# Emerging technologies and disruptive programming research in the design studio

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ABSTRACT: A persistence of technological innovations has called into question the traditional values of urban space and what a future of pervasive technology may mean for the ideal model of urbanism. The influence of technology lies within its ability to adapt and invent, often redefining a technology's performance within the context of a given market over short periods of time, rendering earlier generations of similar technology obsolete. Referred to as disruptive technology, this innovation is a new technology that unexpectedly displaces an established technology. Through a knowledge transfer ideal, the study involves a trans-disciplinary understanding of architectural and urban spatial practices in which the concept of disruptive programming is derived, understood, and ultimately applied. The central objective of this ongoing study is to create the facility within students to re-define and interpret, then strategically position project programming in order to study its effects upon spatial assemblies through an engagement with the proliferation of data and an understanding of the powerful presence of emerging technologies. Recent research of this set of disruptive technologies is analyzed through multiple scales and within multiple contextual situations confronting and questioning the standard methods of programming our built environment. The research was initially isolated within the emerging technology discipline, ultimately contextualized to study its potential in an architectural setting, such as its role in creating urban effects, its influence on project programming, and at the intimate scale, the tracking of an individual's habits or routines through sensors. This research has shown that standard programmatic processes must react to the ever changing nature of a future driven by pervasive technological disruption. Through a concise calibration of programming iterations and a re-interpretation of spatial assembly, we have seen the emergence of new forms and more importantly, new types of space, both within the urban and architectural scales.

Key Words: Disruptive Programming, Disruptive Technologies, Innovation, Technology

## INTRODUCTION

The ambition of the studio has been to map the main issues linked to the development of architectural programming's recently established relationship with the issues and problems raised by the behaviors associated with technological advancement, both by the technology/device and the preoccupied user. Based upon our fields continuing reliance on multi-disciplinarity, it is my assertion that students who are taught and ultimately practice this [research] model of disruptive architectural programming will add to their knowledge base and have advantage within the shifting relationships of our economic, social, cultural, political, and environmental landscapes which exert a rapidly increasing influence in the processes of architecture and urban design at multiple scales.

The study intends to exhibit the processes and products of a combined programming seminar and graduate design studio that had a commitment to the significance of studying technologies' roles in architectural programming. Through a knowledge transfer ideal, this method involves a trans-disciplinary understanding of architectural and urbanistic spatial practices in which the concept of disruptive programming is derived, positioned, and ultimately deployed. But before I advance the attributes associated with our interpretation of disruptive programming, one needs to understand what's behind the disruptive technologies veil and their programmatic potential.

Essentially, three terms are used here to describe technologies; emerging, sustaining, and disruptive. The broadest use term is emerging as it contains innovations from a vast landscape following a typical growth curve. The core of the study develops from the distinction between sustaining technologies and disruptive ones. The former produce incremental improvements in the performance of established products, potentially leaving gaps in overlooked or unexamined market segments. In contrast, disruptive technologies are "innovations that result in worse product performance, near term", yet reach new markets, eroding their competitor's position through routine technological advancements and the appeal of perceived value for the less demanding end of the market. (Christensen 1997, 192)

| | Illustrative rates of technology improvement and diffusion | Illustrative groups, products, and resources that could be impacted[1] | Illustrative pools of economic value that could be impacted[1] |
|---|---|---|---|
| Mobile Internet | **$5 million vs. $400**[2] Price of the fastest supercomputer in 1975 vs. that of an iPhone 4 today, equal in performance (MFLOPS)<br>**6x** Growth in sales of smartphones and tablets since launch of iPhone in 2007 | **4.3 billion** People remaining to be connected to the Internet, potentially through mobile Internet<br>**1 billion** Transaction and interaction workers, nearly 40% of global workforce | **$1.7 trillion** GDP related to the Internet<br>**$25 trillion** Interaction and transaction worker employment costs, 70% of global employment costs |
| Automation of knowledge work | **100x** Increase in computing power from IBM's Deep Blue (chess champion in 1997) to Watson (Jeopardy winner in 2011)<br>**400+ million** Increase in number of users of intelligent digital assistants like Siri and Google Now in past 5 years | **230+ million** Knowledge workers, 9% of global workforce<br>**1.1 billion** Smartphone users, with potential to use automated digital assistance apps | **$9+ trillion** Knowledge worker employment costs, 27% of global employment costs |
| The Internet of Things | **300%** Increase in connected machine-to-machine devices over past 5 years<br>**80–90%** Price decline in MEMS (microelectromechanical systems) sensors in past 5 years | **1 trillion** Things that could be connected to the Internet across industries such as manufacturing, health care, and mining<br>**100 million** Global machine to machine (M2M) device connections across sectors like transportation, security, health care, and utilities | **$36 trillion** Operating costs of key affected industries (manufacturing, health care, and mining) |
| Cloud technology | **18 months** Time to double server performance per dollar<br>**3x** Monthly cost of owning a server vs. renting in the cloud | **2 billion** Global users of cloud-based email services like Gmail, Yahoo, and Hotmail<br>**80%** North American institutions hosting or planning to host critical applications on the cloud | **$1.7 trillion** GDP related to the Internet<br>**$3 trillion** Enterprise IT spend |
| Advanced robotics | **75–85%** Lower price for Baxter[3] than a typical industrial robot<br>**170%** Growth in sales of industrial robots, 2009–11 | **320 million** Manufacturing workers, 12% of global workforce<br>**250 million** Annual major surgeries | **$6 trillion** Manufacturing worker employment costs, 19% of global employment costs<br>**$2–3 trillion** Cost of major surgeries |
| Autonomous and near-autonomous vehicles | **7** Miles driven by top-performing driverless car in 2004 DARPA Grand Challenge along a 150-mile route<br>**1,540** Miles cumulatively driven by cars competing in 2005 Grand Challenge<br>**300,000+** Miles driven by Google's autonomous cars with only 1 accident (which was human-caused) | **1 billion** Cars and trucks globally<br>**450,000** Civilian, military, and general aviation aircraft in the world | **$4 trillion** Automobile industry revenue<br>**$155 billion** Revenue from sales of civilian, military, and general aviation aircraft |
| Next-generation genomics | **10 months** Time to double sequencing speed per dollar<br>**100x** Increase in acreage of genetically modified crops, 1996–2012 | **26 million** Annual deaths from cancer, cardiovascular disease, or type 2 diabetes<br>**2.5 billion** People employed in agriculture | **$6.5 trillion** Global health-care costs<br>**$1.1 trillion** Global value of wheat, rice, maize, soy, and barley |
| Energy storage | **40%** Price decline for a lithium-ion battery pack in an electric vehicle since 2009 | **1 billion** Cars and trucks globally<br>**1.2 billion** People without access to electricity | **$2.5 trillion** Revenue from global consumption of gasoline and diesel<br>**$100 billion** Estimated value of electricity for households currently without access |
| 3D printing | **90%** Lower price for a home 3D printer vs. 4 years ago<br>**4x** Increase in additive manufacturing revenue in past 10 years | **320 million** Manufacturing workers, 12% of global workforce<br>**8 billion** Annual number of toys manufactured globally | **$11 trillion** Global manufacturing GDP<br>**$85 billion** Revenue from global toy sales |
| Advanced materials | **$1,000 vs. $50** Difference in price of 1 gram of nanotubes over 10 years<br>**115x** Strength-to-weight ratio of carbon nanotubes vs. steel | **7.6 million tons** Annual global silicon consumption<br>**45,000 metric tons** Annual global carbon fiber consumption | **$1.2 trillion** Revenue from global semiconductor sales<br>**$4 billion** Revenue from global carbon fiber sales |
| Advanced oil and gas exploration and recovery | **3x** Increase in efficiency of US gas wells, 2007–11<br>**2x** Increase in efficiency of US oil wells, 2007–11 | **22 billion** Barrels of oil equivalent in natural gas produced globally<br>**30 billion** Barrels of crude oil produced globally | **$800 billion** Revenue from global sales of natural gas<br>**$3.4 trillion** Revenue from global sales of crude oil |
| Renewable energy | **85%** Lower price for a solar photovoltaic cell per watt since 2000<br>**19x** Growth in solar photovoltaic and wind generation capacity since 2000 | **21,000 TWh** Annual global electricity consumption<br>**13 billion tons** Annual $CO_2$ emissions from electricity generation, more than from all cars, trucks, and planes | **$3.5 trillion** Value of global electricity consumption<br>**$80 billion** Value of global carbon market transactions |

**Figure 1:** Speed, Scale, and Economic Value of 12 Potentially Economically Disruptive Technologies. Source: (McKinsey Global Institute 2013)

### 1.1. Disruptive technologies

Five sections, one for each technology, will consist of a brief background for each disruptive technology, followed by conceptual implications for architectural program and the spatial assembly process. As resources are shaped and processed through technology, the analysis utilizes technology's enabling role in the operation of social and cultural networks, the market economy, and environmental concerns. A multi-scalar approach allows the capacities of each scale to present their limits, as each scale produces one view of the system, yet simultaneously calls into question the performance of the coherent whole. Disciplinary migration creates new opportunities to study and utilize disruptive technology's transformative potential to reconfigure traditional programming techniques – a study of the reciprocal relationship between disruptive programming and the physical environment. The following rapidly advancing technology areas have been cited as having the greatest potential for transforming life, business, and the global economy (Manyika 2013).

### 1.2. Cloud technology

Cloud technology allows the delivery of potentially all computer applications and services through networks or the Internet. With cloud resources, the bulk of computational work can be done remotely and delivered online, potentially reducing the need for storage and processing power on local computers and devices. The cloud also enables pay as-you-go models for consuming IT, as exemplified by the phrase "infrastructure as a service." The cloud enables some of the most highly impactful technologies – mobile internet, automation of knowledge work, and the Internet of Things. Since apps often rely on cloud resources, the cloud is expected to be a major driver of smartphone use. Through its processing power and efficient streamlining, the cloud already has and will continue to impact the workplace. Adjustments to the off-site | off hours concept is accelerating, while the new employee arrives with a varied set of expectations and standards further delaminating the GPS of the office.

### 1.3. Internet of things [IOT]

The Internet of Things refers to the use of sensors, actuators, and data communications technology built into physical objects—from roadways to pacemakers—that enable those objects to be tracked, coordinated, or controlled across a data network or the Internet. There are three steps in [IOT] applications: capturing data from the object, aggregating that information across a data network, and acting on that information—taking immediate action or collecting data over time to design process improvements. IOT can be used to create value in several ways. In addition to improving productivity in current operations, the Internet of Things can enable new types of products and services and new strategies: remote sensors, for example, make possible pay-as-you-go pricing models such as Zipcar. IOT technology ranges from simple identification tags to complex sensors and actuators. Several technological advances are improving the effectiveness of IOT applications while also reducing costs. The price of RFID tags and sensors is falling, and new developments such as MEMS are enabling new uses. The impacts have incredible depth and breadth. The Internet of Things is an important enabler of better management of infrastructure systems. IOT has broad operational effects upon the urban and agricultural landscapes, from products to services and through individual or serial production.

### 1.4. 3D printing [3DP]

3D printing belongs to a class of techniques known as additive manufacturing. 3DP has several advantages over conventional construction methods. An idea can go directly from a file on a designer's computer to a finished part or product, potentially skipping many traditional manufacturing steps. 3DP has other notable characteristics such as an improving performance curve [reduction of cycle times in design and construction], an expanding array of materials to print, and a rapidly declining price structure. An oft overlooked attribute is its allure in creating a subculture. Belonging to a given culture means, in part, having fluency in its infrastructural languages, and the 'maker' subculture is flourishing. This simple fact has had wide ranging effects. Material infrastructures function by seamlessly binding hardware and internal social organization to wider social structures. It nimbly does so through scale and through its inherent shape shifting characteristics. I refer to its potential to 'act' as product, service, device and programmatic element. Its unexpected collection of functionality makes this position as a disruptive programming element possible.

### 1.5. Augmented reality

Augmented Reality is a technological modification of existing senses for enhanced information processing. This technology has mainly explored the alteration of one's visual experience through a Heads Up Display that overlays the individuals line of sight with hardware such as smart phones and Google glass. Correlation of architectural process and augmentation become flexible, and catalytic. In the same way that this technology augments user's senses, it is also capable of alerting the limits of both physicality and practicality of architectural form. Infrastructure no longer becomes a necessity of traditional spatial practices, making it possible to create complex programmatic conditions with very minimal physical space.

### 1.6. Mobile internet

The growth of the internet has made it a resource of high demand, resulting in a global market of pervasive connectivity. This allows the breadth of technologies to persist through time and space, making the internet a complete and necessary infrastructure, albeit invisible in the traditional sense unlocking new ways of knowing, perceiving, and interacting with the physical world to users everywhere. Through this connectivity they have been given the ability to access information seamlessly. As a disruptor this technology theoretically makes the need for direct human contact, and potentially entire tactile environments irrelevant. This posits the notion that program can persist without traditional confines such as space, time or demand, allowing program to exist everywhere [or nowhere] based on the individuals need to access it through mobile computing devices. Most importantly program is no longer directly anchored to scale.

## 2.0 METHODS

The research approached these developments from an infrastructural perspective and sought to define a corresponding architectural *reaction* to technology as disruptive program. Through moments when the permanence of architecture meets the ephemeral qualities of technology, disruptive programming allows for the experience of permanent spatial practice to become dislodged from a single predefined parameter, and open to becoming a more dynamic response to the needs of its environment. A primary goal was to understand how architecture can respond to frequent programmatic change as a result of technological innovation by using associative disruptive technologies and innovations as a basis for a reimagining of traditional spatial practice. It can be driven by an evolution of culture, not an evolution of technologies directly; the behavioral changes, the physical changes and reflexes brought about by the computer's active role in daily ritual. Expectations of culture are redefined with design objectives and procedures.

> Films….have envisaged changes in the perception of ordinary space brought about by the development of sophisticated interfaces between ordinary and digital space. The notion of enhanced or increased reality suggests a different materiality made possible by the hybridization of the physical and the digital. While this hybridization is not fully developed, some features of the displacement of materiality are already evident.
> (Picon 2010, 119).

As multi-disciplinary knowledge and collaborations become increasingly valuable, this study begins seemingly on or near the 'edge' of conventional architectural thought. It questions the center and the periphery, ceding its migration across scales and disciplines. Studying the set of *disruptive technologies* in isolation as a separate undertaking allows for a biased interpretation, and a resolute position. Sequentially analyzed and synthesized within a directed set of contextual situations allowed for the re-consideration of the relationships between technology and space which are not simply the quantification of one directly adapting to the rules of the other. In isolation the contrast of these two forces is more than the application of design principles from one to the other. Instead it is the result of a cultural clash, creating rifts in reality, and layering the physical with technological posterns. This amalgamation of technology and design as a new and evolving form of program development gives a new perspective to architectural possibilities. The result is a future of disruptive programming.

Calibrating a rhythm of research inside and outside of architecture created opportunity for experimentation in manufacturing effects by tracking, translating and visualizing data, directed through readings, case studies review, and a sequence completely outside the discipline, where we slipped into and out of management information studies. Programming strategies & tactics emerged through the questioning of material and [im]material concerns; the physical, spatial, and relational within related scales and contextual situations. The following summarize the seminar guidelines under consideration; the accessibility and interpretation of Big Data, the notion of material and [im]material infrastructures, the advancing influence of technology, situating program as a material construct within multiple scales, and the transformative potential of traditional programming techniques.

### 2.1. Tactile environments

Unlike the internet, the urban landscape is bound by physical parameters that hold no influence on data space. These parameters make the corporeal realm a static, slowly adapting landscape, the ways in which cyberspace can connect and manifest are impossible to replicate physically, politically, or economically in the built environment. The landscape of this environment serves as active surface, a structure for facilitating conditions necessary for relationships and interactions to be linked through the functions that it supports. The urban surface isn't just the space between buildings, but rather the extensive and inclusive ground plane of the city which accommodates buildings, roads, utilities, open spaces, neighborhoods, and habitats.[4] Contemporary forms of urbanization look at the city as the result of consequential shifts in the fundamental paradigm, effectively moving it away from a formal interpretation or typological assessment, and towards a greater understanding of the dynamic systems of which the city is comprised.

This connective tissue formed through the juxtaposition of permanent infrastructure reveals the impact left by various cultural developments echoed through stylistic design vernacular. Schouwburgplein, a Rotterdam based design by West 8, is a project that examines notion of urban emptiness. Landscape architect Adriaan Geuze believes that urban dwellers are able to create, adapt to, or imagine whatever they want and therefore over-programming a space is a less effective design approach. Instead what is more important is giving the urban consumer a space in which they can find their own meanings in the environments they use. Schouwburgplein is meant to be a place where the public can modify and appropriate the urban surface of the city by creating surfaces that are simple yet are capable of supporting many different types of events.[5] Because the space is surrounded by amenities such as theaters, restaurants, and cafes the project acts as a single public armature between all of these programs, giving them the ability to morph into the space.

## 3.0 DISRUPTIVE PROGRAMMING SPECULATIONS

Today technology has become a driving force of alteration causing the fragmentation of disparate programs, while at the same time creating opportunity for the urban surface to thrive. Mobility and more so the social communities that have been created since the birth of the internet have forced designers to adapt spatial practices by encouraging flexible, multifunctional surfaces. Traditional and sustained programs at various scales have changed very little since their conception.

To manufacture disruptive program one must first isolate a function to its core. In isolation certain program functions which may be viewed through a modern standard as archaic can be distilled. After a programmatic deconstruction a building function can be reformed, removing the familiar perception of function and replacing it with a perspective driven by a new objective. In the case of this argument the reorientation of building function will occur as a reconstructed response to disruptive technology by taking familiar programmatic notions and manifesting possible outcomes, repositioning them with potential disruptors. The research examines two instances of disruptive technologies' impact on urban and architectural programming in the information age.

### 3.1. Student project 1

The first study examines the notion and execution of four conceptual programs and their urban and architectural impacts at a standard block scale. These programs are identified as a Theatre, Marketplace, Public Space, and Archive.

*Theatre*: Augmented reality offered the possibility of the largest spatial consolidation. In this case visual interfacing has the ability to rescale events of multiple sizes and across distances, giving users the ability to experience many different events simultaneously in a tactile environment. Consider conventions, stadiums, concerts, lecture hall, cinema, and theatre as programs that form social experiences in any number of physical spaces, creating a program that is only reliant on personal, wearable devices.

*Marketplace*: The possibility for both commercial and institutional research has become streamlined through three dimensional printing. Production and consumption are no longer hindered by time, costs, or the product inflexibility of traditional distribution. This allows for design and sharing of user generated content to be instant and customizable. Purchasing any items is a matter of the user's desire and interest, allowing for companies and individuals to be the providers, rather than the definers of content. Programmatically this translates largely to boutique, online, and big box style shopping; or dry and wet lab style research, while also allowing for the possibility to serve cultural functions as a gallery space.

*Public Space*: Media docking refers directly to the relationship between user and device. Conceptually parking refers directly to human and autonomous occupation of space. Programmatically the media dock occupies instances where the user is typically a body at rest, identified by functions that are inhabited or require seating, such as cafes, lobbies, restaurants, or park benches. This program leverages the need to recharge peripherals into a social function by connecting and sharing data with local users, facilitating both the sharing of content, and the potential for exchange between people based on data processing and feedback.

*Archive*: The cloud collection is a wireless database existing on linked servers, accessible within the building footprint. Without physical collection, all content exists as data which can be displayed on mobile or static surfaces in a tactile environment. This collection gives users access to licensed software, content developer kits, and various forms of media sharing capabilities. As part of a larger digital network users can navigate other buildings of the same format globally, and manifest their own ways of using data space. Developed as a digital reinvention of the archive the functionality also allows for programs such as libraries, offices, and classrooms to take advantage of the clouds disruptive potential.

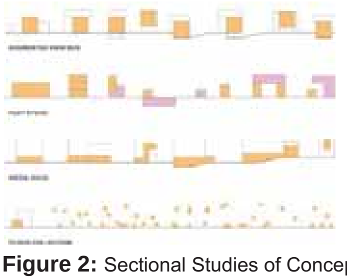

**Figure 2:** Sectional Studies of Conceptual Programs. Source: (Reindel 2014)

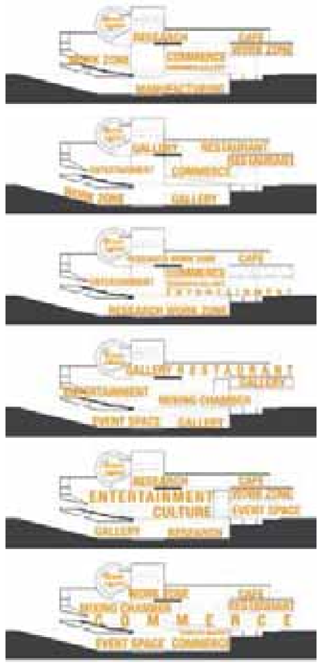

**Figure 3:** Section Model of Program Assembly Configurations. Source: (Reindel 2014)

Due to the unquantifiable physical potential of disruptive technology and its impacts on both culture and the built environment, the working design followed the same notions of urban emptiness enacted in the design of Schouwburgplein. For a tactile space to react to technological change, it must have a degree of freedom so that these conceptual programs can be invented and executed within its confines. The programs conceived where examined through section in a series of diagrams.

A permanent, multi use volume was devised for each concept based on standard programs best suitable for the supporting disruptive technology. Using the Augmented view box as an example, the physical spatial requirements were met by providing sloped seating and a modular stage for standard performances or lectures. Over the course of a day the form could change based on the users demand and accessibility to technology. If implemented today, the space would provide a standard theater experience, but as technology adapts, and wearable visual interfacing becomes common, users can adapt the space to suit their interests or programmatic needs. Instances of multi scalar, event based programming can alter the boundaries of the architectural form. Through the use of a modular sliding construction, a series of configurations can be explored to feed the different programs into each other through the central conduit space.

This temporal based activation can take a cinema and turn it into basketball court, going from a confined program, to a building wide occupancy that engages all of the internal programs simultaneously. This process also allows two opposing volumes to merge together either horizontally or vertically to provide different spatial assemblies, capable of providing drastically different canvases for new functions to be conceived, both inside the building form and into the adjacent public spaces.

### 3.2. Student project 2

The second study is a speculation of the deterioration of post-industrial neighborhoods, its failings, its implications, and its hidden opportunistic traits within our digital culture. The notion of sustained industry and the emerging DIY maker culture is conceptually linked as this unlikely merger re-configures the conditions of urban habitation at multiple scales and within multiple contextual situations – the social, cultural, economic, political, and spatial. The inherent ethos of the open source DIY mentality will ameliorate the lines of distinction between neighborhood and business district, home and factory, resident and worker.

The premise is economically, and perhaps, technologically biased as the hope is for a socioeconomic accelerant through an infusion of industry and architectural programming in a depressed community. Equitable revitalization calls for both preserving and creating, as well as taking steps to minimize untimely and forced displacement of a neighborhood's lower-income resident. A phased revitalizing proposal introduces a disruptive technology, 3D printing [infused industry] into a local node [the distressed | dismissed neighborhood] deploying the contained 'service' function of technology, replacing the typical, orthodox programmatic element, creating a series of changing spaces around it – from the mediatic and didactic to the collective and individual.

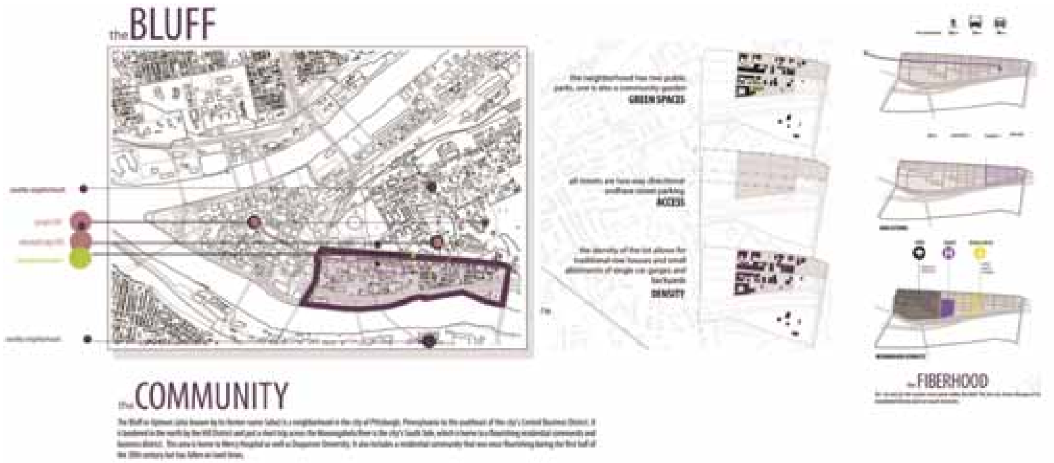


**Figure 4:** Site Analysis Diagram. Source: (Walker 2014)

An ambition for the project is to offer the neighborhood a dynamic and variable meeting point for people of all ages taking part in a wide range of planned and un-planned activities. The disruption creates a viable context for our current production and inventory model as it creates a new market and value network, ultimately, altering and displacing current technology. 3DP's market for producing complex, low volume, highly customizable parts markedly shifts the current model on many fronts; including the lessening of waste and the carbon footprint, the re-partitioning of land due to reduced inventory, and the reduction in cycle times in design and production.

Ideally, the site is transformed into an integrative hyper-connective territory [fiberhood] through an unseen infrastructure of high speed fiber, where access and assets, both knowledge and other, are freely exchanged resources open to the broader public. The land work strives to be surfacial and deep as well as aesthetic and utilitarian. Deemed infrastructural, the territory holds differing combinations of materials | topography and flexible, activated public spaces. Viewed as an active 3D surface in this iteration, program is deployed through existing housing stock and new construction points with mobile 3DP huts, the ANCHOR [work | social incubator], the gardens consisting of activity zones, isolation zones, connector zones, and a conveyor system | park. 3DP assembly is understood here as a hybrid condition where normative construction techniques are used on-site with intended 'gaps' in construction for the off-site customized 3DP building elements to be inserted. As assembly is fast tracked, an inherent attribute of 3d printing, the sites for design and construction merge into one cohesive landscape.

The formatting of a 3DP distribution network | urban design strategy has created a cultural network through its physical proximity and global reliance upon other infrastructures. Exercising the scaling and scaffolding effects of 3D printing through a design project has conflated such issues as innovation in education, reaching disconnected markets, direct and indirect relationships with other emerging technologies, bridging between traditional design and building techniques and emerging ones, and conceptual | pragmatic issues concerning the labor force. [10] The project acts on many levels; re-invigorating a sagging urban brand [PIT], upping the socio-economic ante of a blighted neighborhood, producing an economic boost to a municipal landscape, contributing global presence through an aggressive risk taking strategy, ultimately, reflecting on processes of encountering cities.

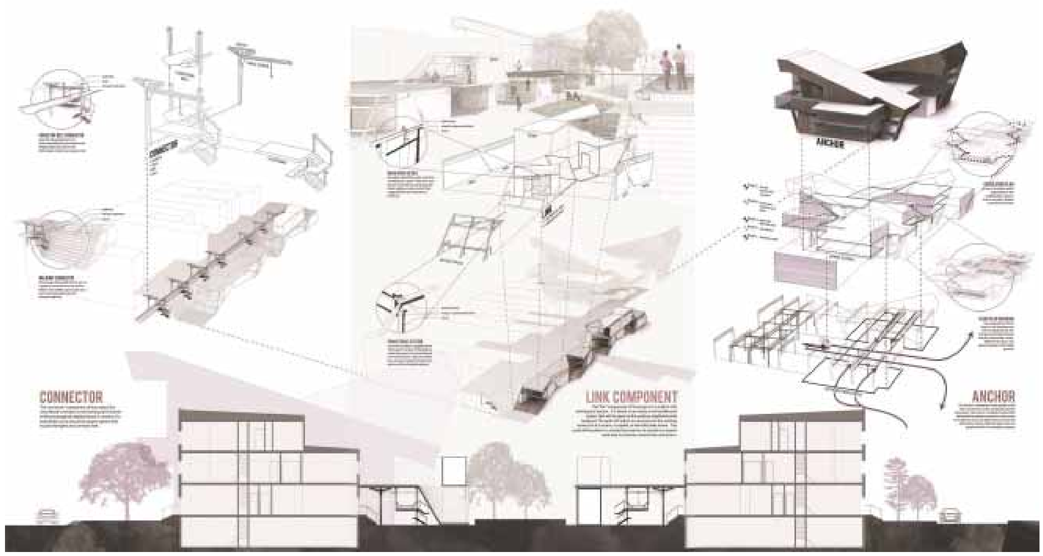


**Figure 5:** Disruptive Program Spatial Assembly. Source: (Walker 2014)

### 4.0 ANALYSIS AND ASSESSMENT

The studio approached the studies amongst technology, design, and economies, initially through a monocular lens, quickly realizing the essential need and value of the multi-disciplinary view of practice. Two stages of analysis and assessment took place; the first was a verbal presentation of teams of 2 students and review with a multidisciplinary set of reviewers, while the $2^{nd}$ level of assessment was based upon the specific technology's integration into the individual student's architectural studio project. The research was initially isolated within the emerging technology discipline where students were able to learn the specifics of the terms, definitions, language and trade lingo, processes, products/services, eventually migrating to an awareness and understanding of technology transfer issues, the layering of knowledge communities, and ultimately its potentials for testing in an architectural study, such as its role in creating urban effects, its influence on project programming, and at the intimate scale, the tracking of an individual's habits or routines through sensors.

Co-construction of knowledge was well established within the student work; there was an apparent ease when manipulating the data as teams, the resistance and difficulties arose from the direct application within the confines of an architectural program, developed by individuals for the remaining portion of studio. The speculations regarding the material influences of technologies was difficult for some to grasp, as most students had previously been 'given' a program to organize and design, thus the singular authorship of program was novel, initially a time consuming undertaking. The various positions in studio were within an acceptable gradient, with the two (Reindel, Walker) presented in depth being the most developed and most appropriate in expressing the variable and scalar approaches to this design probe. Composed of seven M.Arch students, four M.Arch | M.B.A. students and one M.Arch | M.U.D. student, discussion and debate was lively, insightful, and often territorial. The levels of engagement stayed within disciplinary boundaries as the dual M.Arch | M.B.A. students nimbly moved through the exercises and appreciated the cross disciplinary ideas of practice in the studio setting. Neil, the M.Arch | M.U.D. candidate whose project is detailed in the paper, expressed an exuberance, and at times, an overabundance of trade lingo within his studies, but excelled at developing and translating the concept all the way through his project. The M.Arch.

students were divided as some waivered and tended to overlook the growing influence of technology for almost the entirety of the project while the remaining few engaged the novelty of manipulating a re-discovered active agent in architectural programming.

A student generated studio summary follows.

> Architecture has become an entity that is no longer just for people, but for peripherals. Inhabited by devices that hold potential only limited by the user's imagination, digital technology [disruptor] serves as a catalyst to fixed architectural programming [disruptee]. With time, the power and impact of these technologies will continue to challenge the built environment. This research has shown that standard programmatic processes must react to the ever changing nature of a future driven by pervasive technological disruption. Through the concise oscillation of program and spatial practice, new forms, both urban and architectural can begin manifesting into an innovative, disruptive programmatic model. (Graduate Studio 2014).

Through this programming exercise we were able to comprehend a significant modification of past practices through a loosening of traditional relationships and constraints, fundamentally recreating a structure's organization, shape, and scale. Specifically, the two student projects have demonstrated the proposition that project programming can become generative through a socio economic approach to the problems associated with computation and space.

Systemic integration supports and sustains design's impact beyond the visible, object based outcome. Contextual consciousness vividly illustrates the acceleration of change taking place around us and begins to situate design as an infrastructural component. ''It's really about thinking about the often-invisible systems that are supporting our way of living. It's thinking about the context in which we are living, as an ecology that sustains process.'' (Mau 2011). Design authorship and pragmatic acumen have not faded, but are re-aligned with emerging notions of the identities of material, product, service, lifestyle, and programmatic disruption.

Yet it contributes to the search for a new materiality in architecture and "…the crucial role of concrete sensory experience and what I [sic] have called materiality, in other words our relation with the physical world" (Picon 2010, 212). With further iterations, this mode of study should have a critical effect upon both, traditional and emerging building design/practices. Embedding technology with program or conversely, embedding program with technology has required a re-imagination of architectural programming in response to the emerging socio-technological desires as well as the way we conceive architecture.

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