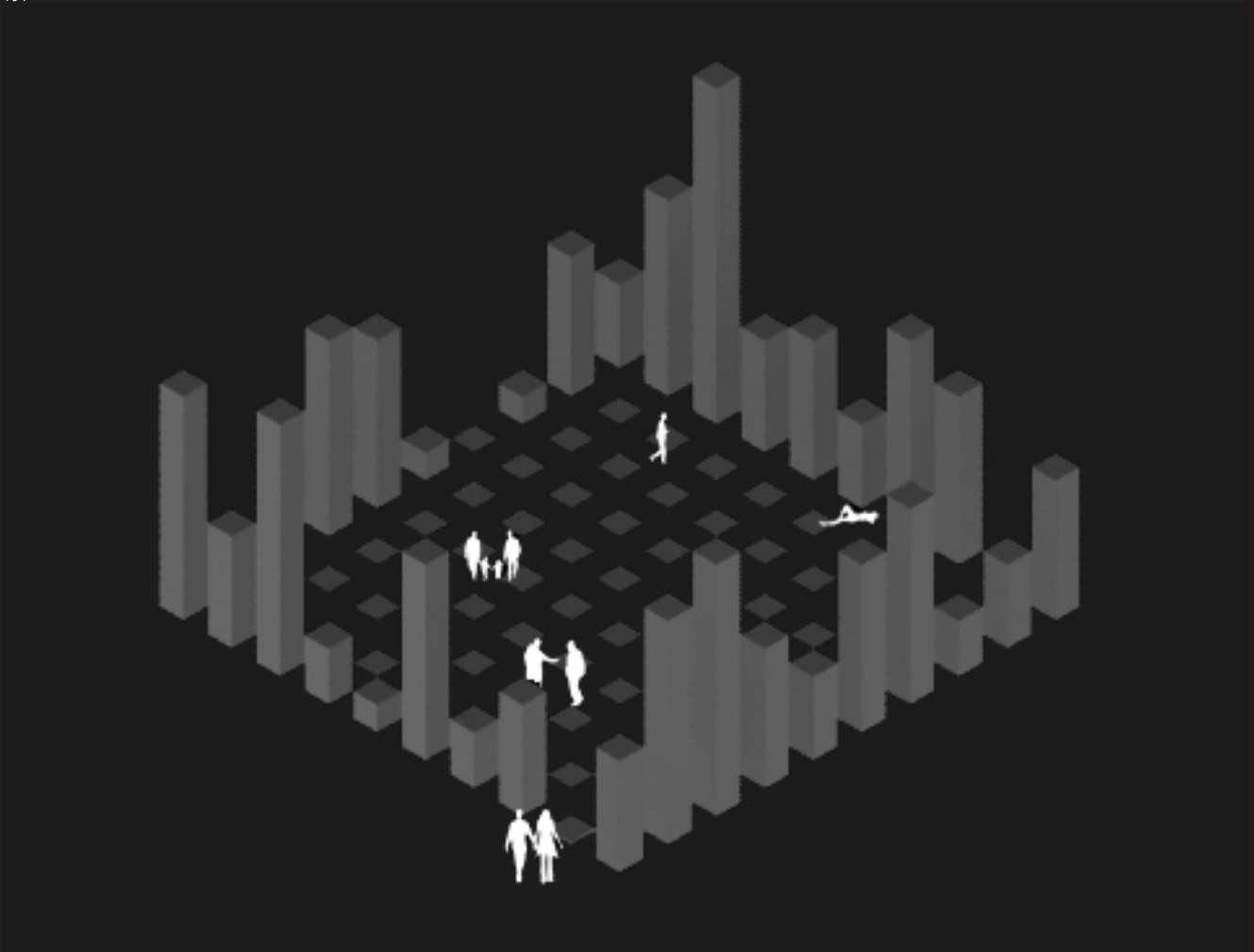
While we increasingly produce and consume large quantities of digital information we rarely elect to dispose of it. Much of what is being created is unique to an individual and will remain on a nondescript server or servers long after the person's death. Can these digital remains be coupled with the physical to create a resting place for the individual and their files?

Data Center as Research Facility

The information that we create and store is increasing at an exponential rate and the facilities that store this information require an increasing amount of computing power to operate efficiently. What if this latent computing power could be harnessed to create research facilities centered around city scale supercomputers. What advances in science, medicine, etc. occur as a result of a greater capacity to compute information? And what if this computing power was made available to the general public? Could this passive computing infrastructure become a catalyst for innovation from the masses and could it be a means for social growth?



Data Center as Research Facility [Image 21]



Data Center as Sculpture [Image 22]

Data Center as Sculpture

The ability for technology to control the physical environment is something that has not been explored in a comprehensive way. What occurs when a user can remotely move and adjust the individual parts that create a space? Can users from a distance create more flexible and intriguing spaces through the act of digitally sculpting?

Data Center as Urban Fill

While the conglomeration of data grows at an increasing rate, where can the data center occur on the surface of the earth to ensure the visibility of the impact of our digital world? Can space that has been traditionally perceived as unusable be repurposed for a function that innately requires little human interaction? Can the periphery of our cities and the voids within them created by infrastructural networks become the host from which our insatiable thirst for data grow from? And can these facilities help to become part of the infrastructure that it attaches to in a positive manner?



Data Center as Urban Fill [Image 23]

Design

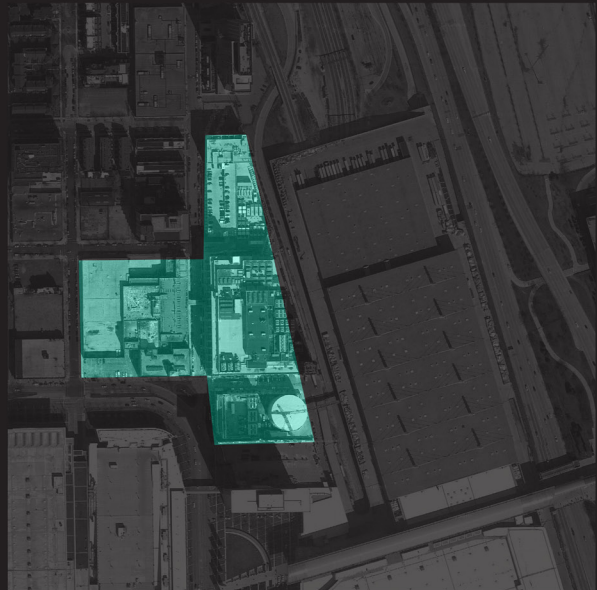
[A Hub for Data and Human Transit and Living]

Scale Comparison



Campus Martius Site

Approximately - 1.75 Acres
Height - 880 Feet



350 E. Cermak Site

Approximately - 10 Acres
Approximate Height - 80 Feet

The site that was ultimately selected is located to the west of Campus Martius on the site where the Cadillac Tower currently sits. This large site sits at 1.75 acres and is a prominent location along the Woodward corridor. Though the site would be considered large by normal standards if we compare it to the site on which 350 E. Cermak is located we find a site that is 10 acres or almost six times as large. The scale for downtown Detroit will be increased through the designs verticality in an effort to ensure creating an iconic and visible building that can begin to educate the public about what the digital world is and what its ramifications are. The selection of this site was driven by its central location within downtown, its adjacency to a major public space and it is at the location where all five of the proposed radial transit lines meet. Following the site selection a series of mapping studies was completed to understand both the potential digital assets of the surrounding area and also how people and information were moving and would move through the site.



Key Local Users

1/256" = 1'

This map highlights investigates where the potential major users of a data center facility are located within the downtown Detroit area. A vast number of these are major local businesses or governmental institutions, but there are a handful of other users. The map shows that there is certainly a market for data center facilities in the area and the location would be in the midst of some of the most prominent businesses in the city.

Site Analysis

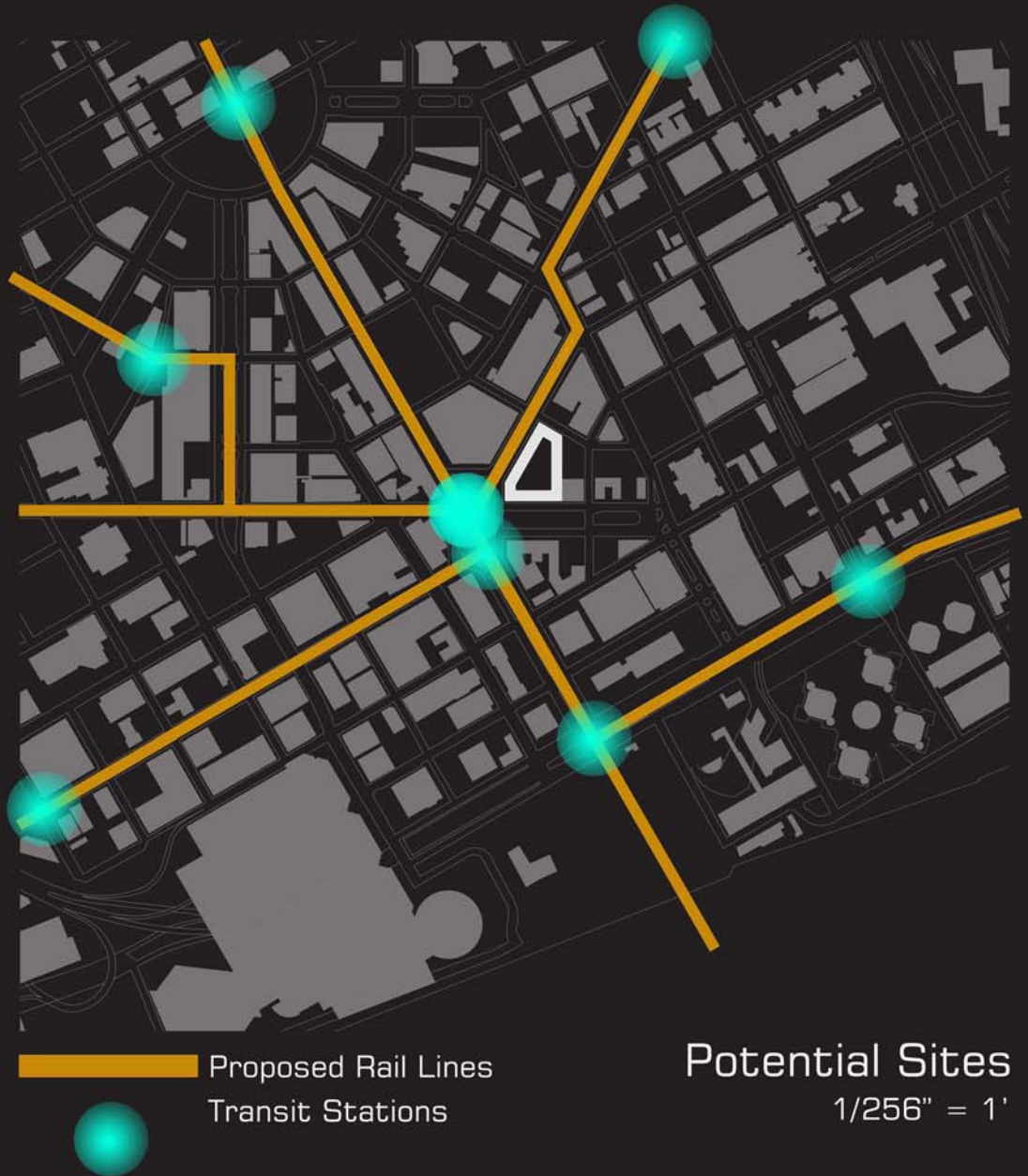
Digital Assets



This map displays the locations of free wireless hotspots around the downtown area. Though most of the buildings that are shown likely have an internet connection the idea of free and open wireless is key to creating a physical presence within the digital world which is apparent and engaging. The more users that are able to digitally connect to the building and engage it the more likely they will be to interact with it physically. As the map shows, most of these hotspots are located along Woodward Ave. with Campus Martius directly adjacent to the site having a park wide free wireless signal.

Site Analysis

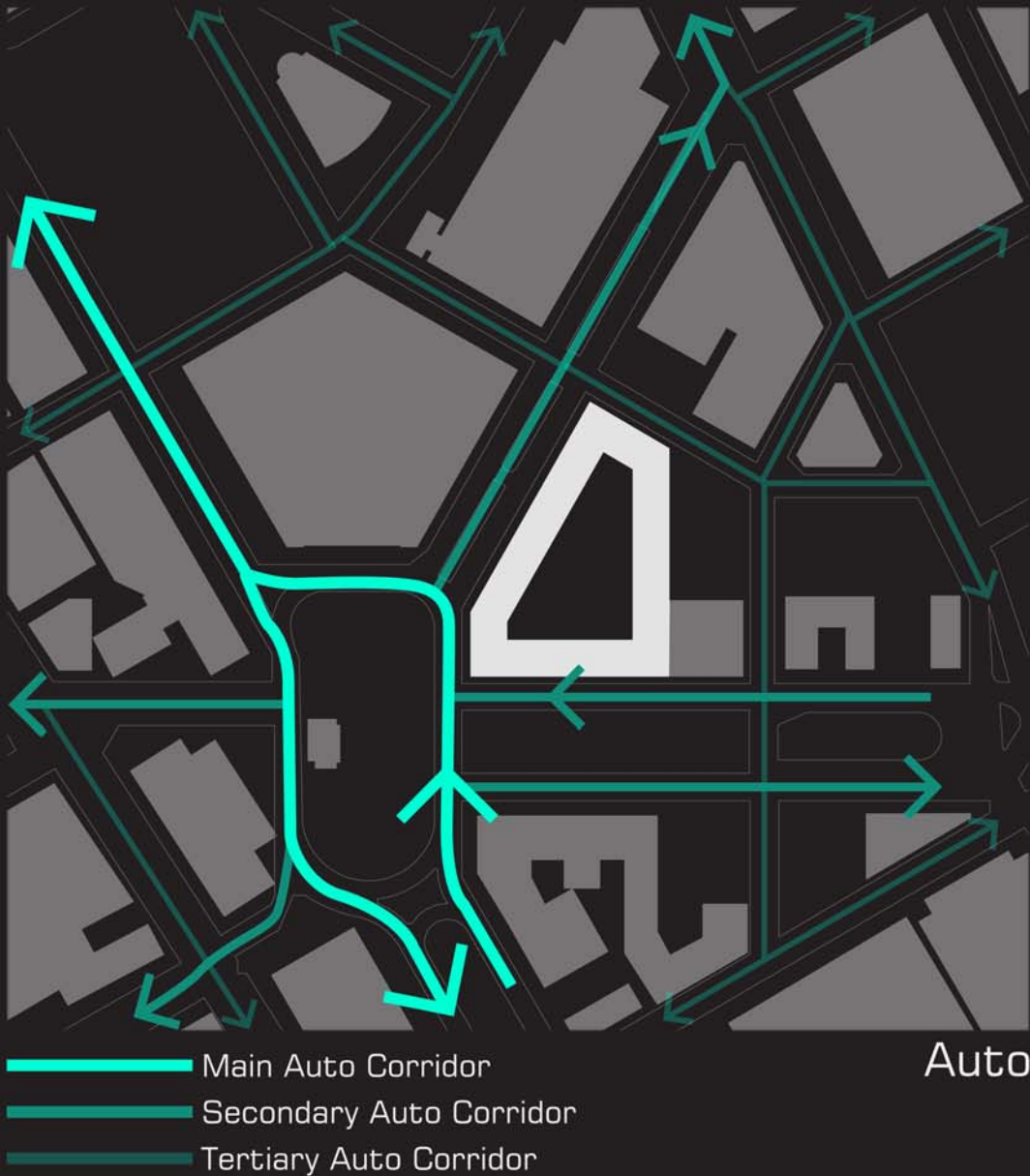
Digital Assets



This map of potential sites shows the locations of other data transit stations throughout the downtown area. As is shown all of the radial lines terminate at Campus Martius or pass through with a station located there. This site stands to connect all corners of the city and across the border to Canada through one point, making the Cadillac site an incredibly important location for engaging the public.

Site Analysis

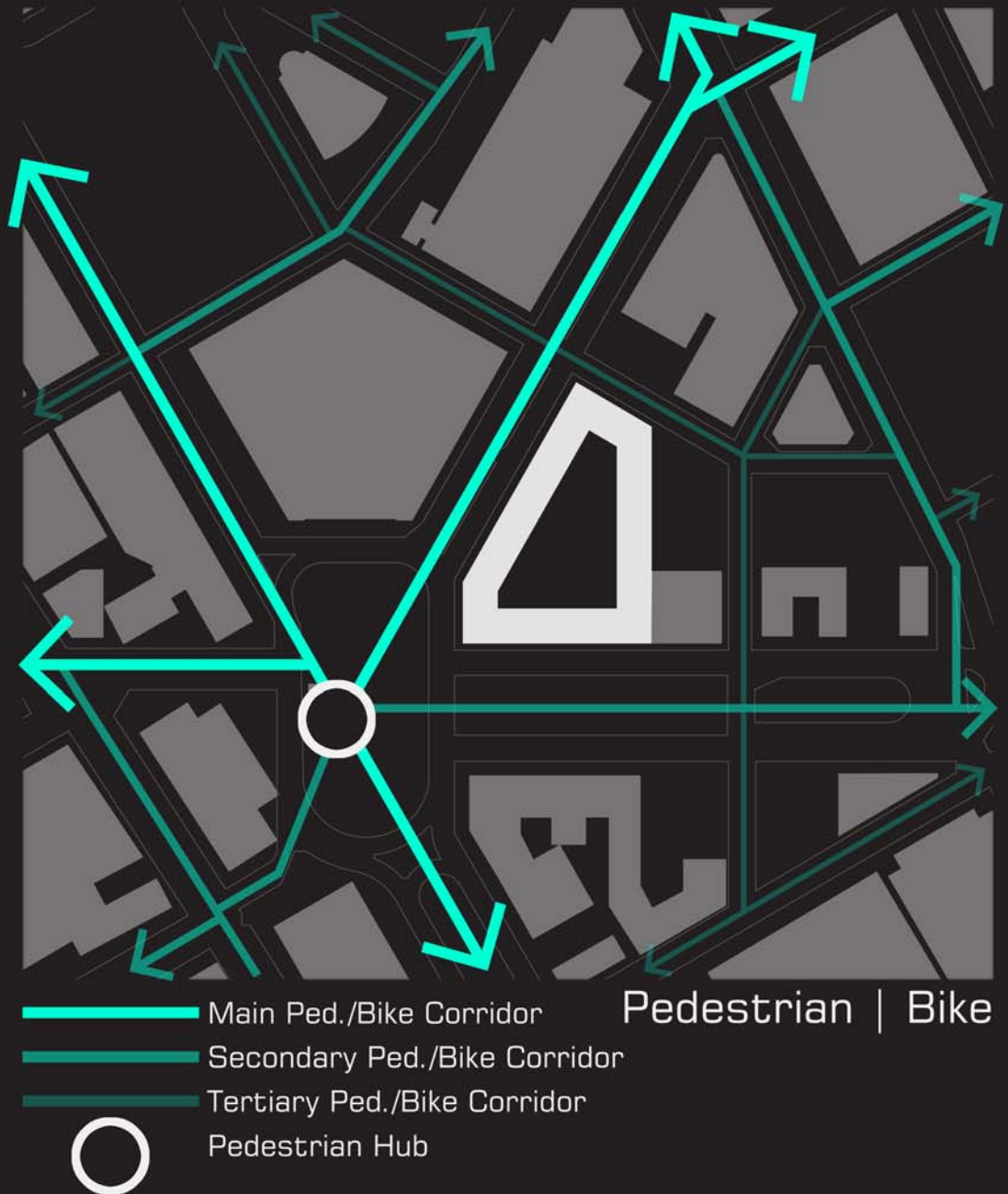
Digital Assets



This map shows the circulation of vehicular traffic through the area surrounding the site. The main corridor is Woodward Avenue which is not surprising, and also not surprising is the fact that all secondary auto corridors radiate off of the hub of Campus Martius. Despite its pedestrian oriented nature, Campus Martius sits strategically at the center of downtown and will continue to be a hub for surface traffic because of the radial nature of downtown Detroit's plan.

Site Analysis

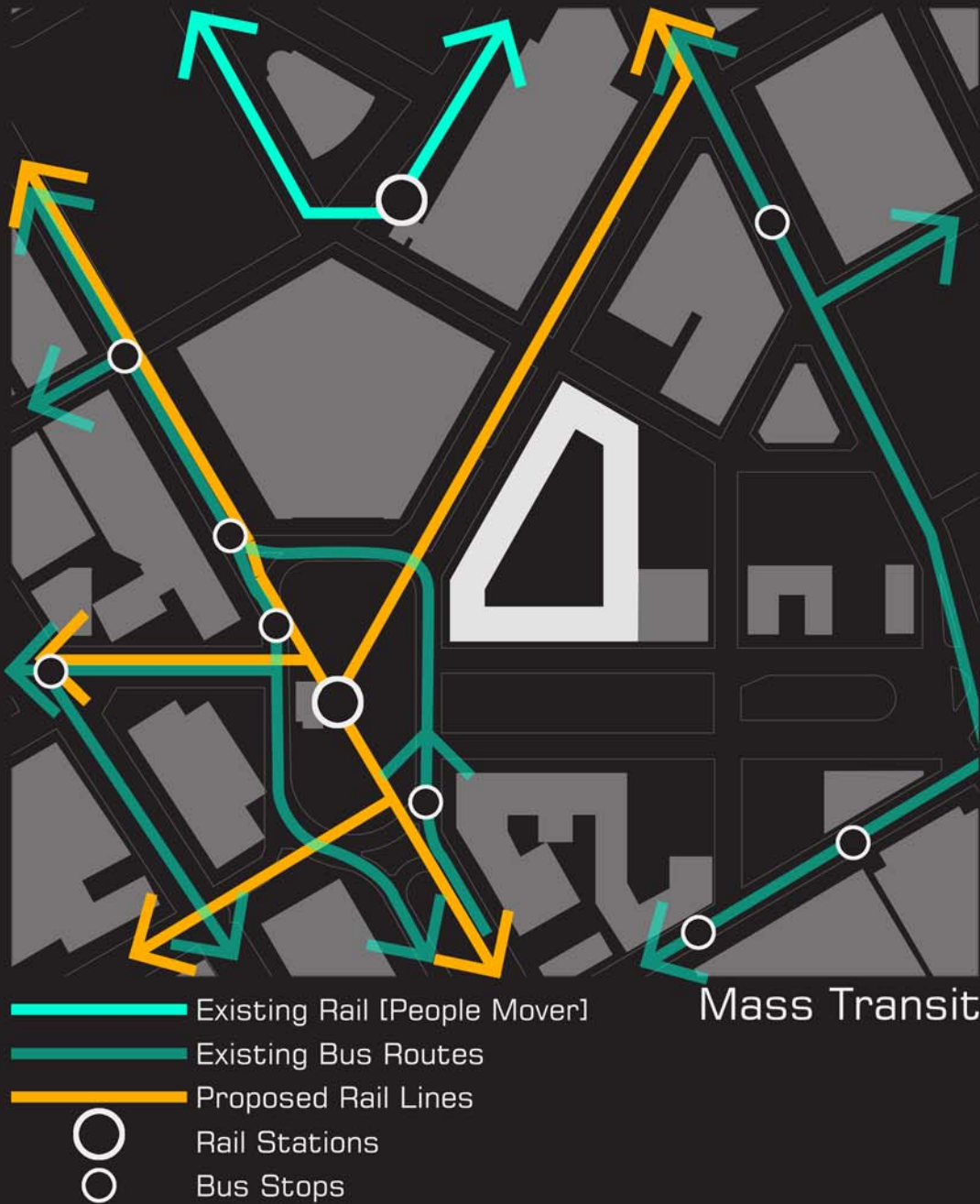
Circulation



This map shows the main corridors for pedestrian and bike traffic. When comparing it with the previous map showing vehicular traffic through the site it is clear that both pedestrians and vehicles follow the same roads as major and secondary axes with only a few exceptions. As shown on the map, Campus Martius Park is the major pedestrian hub in the area, however the main corridors for pedestrian and bike traffic that radiate off of the site move in the directions of other pedestrian hubs. These include Hart Plaza, Grand Circus Park, Harmonie Park, Greektown and Capitol Park.

Site Analysis

Circulation



This map shows how mass transit is integrated into the areas circulation as well as how the proposed rail lines will move through the area as well. The proposed rail as has been stated previously would run along the radial axes spurring off of Campus Martius Park. The existing bus lines run along several of the secondary and tertiary streets as well as Woodward Ave. allowing the bus system to serve as an even more localized means of transit. The existing rail (The People Mover) runs a loop around downtown and has a nearby station at Cadillac Center.

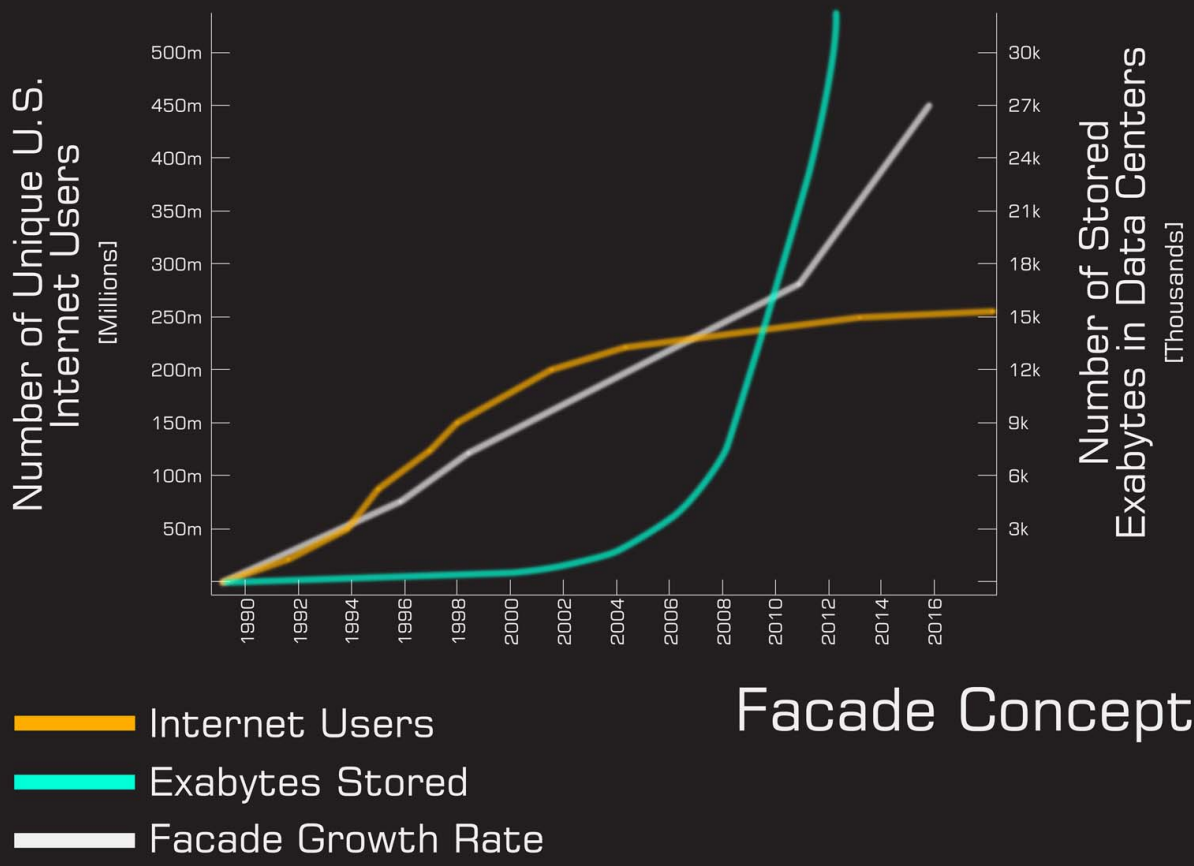
Site Analysis

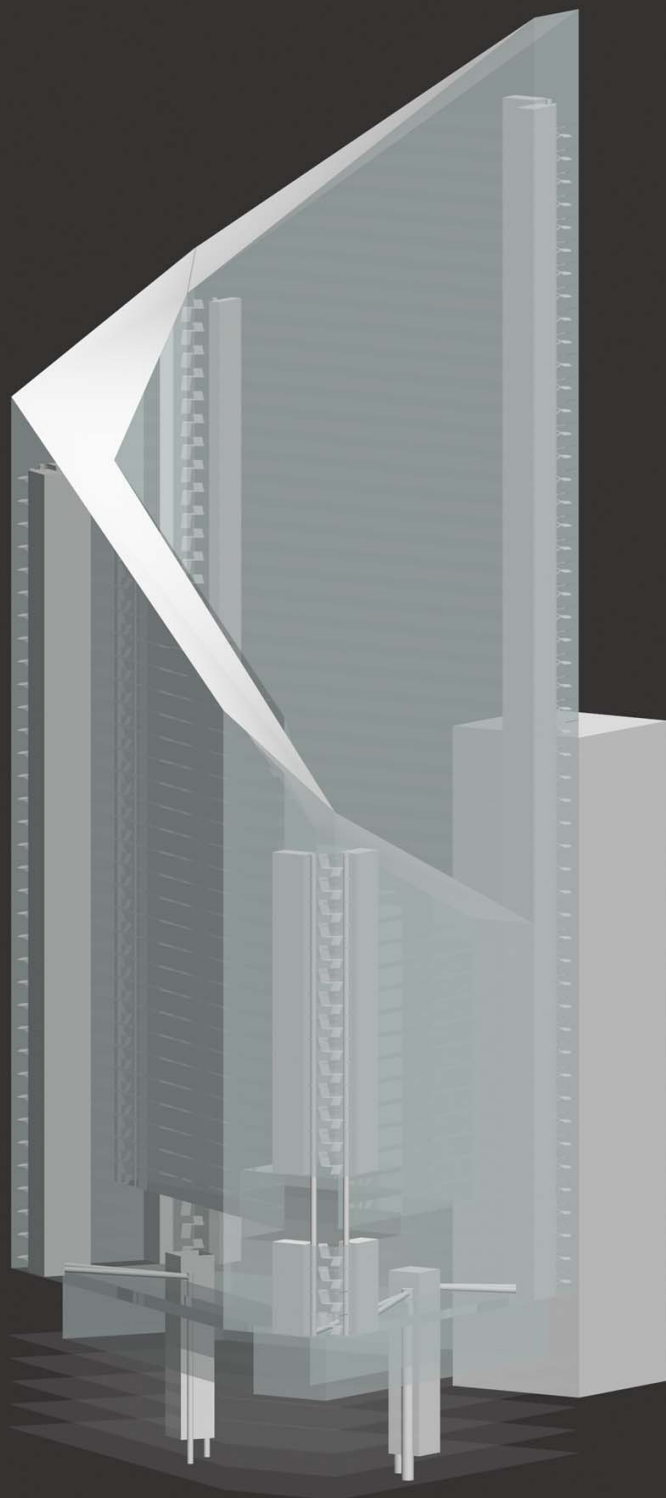
Circulation

The diagram below compares the growth rates of the number of U.S. internet users and the growth rate of information that is stored globally. The third line shows a rough median line that was drawn between the two that was the determining factor in the growth rate of the facades of the building. The building was meant to be a high rise structure that became a dominant and iconic presence in the city of Detroit. The growth rates show the inconsistency between the number of users and the amount of information that is being created and stored. A slowing growth in the numbers of users is still creating exponentially greater amounts of information every year.

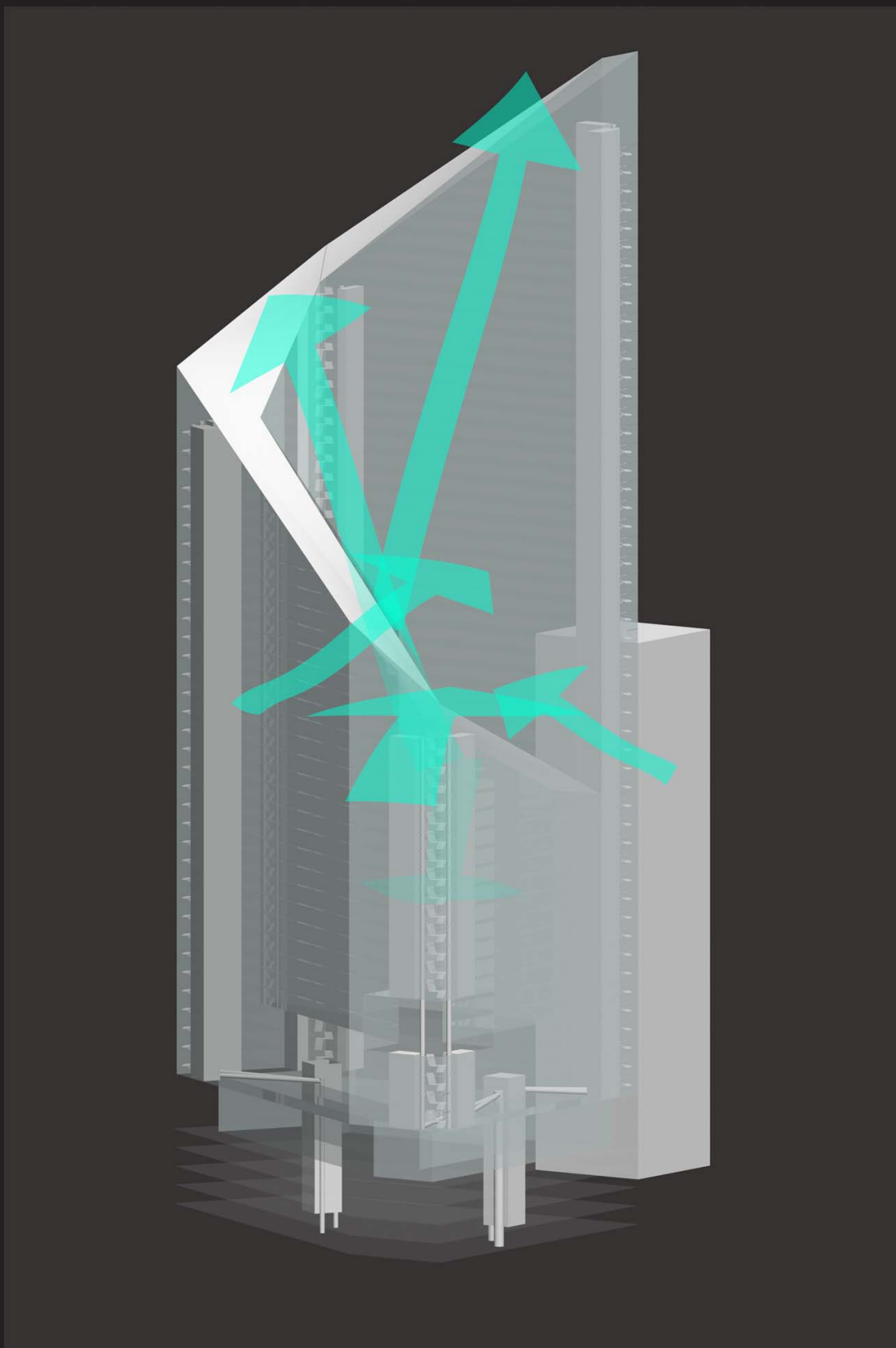
This concept is best shown through the images of the buildings massing on the following page. Here it can be compared to its neighbor, the Cadillac Tower, which stands at 437 feet tall and is already a major influence on the Detroit skyline. The massing model shows that the proposed structure would be twice as tall, making it the tallest building in the city and it would have a footprint more than 4 times as large as the building. For that reason the buildings core was hollowed out and removed after the 8th floor to allow for a double loaded corridor ring. This makes up the remainder of the height of the building which stands at 880 feet tall containing 55 stories.

The second study on the next page shows a diagram of wind interactions with the tower. The wind in downtown Detroit which predominantly comes out of the southwest hits the lowest point of the ring and moves down towards a lifted central courtyard and up the height of the tower. This would potentially create opportunities to derive some of the power required for the building from the wind.

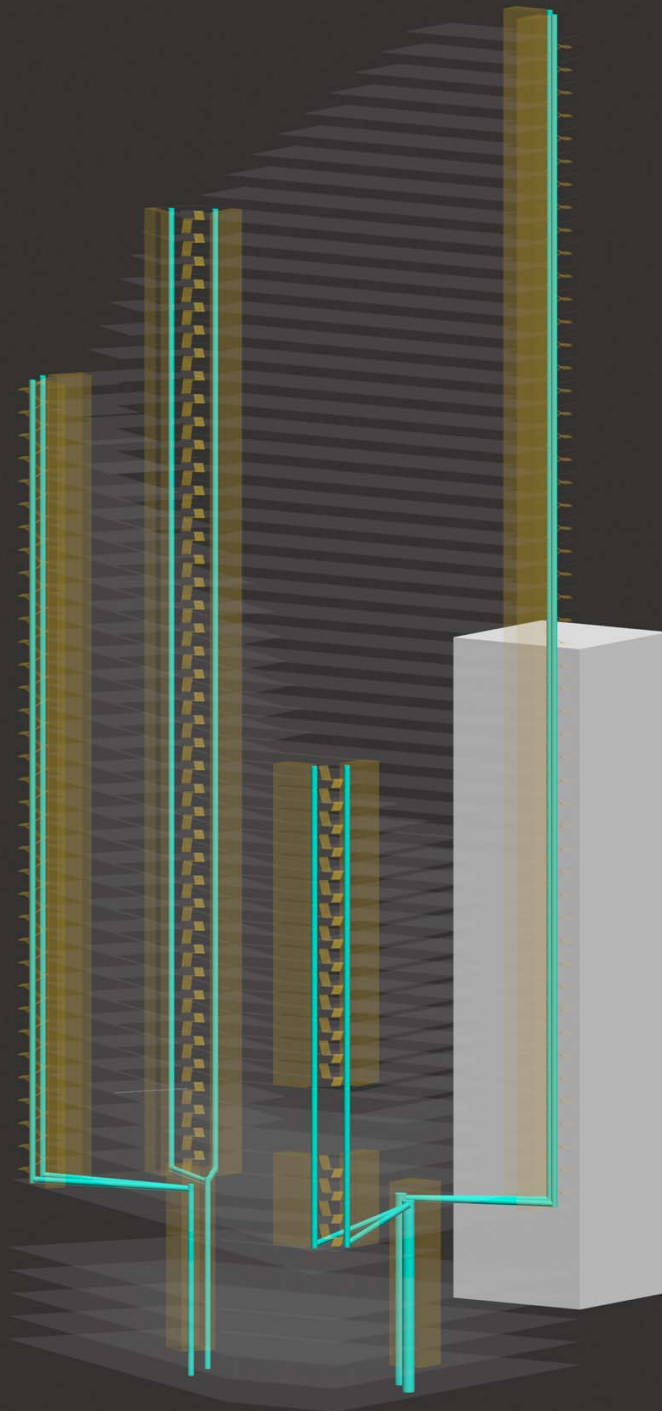




Massing



Wind Study



— People
— Data

Major Circulation

This diagram shows the major vertical circulation of the tower as it relates to both people and data. The goal of the project was to move people and information together. On the macro scale this was accomplished by creating a merger between mass transit and fiberoptic lines which essentially act as the mass transit lines for information. If both were to work together and move in tandem we could begin to visualize the digital world and its scale more clearly.

But what about the building itself? The idea of moving information and people together was carried through the entire building by running the vertical fiberoptic risers with the vertical circulation paths of the elevator banks and egress stairs. The cables, left exposed would move up the tower in the same section of the cores as the stairs. The lines would then be visible to users of the building that were navigating through the tower either up or down. This would allow them to gain a sense of the magnitude of infrastructure necessary to operate a data center of this scale. It would also allow them to perceive the physical movement of digital information in the same way that they perceive themselves moving. These line would also be visibly exposed and expressed through the materiality of the towers exteriors allowing others that are not within the building to see the entire length of the risers as they climb up the tower.

The programming of the building became a layer cake of some of the ancillary functions that were laid out previously. The data center component was then integrated on each level in a manner that allowed users to be cognisant of the server rooms that were storing and broadcasting the digital information contained in the building. This is illustrated on the following pages. The server rooms were treated as a core on the lower levels and as the inner ring of the tower as it rose vertically. Each programmatic function was correlated with the functionality of the server rooms that were located on the same floors.

Sub-Floors | Transit Center [Source]

Starting at the sub-floors the transit center was developed and was seen as the source of information and users for the entire facility. It is on these levels that the data centers core begins and where the P.O.P (point of presence) rooms are housed.

Ground Floor | Lobby [Face]

The ground floor serves as the main lobby for the facility and is recessed back from the streetfront slightly to draw users in visually. It houses the first completely visible section of the data core and is meant to be the first direct impression that one receives as they enter the building from the street level.

Floors 2-3 | Data Center Core [Access]

These floors are inaccessible from anywhere but inside the data center component itself. The core rises for three floors with no visual interruptions to emphasize the scale of the facility. This is because the lobby ceiling heights are increased dramatically and allow for the vertical nature of the structure to be expressed when one first enters. Access points to certain data sets would be located throughout the lobby level.

Floors 4-7 | Commercial [Working]

The floors containing commercial spaces are coupled with server rooms that house information that moves and works regularly, rather than being stored, dormant, for long periods of time. On all floors the user would be able to visualize how the information being stored is moving around the globe through interactive walls showing maps of the other data centers that these server rooms are connecting to.

Floor 8 | Courtyard [Warmth]

Acting as the lobby for the remainder of the tower this floor opens up to the raised central courtyard that was created as the tower was hollowed. The courtyard serves as an oasis year-round by utilizing some of the waste heat that the tower creates to ensure that the outdoor spaces are maintained at a warm temperature. This level also allows a direct visual connection with Campus Martius across the street.

Floors 9-18 | Office [Working]

Much like the commercial spaces below the data sets are active and constantly operating, but in this case the layout changes as the office becomes the first set of rings that make up the tower. The inner portion being the data component and the outer portion the office spaces.

Floors 19-33 | Residential [Stored]

On the residential floors the data sets are comprised of information that is necessary to store, but often sits idle for long periods. On these floors the mapping system is reversed showing how a residential unit is interacting with the global data network on the walls facing the corridor.

Floors 34-49 | Hotel [Transient]

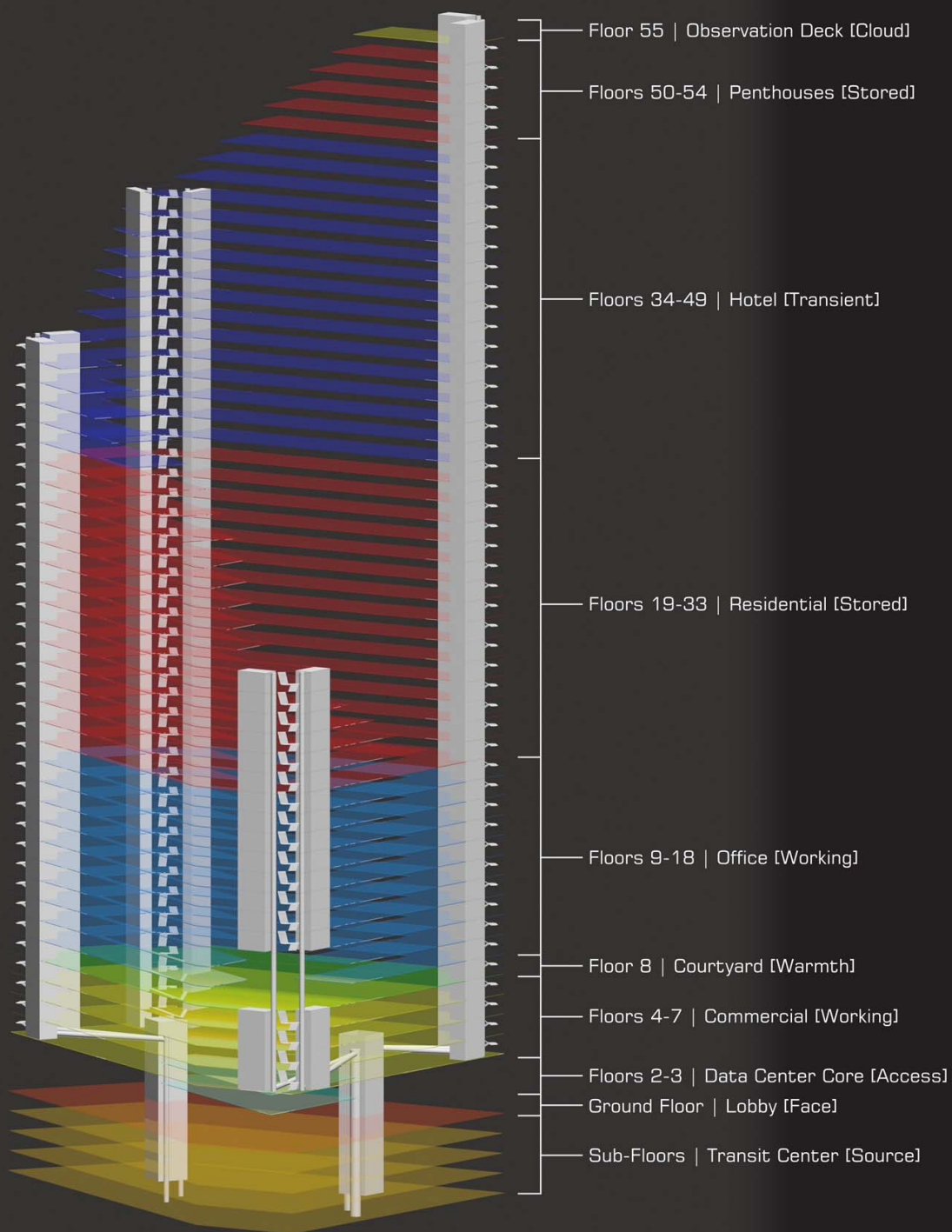
The hotel component becomes a mixture of data sets and falls somewhere between the working and stored sections of the tower. On these levels users would be able to visualize how each room was interacting with the global data network, allowing visitors to what would be the first data driven city to fully understand the impact of their digital world for the first time.

Floors 50-54 | Penthouses [Stored]

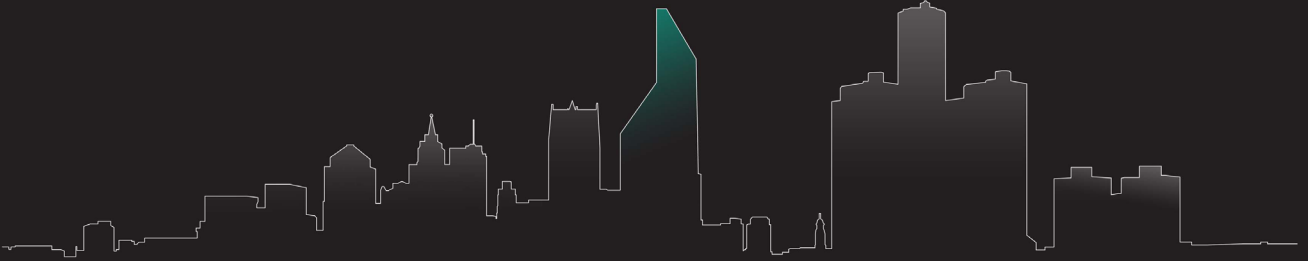
This section of the building is made up of individual, large, residential units that are pair with a single server room. This combination allows for the inhabitant to be constantly aware of their digital lives at all times of day and night. The penthouses create an inescapable sense of what the physical impacts of our digital world are.

Floor 55 | Observation Deck [Cloud]

This floor serves as the location of the observation deck for the tower, offering panoramic views of the city of Detroit. This would allow the individual to have the sense that they were physically in the clouds (though not literally) and allow them to visually connect with the remainder of the digital network as it weaved through the city. The visual impact, and understanding of the vast Detroit network might give one pause and force them to contemplate what our global network means.



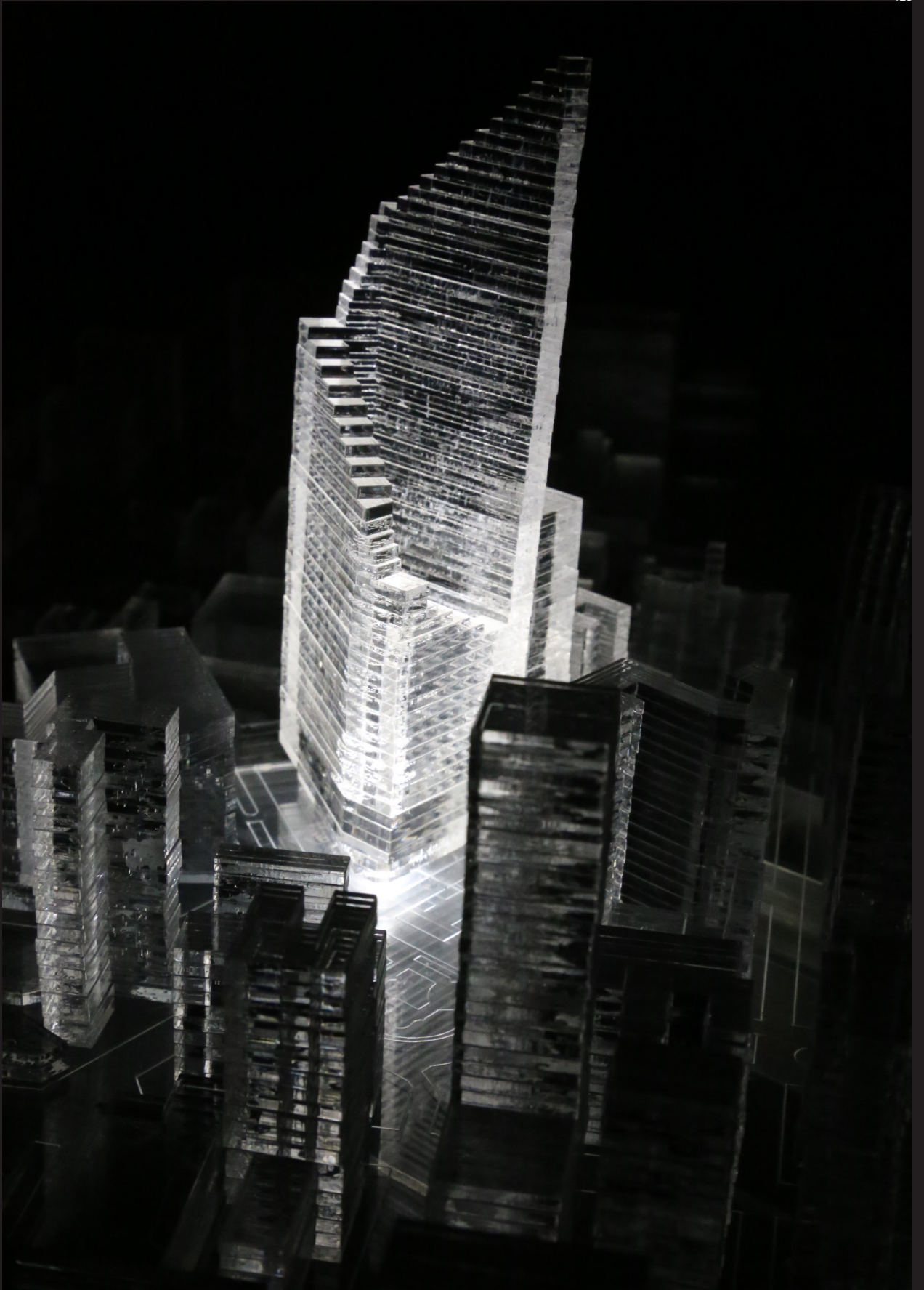
Programming



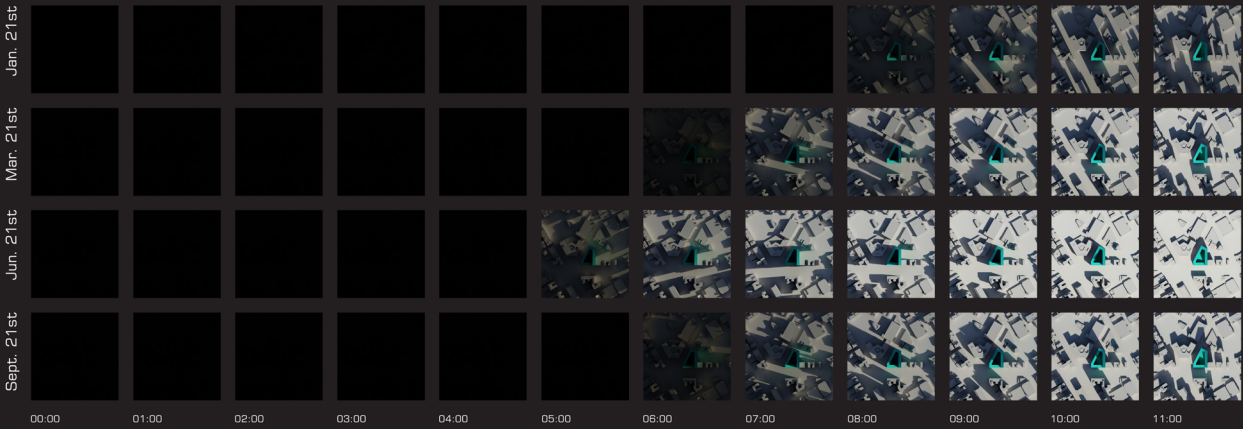
Effect on Detroit Skyline

The image above shows how the building would begin to effect the skyline of Detroit's silhouette. This, along with the images of a physical model of the structure show how the building would stand as a new icon for the city as it takes over as the tallest building in the city. The form is significantly different from that of the surrounding buildings which are largely historical or more traditional in nature. With a changing Detroit, a new local transit network and the city's section of the global information network being developed, the iconic nature of the tower and dominance in the skyline is justified.



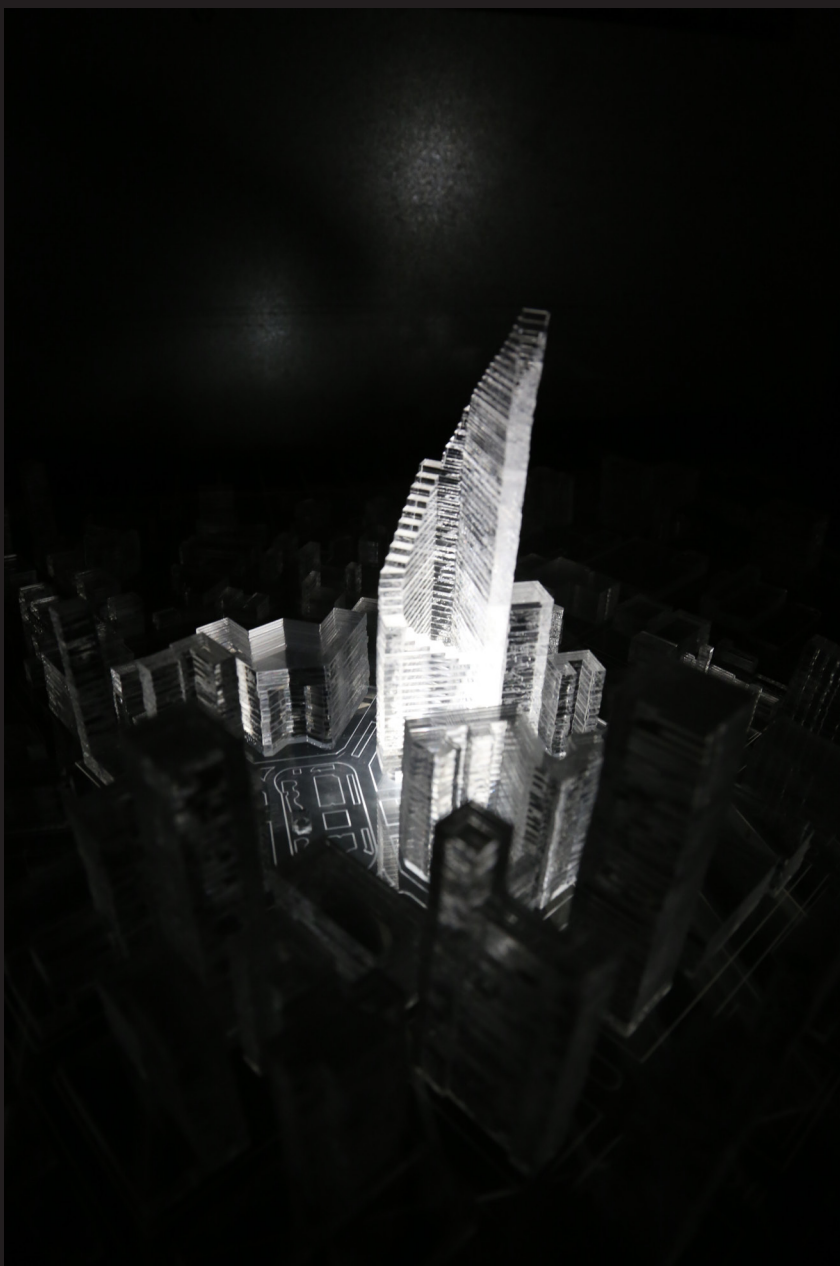


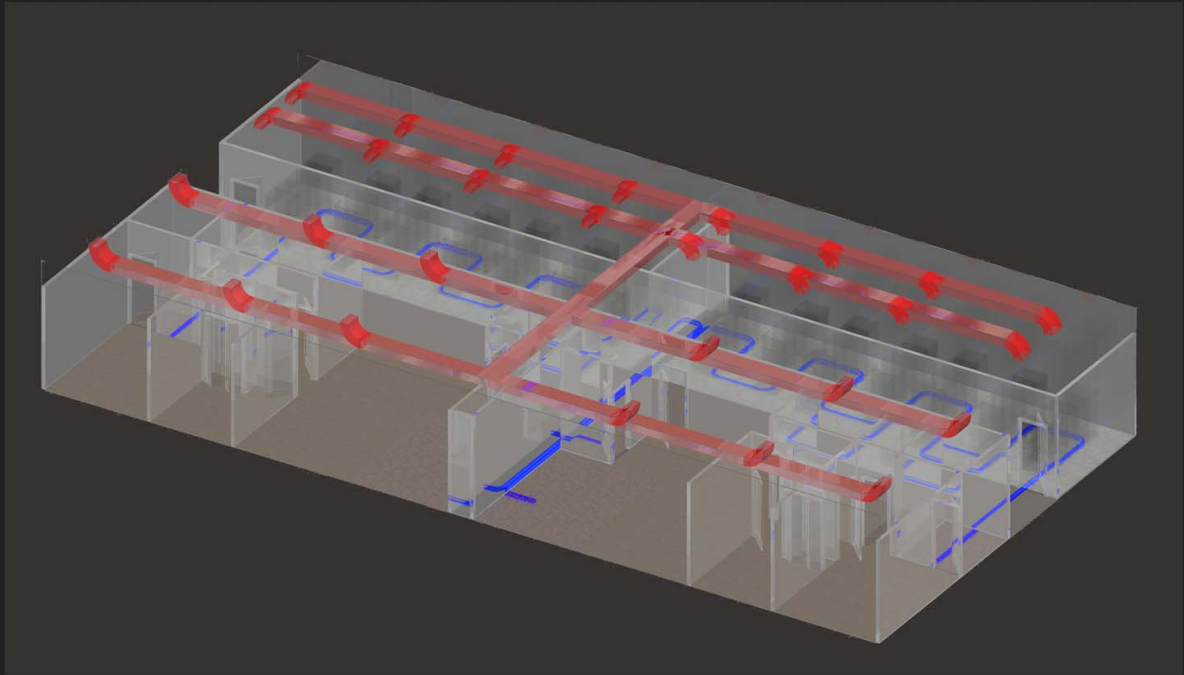
Sun Studys





The long image at the top shows a sun study of the building and its effects on the surrounding context. In truth, the building becomes a wall from the sun for much of the lower rise structures directly north from it. However, unlike in most cases this is not seen as a detriment, but rather just another means that forces this structure and its functionality to be recognized. The two pictures shown of the model highlight how the buildings scale would effect the surrounding and force users of other buildings to also engage in the discourse of our digital world and how we might aim to achieve something better.





— Waste Heat
— Grey Water

Resource Exchange

The diagram above shows how two typical residential units and two typical data units in the tower would interact from a building systems standpoint. Due to the fact that the data pod units would create vast amounts of heat the residential units could then have virtually no heating costs during the winter months. Typically one of these pods would be generating almost 1 million btu/hr. when fully active. This is more than six times the necessary heating requirement for a typical residential unit of this size in Michigan in the winter. When you extrapolate this over the entire building it would create enough heat that it could warm a large portion of the surrounding buildings in the winter through an integration with the municipal steam system.

The residential units also reciprocate in this exchange of resources by recycling the grey water that is created by users and sending it over into the server rooms to help chill the racks and therefore offset cooling costs. This would only offset some of the required cooling loads, but with advances in technology racks are beginning to be able to operate at slightly higher temperatures than in the past.

The remaining energy that is required to cool the servers could also be partially derived through the materiality of the building facade. The dark horizontal banding represented in the rendering on the opposite page covers the 3 foot gap between ceilings and the floors above. The material that makes up that capping systems exterior facing would be comprised of thin film solar cells which can operate in either direct or indirect daylight as well as under fluorescent lighting conditions. This would help to curb some of the massive energy draw that this building would require, but also allow users to understand the magnitude of the systems that must be put in place to try and curb this growing problem.

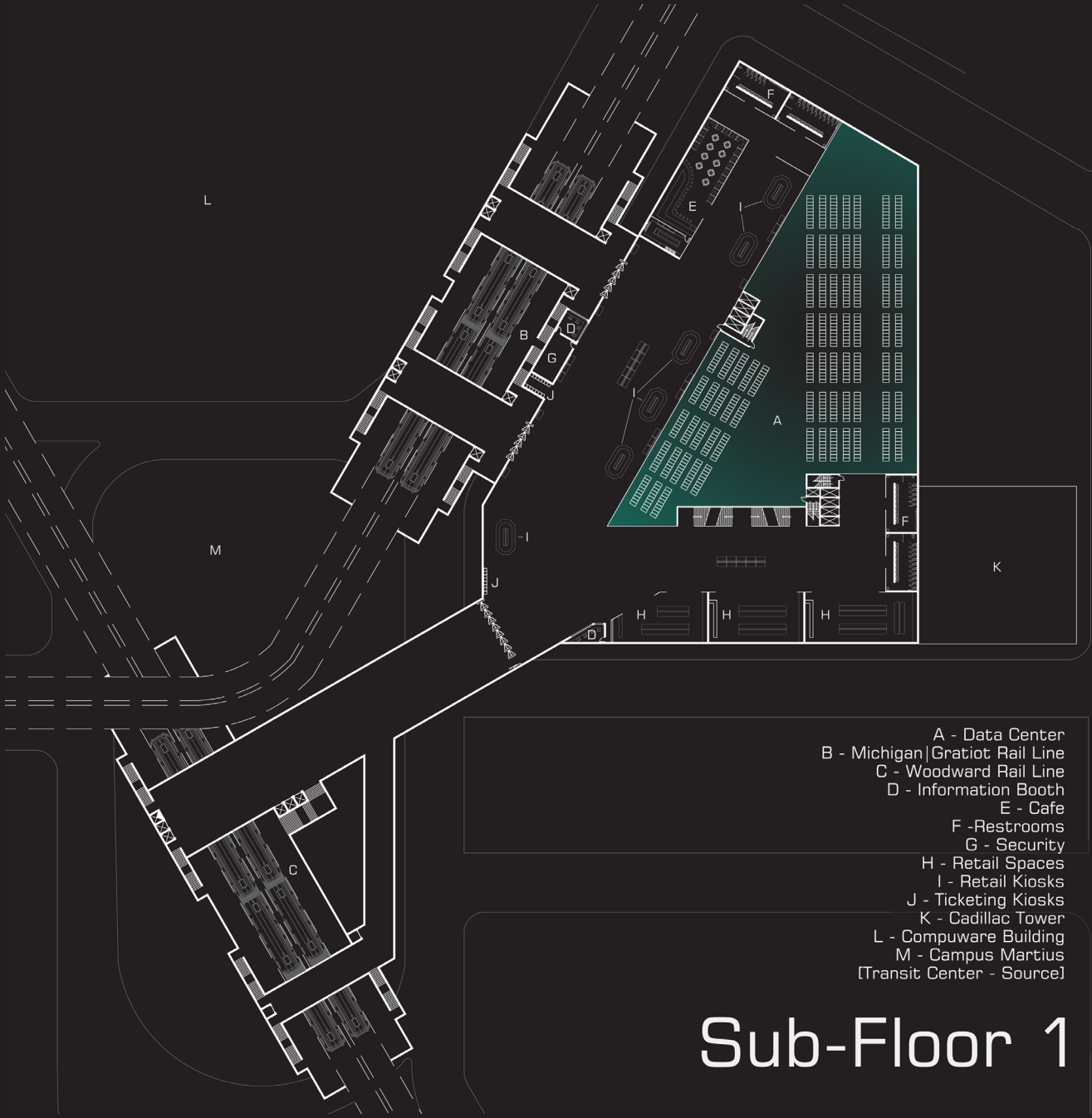


Transit Center [Source]

The sub-floors of the data center comprise the beginning of the data centers exit from the subterranean and into the terrestrial. It is here than we find the source of information and people that will flow throughout the building itself. The four floors that exist underground contain the P.O.P. rooms along with the first sections of the major data center core of the building.

The main non-digital function of the sub-floors is to act as the transit center. In this case it is extremely complex because there are 5 separate transit lines that all meet at Campus Martius Park. This plan shows how the Michigan Ave and Gratiot Ave Lines could be merged to create a single continuous line that served a larger area of this city without the need for as many train transfers. The floor plan also shows how the station platforms for the Michigan/Gratiot and Woodward Lines meet with the building itself and how the lines navigate under and over one another.

Both transit stations link with the towers sub-floors through tunneled walkways that cross over the platforms and into the tower proper. These tunnels would be the first area where fiberoptic cables would be expressed where people were actively walking and engaging a space. This would give the first sense that you were at once part of both the physical and digital world while you moved through the structure.



- A - Data Center
- B - Michigan|Gratiot Rail Line
- C - Woodward Rail Line
- D - Information Booth
- E - Cafe
- F - Restrooms
- G - Security
- H - Retail Spaces
- I - Retail Kiosks
- J - Ticketing Kiosks
- K - Cadillac Tower
- L - Compuware Building
- M - Campus Martius
[Transit Center - Source]

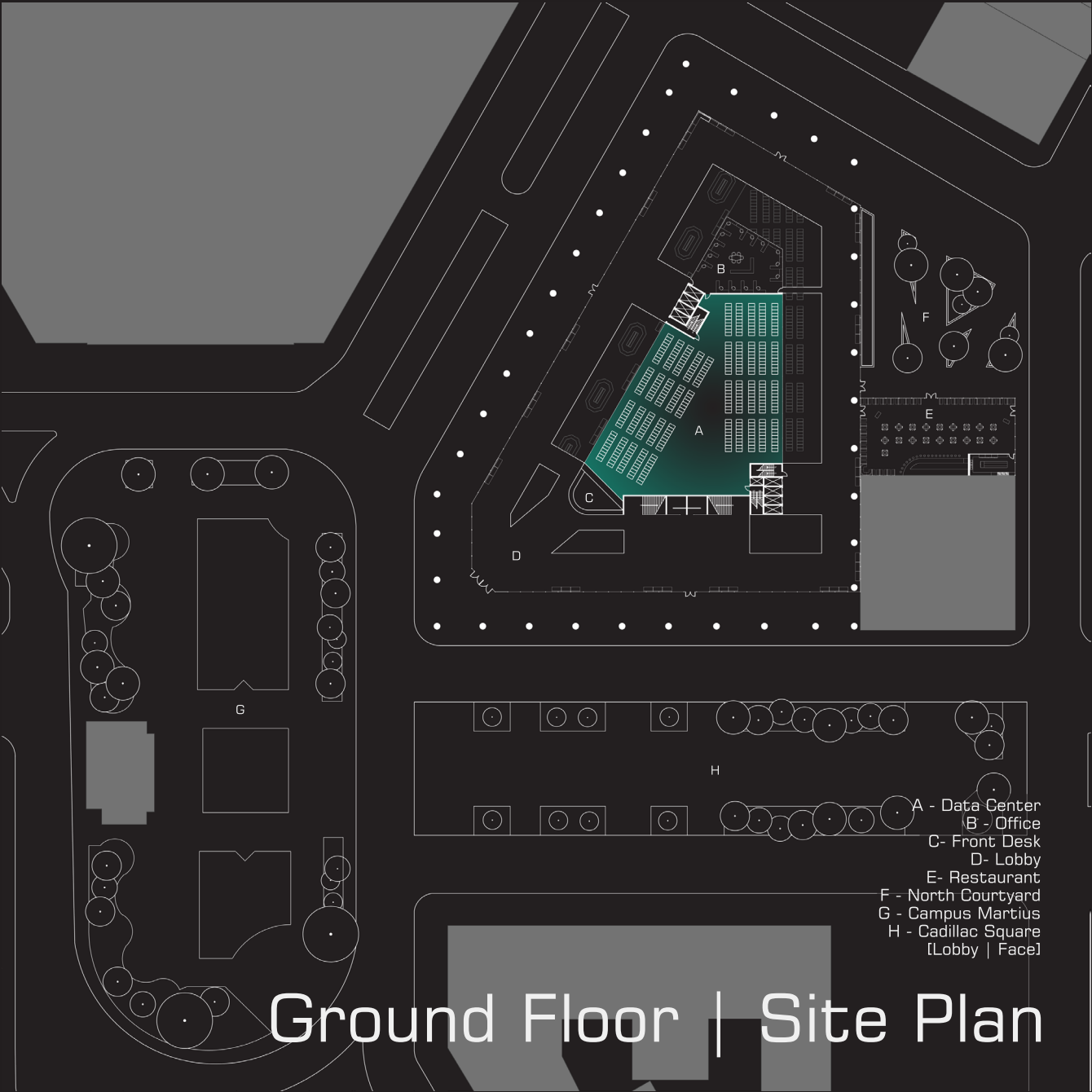
Sub-Floor 1

Lobby [Face]

The first floor, which serves as the buildings main lobby, is the first impression a pedestrian would have upon entering from the street level. The entryways are recessed back 25 feet from the street front for the first three floors creating a visual draw towards them. The user would enter into a space with 45 foot tall ceilings mimicking that grandeur of pre-depression era architecture and expressing the necessary scale of the digital worlds architecture.

Individuals entering from the main entrance from Campus Martius would be greeted by a lobby desk that served as a connection point for various data sets within the facility. Entering from the other side of the building, north of Cadillac Tower, one would pass through a smaller courtyard that would be a secondary public space to the larger Campus Martius. This area is also supplemented by a restaurant. One might envision a restaurant without servers in which you check-in, seat and order for yourself digitally. Once your order is done your food, which is cooked the floor below you, it is sent up on an automated dumb waiter and rises up to the table through the floor.

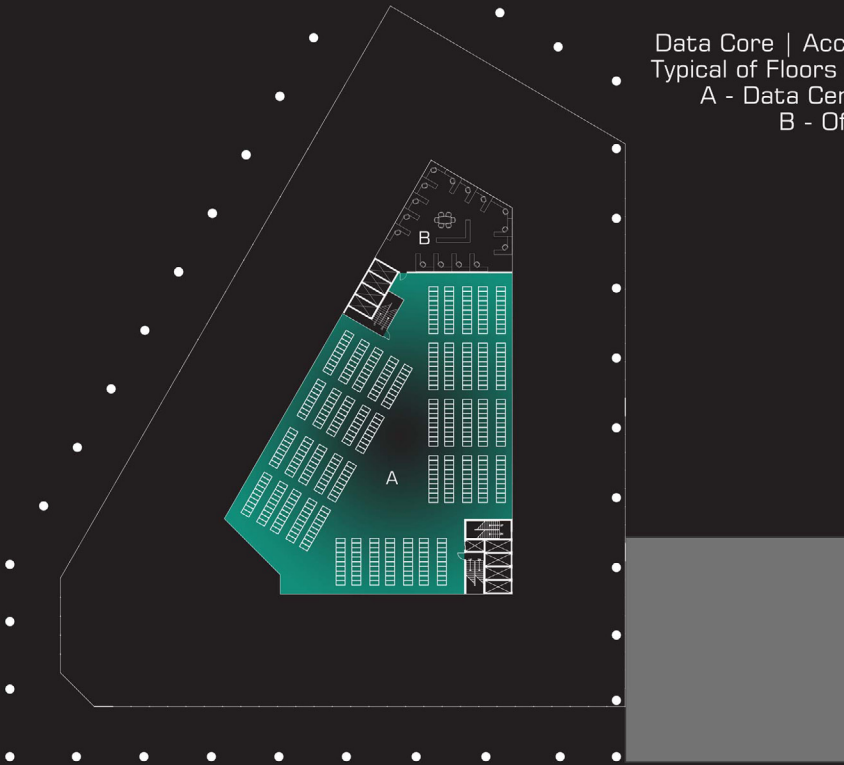
This idea of a world underneath us that is in many ways disconnected is also expressed through the treatment of the ground plane. A large portion of what would normally be the floor surrounding the data core's exterior walls is removed and only reaches the core where vertical circulation paths meet the ground floor. This allows glimpses from above of both the transit center and the lower sections of the data center core.



Ground Floor | Site Plan

Floor 3

Data Core | Access
Typical of Floors 2-3
A - Data Center
B - Office



Data Core [Access]

Above the first floor sit two more levels that make up the remainder of the fully visible data core of the building. These levels are visible due to the high ceiling heights of the lobby space on the ground floor and through the material palette chosen to enclose the server rooms. This section is only directly accessible from the other levels of the data center core.

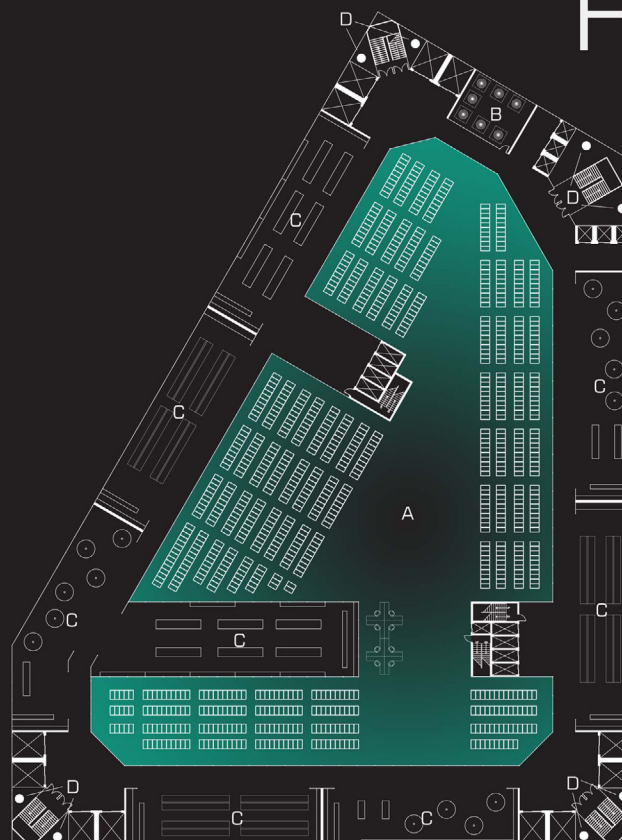
The aim of these levels is to express the functionality of the data center component in the truest manner possible. Since data centers are typically developed to be hyper secure this section of the data component is the most removed physically from the user. Yet, while it is removed physically its visual connection to the user is amplified as it makes up the largest portion of the data center that is visible from any single place in the building.

Commercial [Working]

The four floors that make up the commercial functions of the building are expressed by the typical floor plan shown below. This plan shows how the core component of the data center is continued up through this section of the building with commercial spaces both surrounding it on the exterior facades and intermingling within the core.

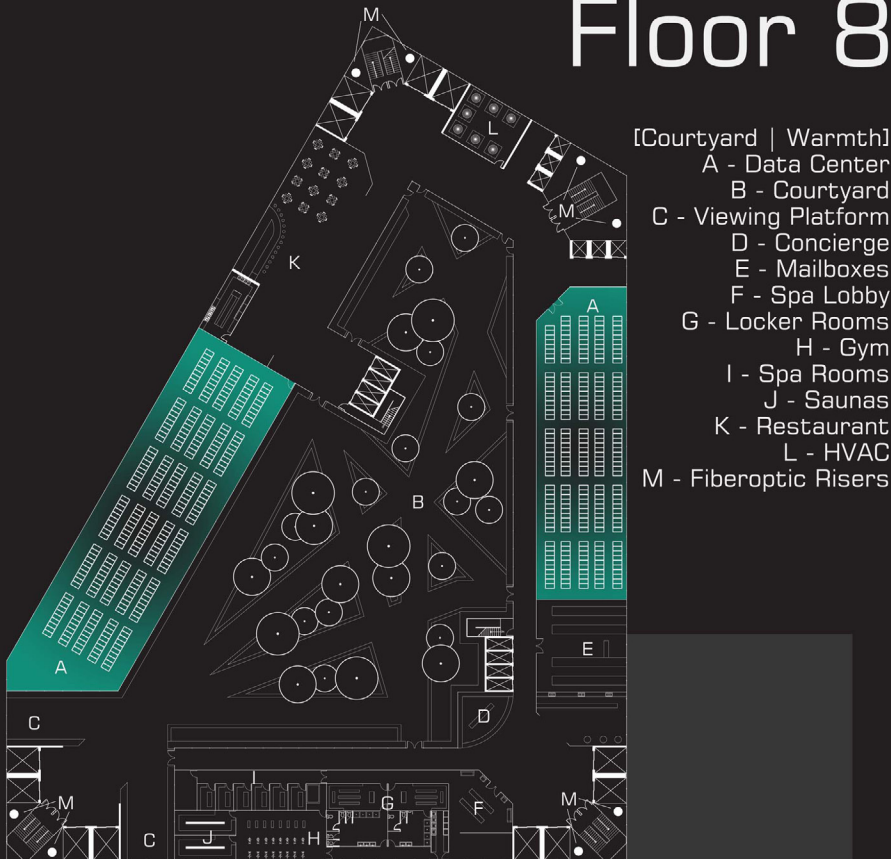
This is also the first section where the scale and movement of information through the fiberoptic risers is present allowing individuals the ability to once again recognize the monumentality of the data centers impact.

Floor 5



Commercial | Working
Typical of Floors 4-7
A - Data Center
B - HVAC
C - Retail Spaces
D - Fiberoptic Risers

Floor 8



Courtyard [Warmth]

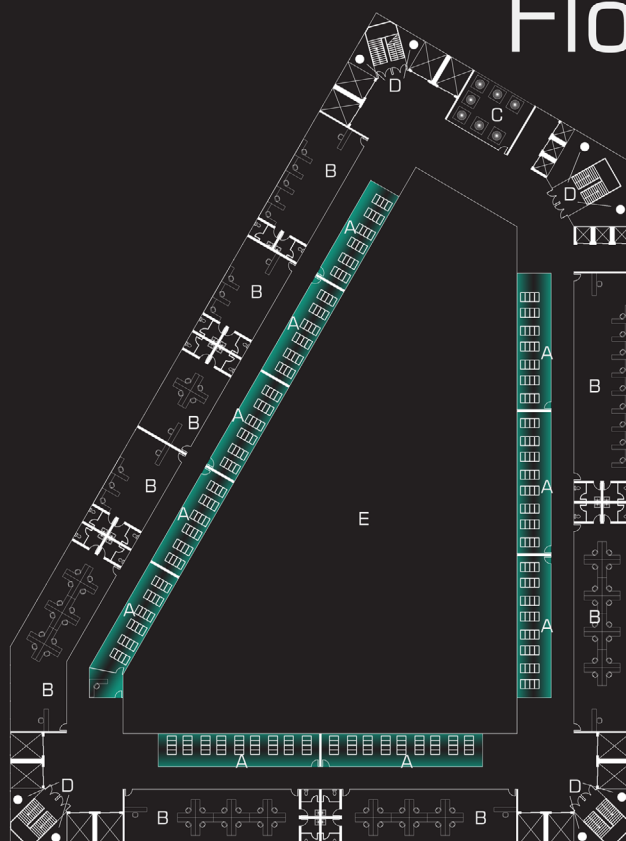
This level was created at the base of the ring with the intent on creating a raised park like experience that would create a comparable space to that of Campus Martius. The concept was that the data centers servers would have the ability to output enough heat during the winter months to keep this courtyard warm while it was cold elsewhere outside. This would provide urban dwellers the ability to find an oasis within the city during the often frigid winters in Michigan.

This level also serves as the lobby level for the residential and hotel components of the building. The programming was expanded to include mailboxes for the residences, a concierge to support both residences and hotel, along with a restaurant, gym, as well as a spa area and saunas to be heated by the data component.

Office [Working]

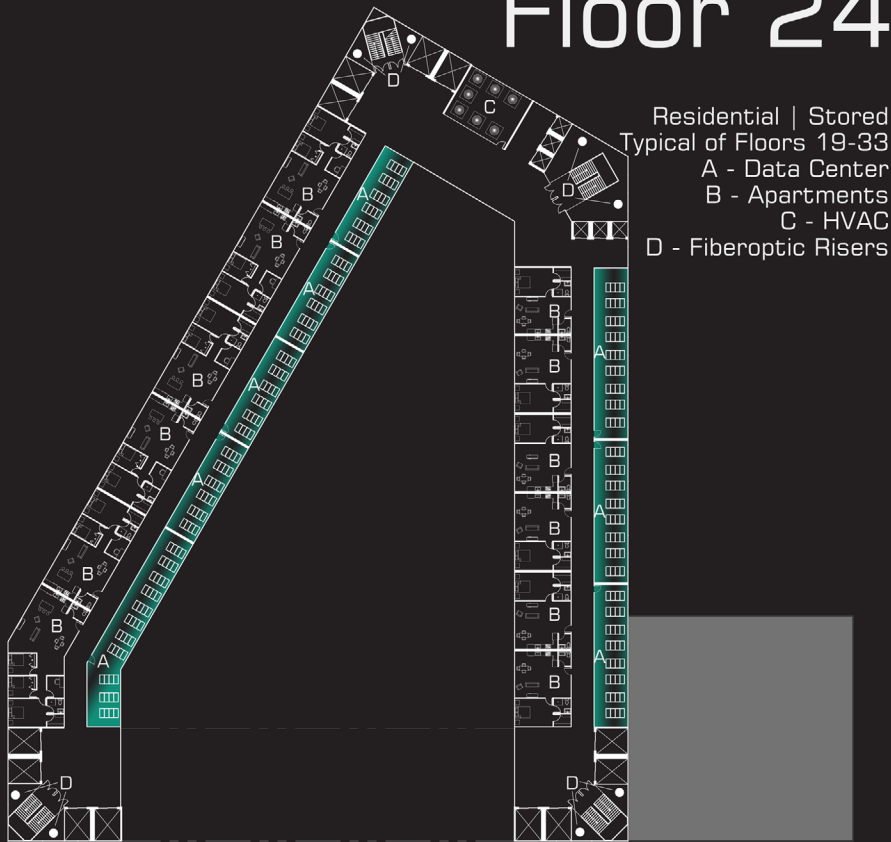
The office section of the tower is the first major section of the ring that comprises the majority of the structures height. It is comprised of various office areas on the outer ring of the building along with an inner ring made up of various data pod server rooms. These are the first levels where one would see both the moving of data expressed as a live map on the corridor walls as well as being the first areas where the concept of direct unit to unit resource exchange would occur.

Floor 12



Office | Working
 Typical of Floors 9-18
 A - Data Center
 B - Office
 C - HVAC
 D - Fiberoptic Risers
 E - Open to Below

Floor 24



Residential [Stored]

The next fifteen levels are made up by a mixing of inner and outer ring data components and residential components. These functions begin to shift from inner to outer depending on daylighting needs for the units as the data center does not need nor desire excessive daylighting. These units would also share resources with one another and display the constantly changing connections of the individual units on live maps on the corridor walls.

The floor plates of each of the residential floors get slightly smaller as one moves up from floor to floor along the tower. This is due to the climbing nature of the facade and massing design. The higher you get on the tower the more personal the connection becomes with the data component.

Hotel [Transient]

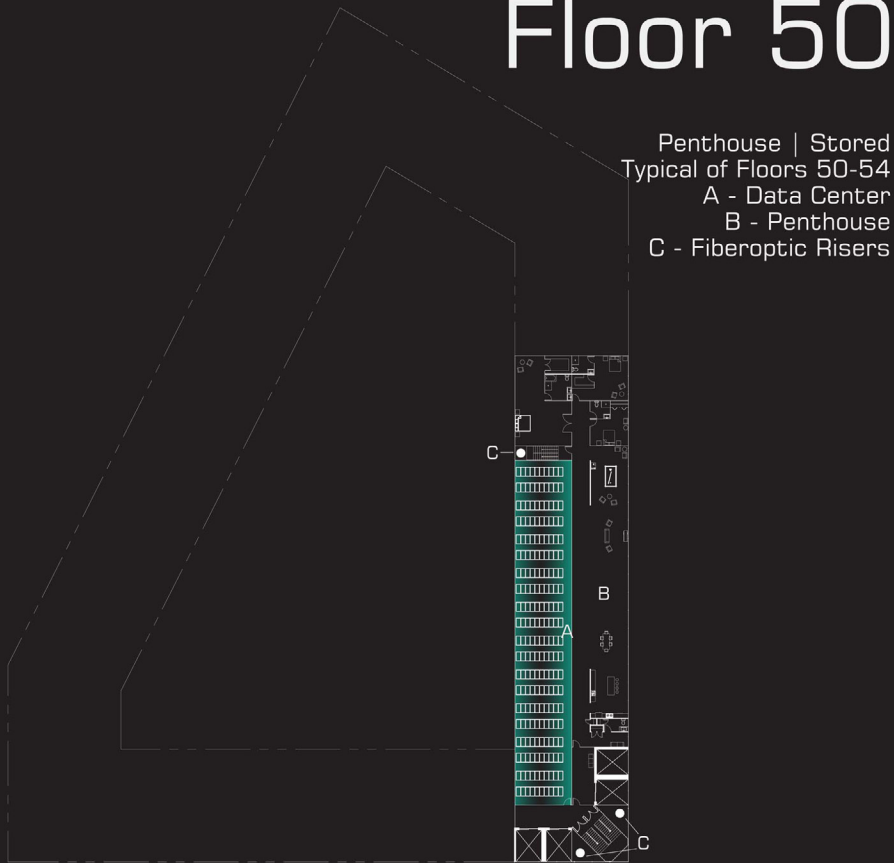
The hotel function of the building is very similar in layout to the residential. The 16 floors that make up this component also increasingly get smaller as you navigate further up through the building. Unlike in the residential component, however, the nature of the information that is stored in this section of the tower is more active than the information stored in the residential sections.

These floors are where individuals that are not from Detroit would be able to begin to understand the scale of the digital world for the first time. These visitors, coming from cities that have data centers that do not even express their own functionality on their facades, let alone introduce other programs into the building, would see the physical and digital not only expressed on either side of a corridor, but also see the two intermingle within the hotel units themselves.

Floor 39



Floor 50



Penthouse [Stored]

The last five levels that are inhabited by daily users of the building are the penthouses. In the same vein as the other residential section of the building the penthouses store information that is generally dormant. What differs is that the penthouse portion is engaged with the data center in every portion of the space.

The user is forced to recognize the existence of the data center while they go about their daily home lives. The data center is constantly present and the user always aware of the inner workings of the facility. Through the lens of translucent walls and live maps the resident of the penthouse would no when the data that is stored adjacent to their home was being actively engaged.

Observation Desk [Cloud]

This last programmatic function sits at the peak of the tower and is the point at which visitors and users of the building would be able to experience the feeling of being in the clouds (although not literally). This would allow panoramic views of the entire city of Detroit and therefore glimpses of the rest of the data transit network as it navigates through the city. It would be the point at which the user was most aware of the scale and complexity of both the local and global network that makes up the physical presence of our digital world.

Floor 55

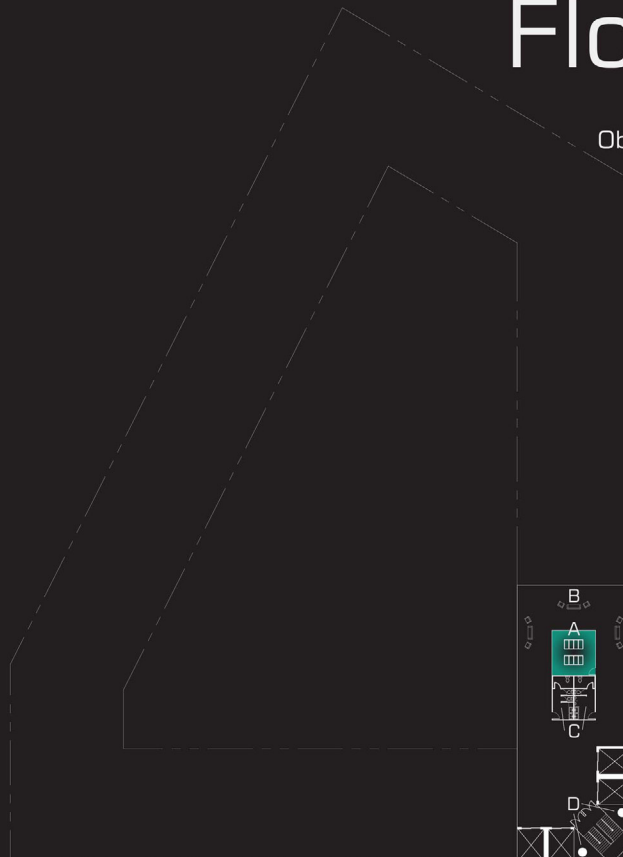
Observation Deck | Cloud

A - Data Center








B - Observation Deck

C - Restrooms

D - Fiberoptic Risers

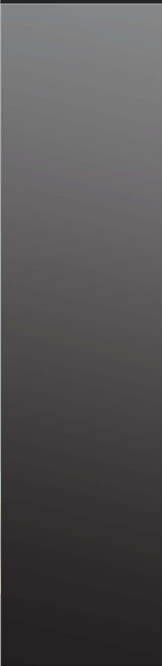
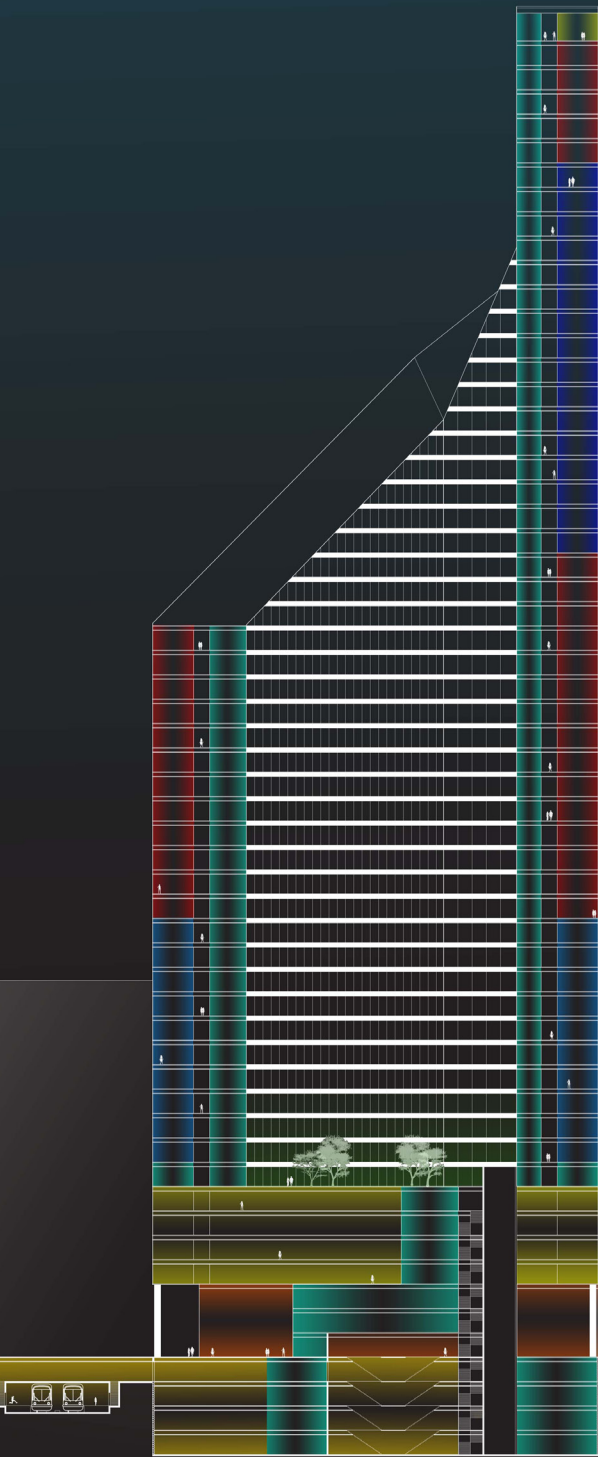
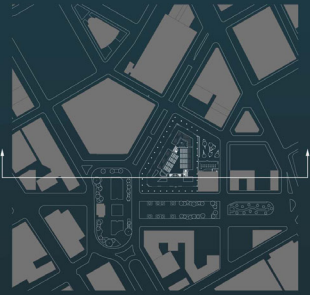


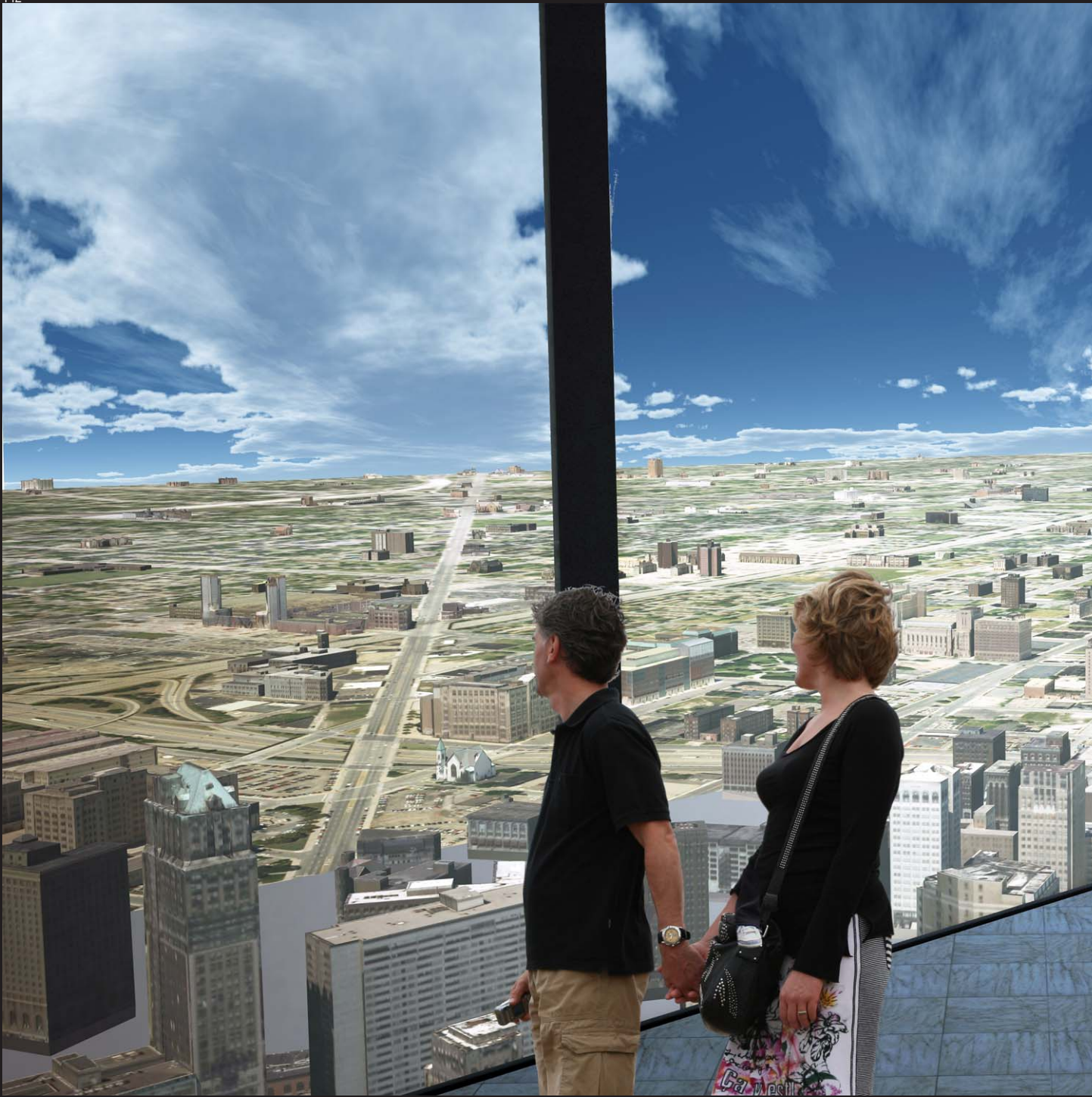
Overall Section

-  Data Center [Access]
-  Transit Center [Source]
-  Lobby [Face]
-  Commercial [Working] & Observation Deck [Cloud]
-  Office [Working]
-  Residential [Stored]
-  Hotel [Transient]

This section was created to highlight show how the data center component interacts with the various levels of the building and the various programmatic functions. It also highlights how hidden the intended warm oasis courtyard is with the monumental core of the structure. At this scale people are dwarfed by the magnitude of their digital world.









This rendering shows the view from the peak of the tower at the observation deck level and how the user can see far out into the city and ultimately see the various iterations of transit and data nodes.

This rendering shows the fiberoptic cables running along the ceiling of the transit centers connecting tunnels going from the station platforms into the building proper. This is the first point at which individuals would become aware of the presence of the digital world moving with them as they go about their daily lives.





Conclusions

[Visualizations of a prelude to a greater concept]



The development of a data center at this scale may potentially be beneficial in terms of efficiency, and through resource management and alternative energy source we might be able to make it more efficient than most urban data centers from an energy standpoint. Yet the question still remains, at what point do we properly recognize our digital world and its ramifications?

With this initial iteration of what the new face of our digital world could look like the scale becomes kitsch. It is large for the very pragmatic reason of being large. This is the most blunt way of explaining the monumentality of the digital world.

But what if this were inverted? If the tower were to go deep underground and maintain the trend that data centers are urban voids we still recognize them? Imagining a tower that became the walls of a thousand foot pit and was simply a data component makes the critique of what data centers are becoming all the more powerful. This project stands not as the culmination of a body of research and development, but rather the beginning of a deeper investigation about how we perceive, build and interact with the physical presence of our digital world.





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