A Case Study: The New York City Yellow Cab System of Systems

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Abstract - In recent years there has been a significant increase in the amount of research done in the field of system of systems engineering. Despite many attempts, there is still a lack of a unified definition and standards for Systems of Systems (SoS). Case study research provides us with an opportunity to extract best practices from real life system of systems cases and set much needed guidelines for SoS governance. The yellow cab case is a well documented example of a System of Systems, which consists of multiple integrated complex systems working together to achieve the objective of transporting passengers in New York City in a safe and efficient manner. The best practices of the yellow cab SoS can be implemented in other SoS domains and the questions developed could be used for discussions in a class setting. Furthermore, these questions could be extended and applied to analyze other SoS cases in a similar manner.

Keywords: New York City Yellow Cab, System of Systems, SoS Case Study, SoS Best Practices

1 Introduction

a. Briefly describe the system of systems being analyzed

The NYC Yellow Cab SoS is an essential part of the NYC transportation network. It consists of over 13,000 licensed medallion taxicabs. It serves about 240 million passengers a year which creates a 1.82 billion dollar industry. NYC Yellow Cabs bring in around 30% of all fares paid by passengers for all trips in NYC and approximately 45% of fares paid for trips within Manhattan (Schaller Consulting, 2006). The taxicabs are privately operated by independent companies or individuals. At the same time, they are closely regulated by the New York City Taxi and Limousine Commission (TLC)

b. Define the perceived System of Systems Engineering process, situation or problem presented in the case (declarative or question form)

2 Background Information

a. Context

The Yellow Cab SoS case can be evaluated from 4 perspectives: i) The TLC, ii) The medallion owners, iii) The yellow cab drivers & iv)The brokers. For the purpose of this paper, this case will be evaluated from the perspective of the governing body, which is the TLC.

b. Relevant theories regarding case development

An important relevant theory regarding the development of the Yellow Cab SoS was the development of taxi customer market segments for various cities done by Schaller Consulting. The theory developed for the Yellow Cab SoS was that the yellow cabs operate on a street hail basis and do not operate on a dispatch basis as shown in Figure 1.
### 3 The New York City Yellow Cab System of Systems Description

#### a. History and development

The “Yellow Taxicab Co.” was incorporated in New York on April 4, 1912. Its fares that year started at 50¢/mile (which would be about $11.38 in today’s dollars). In 2011, the taxi cab rates are $2.50 at entry and then an additional $0.40 for every 1/5th mile covered. In addition, there is also a $0.50 NY state tax surcharge for every trip. Some of the important stages in the life of the NYC Yellow Cab SoS are listed below [3]:

i. **1930s – Medallion System Introduced** – During the great depression there were far more drivers than there were passengers to ride in the NYC yellow cabs. Hence, in 1937, Mayor LaGuardia introduced a license to operate taxi cabs and the medallion system that remains in place today. The law limited the number of medallions to 11,787 until 1996 and today has a total of 13,237 medallions. Medallions are considered extremely good investments with the two most recent medallions being sold in NYC for $950,000 each – a total of $1.9 Million in February 2011.

ii. **1960s – Introduction of Yellow Cabs** – In 1967, all cabs which had medallions were required to be painted yellow to cut down on unofficial drivers and make the official taxicabs more recognizable.

iii. **1970s – NYC Taxi & Limousine Commission was set up** [4] -- The New York City TLC, created in 1971, is the agency responsible for licensing and regulating New York City’s medallion (yellow) taxicabs, for-hire vehicles (community-based liveries and black cars), commuter vans, paratransit vehicles (ambulettes) and certain luxury limousines. The Commission’s Board consists of nine members, eight of whom are unsalaried Commissioners. The salaried Chair/Commissioner presides over regularly scheduled public Commission meetings, and is the head of the agency, which maintains a staff of approximately 400 TLC employees assigned to various divisions and bureaus. The TLC licenses and regulates over 50,000 vehicles and approximately 100,000 drivers, performs safety and emissions inspections of the more than 13,000 medallion taxicabs three times each year, and holds numerous hearings for violations of City and TLC rules and regulations, making it the most active taxi and limousine licensing regulatory agency in the United States.

iv. **1980s – Demographic change in drivers** – From the mid 1980s, due to large waves of immigrants, a large number of NYC yellow cab drivers were of foreign birth. According to the 2000 census, 82% of NYC cabbies are foreign born.

v. **1990s – Change in type of vehicles and operational refusal** – From 1996, when Chevrolet stopped making the Caprice, the Ford Crown Victoria became the car of choice for NYC yellow cabs. Currently about 90% of NYC’s yellow cabs are Ford Crown Victorias.
vi. 2000s – New computer technologies, hybrid vehicles and diesel vehicles – In 2005, NYC offered incentives to shift to hybrid cabs such as the Toyota Prius and the Ford Focus Hybrid.

vii. 2010s – Taxis of tomorrow – This year (2011) there will be an exclusive contract to sell and maintain NYC yellow cabs given either to Karsan (a Turkish company), Nissan or Ford.[5]

b. High level diagram or layout

As shown in Figure 3, the Yellow Cab SoS is a network made up of 13,738 constituents. Each constituent is an independent entity which operates on its own schedule, routes, breaks and services. Despite being independent constituents, the yellow cabs are interconnected with the same power of connectivity and the same equal access to the infrastructure in which they operate. Each yellow cab within the SoS, while on its own, is also a part of the SoS network. They are also interconnected, as the behavior of one, can affect other constituents as well. For example, if X number of cabs were to go on strike and be off the streets, the demand for cabs would go up and consequently the average wait time for a cab would increase; thus making the Yellow Cab SoS inefficient. This happened when a large number of taxi cabs went on strike in New York City in September 2007.[6] Furthermore, the demand for the yellow cabs is addressed by the SoS constituents through social networking amongst themselves, which in turn improves the supply to the customers and thus reduces waiting time and makes the SoS more efficient.

Figure 3: Yellow Cab SoS high level diagram

c. Sponsor, Industry, Country or Budget

The TLC of New York City is the governing body for the Yellow Cab SoS. All drivers need to comply with the NYC TLC policies and regulations for driving either a medallion yellow cab or black car in the five boros which make up New York City. Furthermore, the TLC also makes up the rules and regulations that have to be followed by other stakeholders associated with the Yellow Cab SoS.

d. Mission/Purpose/Goal/Objective

The primary goal of the NYC Yellow Cab SoS is to transport passengers in a safe and clean environment to their destination. They serve as a quick and easy means of transportation across Manhattan, for routes not amply served by the subways or for people who are looking for a faster mode of transportation.

e. Principles/Characteristics

The four guiding principles for New York City’s Yellow Cab SoS are [7]:

i. New York City’s taxi system should offer taxi services that are safe, comfortable, and easy to use for all passengers and drivers.

ii. New York City’s taxi system should provide a good economic value to passengers and service providers.

iii. New York City’s taxi system should efficiently match the supply of taxi services with passenger demand.

iv. New York City’s taxi system should contribute to the environmental sustainability of the city

f. Settings/Structure/Boundaries

The boundaries that the Yellow Cab SoS has to adhere by are primarily the geographical location within the five boros of NYC as well as the number of cabs that serve as the constituents of the SoS.

g. External Factors and Constrains

As shown in Figure 4, the NYC Yellow Cab SoS has several external factors that affect it. These external factors are primarily divided into three categories. The first category includes the external factors that are unpredictable and are not designed to govern the SoS. These external factors include new technology, gas prices, weather, tolls, vehicle prices and other economic factors such as unemployment which corresponds to the usage of yellow cabs and also the demand to drive it as well as the price of the medallions required to operate a yellow cab. The second type of external factor that affects the NYC Yellow Cab SoS is the governing body, which is the New York City TLC. The TLC sets up governing rules for the Yellow Cab SoS based on external constraints which affect the governance of the SoS. These constraints include federal and local laws, environmental constraints, safety and emission requirements, infrastructure constraints and input from other modes of transportation as well as feedback from the Yellow Cab SoS itself. In March 2011, the TLC re-emphasized a policy, which was originally laid down in April 2003, that NYC yellow cab drivers cannot partake in “geographical discrimination” and are mandated by law to take the customer to wherever they wish to be transported [8][9].

h. Constituents (new/legacy, scope)

The 13,237 independent yellow cabs are the constituents of the NYC Yellow Cab SoS.
4 SoSE Analysis

a. Analysis and analytical findings

The Yellow Cab SoS was analyzed by Gorod, Gandhi et al [2], using the Boardman Sauser distinguishing characteristics of SoS, which were: Autonomy, Belonging, Connectivity, Diversity and Emergence. Within each characteristic, there is a spectrum of forces influencing the characteristics. To explain that spectrum, we are discussing only the two extremes of the opposing forces for each of the characteristics. Along the spectrum, there is a point where those opposing forces meet and find equilibrium. The study of the case was done on the basis of the five distinguishing characteristics and was analyzed as follows:

i. Autonomy: The two opposing forces within autonomy are conformance and independence. The analysis revealed that the Yellow Cab SoS leans more towards independence. This was because despite the TLC setting up regulations such as the taxi fares and the inspections required for safety reasons; each medallion cab was primarily operated on an independent basis. The independent drivers made their own choices in regards to schedules, routes, breaks and services.

ii. Belonging: The two opposing forces within belonging are centralization and decentralization. Due to significant freedom for the cab drivers, the Yellow Cab SoS leans significantly towards decentralization. The taxicabs operate independently and cannot be prearranged for pick up but operate on a street hail basis.

iii. Connectivity: The two opposing forces within connectivity are platform centric and network-centric. The Yellow Cab SoS leans towards being network-centric. This is because all the constituents of the SoS have the same power of

![Diagram](image_url)
connectivity and the same equal access to the infrastructure in which they operate. Each yellow cab within the SoS, while on its own, is also a part of the SoS network.

iv. Diversity: Homogeneous and heterogeneous are the two opposing forces within diversity. The Yellow Cab SoS was analyzed to highly lean towards being heterogeneous because of the current diversity of cars, drivers (aside from gender) and operators.

v. Emergence: The two opposing forces within emergence are foreseen and indeterminable. Since the NYC Yellow Cab SoS is highly adaptable to the environment, whether it is intended or unintended, it leans towards the indeterminability side within emergence.

In addition to the above analysis, there was a survey sent out to subject matter experts about the NYC Yellow Cab SoS characterization. According to Gorod (2009), the findings from this survey included (10):

1) Each stakeholder has a different perspective about the characterization of the Yellow Cab SoS
2) For the diversity characteristic, there was an equal distribution between leaning towards homogeneous and leaning towards heterogeneous.

b. Lessons learned & best practices
The important lessons learned and best practices extracted on analyzing the Yellow Cab SoS were:

i. The assessment of the SoS characterization can vary from stakeholder to stakeholder. For this analysis, the Yellow Cab SoS was analyzed from the perspective of the TLC. Conversely, if the case was analyzed from the perspective of the cab drivers, the findings of the analysis could have come out to be very different. The best practice that can be extrapolated from this learning is to identify as many stakeholders as possible associated with the SoS.

ii. The assessment of the SoS characterization also varies based on time and external factors that could affect the SoS. For example, in 1971 the price of a medallion dropped to $10,000. Conversely, in February 2011, a pair of medallions was sold for $1.9 million. The best practice that can be extracted from this lesson learned is to identify as many external factors as possible for the SoS. Since the characterization varies based on time, it is also important to understand the criticality of the SoS and the feedback associated so that the governing body can decide how frequently this iterative process should be carried out in a cost efficient manner.

iii. An important lesson learned from the Yellow Cab SoS is to understand the importance of having the right amount of flexibility associated with the SoS. The balance obtained between control and flexibility due to which the SoS operates in an efficient manner. Despite the Yellow Cab SoS having 13,378 constituents, 100,000 drivers and numerous factors which influence the SoS, the passengers are transported in a safe and efficient manner while also keeping the drivers content with their working conditions due to the amount of independence and flexibility provided. The best practice from this lesson learned is to not exert too much control but at the same time have a strong influence.

iv. Due to being run in an efficient manner, the average wait time for passengers is approximately 5.59 minutes.

v. The governing agency of the SoS should come up with enough incentives to encourage the constituents to belong to the SoS. The best practice is to develop and implement a set of stakeholder incentives for every SoS.

vi. It is also important to also understand and implement the means and extent to which feedback is received regarding the SoS.

vii. Lastly, it is imperative to have a clear understanding of the way in which the TLC, which is the governing body, uses the constraints as guiding factors to set up operating policies for the Yellow Cab SoS.

It is important to keep in mind that these lessons learned can be extrapolated to SoS in different domains as all SoS display different intensity of the five characteristics discussed in this paper.

c. Steps and conditions for replicating the SoS elsewhere
Models and tools, which have been applied to the NYC Yellow Cab case, could also be applicable to different industries. One of the models which has been applied to different domains of SoS is shown in Figure 4 of this paper. This is a generic SoS governance model that can be applied across various domains and allows the governing body to better understand the dynamics of SoS by identifying external factors and constraints associated with the SoS. This, in turn can lead to better organizational performance while remaining competitive, and providing a new dimension to SoS Management, which is a continuously growing field in today’s complex dynamic environment.

5 Conclusion

The New York City Yellow Cab SoS is a good example of a System of Systems. The objective of the TLC
is to govern the SoS to ensure safe and efficient transportation of passengers in New York City. This helped to identify lessons learned based on which, best practices that could be extracted to other SoS have been established. This case also raises questions for discussion which can be applied to other case studies and be used as a benchmark for other cases. It is an initial condition for modeling and simulation of case studies overall.

6 Questions for discussions

a. Are there any other stakeholders in the Yellow Cab SoS? How will the characterization of the SoS vary if done from this newly identified stakeholder’s perspective?

b. How would you analyze the SoS if done using other characteristics of SoS?

c. What would happen if there was no restriction on the number of constituents in the Yellow Cab SoS?

d. What would happen if the TLC would use a “dispatch only” business model?

e. To what extent should the governing body control the individual yellow cabs?

f. Do you agree with the policy that yellow cab drivers are required to transport passengers irrespective of their destination?

g. How would the SoS characteristics vary if only one company were in charge of selling and maintaining all cabs in NYC?

h. Can a similar model work for other modes of transportation in NYC?

i. How would the characteristics of the Yellow Cab SoS vary with time?

References


