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Accountable Technologies: An Interdisciplinary Investigation into the Design and Engineering of Transportation Systems

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Abbreviations

AAPL	Apple Corporation
ANT	Actor Network Theory
BART	Bay Area Rapid Transit
ETT	Evacuated Tube Transport
GHG	Green House Gases
GM	General Motors
Hyperloop-CAL	California based Hyperloop
HSR	High Speed Rail
IPO	Initial Public Offering
PPP	Public-Private Partnership
REE	Rare Earth Elements
SWOPSI	Stanford Workshop on Political and Social Issues
TNC	Transit Network Companies
VHST	Very High Speed Transit
XOM	Exxon Mobile Corporation

ABSTRACT: *Technology—the extension of human capabilities by way of scientific principles and knowledge, fundamentally alters not only human experience, but also human consciousness itself. Humanity's intimate relationship with technology in both a material and abstract sense constitutes a significant part of our condition as social creatures. While undoubtedly powerful, technology has often been misunderstood—inaccurately romanticized or unjustly demonized. Such misunderstandings arise, as shall be shown, when technology is mistakenly conceived as a static and distinct ontological object of study. Using an interdisciplinary approach grounded in philosophy of technology and social theory, this essay investigates the multifaceted topic of transportation systems in California including Bay Area Rapid Transit (BART) and the theoretical design for the Evacuated Tube Transport (ETT) system, Hyperloop. This essay advocates for human centered, "accountable technologies" that are multidimensional, preemptive, egalitarian and responsible technologies capable of maximizing human progress.*

KEYWORDS: Technology, Public Transit, Hyperloop, Bay Area Rapid Transit, California

Preface

As a Bay Area native, I find the social dynamics of public transportation systems fascinating. For those with the means to avoid these structures, they appear an idealization, a milieu of "otherness," which is often unexplainable or unintelligible. While my endless hours riding Bay Area transit—from BART to Caltrain and to AC transit—has stimulated deep affective reactions to me, it was not until I attended UC Santa Cruz that I was able to articulate these subtle but meaningful moments in a new light. From the scholarship of Foucault, to Kant, to W.E.B. Du Bois, (who I often read during my waiting time between connections in busy terminals) I began to realize the profound ways in which human behavior is intrinsically linked to the power and infrastructural dynamics of distinct systems. The more I read of the effects of institutional power, the more these ensuing social divisions have puzzled me. While the results of historical decision-making processes have come to effect the lives of so many, the marginal few remain seemingly oblivious to their systemic and corrosive effects.

While my initial inspiration for this project was my affective understanding—a key feature, which perhaps is the dividing force between the marginal and the marginalized—my enduring duty has always been toward the justice of all. As I hope my readers will come to agree, I strongly believe in the power of education and awareness to change these conditions. If such conditions can be made, there is no doubt they can become unmade. While this work cannot fully encapsulate such circumstances, I hope it will question the minds of readers as a step in the right direction.

Background: The Philosophy of Technology

Philosophy of technology, the study of the fundamental nature, processes and effects of technology as defined in the broadest sense possible, has become increasingly urgent as humanity becomes increasingly entangled and reliant on its diverse forms. Technology, which shapes, conditions and cultivates human life, can lead to the development or deterioration of the world at large. As philosopher Frederick Ferré describes this predicament in *Philosophy of Technology*, (1988) "Our age needs nothing more deeply than careful, comprehensive thinking about technology, our modern pride and peril" (p. X). A wide-ranging and thorough understanding of technology is critical in developing "accountable" technologies capable of resolving critical problems that impair human development without creating new problems in the process.

Accountable technologies are imminently human centered devices that revolutionize not only our physical means, but also the way in which we conceptualize our own humanity. These technologies incorporate sustainable practices and efficiency in the decision making processes to maximize the scope of human potential and progress across numerous dimensions of society. Accountable technologies minimize adverse effects by introducing preemptive analyses to account for the full range of potentialities. They are responsible technologies that evaluate the effects of design on socio-cultural, legal, moral, environmental, economic, and political grounds. Accountable technologies are inherently egalitarian as they adhere to fundamental, critical social problems.

A proper definition of technology—a seemingly self-evident term—is required to discern the nature and scope of our inquiry. Common dictionary denotations of "technology" according to Ferré (1988) refer to "the study of practical arts or…the science of the industrial arts," (p. X). However as Ferré (1988) points out:

> The term…point[s] to…the implements, instruments, crafts, devices, utilities, contrivances, inventions, machines, artifices, tools, engines, utensils, and techniques that constitute the first-order subject matter of the institutes of technology," (emphasis added) (p. X).

The term "technology" thus essentially applies to any human feat, act or interaction that manipulates nature or extends human ability.[1] Technologies are the implementation of tools and methods, which allow humans to meet desired ends. In Ferré's (1988) conception technology is defined as any, "practical implementation of human intelligence" (p. X). Technology may comprise anything from an aboriginal digger stick used to unearth edible roots, to the entire panoply of the military-commercial GPS system with fleets of rockets and satellites, racks of servers and millions of lines of software code.

In *The Question Concerning Technology* (1977), philosopher Martin Heidegger theorizes about what technology fundamentally is, citing two primary characteristics of technology Ferré (1988) defines as, "an end-seeking human activity and…the use of equipment, tools, machines and the like to achieve those ends" (p. X). Technology, in this broad conceptual sense is ontologically divided by what I define as process—i.e. an adaptive, productive human activity deeply related to the needs, wants and constraints of the human condition and product—i.e. a static object (including its architecture and

[1] It should be noted that philosophers of technology do not agree on how to define "technology." Philosophers of technology vary widely on whether technology is made of matter, whether it necessarily is scientifically based or "unnatural" (e.g. an "artifact," "artificial" or "natural" object) and so forth. There is also disagreement as to whether tool-using animals (from insects, to birds, to higher primates) should be considered users of technology.

materiality) which can be utilized as the means to a given end, and a contextually fixed object. Heidegger (1977) attempts to consolidate these two distinct notions technology is often directed toward, arguing the need for a unified view.

Connecting technology as both process and product, we accurately and holistically capture technology's essence. Technology, which is multifaceted, necessitates a view that encompasses its entirety, as neither product nor process alone may capture its full essence. As Heidegger (1977) states, "The two definitions…posit…and…belong to what technology is. The whole complex of these contrivances is technology" (p. X). Although technology might seem oddly depicted as both a physical object and an abstracted theory, this definition need not be in conflict. Employing anthropologist and sociologist of science Bruno Latour's (2005) Actor Network Theory (ANT):

> It [is] possible to have two completely opposite meanings for the same adjective, granted that each, pursue[s] simultaneously…different tasks…settling the controversies…and trying to solve the 'social question' by offering some prosthesis for political action.

Indeed, technology (as product) in relation to human interaction and use (as process) grants it complex capacities with many dimensions. In what follows, technology will be analyzed in terms of its two natures as both product and process. Key principles that define technology's dual properties will be outlined to articulate the many ways technology performs in relation to human usage.

Technology as Product

Technologies as products exhibit several key principles that define their form. In what follows, these criteria will be detailed at length. These principles include:

Principles of Technology as a Product

1. ***Extension of Nature or Human Capabilities.*** Technology is defined as the reflection of an organic quality, human ideal or potential. It is derived by nature and reflects its design;
2. ***Materiality.*** The matter, form and physical constraints that shape technology as extant in space-time. Physicality, which produces real world effects;
3. ***Architectural Structure.*** The plan and composition of parts, relation and complexity of its pieces;
4. ***Non-Agential Tool.*** As an instrumental tool lacking in intentionality or agency, necessarily secondary to human beings; and,
5. ***Functionality.*** Designed for a specified goal, with impute and outputs. Built to "problem solve."

Extension of Nature or Human Capabilities

Technologies generally imitate or derive from organic entities in their utility, architecture, or scope. While technologies often reflect or model human capabilities, they usually magnify pre-existing human abilities distinctly. To exemplify this point, consider the function of neurons, which I will here divide into the standard three categories—sensory neurons, interneurons and motor neurons—as an example. Sensory neurons and the five senses allow us, for example, to measure relative temperature, time, pressure and pain. The sensory neuron system gathers information from stimuli, transports, processes and makes it available to the meaning or contextual processes by which we understand and then use the originally raw stimuli.

In this same manner, many information technologies emulate organic systems. For instance, through simple electrical circuits, information technologies can simultaneously measure and adjust temperature, such as when a thermostat with a mercury switch turns off and on a gas furnace (Walsh Denis, and Huneman 2013). Similar to the way humans maintain homeostasis, a thermostat is capable of maintaining and measuring the temperature of its environment. At a more sophisticated level, modern digital technological systems can utilize visual pattern recognition while discerning packages on a FedEx conveyor, or reading complex symbols through QR codes. Machine vision has even begun to recognize facial expressions, and in the future may simulate human intelligence to the level that the line between human and machine intelligence becomes blurred.

Moving past organic sensory systems and their technological counterparts, motor systems allow humans to control our physical mobility and movement as well as regulate biological processes including breathing and heartbeat. It is no surprise that airplane "wings" resemble those of a bird, as the laws of physics and aerodynamics apply to both. Indeed, the engineering field of biomimetics—a study of the imitation of nature's efficient and remarkable efficient designs applied to technologies—is based on the foundational assumption that technologies can learn much from natures pre-existing functions (Penn 2013).

Using nature's plans and specifications, biomimetic engineering can make vast strides. For example, studying the aerodynamics of winged birds, engineers at Penn State are designing aircraft wings, which are flexible enough to alter their shape as they move through different phases of flight the same way birds do. Biomimicry is also used often in the field of robotics where the movements of anthropomorphic robots are modeled on human motor capacities and physical abilities. Robot arms used in assembly operations resemble human arms and model biological structures such as joints and muscles allowing the mechanism to shift, extend, lift and manipulate in much the same fashion as a human worker might operate.

Interneurons embedded deep in central nervous system act as interlocutors passing signals between sensory and motor neurons as well as to one another. Interneurons, used for cognition, sensation and reaction function in a strikingly similar way to complex technological systems today. Modern networked communications systems are built from millions of lines of code from complex math that involves probabilities, matrixes, relational logic, and so forth. These technological systems resemble human languages and are essentially a cognitive technology of semantic and syntactic codes with "rules" to derive meaning from the complex relations of the simpler systems from which they derive.

Though technological systems often resemble natural systems technologies do not identically replicate nature. As sociologist Tiziana Terranova (2004) writes regarding biological computing in *Network Culture: Politics for the Information Age*, "Human technicity does not so much construct...extensions of man, but rather intensifies at specific points its engagement with different levels of the organization of nature" (p. X). As such, the most critical distinction between technological and natural systems is that technologies magnify nature, and respond to human needs in a distinctly efficient manner or to a scale or degree beyond the scope of natural systems. Because technologies are inherently "unnatural" or more precisely, extra-natural, their greatest value is that they extend human capabilities in the service of addressing human needs through value systems. Thus, while a fork may resemble a human hand in its design and function, a fork without the aid of its human manipulator is in every sense useless as well as valueless. That is, we—the humans—give a fork its function.

<u>Materiality</u>

Technologies as products are defined and constituted by their physical presence, i.e. their matter and space. Materiality relates to isolated features such as geography, or the accessible physical resources and components available to make a technology. For instance, objects comprised of precious metals or elements such as rare earth elements (REE) are exceedingly difficult to harvest and acquire due to either their scarcity or to the unevenness of their concentration. Although abundant, 97% of REE production occurs exclusively in China where deposits are in higher concentration (and are more profitable) relative to other areas of the world. According to G.P. Thomas, because REE's have, "the widest ranging application of any metals, and are essential in the electronic, optical and magnetic industries," (p. X) these elements—by their sheer materiality and the politics surrounding them, become much more precious.

Technologies' materiality is influenced by numerous considerations. From broad geo-political impacts to more inherent factors such as the raw elements available, many elements play a role in how technologies are materialized. This principle becomes significant when engineering complex technologies, particularly transportation systems, which require massive resources and regions. Fundamentally, geo-politics conditions not only what technologies may be constructed, but likewise where and how they can be built.

Architectural Structure

Though materiality and architecture are connected, architecture pertains to the relations of parts while materiality refers to the physical nature of particular units. As philosopher Rasmus Grønfeldt Winther (2009) describes in his article, *Part Whole Science*, “There are multiple crosscutting manners of abstracting a system into kinds of parts—i.e., there are multiple partitioning frames” (p. X). A partitioning frame might be seen as a reference point or, “a set of theoretical and experimental commitments to a particular way of abstracting kinds of parts” (p. X). An “internal” architectural structure might refer to the way in which a cell phone interface interacts with software and hardware including a circuit board, battery, and antenna, whereas a much larger external architectural structure might be the University of California system. Architecture in both examples is the causal relationship of parts to a whole that shapes, limits and conditions the outcome and potentials of a technology.

To illustrate how materiality and architecture both differ and complement one another, consider the city of Los Angeles. Within its 469 sq. miles, automobiles outnumber people. Yet despite its huge size, it's huge space, Los Angeles has some of the most notorious traffic in the world. Comparatively, in New York City the Metropolitan Transportation Authority—the largest transportation network in North America, which serves 15.1 million people, carries more than 280 million vehicles per year. However, the New York City Metropolitan Transportation Authority also manages to "avoid about 17 million metric pollutants while emitting only 2 million metric tons, making it perhaps the single biggest source of greenhouse gas (GHG) avoidance in the United States" (p. X).

Indeed, the sheer materiality of cars—which take up a vastly larger surface regions compared to other transit forms that carry the same number of bodies per capita—is much more problematic when aggregated. While the features of cars such as their mass and size relates to their materiality, the infrastructural whole of many cars within the greater system, constitute the cities architectural technology, with only the later being problematic in this case. Physical constraints, as well as architectural structure—the density of cars in an area—both create significant effects when taken into account.

Non-Agential Tool

Technology must be understood as subordinate to human beings who deploy these instrumental tools. Technology, which is created to adhere to human needs, derives its value from human usage. As products, technologies cannot possibly contain the inherent value of the living beings that invent, evolve and use them. Instead technologies are defined in terms of their utilized value or market value—i.e. their commodity or exchange value. As tools, technologies have no fundamental rights or dignity rather their value extends only to their utility in relation to humans. No matter how powerful, precise, or even how closely they resemble humans in their design, technologies cannot be mistaken as ever fully autonomous. Technologies cannot self-generate or produce like living beings and lack agency.

Philosopher Immanuel Kant's conception of autonomy is critical in distinguishing the subtlety of this argument. According to philosopher Lara Denis (2012) in *The Stanford Encyclopedia of Philosophy*, Kant defines autonomy as:

> The property of the will by which it is a law to itself (independently of any property of the objects of volition…the will of a moral agent is autonomous in that it both gives itself the moral law (it is self-legislating) and can constrain or motivate itself to follow the law (it is self-constraining or self-motivating). The source of the moral law is not in the agent's feelings, natural impulses or inclinations, but in her pure, rational will or noumenal self…Heteronomous wills, on the other hand, are governed by some external force or authority—that is, by something other than a self-given law of reason. Kant assumes that all nonhuman animals, for example, are heteronomous, their wills governed by nature through their instincts, impulses, and empirical desires, (Emphasis added) (p. X).

Invoking this definition we should recognize technologies as non-agential and unable to be self-determinate, self-reliant or self-sustaining. In the same way a child is forever indebted to their parents, technologies, as produced objects rely solely on us for their existence, guidance or understanding in the world. Without human beings, technologies are just things rusting.

Citing Latour's (2005) Actor Network Theory (ANT) I do not allow for, "the establishment of some absurd 'symmetry between humans and non-humans,'" nevertheless, "Objects, by the very nature of their connections with humans, quickly shift from being mediators to intermediaries" (Latour, 76). By this point, Latour attempts to convey that objects may be traceable in the same manner society itself may be traceable—they leave empirical effects. That is, what matters in determining an object of study is what constitutes a, "critical difference" as it regards human or non-human actors. As Latour (2005) contends, "When we say that a fact is constructed, we simply mean that we account for the solid objective reality by mobilizing various entities…non-human entities have to play that major role" (p. X). While holistically the account in this thesis differs with Latour's ANT in many fashions, ANT helps provide a more thorough understanding of how non-human actors or technologies produce real world effects.

Latour's ANT will be further clarified and discussed as we turn to technology as a process.

Functionality

Technologies are also defined in terms of their functional use. Functional technologies may be identified in terms of their quantitatively measurable outcomes. Technologies produce real world results that may be empirically or mathematically measured. However, in the sense that a technology's function directly responds to a particular social need, technologies' *effects* transcend their object forms producing both intended and unintentional results. Similar to philosopher John Dewey's (2006 X) view of technology as, "the power to transform the world," utilized, "to serve ideal ends" technologies objective is always to solve a social problem—whether that is for communication, entertainment, mobility, health, shelter or sanitation for instance (Levin 2006). Therefore, technology's functionality also relates to the specific need(s) a technology addresses.

Technology's function also grants it an inherent utilized value, relating to objects usefulness and utility. Similar to Marx's conception of "use value," utilized value is objectively determined but related to a technologies social need. Technology's function makes its object a commodity according to its practical power to yield a particular result within a given context. As commodities, technologies derive meaning from their purpose, whereas market value derives from market conditions. However, technologies may also retain value from their social value that is, from society's perceptions of how well or how useful a particular object functions to yield a desired response. Directly related to utilized value is a social calculation of quality, i.e. how well a product functions, that in turn creates its market value. Social value also may be measured by how well a technology is able to respond to a plethora of social needs. Price is thus determined not solely by the market conditions of supply, demand, or labor, but also by the perceived utility or quality of the technology, especially in comparison to technologies of the same or similar functioning.

Often, technologies have multiple functions that operate simultaneously. These functions can be designated as primary design functions and sub-functions. Unlike primary functions, sub-functions may or may not be deliberately considered in the design process. Sub-functions may also shift over time, especially in regard to evolving social needs and historical context. For instance, while the primary purpose of a train might be to carry passengers or transport cargo, many who ride the train have the added feature of leisure, including the added time to read, write, rest or listen to music. Thus, technologies often exceed their primary design function producing many sub-functions, which can either add or subtract benefits.

Invoking the "law of unintended consequences," a notion conceived by renowned sociologist of science Robert K Merton, often sub-functions are unforeseen, especially those that are problematic (1936). For instance, the Internet became the ideal platform for the most egregious and extensive distribution of pornography the world had ever seen. Particularly, the heinous crime of child pornography— by nature clandestine and requiring anonymity—is rampant across the Internet. The unintended consequence of child pornography flows from the very architecture of the Internet as both a vast interconnected and anonymous platform, but at any case is most fateful. However, as should be noted, intended and designed functions as well as unforeseen sub-functions are the primary source of the meanings of technology as we turn to technology as a process.

Technology as Process

Principles of Technology as a Process

1. ***Teleology of Progress.*** Advancement as a theoretical ideal in which technology is adaptive and evolving;
2. ***Law of Obsoletes.*** Laws governing the recreation and interchangeability of technologies that become outdated or "dead" and eventually useless;
3. ***Double-Feedback.*** Loops consciousness and psyches, embodies ideals, and reflects humanity both materially and symbolically;
4. ***Humanistically Embedded.*** Technology as an essential part of the human experience for better or worse, entrenched, inert, unavoidable, and co-constitutive; and,
5. ***Decision Fossilization.*** Technologies reliance on the social construction of value becomes ingrained and crystallized as it advances.

Teleology of Progress

If we are Darwinists and recognize a teleological process in evolution (even if the causes are random mutation over millions of years), then a teleology of technological progress may be a corollary to be expected. Given human intelligence, desire, capacities and the will towards safety, comfort, full stomachs, etc. technology—which delivers the results—is bound to have a purposeful direction, a vector if you will. Technology as a process is additive and exponential, meaning they accumulate and magnify, beginning with ideal as potentials that become materialized and actualized. Thus, it is not difficult to discern a teleology of technological progress, coded perhaps in the genome that will someday be teased out by techniques themselves.

As an additive process, the more we build, the more we are capable of building. The additive nature of technology, which stems from its response to social needs, necessarily makes it a process, requiring human Technology is also generative, where the technological-human relation is holistically reproducing but nevertheless technology by itself remains static. Technology's dependence on more fundamental basic scientific knowledge explains how and why it progresses the human species as such. Technology evolves and is adaptive— modeling and remaking itself in a more or less linear, progressive fashion as more, knowledge and complexity are added.

While technology immensely and inevitably alters human life, it does so in a way that makes regression impractical and exceedingly rare. That is, technology depreciates but it does not degenerate, it may stall, but—if history is a guide—never stagnates. Because technology is a social and historical phenomenon, it is bound to human progress at large. In the same way the human race continues to evolve despite the death of any single human being, so does technology advance and proceed despite the erasure of any specific object. While technology may slow down, as a change agent it can never plateau or halt forever. If technology fell backwards during the Dark Ages, aggregated over a holistic timeline it recovered and surged forward again.

In addition to the additive, technology is also accelerative. As progress begets progress, the technological enterprise speeds up. One example is the rapid progression of mobility in the past 150 years relative to the span of history, where humans have shifted from oxcart, to horse and buggy, to Model T to the Tesla roadster on the four-wheel track. Furthermore, though the motorcycle may duplicate the primary function of the bicycle, to mobilize more potently the bicycle is not easily discarded. A bicycle retains its sub-functionality; it may be used to stay fit, or to travel on mountain trails a motorcycle can't access, or to commute short distances where parking is a problem. Bikes have the added sub-function of helping to create human oriented cities. Technological progress allows bikes to incorporate electric motors to increase their functionality. As such, bikes are constructed to adhere to additional social needs, maintaining their human centric nature while also expanding their utility to those who opt for this alternative (e.g. those who may not want to combine a workout with a commute). Finally, a teleology of progress describes tools that have reached their capacities and become effectually "dead." Dead or obsolete technologies are those whose principal functions can no longer be maintained or whose social needs can no longer be met.

Law of Obsoletes

As technology evolves, particular outdated technologies may decrease in their utilized, market, and social value. This loss of value might be called the "law of obsoletes," which applies to the process of obsolescence, the lifespan of technologies, and the stages by which particular, time-delimited technologies lose value and are finally (in the main) discarded. Technologies maintain a lifespan and become "dead" for various reasons. However, the law of obsoletes is not necessarily inversely related to the teleology of progress, (i.e. as progress increases, more things become obsolete) nor does the teleology of progress explain fully how and why some technologies lose their value.

Besides malfunctioning technologies, two salient facts are use-obsolescence and social-obsolescence. A particular technology may eventually lose so much utilitarian or use-value as to become almost totally extinct, except as an antique. An example would be the horse and buggy relative to the car. Many technologies become socially obsolete by their loss of social value. Social value—the most complex and fluid of these "values" is ever-changing and determined by societies and individuals in particular contexts.

Technologies become use-obsolete when they surpass a threshold value relative to newer more efficient or powerful technologies that even at a discounted price they don't sell. Yet, as social value decreases, we feel compelled to replace older technology for newer technology even though there isn't as bright a utilitarian line. For example, “early adopters” want the newest cell phone with a 15-megapixel camera when the 8-megapixel cameras take almost identical pictures. This example included, not all technologies are created equal thus, when more functional or current technologies come forth that meet more social needs of the users including functionality and sub-functionality, others may be discarded.

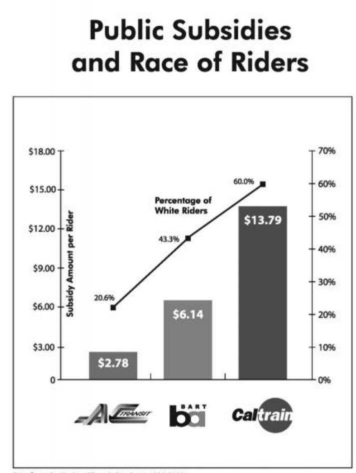
Of course, there are strong market-social forces apart from technological that drive the “fetishization” of consumer products like cell phones. As sociologist Herman Gray (2013) writes in *Subject(ed) to Recognition* neoliberal capitalist agendas, coupled with market identities, produce a new form of brand loyalty and subculture affiliation. Applied to technologies, strong social-obsolescence pressures on consumers to keep up with the latest products are often tied to affective means of belonging. Regardless of the process by which technology loses use and social value and is replaced, the law of obsoletes provides that old technology is readily and easily substituted in terms of its function.

Double-Feedback

As they interact with humans, technologies shape our individual psyches, embody human ideals and values, and reflect social realities in a myriad of ways. In *The Human*

Challenge in Engineering Design, Rolf A. Faste (2001) a Stanford mechanical engineer articulates the expanding role of the engineer to more comprehensively incorporate "the entire spectrum of humane concern[s]…to…generate successful products." Among eight key tactics Faste (2001) posits the need for engineers to, "understand…when they design products…they are designing behaviors and experience…as well as providing functional utility…The conception and realization of products is no longer neatly divisible." Indeed, as the word double-feedback suggests, technology as a process is *reciprocal*, a two-way activity in which humans and their technologies interact and simultaneously effect/affect and shape one another. Moreover, this process is "double" as it related to the dualistic way in which technologies can be measured both by their material and symbolic levels as well as intra between the two dimensions.

Public transportation for instance, is a prime example of how social relations are quite literally "mapped" in terms of socio-economic class, race and gender to particular transportation technologies. Stigmas "attach" to inter-city buses and light rail while status is mapped onto Caltrain and Google buses. As a double feedback, technology and its environment react to one another anteriorly, concurrently and subsequently to produce, reflect and account for particular outcomes. Thus social mappings create, reflect and produce social perceptions and bias in a looping effect.



However, this is not just a matter of perception, funding disparities and other material forces are behind these social outcomes. Studies from several sociologists including, Kawabata and Shen, 2007; Fleetwood, 2004; Leyden, 2003; Freeman, 2001; Yago, 1983; Rabin, 1973 have shown significant correlation between physical mobility and social mobility and the with high levels of inequality prevalent in institutional and economic practices of public transit systems that correlate to the many ways built societies influence individual and social perceptions of communities.

Additionally, our attempt to "improve the world" through invention and engineering, creates and embodies reality as we wish to see it—often in a more uniform and "logical" world. As sociologist and philosopher of technology Lewis Mumford (1934) argues the clock transformed human consciousness and reality, "helped create the belief in an independent world of mathematically measurable consequences." Indeed, as author Michael Shallis (1984) writes, the clock revolutionized human's conceptualization of time itself, creating a more:

> Linear, progressive, sequential awareness of time, in place of the organic, cyclic perception of time man had before. The clock transformed society and subjected people to the rule of time, to work by the clock…rather than when ready to be done…the mechanization of time…paved the way for the mechanization of speech, through the printing press, and the mechanization of space through modern transport, (p. X).

Undeniably, technology transcends its mere material realm and produces powerful consequences that deeply alter the ways in which humans experience and understand the world.

Actor Network Theory (ANT) is useful in tracking the way in which humans and technologies produce effects on one another, or as he writes, "the tracing of associations…a type of connection between things that are not themselves social" (p. X). Latour's (2005) deployment also helps to "restrict in advance the social to a specific domain" (p. X). As our object of study—technology— entrenches so many divergent aspects of humanity, ANT allows us to “trace” these ends accurately. Moreover, ANT is empirical and does not theorize or make assumptions about agents. Thus from a sociological perspective, we can study precisely what people say and do without making unjustified inferences.

Humanistically Embedded

Related to technological development as a process, is the principle of technology as humanistically embedded. Technology is dependent and coupled to human experience—built slowly from scientific, historical and cultural phenomena that have shaped the human reality in profound ways. Technological innovations have marked monumental points in human achievement, from the first Oldowan stone tools to the Apollo 11 moon landing. Technologies cultivate our existence arguably, as much as we cultivate it. It is our profound dependence on technology that makes it so valuable but also, so potentially dangerous.

Lacking alternatives, we are often bound to technologies that at best, no longer meet our needs and at worst, are self-defeating. Returning to our example of transportation in Los Angeles, this car centric city has been *designed* to require car ownership—even for those who would prefer other options. Conversely, for New York City dwellers, a reliance on public transportation is crucial, as other transit options are often less reasonable or feasible. Indeed, we are bound to technologies, for better or worse. As the teleology progresses, technologies only become more strongly bound to us—through dependency and co-constitution technologies become not just our extensions, but a bodily part of us.

It is no surprise that as technology has become more advanced, so have thinkers become more critical of it. Humanitarian intellectuals like Herbert Marcuse in *One Dimensional Man* (1964), or Alex Huxley in *Brave New World* (1932) and even Suzanne Collins in *The Hunger Games Trilogy* (2008) portray technology as inherently dystopian. Technology is seen an incessant, dominating or manipulative luring us to greed, corruption and ultimately, self-destruction. Yet by a similar token technology is frequently romanticized as well, often in an unrealistic or uncritical manner. Because technology is non-agential, a more accurate analysis would account for the human element of technology. That is, we ought to be more critical of how we employ technology. As we utilize technology to eliminate social woes, social forces will always drive the design and consequences of particular technologies. It is best we take a realistic, and pragmatic approach toward technology, recognizing its potentials and simultaneously, our inevitable dependence to it.

Decision Fossilization

Finally, considering the trail thus far it should come by no surprise that technology, which is directed by decision processes on many levels, begins in rough, schematics and accumulates and accelerates over time. While there is an internal teleology, (a natural progression of technology that inherently takes place without apparent direct human intervention), each individual technological enterprise—necessarily requires decision making to suit the scale of the innovation itself. Less complex technologies that require fewer design decisions necessitate less pre-emptive measures and processes in their development. Engineering and design necessitates consideration so technologies optimally perform to advance particular social aims. Technology will always produce consequences, but the question is whether or not these will adhere or deter human progress. As Faste (2001) argues,

> The fundamental need for engineering in the new century is to acknowledge and embrace the human nature of its endeavor…a spectrum of human concerns beginning with straightforward design issues and escalating philosophical assumptions about the nature of man, (p. X).

Indeed, there are innumerous considerations to account for within the engineering process than often span several aspects of human experience.

Technologies, as human centered tools, transcend their forms as pure objects or artifacts and are fossilized. Proper forethought of how technologies are produced and what aspects of humanity they seek to magnify are of the upmost importance in engineering. Because of this, we must make decisions as to what our true purposes are and what we value as objective ends. If we seek to truly strive toward a society with better potentialities, this proper and necessary consideration will be a key requirement.

The Value and Neutrality of Technology

The debate as to whether technology is innately neutral or inherently value laden brings us to another philosophical divide that has troubled intellectuals over the ages. Here, it is useful to recall our definition of technology as both product and process, which allows us more nuance in our analysis. Heidegger (X) particularly was amongst those who rejected the neutrality thesis, which asserts that unforeseen consequences are the fault of their users or developers not technologies themselves. Arguably there are some technologies that by their very design are inherently flawed. Given a Kantian view however, technologies as objects do not have the autonomy necessary to be held liable, thus Kant (X) may be among those who uphold the neutrality thesis. While indeed technologies are not necessarily themselves to blame, as Latour (X) shows us with his ANT, non-human agents may nevertheless produce real world, adverse effects. In this sense, they should nevertheless be seen as value-laden.

While both Kant and Latour are right to differentiate between humans and non-humans as technologies are not level with human actors as intentional and self-conscious beings, technology's *application* is where this question becomes important. Technology is enmeshed in many forms of social life and in many ways cannot be separated except perhaps theoretically. To this end, we are in need of accountable technologies that are held to more stringent criteria beyond these theoretical bounds. Accountable technologies take into account complexities of human life and the actualities of real world conditions.

Moreover, not all technology is created equal, some technological objects are more valuable, more extensive and more pervasive than others. Therefore, while we may develop an even measure or criteria to evaluate different technologies, different outcomes will inevitably ensue. While some technologies have noble and righteous objectives, others are quite frivolous or even immoral. Weapons of mass destruction and prosthetic limbs are equally valid technologies but may not retain moral equivalency. What is critical in considering the value or neutrality of technologies relates to what to our original conception of technology as both product and process, that is—what it is designed for and how it may be used to a given end.

Science and technology are not new phenomena, and yet, the more we rely on technology, the more urgent it is we as a society understand the true way in which technology functions in our lives. In furtherance of this need for understanding, we must understand and be skeptical of who is deploying technology and to what end. As astronomer and astrophysicist Carl Sagan (1996) warns in an interview with American talk show host, Charlie Rose:

> There's two kinds of dangers…one is that **we have arranged a society based on science and technology, in which nobody understands anything about science and technology** and this combustible mixture of ignorance and power, sooner or later is going to blow up in our faces…who is running the science and technology, in a democracy if the people don't know anything about it? And the second reason…is that science is more than a body of knowledge. **It is a way of thinking**, *a way of skeptically interrogating the universe with a fine understanding of human fallibility*. If we are not able to ask skeptical questions, to interrogate those who tell us that something is true, to be skeptical of those in authority-- then we are up for grabs for the next charlotten, political or religious who comes ambling along. It's a thing Jefferson lay great stress on. It wasn't enough, he said to enshrine some rights in a Constitution or in the Bill of Rights, the people had to be educated and they had to practice their skepticism and their education otherwise we don't run the government, the government runs us, (Emphasis added) (X).

Though Sagan's account a politically focused warning his complex understandings of the dangers of technology are properly placed. In the wrong hands or without proper regulation, accountability or transparency, technology can be lethal and immensely destructive to societies at large. As a public, it is our duty to be informed, not only of technology as product, but moreover as a process with a deep understanding of where human err lies. It is our obligation to demand that technologies fit our needs rather than controlling our futures.

Overview of California's Public Transportation—History, Design, Efficacy and Barriers

Our national welfare depends on the provision of good urban transportation with the proper use of private vehicles and modern mass transit to help shape, as well as serve, urban growth.

--John F. Kennedy, 1962

History of Los Angeles's Public Transportation

America has had a long love affair with the automobile, coveting car ownership since the invention of Ford's Model T in 1908. Henry Ford's first mass-produced and mass-marketed car was affordable to the working classes, at a price as low as $345, mitigating the social status that cars were only for the wealthy (X). As historian Clay McShane (1995) writes, "More than any other consumer good the motor car provided fantasies of status, freedom, and escape from the constraints of a highly disciplined urban industrial order" (p. X). Of course, escape from the archaic rural order was also possible, especially when a network of paved roads replaced what had been mud trails.

The introduction of the automobile as an idealized commodity not only epitomized the American Dream, its rapid expansion over the years 1950 to 1980 in which, "the number of cars would increase from 50 million to 350 million," (p. X) transformed major cities all over the nation, prompting architects and city planners to accommodate to the "landscape of the car," (Bell, 2001). Indeed, this massive surge of car ownership and the adaptation of the surrounding infrastructure in response to the car is omnipresent to this day, and to an even greater magnitude, as projections of worldwide car ownership in 2030 reach as high as one billion units (X).

While Americans undoubtedly love their cars, there exists a common misconception that urban and suburban infrastructure exclusively reflects market demand for the automobile. Consumer choice has been heavily conditioned by market and advertising factors as well as political influences, which have often led to the dearth of alternatives. In *Building American Cities: The Urban Real Estate Game*, sociologists Joe R. Feagin and Robert Parker (2002) oppose historian Scott Bottles's (1987) thesis. Bottle (1987) writes, "American's present urban transportation system largely reflects choices made by the public itself" (p. X). As Feagin and Parker (2002) portray the same events, "the complexity and shape of cities…[is] ***determined by technological developments*** in transportation…including… capitalistic history and ***decision-making contexts***…resulted in the positioning of automobiles at the heart of the U.S. transportation system," (emphasis added) (p. X). As the principle of decision fossilization suggests, Feagin and Parker (2002) argue that historical choices were instrumental in shaping Los Angeles's auto-centric society.

Prior to the expansion of cars, at the turn of the 20th century, most cities—Los Angeles included—had highly developed mass transit systems jointly facilitated by government and private enterprise. These systems included "electric trolley routes, elevated railroads, and subways," (p. X). Citing research conducted by sociologist Glenn Yago, the authors make the case that following the automobile boom in 1908, by 1916-1923, enterprises resulting from mergers between transit firms and newer companies showed evidence of corrupt accounting practices, with the "over-extension of lines for real estate speculation, and overcapitalization" which in turn resulted in "bankruptcy of more than one-third of the private urban transit companies," (p. X) and consequently discouraged further funding or investing. As a result, public transportation became increasingly worse in quality and stagnated.

Interestingly, in both Bottles (1987) account, and in Feagin and Parker's (2002), there is no argument that "the auto-oil-rubber industrial complex," (p. X) not only capitalized on the expansion of the auto industry in throughout the nation, but— most evidently in Los Angeles—the companies equally conspired to create an egregious monopoly through links to corrupt politicians and public officials. Bankers, who also favored the auto industries, participated by selling obsolete and bankrupt public transit systems at inflated prices to make immense profits. Moreover, public transit systems, which threatened these businesses, were eventually taken over and systematically dismantled. These companies destroyed the trolley system in Los Angeles (the largest and most effective at the time in the state), moved Greyhound from railroads to GM manufactured buses and bought up electric transit systems "in 45 cities from New York to Los Angeles," which evidently, "had little to do with consumer choice" (p. X). Criminal conspiracy charges were brought forth in Federal court for antitrust violations which brought both acquittals and convictions, however the men in charge, "each received a trivial $1 fine. The corporations were assessed a modest $5,000 penalty" (p. X).

Against Feagin and Parker (2002), Bottles (1987) asserts a version of the law of obsoletes, that the destruction of public transportation was necessarily justified, as the system was already insufficient. Bottles claims that industries and politicians has planned to replace the inefficient and lacking systems with buses year priors to these decisions due to its poor quality and declining ridership. As Bottles claims, these changes and investments in new infrastructures such as freeways were inevitable, and that "Frustrated by the inadequacies of rail transit, many urban dwellers turned to their automobiles as early as 1910…a viable alternative…and individualistic response to the failure of progressive reform…a symbol of the democratic impulse" (p. X). In Bottles' view—a version of the law of obsoletes—public transit in Los Angeles was already inadequate to respond to societal needs.

While these two sets of authors dispute causation, regardless of whether the causation rests with the advent of the Model T and car culture, the poor quality of the preexisting platforms of public transportation or systematic manipulation of market conditions by business elites that conditioned choices— both sets of authors seem to ignore the greater consequence, that the city of Los Angeles is today, an unsustainable city. Los Angeles, like many cities across the country, necessitates the use of car in a global climate in which exponential population growth, massive global warming and pollution, growing economic inequality, and limited fossil fuels among other social epidemics simply will not allow these lifestyle choices. Cars have become embedded to such an extent, that the constraints of a built environment, coupled with cultural stigma, makes using alternatives transportation choices extremely challenging, (p. X). Moreover, the argument over which of these causes overlooks that both might be simultaneously true either in aspects, or perhaps inversely related (as car culture demand increases, interest and investment in public modes wither) and yet neither get us out of our current troubles.

The advent of the Model T was a critical tipping point; thereafter, the perceived functionality, value and utility of cars was heightened as the perceived functionality value and utility of public transportation rapidly decreased, creating great wealth for Henry

Ford and those who followed. These dueling forms of transportation—cars and public transit—embodied the ideals of the time; expressing individualism, rationalization, wealth and class social hierarchy and democratization—or a lack thereof, (p. X). Their utility reflects real historical, political, and economic conditions and have become socially relied upon to different extents, not only as systems of social transport, but also in terms of the assigned socio-cultural values. Cars and public transit became symbols of wealth and sites of stigma and disparity, respectively, reflecting a double feedback. Indeed as writer and photographer Jonathan Bell (2001) writes in Cariculture, "The car defines our space…[and] has been an integral part of metropolitan life for so long that it has become part of the urban fabric," (p. X) which is quite literally, geographically and architecturally embedded in cities across the country. These infrastructures therefore cannot be simply reversed.

However, in many ways cars have outlived cities and become "dead," at least to the extent they are used as the natural effect of the teleology of progress. In cities like Los Angeles where massive traffic, increasing gas prices, urban sprawl and other impediments are immense, the heavy reliance on cars insufficient to adhere to new human needs or progress. Indeed, as one of the most congested cities in the nation, Los Angeles will need to adapt and develop new alternatives that can maintain the speed we need and luxury we crave, while simultaneously being public, universal and accessible enough to meet even larger, more pressing demands and volumes.

BART in the San Francisco Bay Area

> BART…stands as an example of legislation through technology to constrain, if not enforce, social choices. In effect, BART is a product not only of technology but of technocracy…Technocracy, since it is inherently corrosive of the democratic process, is not a legitimate exercise in our culture. Thus… deciding to build BART, was…politically irresponsible …and…the subsequent implementation of that decision was removed from public influence. (Emphasis added) (p. 201-208).
>
> --Stephen Zwerling, *The Political Consequences of Technological Choice* (1974)

On July 1st 2013, employees of the Bay Area Rapid Transit (BART) system—the nation's 5th most highly utilized public transit rail systems—went on strike for four consecutive days after disputes over wages, healthcare and pension costs for workers could not be resolved (Associated Press 2013). The BART strike generated much public controversy, with anecdotal opinion articles from media sources, social media blogs and web pages showing great public displeasure. More thorough research surveys suggest that community members were generally unsympathetic of the BART administration, but surprisingly, even more upset by the union's demands (p. X). Why is it then, that Bay Area residents seem to be so dissatisfied with BART, and what drove BART workers to these consecutive strikes in the first place?

It is axiomatic that BART has a profound effect on the lives of millions of Bay Area residents in the three largest counties in the Bay Area it serves—San Francisco, Alameda, and Contra Costa. BART has 400,000 riders each day, (X) yet system capability has rapidly declined in comparison to other subway/rail systems since opening in 1972. In fact, the technology underlying the BART system has been arguably obsolete since its opening day. In the past five years, reports concerning crime and safety, sanitation, civil rights and disparities, and other issues have spiked, (X)(X).

Over the last half decade, BART has been the nexus of controversial events, including the most recent strike, which has drastically affected the Bay Area, and the nation at large. These recent events encapsulate an array of societal practices and ramifications in which public transportation—in this case BART—is the central playing field. Indeed, public transportation is an arena where complex social realities and interactions are crystallized, performed and reaffirmed. As a site of significant social interaction in terms of both magnitude and intensity, we should be concerned with how BART and more broadly, public transportation at large, literally and symbolically reflects, shapes and reaffirms our social architecture.

As I will show in this next section, while BART itself is useful in many aspects, its utility is crippled by design failures or poor decision-making choices that began at its onset. BART does not meet the stringent demands of an accountable technology, and while it has made tremendous strides since its beginnings it nevertheless is limited as a cross-demographical regional public transit system in meeting the holistic social needs of Bay Area residents.

Planning for BART began in the 1950's and continued into the 1960's with the optimistic expectation the new system would be, "automated, fast, comfortable and attractive; a modern, space-age version of the rail transit systems in the leading systems of the world" (p. X). While the space age dream was theoretically possible, BART failed to respond to other evolving social needs. According to the Final Report of the BART Impact Program—a five-year long empirical study published in 1979—the rail system

"Hasn't fulfilled some early predictions about its performance and patronage. BART's operating problems have prevented its attaining the service goals," (p. X).

There are several primary reasons BART has struggled to meet its desired serviceability. These aspects, while distinct in themselves, underlie a more fundamental misunderstanding and misapplication of the philosophy of technology as was illustrated prior. These errs include:

1. ***Design Ideology and Methodology.*** BART was not constructed for the larger the public, but was designed as a "specialized" system for suburban corporate workers who needed fast transport to downtown SF offices;
2. ***Technology and Engineering.*** Out of date technology, "obsolete" mechanical systems;
3. ***Efficiency and Efficacy.*** Slow durations, infrequent service on weekends, not meeting public demands;
4. ***Political Impediments.*** Law suits, government constraints and undemocratic practices;
5. ***Safety and Society.*** A poor safety record as a result of poor decision-making, design and social factors; and,
6. ***Economic Influence and Cost.*** Vastly exceeding projected estimates, wasting taxpayer money, which resulted in private enterprise alternatives.

<u>Design Ideology and Methodology</u>

BART—the first US rail transportation system built within the previous 50 years—began with a vision of a commuter rail system rivaling automobile use because of its speed and convenience. BART's primary objective was to, "facilitate travel from outlying suburbs to downtown areas…more like a commuter rail system (with long lines and widely-spaced stations) than a New York or Chicago-style subway system of interlocking cross-town lines and frequent stops," (p. X). In other words, "BART is a relatively specialized transportation resource…its most important…commute trips made in peak travel periods," (p. X)(1979) (emphasis added). Explicitly stated and implied within the description of BART's design, was the acknowledgement that the system was constructed for suburban commuters who needed access to downtown San Francisco corporate offices, prioritizing this demographic. The planning and engineering of BART took little notice of riders outside the suburban commuter target group although many came to rely on or utilize BART. What appeared to be smart planning has created precarious conditions that have accumulated and fossilized to the present day.

As Bottles explains, the concept for a BART type system, first seriously discussed in the aftermath of World War II, actually began a century prior when:

> Factory owners…relocate[d] in nicer quarters somewhat removed from the noisy factories and boisterous working-class neighborhoods. The separation of work and residence consequently resulted in the emergence of the central business district…[and] also encouraged the rise of residential neighborhoods organized along class lines," (p. X).

During the interwar period Bay Area industry consolidated and not only fashioned distinct neighborhoods, but also through internal emigration attracted new, diverse residents:

> Eastern and Western corporations alike brought a succession of racial and ethnic groups to East Bay cities…with the completion of the transcontinental railroad…Between 1940 and 1945, the black population of the Bay Area grew from 19,759 to 64,680, or by more than 227 percent, (Johnson 1996) (p. X).

By the 20th century, particularly after WWII and the spike in industrial growth such as amongst shipyards and industrial companies, cities were more segregated than ever by racial and socioeconomic lines, (p. X). As Historian Marilynn S. Johnson (1996) writes of the period:

> As white migrants moved out to the suburbs and black urban migration continued, federal migrant settlements became the minority enclaves of postwar cities…wartime social programs shaped postwar urban community life, setting boundaries for…'two societies, one black, one white…' over the next two decades…the persistent belief that war migrants had 'ruined' East Bay cities by

> bringing a scourge of crime and delinquency fueled white flight to the suburbs and helped justify decisions about urban redevelopment that… displace[d] these families from their homes, jobs and communities, (p. X).

BART is a prime example of a humanistically embedded, and double feedback technology. The product of its era, BART’s “main role in the transportation system in the Bay Area is to carry commuters on relatively long trips between their suburban homes and their workplaces in central cities,” (p. X) that is, to transport upper and middle-class residents from the areas of Walnut Creek, Dublin, Fremont, Millbrae and Berkeley to the metropolitan San Francisco. This was the perceived need of the time. Visually even, BART’s double feedback is apparent, its design literally reflecting the “center points” of Oakland and San Francisco, which consist of the most frequent stops. As a “specialized” rail service in a diverse geographical region, BART fails to meet the needs of many groups that fall outside the commuter population, for instance, the elderly, minorities, students, the disabled and so forth.

Moreover, BART does not effectively rival cars. Car owners are among the least likely to take BART, particularly as BART is not efficient, practical or convenient enough to provide an alternative. Although BART extensions to the South Bay have been proposed, those actually built are not extensive enough to rely on. With minimal bus connections to the South Bay and North Bay-- some of the highest growth regions-- there is no access to the Bay Area’s most vibrant communities including the Napa Valley Wine country and the tech-savvy Silicon Valley. Because BART was not planned in a preemptive, thorough, or inclusive manner, the results are poor. BART has also been criticized in its impact reports:

> In view of the plight of many central cities…where jobs, population, and financial resources have been drained in the outward shift to suburban areas…people who remain in the these cities, many of whom are minorities, are deprived of many of the urban services …necessary for their wellbeing (1979) (p. X).

There are direct correlations between easy access to public transportation and life chances, (X). The engineering of BART reinforces and reflects initial design ideologies and brings up the question of who is a presumed member of the "public."

Technology and Engineering

BART technology malfunctioned from the onset. Problems included, "A system-wide lack of sufficient facilities for removing malfunctioning trains," and, "equipment and design problems," (p. X) (1979). BART was relatively up-to-date technologically in the 1940's, its long period of construction made it relatively obsolete in the 1970's. The Mexico City Metro system for instance, was designed, developed and built contemporaneously with BART starting in 1967, (X). Featuring pneumatic tire carriages, the Metro's French, Canadian and Spanish-built cars are quieter and faster than BART. Most glaringly, the Metro was built in 7 successive waves of construction, (X). The system now connects a vast metropolitan area as large as the Bay Area with almost double the miles of track, with 195 stations to BARTs 44 stations and 390 trains to BARTs approximately 100, (2014)(X)(X). The Metro has just over 1.6 billion annual riders whereas BART has 117 million annual riders, about 7% of Metro (X)(X). Thus, a technology with inherently larger engineering capacity will inevitably be more capable of reaching the various needs of its public, just by its sheer magnitude. Metro, which was closer to an accountable technology, was not built for a "target" demographic, and thus was a much more capable technology. Though distinct categories, BART's design ideology and methodology had much to do with its engineering shortcomings.

Efficiency and Efficacy

One of the primary reasons BART did not appeal to its commuter demographic was its low efficiency. Modern Americans are constantly running out of time, making time itself a valuable resource. Not only does the loss of time create an unnecessary burden of stress, it directly inhibits production and thus job success. Efficiency is efficacy. Efficiency is a critical social need increasingly magnified over time. According to BART's website, the system is limited to "maximum speeds of 75-80 mph," (X). But average speed is only "45 mph, including station stops," (X). Moreover, according to data from BART's Final Report, "The average BART trip is 13 miles long…and takes 45 minutes, including 20 minutes getting to and from the station and waiting for a train," (X). Unsurprisingly, "The greatest time savings occur on trips *from the suburbs to downtown areas*…however on average, transit time still takes nearly *15 minutes longer on the same trip by automobile,*" (1979) (Italics added). With these realities, it is no wonder that those who can travel by car do so. In addition, BART service ends slightly past midnight with less frequent intervals on the weekends, "12 minutes during weekdays, 15 minutes on Saturdays and 20 minutes on weekday evenings and on Sundays" (X) which further lowers ridership especially among younger demographics and tourists who primarily travel on off-peak hours.

As a technology, a fundamental and primary function of transportation is to decrease the time spent travelling. Transportation systems are an extension of human capacities in that they magnify our ability to travel, all owing us to go farther in less time. If a given transit system cannot meet this social need fully, the law of obsoletes operates to dialectically respond with a newer and better technology that can. BART, while useful to some in its intended public, nevertheless fails to decrease time spent travelling and thus fails to rival the automobile.

Political Impediments

Public transportation as a nexus for publicly demonstrated political contentions is not a new phenomenon. From the Montgomery Alabama bus strikes of the 1960's to the more recent protests and stoppages of the Google buses transporting the new, tech-savvy elites to and from their corporate parks in Silicon Valley, transportation infrastructure has been a venue for conflict and politics. Transport infrastructure is symbolically important because it is a locus where questions of who and what is considered "public" and "private" are played out. Very real and material aspects of race, class and socio-economic differences become visible and practiced in these social arenas.

As evidenced by the design intentions as well as the actualized outcomes, it is no secret that the BART system deems suburban residents and commuters the assumed "public" in the term public transportation. Given this reality, it is not surprising that BART (and other forms of public transportation) have been the stage for political uprisings which often take place because of the inequalities insufficient transit systems produce and sustain. BART likewise has a history of being a site of labor disputes, the first occurring in 1976 with another lockout strike in 1979, (X).

BART took roughly 25 years to build, delayed by various suits litigating "[t]he validity of the bond election, and the legality of the District itself," (X). As a result of delays, inflation and legal costs increased the price substantially. As it began during a period in which no regional planning institutions that might oversee such a project in California existed, BART faced political obstacles at its outset (X). BART was entirely locally planned. Despite being a public project, according to author Gordon Lewin writing for the *Stanford Workshop on Political and Social Issues* (SWOPSI), "BART has failed to involve significant citizen participation," and, "illustrates…insensitivity to the public," (p. X)(1974). BART encapsulates a double feedback and as a technological process, fossilizes, reflects and reproduces social tensions and divides.

<u>Safety and Society</u>

There is a pervasive ignorance as to the relationship between the accumulation of decisions regarding technologies—such as for BART—and their social ramifications. One of the most contentious and tragic episodes of social unrest involving BART was the negligent shooting death of a Bay Area native Oscar Grant, shot and killed by BART police on New Years Day 2009 after an altercation at the Fruitvale Station, (X)(X). Public discourses following the Grant shooting exemplify BART as a double feedback system. By analyzing public outrage and discourse around the Grant shooting, we are able to trace the social conflicts, which characterize BART as well as the surrounding conditions that produce and sustain such effects.

Attitudes toward the recent film debut of Fruitvale Station—written and directed by first-time director Ryan Coogler starring Michael B. Jordan—acutely portray the significance of the killing and the symbolic and literal meanings attached by various communities, (X). In his film review of Fruitvale Station in Forbes Magazine, columnist Kyle Smith (2013), criticizes the film for, "dance[ing] around the facts," and "more damning…no[t] mentioning the fact that he [Grant] was once convicted for illegal possession of a handgun" (X). While Smith claims that "Even had Grant been the worst man in the Bay Area…he should not have been shot in the back by a cop while lying face down on a subway platform," (X) Smith implicitly contends that director Coogler should not have implied that the death of Grant did not deserve to, "spark [civil rights] rallies and riots and federal charges," when in fact, "It was instead a monstrous accident" (X). The language and rhetoric of Smith's review is a tinged with contempt; the review argues the shooting was a "colorblind" error. Smith hints in less obvious ways that Grant was a criminal as opposed to a victim (X)(X) and leaves out several critical details surrounding the altercation including racial slurs that were voiced by Officer Mehserle.

Institutional racism, which is passed on by individual actors, is enabled through various mechanisms, which justify and prioritize the rights of some at the expense of others. In the same way social scientists can utilize ANT to trace the empirical patterns of actors, we can trace decision-making procedures to understand how pernicious outcomes come about. While not all actions can be foreseen, we nevertheless need to adhere ourselves as a society to a higher standard of accountability based on *outcomes* as opposed to *intent*, (X)(X). This need for accountability for societal wrongdoings—in technologies themselves as well as in our social relations must be recognized, acknowledged and properly mended.

Using Latour's ANT (2005) —which affirms that non-human agents may produce real world effects—we see that BART is indeed a primary structure facilitating socio-cultural and socio-economic relations between Bay Area residents. Due to its fundamental design ideology, the BART setting abstractly and literally reflects disparities and produces lived encounters of inequality on several fronts. BART itself is the product of the accumulation and fossilization of real world decisions that embody and reflect both ideological and methodological discrimination. Regardless of intentionality—something a technology should not be held accountable of, we must hold ourselves accountable as well as the effects produced by non-human agents in our hands. We must recognize deeply correlational effects: the intention of BART, which was never designed for people like Oscar, and the "unintended" results that ensue when socio-cultural phenomena culminate and interact.

Economic Influence and Cost

The BART construction funding was problematic from the beginning. Except for a very limited Federal grant, BART was a locally funded venture, financed by a $792 million dollar bond approved by voters in November 1962 (X). Before construction began this was, "at the time…the largest single bond issue in history…with one ballot, the voters of the counties were more than doubling their indebtedness"(p. X). Due to numerous delays and the ravages of inflation, the capital costs grew to $1.5 billion dollars, "not includ[ing] over $715 million in interest on the bonds or the $38 million in interest," (p. X) over the 12-year span of construction. Indeed, the massive budget overruns of the system drastically conditioned the project to failure.

BART in many ways has never recovered from the initial financial blow. The system, which for years had deteriorating seats with reports of fecal matter and drug resistant bacteria resembling MRSA in the upholstery, was only able to revamp new seats in 2012 after national media attention in the New York Times (X). BART has been doing its best to keep up and plans to roll out new cars sometime in 2014, but the system continues to suffer funding problems. Beyond the capital and operating budget problems, BART is also an economic obstacle for many riders, especially those who rely on it the most. In author Lorien Rice's (2004) book, *Transportation Spending by Low-Income California Households: Lessons for the San Francisco Bay Area*, one of the key findings is that, "Transportation is the third-largest budget item for low-income households in California's metropolitan areas," (p. X).

There is no cost effective transportation alternative for low-income people that we know of other than free Muni for youth (X). However at the high end entrepreneurs have stepped in to fix taxi industry problems that stem from the 1920's. New TNC (transit network companies), which are smartphone-based have created a "[ride] sharing economy" beginning with Uber—a company started in 2009 by Travis Kalanick that connects everyday car owners looking to make a buck with riders in need of efficient and reliable alternatives to taxis (X). Uber, along with other rival companies such as Lyft and Sidecar, epitomize the Bay Area—tech savvy, entrepreneurial and socially open. But if society has really become more altruistic, than it is at a hefty cost.

It is important to note the conditions in which these economic activities take place, namely, a struggling economy in which many people lack job-skills or cannot obtain work but have access to a car, and mostly young people who can afford the fare but who either choose not to, or cannot afford cars, and so on. Moreover, a Smartphone, a cell-phone plan with Internet connection, enough money to pay for the ride (comparable prices to Taxis) and so forth are required. While an ingenious entrepreneurial idea, these platforms simply aren't accessible to all walks of life and operate in niches at the margins of much larger "public" needs.

All of this is not to say that platforms such as BART or Uber are without value—on the contrary it is to say only that *they are perfectly well suited for what they are* ***designed*** *to do*. That is their biggest limitation. A system designed for X can only produce X, as opposed to Y, Z and much less Q. Similarly, a system that is designed without the consideration of a particular function, will seldom produce that function. The BART system, designed around a presumed population of interest with the further assumption that BART would forever only need to uphold this population's needs exclusively, is unrealistic. System overload or breakdown occurs when social forces at play demand more from the system that it was designed to produce. Conclusion: a

Commentary on BART's Sufficiency

While BART has made repeated efforts to respond to social needs, the system has been significantly constrained by the outcomes of accumulated decisions that continue to prevent progress. It should be noted, that since it began operation, BART has improved, in terms of many metrics (X). As the teleology of progress allows, technologies themselves necessarily evolve with respect to human users. Though BART is no exception, the system has been severely limited in how far it has progressed. BART was never engineered to be holistic, socially inclusive or flexible and is irreversibly limited as a result of its design structure and ideological framework. Though BART is embedded—as we as a society rely on it, this does not make it effective in meeting a full array of social needs in the same way that Los Angeles's auto-centric infrastructure does not make it effective either.

As Faste (2001) writes, technology and engineering specifically ought to "incorporate[ion] [of] the entire spectrum of humane concern[s] in its practice," (p. X) and this is the critical pursuit which innately defines our notion of accountable technologies. Understanding the shortcomings of BART as well as BART's successes is to understand the complex role of technology in our lives, and to be better able to devise accountable technologies.

According to engineer Hitachi Abe, the chairman of Architecture and Urban Design at UCLA, "As with all innovations of this scale, it's not the technology itself that is the most important but how cities and people change because of the technology and how these changes are reflected in the urban environment" (X). Understanding the critical effect of public transportation on individuals and populations at large is the most fundamental aspect of accountable technologies. It is essential to gauge disparities and to adhere to the shortcomings of these systems. Accountabilities as democratic entities, are essentially publicly accessible and utilized, having moral responsibilities to the communities they represent.

Context and Introduction to Hyperloop

Whether you think you can, or think you can't, you're right.

--Henry Ford (X)

In 2008, California voters approved Proposition 1A a measure that would direct $8.6 billion dollars in state funding to build the state's largest public work's project to date, Governor Brown's High-Speed Rail (HSR) Project—running San Francisco to Los Angeles travelling at top speeds of 220 mph (X). The project, conceived and planned between the 1980's and 1990's, was to begin construction in 2014 but has been slowed on numerous fronts (X). Legal battles, funding obstacles, and the catastrophic loss of public support now plague the project (X). Controversy surrounding HSR initially took rise in 2011 when the project budget skyrocketed from $8.6 billion, to over $120 billion dollars then to $68 billion as a result of complex factors. News reports quoting expert testimony in Senate committee meetings contend that HSR will not meet its promised speeds due to various engineering problems. These reports—and others—have created a backlash amongst Californians. An article on Bloomberg.com written by Michael B. Marois at on June argued, "While 53 percent of voters approved a bond issue…a USC Dornsife/Los Angeles Times poll published…found that 59 percent would oppose it if given anotherchance to vote" (X).

As the controversy accelerated, prominent public figures came out in favor or against continuing the proposed project. Among them, Elon Musk—the billionaire Silicon Valley entrepreneur and CEO of SpaceX and Tesla Motors— voiced particularly strong opposition to HSR, criticizing the project as "a bullet train that is both one of the most expensive per mile and one of the slowest in the world" (X). Musk drafted a 58-page long alternative to HSR, which took the public by storm when released with a PR fanfare. In his white paper, Musk introduces Hyperloop-alpha, the theoretical design for a high-speed tube transportation system promising speeds of roughly 760 mph, that is, "Mach 0.99, or just before the speed of sound," (Statt, 2013) put otherwise, "the speed of a cruising F-15," (X). Better yet, Hyperloop costs "less than $6 billion USD…less than 9% of the cost of the proposed passenger only high speed rail" (X). Hyperloop, a dialectical response to HSR as the epitome of everything HSR has failed to do, is a promising technology, as well as a potentially economically and environmentally superior system.

<u>Who is Elon Musk?</u>

If Hyperloop is the Motel T of the 21st century than Elon Musk might be the Henry Ford of modernity, a revolutionary technologist and thinker who is transforming global conceptions of transportation. Musk the CEO of Tesla Motors— a Silicon-Valley company manufacturing the first viable line of fully electric cars— is like Ford in that he understands the delicate relation between efficiency, quality and price. His strategy is to infiltrate the market is primarily driven to move consumers to more sustainable and effective technologies.

Musk, who also runs SpaceX, has put a similar philosophy towards space explorations. Taking on the military industrial complex with his private enterprise startup, SpaceX has gained worldwide attention for a series of historic milestones. SpaceX is the only private company to ever "return a spacecraft from low-Earth orbit…in December

2010…[and] again in May 2012 when its Dragon spacecraft attached to the International Space Station, exchanged cargo payloads, and returned safely to Earth"— a technically challenging feat previously accomplished only by a handful of governments (SpaceX, 2014). Musk made a $1.6 billion dollar contract with NASA to collaborate and improve their space exploration efforts. Musk's endeavors, from SpaceX, to Tesla, PayPal and SolarCity (two other Musk startups) follow a business plan that aligns strongly with the teleology of progress. His entrepreneurial vision—with its haunting Fordist sentiment—is the embodiment of entrepreneurship and innovation.

<u>History and Technology of Evacuated Tube Transport</u>

Musk's Hyperloop is actually the latest iteration of an old, robust design idea well over 100 years old. According to Jay Yarrow a writer at Business Insider, it is likely Musk conceived of Hyperloop based on a 1972, "paper written by physicist R.M. Salter that detailed an underground tube system that could send people from Los Angeles to New York in 21 minutes…called…the Very High Speed Transit System, or VHST" (2013). Generically, the concept is Evacuated Tube Transport (ETT), a technology based in robust physics that is simple at its core. ETT is bullet in a vacuum tube. Absent air—and air friction—a bullet or a passenger pod can travel very fast at very low energy cost. And as Newton's First Law of Motion explains, a body in motion tends to stay in motion, absent forces like air friction. If then the body in motion is a passenger pod traveling in a straight line, very speeds are possible, and riders would experience little turbulence, far less than a plane, car or train.

Although ETT technology has been around for over a century, the necessary engineering and mechanics required on a massive scale like the Hyperloop system were not ever mature enough for ETT to be conceived. In 1869 a non-evacuated tube transport system was built in New York City, the Beach Pneumatic Transit System predated the subways and four hundred thousand tickets were sold in a three-block wide demonstration project before financing and political inference shut it down (X).

American inventor-engineer Robert Goddard, the father of rocketry who patented multi-stage and liquid-fueled rockets, also proposed an early ETT system that would launch a rocket to the moon. The harsh criticism it received was reminiscent of the many doubting responses to several of Musk's endeavors, including Hyperloop. To this end Goddard responded to the reporter from the NY Times, "Every vision is a joke until the first man accomplishes it; once realized, it becomes commonplace" (X).

Since then, several attempts to build an ETT transportation system throughout the world have tried and faltered. The closest, the Swissmetro funded and development by the Swiss government 1990's was ultimately abandoned politically but is being kept alive by a small group of former employees (X). The problems cited for shutting down the Swissmetro were: its high cost and long construction cycle, technical and market unknowns, and significantly, the EU policy supporting High Speed Rail which they feared would compete for routes with Swissmetro (X).

Design and Feasibility of Hyperloop

While indeed a huge technical challenge, Hyperloop is nevertheless a potentially huge technological breakthrough with innovative features that far exceed prior transportation modes. As UCLA Architecture and Urban Design Professor Craig

Hodgetts believes, “There’s not a single element of science fiction…Hyperloop is the same thing as the pneumatic tube” (X). Generally, there seems to be a consensus amongst experts that Hyperloop, based on ETT technology is feasible and mechanically sound. According to Nick Statt a staff writer at CNET, “computer-based engineering simulation company Ansys…is…tackling the Hyperloop concept virtually”(X). Sandeep Sovani at Ansys admits, “Hyperloop could be a reality in a decade or two,” and that in fact, “All of the tools needed are all there…[for] an actual physical prototype, all of the homework essentially is done” (X).

The Need for “Accountable Technologies”

Given our multifaceted technology our aim now is to cultivate technologies themselves both as products and processes that adhere to our stringent but necessary demands for responsible usage. In democracies, many interests compete. Powerful, self-interests can corrupt the process, and inevitably hurt the system at large. We must guard our hard-won transparency; shine the light far and wide. As citizens, we must become involved and stay involved—our critical duty as agents who deploy technologies. At the local grassroots we can often be heard and further uphold true forms of democracy.

Higher up the decision chain, politics and power relations makes this difficult. We should insist our governments remain free of undue influence, transparent and fully participatory, and moreover we should demand to be included in the decision making processes of transportation that effect us in a plethora of ways. Accountable technologies will be a vital resource in the future that may propel us toward the advancement of not only mankind, but also the world at large. Hyperloop, with its vast mechanical abilities has an incredible potential as an accountable technology—that is, a technology that is sustainable, efficient, inclusive and promising in responding to the most fundamental and critical social problems at large. What is missing is our political will for such a project, and an accountable engineering and design process, which will incorporate a holistic set of aims.

<u>Proposal for Hyperloop</u>

A local, California-based Hyperloop (Hyperloop-CAL) could revolutionize long distance transportation in our state. If successful, it is inevitable that Hyperloop should expand elsewhere throughout the world as a proven and viable technology. A national Hyperloop would bring profound changes on a continental scale. A fully built international Hyperloop has the potential to transform social, economic and political relations globally and change how we think about vital issues, from social class and status, to environmental issues, to various other socio-cultural and psychological phenomena. As previously shown, any technology of this magnitude has the potential for beneficial as well as detrimental outcomes, therefore the Hyperloop value proposition must then be considered across a broad spectrum in a holistic fashion. However the value issues must be addressed through a taxonomy if they are not to overwhelm us, what we are naming a Social Impact Review that encompasses and transcends decades of experience with Environmental Impact Review (EIRs). This structure should follow:

A Structure for Social Impact Reviews:

1. ***Social Issues:*** A comprehensive analysis of the social forces of power and inequality including questions of who benefits and who loses and how to equitably spread gain and minimize the loss among social groups? Sub headings include: equality and social justice, cultural

sensitivities, safety and security, social psychology and community building and psychology.

2. ***Environmental Issues:*** Sustainability vs. disruption. How to create a new built human environment without minimal invasion or harm to existing natural and built environments? How to adhere to a growing population with evolving needs/resources.
3. ***Political and Democratic Process:*** Transparency and participation across a broad spectrum. How do we insure honest and democratic participation? How do we create buy-in by making debate and participation matter in the decision processes?
4. ***Economics and Funding:*** To make Hyperloop affordable and accessible to all and to ensure price stability. This will also include resource tradeoffs and public vs. private funding.

With the SIR structure above in place, we can now turn to Hyperloop and ask probing questions. It is beyond the scope of this work to address the national and international issues that may someday need to be thought through, so we will focus instead on the actual proposal by Elon Musk, with amendments and counterproposals that seem to be warranted.

<u>Social Issues</u>

Currently, researchers at UCLA are working on the initial design and proof-of-concept stage a Hyperloop (X). This private citizen group is still very small and outside the realm of politics. However, if such a project were backed by the state, a Hyperloop-CAL bill would begin in the California legislature and be signed by the Governor to fund research. Then, for instance, we could easily have a high tech jobs program for generations of engineers, materials scientists, draftsmen, prototype machinists and so forth that could be centered in vigorous competition between California technical Universities. Transit centers already exist at several of the UC campuses including UC Berkeley and UC Los Angeles (X). These platforms would be ideal to utilize on in order to actualize the Hyperloop-CAL system.

At the implementation stage Hyperloop-CAL would be a massive jobs program tunneling, heavy construction, etc. and a technological spin off engine rivaling NASA. Many new technologies would emerge from Hyperloop-CAL in the fields of robotics, materials science, control systems, tunneling, heavy construction, etc. New industries will create jobs and economic stimulus as well as international recognition. These experts (particularly those connected to powerful academic institutions) could implement the sort of comprehensive social analysis necessary for such a wide-scale project.

Equality and Social Justice

Access has always been one of the most pervasive inequalities within public transportation. We need inclusion in public transportation, especially in terms of its affordability. Invoking our notion of double feedback, both abstract and materialized consequences are responsible for the unequal access to public transportation in the Bay Area. Access can either be a matter that public transit simply is not physically accessible or available, or, that financial and social stigma is a deterrent. Geography may also act as a barrier, particularly the geography of race and class. We must design and implement Hyperloop-CAL so that marginalized communities of color, the economically disadvantaged, the elderly, women, youths and students, and disabled persons are not excluded and further disenfranchised.

Hyperloop-CAL has the capacity in California of drastically changing patterns of employment and residence. As sociologist Glenn Yago states, "the…mismatch between residential location and employment opportunities among the urban poor, and social isolation of youth, aged, handicapped, racial and ethnic minorities, and women" (X). One of the lessons BART can teach us is that design and engineering should never be specialized, rather, access should be an inclusive as possible on multiple dimensions including the physical geography of where the system access points are. These decisions are beyond the scope of the current work but we note their critical important. Conceptually speaking, Hyperloop-CAL has the potential to overcome social challenges and to be a truly egalitarian platform. Due to its efficiency, magnitude and reasonable-cost as compared to its benefit, Hyperloop-CAL could work for a far broader geography. This would likely translate to its ability to reach to a much wider demographic in terms of diversity as well. Although the technology is advanced, the system can be aesthetically pleasing, culturally sensitive and of high quality. With active political and cultural measures to not stigmatize the system as an elitist, or "techie," corrosive identity politics can be avoided.

Because Hyperloop would be a long-distance mode of transportation, it would perform like a mass transport vehicle. A blend between an efficiency train, and a plane, Hyperloop might be utilized for everyday transport as well as for more involved trips, tourism and travel. Due to the sheer volume, Hyperloop could easily run all night, opening up revenue and furthering accessibility as, "The capsules leave on average every 2 minutes from each terminal carrying 28 people each (as often as every 30 seconds during rush hour and less frequently at night). This gives a total of 7.4 million people per tube that can be transported each year on Hyperloop" (X). This frequency and powerful level of efficiency would certainly work against spatial mismatch particularly between job employment, and residency. This accessibility might allow people to easily commute from their hometown of Fresno per se—one of the proposed stations of Hyperloop—to Los Angeles, in approximately the time it might take that same individual to drive to a job in San Francisco—without traffic.

Cultural Sensitivities

Hyperloop-CAL, could universalize access within California, and likely follow the pattern of most breakthrough technologies and vastly expand in scope thereafter. Hyperloop-CAL would likely be utilized and ridden by individuals on an international basis as a tourist attraction. To meet the needs of Californians, which already constitute a very diverse population, the "public" in this conceptualization of public transportation needs to be properly accounted for. Ethnic and political concerns, language barriers, immigration and nation affiliation would likely be some of the concerns that would surface in entirely new fashions. Hyperloop should employ best practices from airport protocol, as well as from subway systems. Thus, tactics such as, a universalized payment as well as a thorough, but efficient and minimally invasive security system would be ideal.

Another often overlooked but significant fact within the engineering and design of public transportation is the usage of these "public" sites as spaces of cultural and artistic expression. That is, we must ask how the physical design of a system like BART or Hyperloop, effects what kind of public or public spaces are produced, and what sort of expression it may restrict, or be conducive of. For instance, it is well known that the "accidental" acoustics in the Paris and New York City subways were incentives that brought aspiring musicians from all over the world to use these transit systems as sites of performance (Chodos 2014). Historically, diverse forms of performance have become recognized on public transportation and are expressive of the communities and culture across the globe. Performance, which has become a culturally embedded phenomenon within the sphere of public spaces, can also create an affective and ideological sense of belonging and connection to ones community. Hyperloop should be built in a way in which to preserve this cultural expression for the best.

Materiality in design plays a critical role in how public sites are used. Simple features, such as the types of chairs used in waiting or resting rooms might either be conducive, or restrictive of a person using a laptop to email or do their homework, or for another to sleep. These minute choices, accumulate and magnify reflecting the law unforeseen consequences—that is unless we account for them. It will be necessary then in the construction and actualization of Hyperloop to consider these decisions seriously, and to ask, but not assume the hard questions required in such a process.

Safety and Security

Safety—which includes both a physical, as well as a socio-psychological understanding, is necessary for all parties including passengers and well as workers. The emphasis is to highlight the Hyperloop system as a human-centered technology, and to bring to light, the many ways in which safety is considered. Safety and wellbeing for a diverse group of agents on Hyperloop, will likewise include various design factors, as well as extending beyond such material forces.

Fortunately, Musk's Hyperloop-alpha white paper has already incorporated thorough beginnings in terms of the physical safety components of the system. As stated, "The design of Hyperloop has been considered from the start with safety in mind…with human control error and unpredictable weather removed from the system, very few safety concerns remain" (X). To control human factors, Hyperloop plans to instate streamlined security checks, as to not impair the flow of traffic. In terms of its mechanics, Hyperloop's structural architecture and some of its material factors inhibits many forms of crime and hazard. Among these benefits include; weather-proof capsules each with direct radio service and first aid, mechanical breaking, measures to make it immune to power outages, reserve air supplies, pressure sensors and oxygen masks in case of depressurization and earthquake proof measures such as shock absorbers (X).

One of the most serious considerations on Hyperloop would be for homegrown and international terrorism. As Times writer Matt Peckham articulates his fear, "we're talking about tubes that could cover up to 1,000 mile stretches…then imagine if that border also included hundreds or even thousands of potential human targets — locked inside tubing…at any given moment"(p. X). While this concern is valid, this potential is not unique to Hyperloop, nor is reason to abandon such modes of transportation altogether. Airport security for instance, even with enhanced measures in the past 15 years, is still deeply flawed.

While in many ways, our societal affect is more wary of international terrorism, especially subsequent to September 11th, with the advent of the Patriot Act, in actuality domestic and international terrorism have in fact been declining since 2001 (X). Sociologist Charles Kurzman, who studies Muslim American terrorism argues that post 9/11, "compared to the 14,000 murders in the U.S. last year, the potential for Muslim Americans to take up terrorism is 'tiny'"(X). Many have pointed to the fact that government agencies have played off of the fear of terrorism to pass legislation such as the Patriot Act as well as infringe on constitutional privacy rights in an unprecedented way. As an article in the NATO review adds, "The intensification of the search was bound to produce more arrests, even without more terrorism, just as the Inquisition was sure to find more witches" (X).

Regulation while critical in maintaining safety, should never become a burden that infringes on efficiency, or worse, replicate new forms of injustice in an institutional manner. As a democratic nation, our foundational ethos is that of presumed innocence until decidedly proven guilt. Potential threats should be recognized and marginalized but not at the expense of targeting stigmatized communities, or reducing the freedom or rights of the majority. There is a delicate, but rational balance between policing and regulation, preemptive targeting, and freedom for all. It is highly recommended that Hyperloop should do all that it can to minimalize policing as much as possible by design factors. As the principle of double-feedback suggests, often our fears become a self-fulfilling prophecy. We should do all we can to avoid overregulation that turns to extremism or any version of a witch-hunt.

Community Building and Social Psychology

Material and architectural factors do not only inhibit, but may also produce community kinship and feelings of connectedness which Hyperloop should consider in its engineering. In terms of design, Musk's Hyperloop intends to cater to a "minimalist but practical" layout, "much simpler than airports" (X). Although it gave no explanation it can be assumed Hyperloop's aim is to remain low-cost. A minimalist design may be costeffectiveness and aesthetically pleasing to a wide demographic of users. Hyperloop should seek to incorporate design elements that allow for flexibility, and community kinship in terms of built in constraints and abilities.

To exemplify this point, consider one of the most salient examples of how such structural forces may be conducive to a pleasant encounter is the quintessential experience of entering Disney World—the "happiest place on earth" (X). In their work, *From the Panopticon to Disney World*, sociologists and criminologists Clifford D. Shearing and Phillip C. Stenning argue that, "Disney World…seeks to combine a sense of comfortable…familiarity with an air of innovative technological advance…Disney …claims also to be a design for better living…yet the Disney order is no accidental by-product. Rather, it is a designed-in feature" (p. X).

Shearing and Stenning point to a variety of factors, from the onset of friendly workers who greet guests at the gates, to the rails and safety features of the Disney train with its automatic doors and instructions, to the other embedded control measures that, the entire Disney experienced is a micro-managed, and highly calculated setting in which the optimal level of "happiness" can be derived while simultaneously be used as a form of crowd control.

While this hyper-regulation and systemization may seem daunting to some, much can be learned from this analysis in terms of Hyperloop. Regulation of this sort, so long as it is utilized for the betterment of all, is not necessarily wrongful. Moreover, depending on particular architectural and material forces to constrain particular acts can be vastly more ethical than relying on the over-regulation of individuals by a more formal police task force. Particular architectural aspects might also allow for experiences that would otherwise be non-existent.

Psychological

Hyperloop is a "hybrid" technology, which inherently permeates an array of social spectra, likewise impacts the individual sphere on a psychological level. As ANT and other examples have shown, non-human, material "agents" often shape human relations on a macro level. Similarly, design features of technologies such as Hyperloop result in individualistic realities. Hyperloop's should endeavor to generate community kinship not just on a macro, but also on a personal level. Hyperloop's theoretical design functions such as its tubes and capsules which conceal its "tracks" for instance, necessitate a similar material barrier as describes in the case study of Disney World where, "Potential trouble is anticipated and prevented…[and] minimized…by physical barriers which severely limit the choice of action available and **an omnipresent surveillance**" (p. X).

While seemingly irrelevant, something as simple as a barrier may literally be the difference between life and death. Every year on average, "12 people die on Caltrain tracks, and most are suicides" (X). For the train operators especially, this type of unanticipated, horrific and grim trauma can leave lasting and unfathomable psychological effects including severe PTSD and lasting guilt. Caltrain is no anomaly either—in fact in 2011 alone there were 702 fatalities nationwide on train tracks (X). Unlike many conventional trains and rail systems, Hyperloop is equip with an emergency breaking system, contains no visible rails, and includes emergency exists. Hyperloop's design makes many of the potential injuries and complications that these systems face physically impossible. While that is not to say other forms of emergencies would be possible, preemptive measures and insightful engineering can avoid such tolls. Accountable technologies like Hyperloop are inherently safer not only in terms of their mechanics, but also in these less obvious, but nevertheless catastrophic ways.

Hyperloop, with its superior technology is better apt to adhere to societies complex needs and will likely produce more social cohesion, as individuals feel better connected to their communities. Using social identity theory—the view that, an individual derives their self-conceptualization in relation to their association to a particular social group—we can explain and individuals behavior and understand group dynamics that consequently ensue (X). The primary hypothesis of social identity theory is that members of a group enhance their self-image by identifying negative features of "out-groups" (X). However, public transportation can either sustain or challenge social hierarchies, the aim being the later. On a micro level, individuals who interact with one another in a safe and healthy way will feel more connected and less isolated.

However, micro effects often have macro explanations. It is no coincidence that in the last 50 years as our society has become physically more disperse than ever, simultaneously there have been record numbers of individuals who have become more anxious and depressed than ever. Increasingly, we are facing now a depression epidemic. According to an article in Forbes,

> The U.S. tops the list, with 9.6% of the population experiencing bipolar disorder, major depressive disorder or chronic minor depression over the course of a year. That's compared with a .8% rate documented in Nigeria. The findings are part of a 2004 study of 14 countries by researchers from the World Health Organization (WHO) and Harvard Medical School (X).

Although we are more connected than ever, we arguably feel more isolated and desperate than ever. In a more critical sense, technology has allowed us to become lazy—to replace human interaction with digital stimulation and omnipresent information, as opposed to true compassion or understanding. However, technology as a tool also has the opportunity to be a platform conducive to better forms of interaction and new ways of being.

Visibility, particularly of "difference" including "outgroups," can be conducive to inclusivity when coupled with a more righteous social ethos, but of itself visibility does not necessitate a cohesive society. Still, the effects of visibility for better or worse are one active way in which new social ideals can be introduced. In the case of public transit—an immediate, commonplace and authentic experience—user experience has the power to change adverse social relations. For instance, forms of public transportation make areas of the city, which are often "hidden" visible, such as graffiti in industrial areas, homeless "camps" which are often near these areas etc. This images shape the way we view our community. Hyperloop can be engineered toward these ends to reconstruct the way we envision societies.

Environmental

Hyperloop encapsulates the term "accountable technology" as an investment in low-cost, low-energy, sustainable system of transportation. There is both an ethical, and practical argument within the development of sustainable technologies. If we wish to initiate the "phasing-out" of the limited resources of fossil fuels, we must turn to better technologies and resources that can adequately fill these voids, as the law of obsoletes provides. And indeed, our reliance on fossil fuels in increasingly becoming less viable—

breaching its "death." Hyperloop-CAL is highly disruptive of transportation systems that are themselves environmentally questionable. Hyperloop-CAL is intrinsically green utilizing low energy in construction (especially if tunneled, a design concept we would hope is explored) and in its use (Musk calls for solar panels on top of the tubes) which "allows this linear accelerator to only draw its average power of 8,000 hp (6 MW) (rather than the peak power of 74,000 hp or 55 MW) from its solar array " (X). However, Hyperloop is also sustainable in that it relies on sustainable energy sources, and is simultaneously cost effective.

In terms of duration, sustainability means that technologies are flexible and adaptable so they do not become obsolete and thus wasteful. Hyperloop therefore must also be designed in accordance with the teleology of progress in mind—i.e. it must be built into the preexisting infrastructure adaptively, with the firm engineering goal that it will expand and evolve. BART primarily became obsolete because its fundamental technology was outdated before its initiation. Lasting technology, such as the New York Subway system, which initially opened in 1904 (X), must be embedded into its culture and the greater architecture of the city. Sustainable and accountable technologies continuously "expand" in their capability and are able to keep up with human needs as human centered technologies. Like the New York Subway system, Hyperloop is cutting edge for its time, however, the system should be built in a way in which it may be adjusted in the future to readapt and conform to new social problems and needs.

Economics and Funding

Hyperloop (as promulgated in Musk's 2013 white paper) is touted for its low cost relative to HSR as well as its potential as a jobs engine and source of revenue. However, one of the most cogent criticisms is that its budget may be vastly underestimated. Musk, who claims he can build his Hyperloop for 10% of the HSR cost at a, "total cost of…$6 billion USD for two one-way tubes and 40 capsules,"(X) has had to make serious engineering trade-offs in order to keep Hyperloop at a build cost to deliver an optimal, "total [ticket price] of $20 USD plus operating costs per one-way ticket" (X). While these numbers have raised eyebrows, Musk is no stranger to creating high quality technologies with limited capital, and claims that this allocated $6 billion is, "more than Tesla, SpaceX and Solar City have spent, combined" (X).

Though critics like Johnson have criticized the plan, even if Hyperloop came out equal in price to HSR, the system would arguably still be a much better investment. Even in more conservative estimates, the cost of developing and maintaining Musk's Hyperloop would likely be marginal compared to the cost and ticket price of HSR "currently $68.4 billion USD proposed cost… Average one-way ticket price of $105 one-way…$158 round trip by air for September 2013…$115 round trip by road ($4/gallon with 30 mpg vehicle)" (X). Because technology is economically embedded, it is no leap to argue that an investment in public transportation is similar to the trade-offs and benefits understood in other investments, such as real estate or education. Given the recent state of the economy, public-private- partnerships (PPPs) that stimulate the economy and lessen socio-economic inequality might be a good thing.

California, the 8th largest economy in the world, should invest in accountable technologies that are sustainable, profitable and socially sound for the long run. Transportation is a bottom line issue. According to a research proposal written by

Frontier Group and CALPIR, "Public transportation prevented more than 70 million hours of traffic delay in nine California metropolitan areas in 2005, preventing the economy from losing more than $1.2 billion in wasted time and productivity" (X). A built system such as Hyperloop-CAL would require a vast, and dynamic collaboration.

Hyperloop-CAL could be a new model for joint enterprises between public and private entities—a new paradigm for PPPs. We should not forget that both the New York City Subway, as well as the interstate railroad system began as private enterprises and merged into PPP's with great success. The NYC subway system was eventually absorbed into the NYMTA, but commercial railroads remain privately owned and run (X).

Political and Democratic Factors

Musk's Hyperloop is not without its political controversy, from its evident contention with HSR, to its controversial claims around its capacity as a technology. As New York Magazine writer Kevin Rouse writes:

> Lost in the debate about the Hyperloop's feasibility… is the fact that Musk's plan… is…a political statement aimed squarely at the Establishment… Musk is taking aim at the government's monopoly on large public works projects. He's saying to policymakers in Washington and Sacramento alike: *I can do your job better than you*" (p. X).

Rouse recognizes Musk's history of political engagement and defends Musk further stating, "Elon Musk is the pack leader of a group of tech-world elites who are committed to solving major societal problems…These do-gooders see their roles not as hackers of computers, but hackers of processes. After all: Silicon Valley makes better and faster hardware every day. Why can't it also make a better government?" (X).

As Rouse suggests, Musk's philosophy exceeds a purely capitalistic drive, as he seeks to transform old and broken systems by offering more viable and dynamic alternatives. Musk is no ordinary entrepreneur he is essentially a social entrepreneur who aims toward accountable technologies. Though Musk is financially successful his primary objective is not wealth, but social progress.

Perhaps the strongest argument for Hyperloop in terms of its politics is that it is in many ways in fact, a truly non-partisan issue. National politics for years have been gridlocked by the polarization of the two-party system, which has perpetuated immense stagnation and even lead to the first government shutdown in ages. Author and journalist Bill Bishop, who wrote *The Big Sort* argues that homogeneity of communities themselves where:

> Americans have been sorting themselves over the past three decades into…not at the regional level…but at the micro level of city and neighborhood," has ideological consequences which "breeds economic inequality, cultural misunderstanding, political extremism, and legislative gridlock (p. X) (2008).

Hyperloop, a system that physically integrates people in a radical way, and redefines notions of the "public" has incredible potential to mend these consequences. Both abstractly and literally, Hyperloop merges ideologies together. It intersects many ideological commitments and standpoints from many political backgrounds from environmentalism, to economic stimulus, to social justice. Framed and actualized as an accountable technology, Hyperloop would certainly have profound effects and is truly the best of both worlds.

Finally, the significance and attention brought to California as being the first location in the world to have succeeded in actualizing the creation of ETT technology would be a political milestone and achievement. Not only is California the most ideal setting for such a project—with its capital, resources, geography, political and social climate, and so on, but also California with the political controversy of HSR is in a vital moment that is beckoning for a radical shift. With California's diverse regions, Silicon Valley, Los Angeles and the San Francisco Bay Area, we are rightly aligned for this sort of transit project. As the teleology of progress shows, stagnation may only last so long, and eventually change must ensue.

Unintended Consequences

It is not our intention to create a full employment system for narrowly focused sociologists and academicians or even jobs for broadly oriented humanistic, liberal arts graduates. Rather, we attempt to argue from facts and from historical consequences that in the increasingly complex world we inhabit, Social Impact Reviews are needed. We must think long and hard before we put the shovels into the earth about unintended consequences. We must organize the consequences, group them and classify them but not so rigidly that we create information loss. Next we have to dive deep into them and tease out connections to other consequences and unknowns. The process must be both fluid and intuitive as well as rigorous and mathematical. We must listen avidly to what might seem the mutterings of the irrational; sometimes the incoherent turn out to be prophets.

But we can never fully know the unknown. Just as the technologists of antiquity could not have dreamed that flint would lead to brass, then to iron, then steel and eventually graphite fiber composites, so too we cannot know where the technology we decide to embrace will lead us. On the other hand, man is a technical animal. We live in a built environment that has its existential dangers but that we are not going to give up any time soon. Therefore, we must not doubt our capability to master and control technology by opposing all new alternatives. Although it is not surprising then that as soon as Musk shared his plans for Hyperloop he was attacked as a techno-zealot. But we should resist the desire to attack visionaries.

A version of Musk's Hyperloop is possible and Hyperloop-CAL, a public-private-partnership between visionary entrepreneurs, visionary academics and visionary politicians is even more possible. Our socio-political structures will need to change as partly outlined in this paper. The forces of gridlock and political cynicism are powerful. We cannot know when the law of obsoletes will kick in or how much human suffering will take place in the meantime. While Elon Musk's tiny development team is working on his private version of Hyperloop, ETT technology that is human centered and embedded in accountable technology requires that the public to step up to the plate. In California, much seems in alignment for such a project. A truly egalitarian and accountable technology for the future may be at hand.

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