Bringing Order to Emergent Order: The Importance of Highway Patrol Troopers*

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Abstract: Within the context of an emergent traffic order, this article explores the potential benefits a highway patrol trooper has on the free flow of traffic when a driver is detained for a traffic violation. As such, this article examines the macroscopic character of an arterial highway using the Constructal Law. Microscopically, complex adaptive systems theory and three phase traffic theory are used to better understand traffic flow mechanics. Furthermore, Hayek's rule of law, primarily the distinction between law and legislation, provide an outline for maximizing the free flow of an emergent traffic order while adhering to a Constitutional framework.

Keywords: Hayek, Constructal Law, complex adaptive social system, rule of law, emergence, traffic flow, highway law enforcement

INTRODUCTION

What is the performance impact of a free-flowing, complex social system when a conscious agent's individual movement is restrained due to a rule-set violation? This article explores the operational environment of an arterial highway through the lens of a dynamic flow system. As such, in order to facilitate the free flow of an emergent traffic order, the article examines the latent benefits of a trooper patrolling an arterial highway for traffic violations.

The article is structured in the following manner. First, it establishes that the natural flow design and purpose of an arterial highway is best illustrated using the Constructal Law. Second, complex adaptive system theory and three-phase traffic theory, respectively, further explain the mechanics of interacting drivers and traffic flow degradation. Third, it employs F. A. Hayek's contributions to the literature on the Rule of Law as a backdrop for discerning the propriety of rule sets that naturally emerge within a complex adaptive social system. Fourth, the article then explains why a highway patrol trooper benefits the free flow of an emergent traffic order. Finally, a fifth component of the article suggests applying agent-based modeling as a potential research method for further highway flow analysis.

CONSTRUCTAL LAW

In reaching out to a diverse public, communicating the general operational environment of a highway flow system can be challenging. As such, scientific constructs may benefit a broader audience in expressing the nature of an arterial highway and the important role a highway patrol trooper plays within an emergent traffic flow order. The article begins with describing the macro level aspects of traffic flow continuing down to the micro level. First, however, what exactly is an arterial highway and how does an arterial highway come about?

The functional classification of an arterial highway, according to the Federal Highway Administration (FHA) in the United States, is a highway that "[p]rovides the highest level of service at the greatest speed for the longest uninterrupted distance, with some degree of access control." (Federal Highway Administration, 2012) In their book *Nature in Design*, Adrian Bejan's and J. Peder Zane's (2012) Constructal Law is used to provide a 50,000 ft. (15,000 m) view of an arterial highway's natural design and emergence within the context of a traffic flow system. The Constructal Law suggests: "For a finite-size flow system to persist in time (to live), its configuration must evolve in such a way that [it] provides easier access to the currents that flow through it." (Bejan and Zane, 2012, 3) The Constructal Law suggests that flow systems, both animate and inanimate, naturally develop branched tree-like structures as the most efficient design to facilitate the flow of mass from point-to-area and area-to-point. (Bejan and Zane, 2012, 4)

Within a vehicle-based flow system, equilibrium for the flow of mass is reached through a series of interconnected transitions from slow-moving areas toward fast-moving areas (and vice versa). Furthermore, the natural tree-like design associated with the Constructal Law states a natural hierarchy of flows (Bejan and Zane, 2012, 155). That is to say, slower movement is common for shorter distances, whereas faster movement is typical with longer distances. According to Bejan and Zane, these flowing interdependencies can also be described as a form of "vascularization." Indeed, "[t]he most familiar template for this is the vascular structure of our circulatory system, which delivers life giving blood to all the cells in our bodies" (e.g. arteries, veins, capillaries)." (Bejan and Zane, 2012, 154)

While the construction of our transportation systems may be deliberate, its design and configuration for efficient flow naturally emerge in a manner similar to many other flow systems, including rivers, lightning bolts, and veins. We find the Constructal Law in many of our daily travel routines (Bejan and Zane, 2012, 61); individual drivers will first walk (i.e. flow) from their house to their vehicle in the driveway. Those vehicles then travel slowly on shorter side streets which transition to longer/larger main roads where vehicles gain speed. Main roads then flow into faster-moving and longer-distance arterial highways.

Throughout the transportation system, vehicle flow is slow and short with transitions to fast and long (Bejan and Zane, 2012, 196). The Constructal Law provides a scientific foundation which not only compliments the FHA's definition of an arterial highway, but provides a basis for the highway's purpose within a holistic traffic flow system. While the Constructal Law illustrates the physics of how traffic systems flow, the following section discusses *"the what"* of traffic flow (Bejan and Zane, 2012, 200).

MECHANICS OF FLOW

As stated above, the Constructal Law provides unique insight into the natural design of animate and inanimate flow systems on a macro level. It does not, however, address in detail the mechanics of *what* it is that flows. As traffic flow is vehicle flow, this section provides the micro level aspects of the mechanics of vehicle interaction and traffic flow breakdown. From a mechanical standpoint, complex adaptive system theory is applied for contextualizing the interactions between individual vehicles. In addition, three-phase traffic theory is used to explain the dynamic nature of highway traffic flow breakdown (Kerner, 2009).

While it may seem semantic, this article makes a distinction between a complex adaptive system and a complex adaptive *social* system. So, what exactly is a complex adaptive system? Melanie Mitchell (2009, 13) defines a complex adaptive system as "a system in which large networks of [individual] components with no central control and simple rules of operation give rise to complex collective behavior, sophisticated information processing, and adaptation via learning or evolution." Generally, complex adaptive systems are "[s]ystems in which organized behavior arises without an internal or external controller or leader … [such systems] are sometimes called *self-organizing*. Since simple rules produce complex behavior in hard-to-predict ways, the macroscopic behavior is sometimes called *emergent*." (Ibid.)

In the context of complexity, John Holland (1995, 7) asserts that "[i]t is useful to think of an agent's behavior as determined by a collection of rules." For instance, "[f]lying birds adapt to the actions of their neighbors, unconsciously organizing themselves into a flock." (Waldrop, 1992, 11) Applying such a model to the free flow of traffic, as individual vehicles obey simple rules they can spontaneously self-organize and adapt vis-a-vis other vehicle actions. Absent centralized control, interacting vehicles obey simple rules, where spontaneous and self-organizing complex adaptive traffic flow collectively emerges from the bottom up.[1] By utilizing complex adaptive system theory, we are able to better understand the micro level interactions of individual vehicles.

The next segment of our conversation describes how these diverse vehicle interactions influence the free flow of traffic. Three-phase traffic theory aids our understanding regarding the spatiotemporal mechanics of traffic flow and traffic congestion. Briefly speaking, this theory suggests that when traffic is in free flow, and vehicle density is small, vehicle interactions tend to be more limited, which allows drivers to travel at their maximum desired speeds. (Kerner, 2009, 13) As vehicle densities increase, congestion is bound to occur. With congestion, traffic flow becomes sensitive to perturbations. (Ball, 2012) Consequently, various perturbations can trigger a traffic phase transition where traffic flow breakdown occurs, resulting in bottlenecks and ultimately a traffic jam. (Kerner, 2009)

From the point of view of highway law enforcement, these perturbations are likely the consequences of traffic violations (i.e. violations of rules sets). Furthermore, traffic violations contribute to vehicle crashes and fatalities. Note, however, that up to this point we have not considered the human element when describing the characteristics of traffic flow. Although physics enables a deeper understanding regarding the natural design and mechanics of an emergent traffic flow system, driving is in a fundamental sense—a social activity.

While there is a technical basis for using "agents" and "rule sets" as an abstract illustration, the free flow of traffic is a *social* interaction between vehicle drivers adhering to traffic law. While the flow of vehicles (i.e. mass) cannot escape the laws of physics, drivers are not deterministic automatons either. Drivers are people, and people are deliberate, conscious and generally rational—though occasionally irrational—actors. Hence the emergent order of the free flow of traffic on an arterial highway can be interpreted as a complex adaptive social system.

As traffic density and/or vehicle velocity increases, human interactions become more dynamic and complex. If an orderly flow of traffic is to emerge, a driver's compliance with the rules is paramount. The challenge of a free society, however, is creating rule sets where social agents will *voluntarily* comply.[2]

LAW CONSTRUCTAL

Not only does the physics of flow mean life, it also means freedom to move. (Bejan and Zane, 2012) In an emergent free flow of traffic on an arterial highway, the policy challenge is developing traffic laws that promote the following rule outcomes—all of which should occur simultaneously:

1. Voluntary compliance of individual drivers
2. Maximized freedom of movement for individual drivers
3. An emergent and free-flowing traffic order

In realizing these outcomes, the contributions of Hayek's *Law, Legislation, and Liberty* (1973) can help us to understand the distinction between "law" and legislation. Hayek discovered that in most cases, the rules to achieve these outcomes are already present before they are codified in legislation. In other words, many of the abstract rules regulating social interaction ("the efficient flow of society") are exemplified through mores, habits and traditions permeating through a cultural heritage. (Hayek, 1973, 17)

In selecting appropriate traffic laws or rules, the policymaker's task, as Hayek said of legislation in general "will be regarded as one of discovering something which exists, not as one of creating something new, even though the result of such efforts may be the creation of something that has not existed before." (Hayek, 1973, 78) In other words, legislation prohibiting "texting while driving" did not exist prior to its enactment. Still, the shared "rule" inferring that it is unsafe to drive while texting became intuitively apparent prior to the legislation prohibiting it. Just like the Constructal Law is a natural design for the efficient movement of mass in a flow system, socially acceptable "rules of the road" naturally emerge to facilitate the efficient flow of traffic. Hayek also provides policymakers a framework for appropriating an existing socially accepted rule into legislation.

Applied to a spatiotemporal traffic flow framework, Hayek provides guidance for crafting legislation that maximizes driver freedom. He suggests that "[t]he state should confine itself to establishing rules applying to general types of situations and should allow the individuals' freedom in everything which depends on the circumstances of time and place, because only the individuals concerned in each instance can fully known [sic] these circumstances and adapt their actions to them." (Hayek, 1973, 83). But how does this apply to driving?

The free flow of an emergent highway traffic order is an adaptive, bottom-up, and decentralized process where decisions are spontaneously made by individual drivers based on localized information. Therefore, if drivers are to freely traverse an arterial highway, communication and coordination between drivers is critical. For instance, in avoiding the "perturbations" that can lead to a traffic jam (or worse), universal rules such as requiring a luminous signal (i.e. a blinker) to

be used before changing lanes helps mitigate the risk of collision. A blinker on a vehicle is a communication and coordination device that telegraphs to other drivers that movement is about to occur.

The basic rule of requiring drivers to use a blinker when changing lanes is what Hayek refers to as the "circumstances of time and place." (Hayek, 1973, 84) A blinker increases another driver's ability to interpret the circumstances of time and place, which in turn provides opportunity for spontaneous adaptation. As drivers *voluntarily* comply with simple and general rules, a spontaneous traffic flow order that is complex, adaptive, decentralized, and leaderless naturally emerges.

The next section, however, discusses the potential impact on an emergent traffic order when traffic rules are violated. Not only might traffic flow cease when drivers fail to comply with traffic law, but catastrophes might occur. To recapitulate an earlier point, traffic rules that promote both individual freedom and voluntary compliance do not necessarily originate from a policymaker. In many cases, legislation merely institutionalizes prevailing customs. Likewise, traffic legislation which institutionalizes existing social customs increases the likelihood of voluntary compliance.

Within the context of the free flow of traffic, the purpose of legislation could be interpreted as a way to enforce prevailing social customs. Hayek himself contended that, in order to facilitate a spontaneous and emergent social flow, "the organization which we call government becomes indispensable in order to assure that those rules are obeyed." (Hayek, 1973, 47) This passage alludes to the vital role of the highway patrol trooper.

RULE SET ENFORCEMENT

In many ways, the creation of the highway patrol as a specialized area of law enforcement is also an emergent phenomenon. In the early part of the twentieth century, the free market propelled the United States into what John Steele Gordon (2004) called "an empire of wealth." Fueled by the industrial revolution, "[b]y the 1920s the automobile industry had become the largest in the American economy." (Gordon, 2004, 299) Gordon notes that in spite of barely any paved roads in 1900, there were 662,000 miles (1,066,000 km) of paved roads in the United States already in 1929. (Ibid.)

Freedom, then again, does not necessarily mean license.[3] In fact, freedom requires the individual to exercise some degree of self-restraint. Unfortunately, "[b]y the 1920s, accidents were frequent and many people were killed or injured every year on the roads and highways. In 1924, there were 23,600 deaths due to auto accidents, 700,000 injuries, and more than [US]$1 billion in property damage." (Melosi, 2010)

The emergence of the Utah Highway Patrol (UHP) highlights Hayek's distinction between law and legislation. With the development of the automobile, in 1923 "the Utah State Legislature empowers the State Road Commission [later designated the UHP] to patrol the highways of the State." (Utah Highway Patrol, 2013) Using prevailing custom as a standard for enforcement, the "State Road Commission adopts a regulation requiring traffic to stop before entering an arterial highway." (Ibid.) The challenge of a decentralized and emergent traffic order is that drivers within a free society need to voluntarily comply with the rules. But what happens if a driver refuses to voluntarily comply?

"Our Mission is to provide professional police and traffic services, and to protect the constitutional rights of all people in Utah"
– UHP Mission Statement

The emergence of the UHP is an explicit acknowledgement that an enforcement mechanism is required for curtailing driving behaviors that may disrupt the free flow of an emergent traffic order. From a public safety standpoint, the emergence of the UHP facilitates the safe and free flow of traffic within an arterial highway. However, does a trooper's detainment of an individual driver for traffic law violations bring order to the free flow of an emergent traffic order?

Consider the following hypothetical example: a driver is speeding, making improper lane changes, and failing to operate within a single lane; he or she is subsequently detained by a trooper for corrective action. Is the freedom of other drivers to pursue their self-interest increased by the trooper detaining the reckless driver? Yes, because by detaining a non-compliant driver for reckless driving, the trooper has intercepted a potential hazard from disrupting the overall free flow of traffic.

It is important to recognize that highway patrol troopers do not depend on a central authority to initiate a response[4] to a rule set violation. (Villarreal, 2008, 44) Indeed, embedded in the free flow of traffic, troopers patrol in a decentralized manner and confront potential hazards automatically and with no central instruction. (Ibid.) Nevertheless, affected drivers may also "tag" a violator by communicating to a centralized dispatch the violator's behavior, location and

identifiers so they can be found.[5] In addition, highway patrol troopers are not only instrumental in responding to vehicle crashes for scene safety and investigation purposes, but also in coordinating medical responses for the injured and in clearing any obstructions so the free flow of traffic can resume.

Within a complex adaptive social system, highway patrol troopers are key social agents. One could describe troopers as the "craftsmen" of highway safety.[6] Every highway incident is unique and thus often requires an immediate and customized plan when responding to the circumstances of time and place. Moreover, what makes a highway patrol trooper a professional is that their individual actions are accountable to constitutional rules.[7]

Hayek, while he acknowledged the value of government enforcing rules, also cautions against arbitrary government interference. Hayek suggests:

> While every law restricts individual freedom to some extent by altering the means which people may use in the pursuit of their aims, under the Rule of Law the government is prevented from stultifying individual efforts by *ad hoc* action. Within the known rules of the game the individual is free to pursue his personal ends and desires, certain that the powers of government will not be used deliberately to frustrate his efforts. (Hayek, 1973, 81)

In the context of the free flow of traffic, the Hayekian Rule of Law not only provides direction for drivers, but equally important, places restrictions on the government. For a trooper to detain a driver a violation is required. If a driver is unlawfully detained, the government is arbitrarily interfering with the free flow of traffic instead of facilitating it.[8] Any additional criminal evidence recovered from an unlawful stop would be determined to be invalid.[9] As such, Hayek's contributions to the Rule of Law can also be interpreted as a constitutionally-based framework for enforcing rules within a complex adaptive social flow system.

Although highway patrol troopers are primarily an enforcement mechanism, troopers are also educators; a complex adaptive social system is also a learning system and adaptation can occur through public information and education. For example, educating the public regarding the dangers associated with not wearing a seatbelt or with excessive speeding can lead to greater voluntary compliance. As another example, the analysis of crash data can support data-driven strategic planning for the purpose of maximizing the free flow of traffic. Crash data not only assists targeted enforcement (McFall, 2013), but can also intelligently alert various public safety stakeholders to the problems associated with motor vehicle crashes. (Utah Highway Safety Office, 2011)

"CRAZY" AGENT-BASED RESEARCH

Earlier in the article it was suggested that applying an agent-based model could be a potential research tool for further highway-flow analysis. Then again, as previously expressed, drivers are not deterministic agents but people. In any type of controlled experiment, such as an agent-based theoretical computational model, an agent will become a non-sentient automaton.

Even so, utilizing a computer model to reveal real-world traffic flow insight can energize opposition. In their book *Complex Adaptive Systems*, John Miller and Scott Page provide the rationale for employing computational modeling when analyzing agent behavior in complex adaptive systems:

> A common objection to computation is that the answers are "built-in" to the model, and thus we can never learn anything new from these techniques. Clearly, the first part of this objection is absolutely correct—the results of the computation are built-in since the computer will, without error, follow its predetermined program. Nonetheless, the inference that somehow this makes an unacceptable theoretical tool is wrong. (Miller and Page, 2007, 69)

The purpose of employing an agent-based model here is not to predict the future behavior of an agent, but to test an earlier claim. Specifically, can rule set violations by individual drivers within an arterial highway degrade the free flow of an emergent traffic order? The primary purpose of this research would be to study the potential consequences to the free flow of an emergent traffic order when agents violate the rule sets.

An agent-based model could be programed to simulate tasks a driver on an urban arterial highway would be expected to perform. For example, an agent would be required to travel a certain speed, operate within a single lane, not follow other drivers too closely, secure loose cargo, travel the same direction as traffic flow, use a blinker when changing lanes, etc. While this is a short list, agents could potentially be programed to mimic the traffic rules outlined in a state's traffic statute. Moreover, perhaps using a random number genera-

tor, certain agents would also be programmed to intentionally violate the rules. Additionally, such an agent based model may also provide insight regarding the impact a constitutionally restricted enforcement agent has on facilitating the free flow of an emergent traffic order.

CONCLUSION

This article has argued that the natural flow design and purpose of an arterial highway is best illustrated through the Constructal Law. In addition, complex adaptive system theory and three-phase traffic theory help explain the mechanics of interacting drivers and traffic flow degradation. Hayek's distinction between law and legislation explains that the rules within a complex adaptive social flow system have a tendency to emerge naturally. This provides an explanation for why a highway patrol trooper facilitates the free flow of an emergent traffic order within an arterial highway.

A feasible component of measuring the general public's quality of life could include a free and continuous flow of traffic. (Sullivan, 2014) From an economic standpoint, "[t]he transportation sector moves goods and people, employs millions of workers, generates revenue, and consumes materials and services produced by other sectors of the economy." (Bureau of Transportation Statistics) As it relates to the economic benefits of the transportation of freight, it's estimated that in 2002, the "transportation-related goods and services accounted for more than 10 percent—over $1 trillion—of U.S. Gross Domestic Product." (Ibid.)

In a free society, the expectation of the motoring public is to seek out their individual self-interest with minimal interference, whether such activity is commerce, going to a sporting event, or taking the family to church. One way to achieve this shared community goal is for individual drivers to voluntarily comply with the traffic rules. However, in order to maintain the free flow of a complex adaptive social system, an enforcement mechanism provides a required corrective action when a social agent violates the rules.[10]

At the end of the day, in bringing order to the free flow of an emergent traffic order, if a highway patrol trooper didn't already exist—we would have to invent one.[11]

NOTES

* The views expressed in this article are those of the author and do not reflect the official policy or position of the Utah Highway Patrol or the Utah Department of Public Safety.

1 In the context of a complex adaptive social system, Daniel Klein highlights the folly of central planning using an ice skating analogy. Klein depicts an ice skating rink owner that "hires a man with the reputation of a saint, and with two PhDs from Yale, one in civil engineering and one in ethics. This smart saint stands in the organ booth, holds a bullhorn up to his mouth, and calls out directions: 'You in the blue jacket, speed up and veer to the left.' 'You in the black overalls, I want you to slow down and move toward the inside.' And so on." (Klein, 2012, 5) (Needless to say, as Klein suggests, this type of central planning would be a disaster.)

2 Hat tip to Sergeant N. Croft.

3 Previous conversations with John D. Harman.

4 At least implicitly, Israel Kirzner's (1997) contributions regarding entrepreneurial discovery may apply to both drivers and troopers. In a Kirznerian discovery process, an alert driver can observe other drivers commit rule set violations, and to a certain degree, anticipate potential hazards, spontaneously adapting in order to avoid them. Also, each driver has additional incentives to be alert for potential hazards because their safety (i.e. well-being) and property (i.e. vehicle) can be negatively impacted if they are not. Entrepreneurial discovery can also apply to law enforcement. For instance, if a driver speeds past a trooper, the trooper did not "discover" the vehicle—he merely observed it go by. That being said, when the trooper detains the vehicle and interacts with the driver, an alert trooper—through the scope of his investigation—may discover the driver to be impaired, to be in possession of drugs, to have outstanding warrants, to be involved in human trafficking, etc.

5 Troopers cannot be at all places at all times. As such, it's not uncommon for drivers to call 911 and report a reckless driver and/or other types of highway hazards.

6 For a broader discussion regarding the craftsman as an intellectual, see *The Sociological Imagination* by C. Wright Mills (2000).

7 Of course, every officer in law enforcement is accountable to the same constitutional rules.

8 From the standpoint of transparency, the patrol cars of UHP field troopers are outfitted with video and audio equipment to document the integrity of the stop.

9 In American jurisprudence, this is also known as "The Fruit from the Poisonous Tree."

10 For an additional perspective on the benefits of a highway patrol trooper, see Life and Death in the Fast Lane: Police Enforcement and Traffic Fatalities, by Gregory Deangelo and Benjamin Hansen (2015). Also, special thanks to Sergeants N. Croft, D. Moreno, and J. Cox for their feedback, either written or verbal, about the flow of traffic.

11 Paraphrase of a United States Marine Corps recruitment video.

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