

Communication System Dynamics of Mega Rail Transportation: Study into Sydney's Ridership Issues

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Abstract—This study reviews some of the most crucial rail transportation patronage for Sydney, Australia. Specifically, Sydney's transportation patronage and their associated communities are analyzed for a variety of demographic and population complexities. Sydney has a high population density and other issues which complicate the city's ability to provide satisfactory patronage. Although surface issues appear as late trains and significant network disruptions, a greater area of concern is the challenge encountered in communications system. This paper will investigate key communication system dynamics that relates to three specific requirements. These are a) exact incident detection and communicate, b) precise reliability and c) efficiency. The dynamics forms the backbone of Sydney's rail transportation infrastructure. Due to its great size and system challenges, meeting these measures can allow Sydney's ridership issues to be further assessed and mitigated. Subsequently, this can lead to creation of frameworks and strategies to better plan and manage rail transportation infrastructure.

Index Terms—Communications dynamics, rail patronage, Sydney's ridership

I. INTRODUCTION

In general, the aims of rail transportation are to provide a basic service, improve the quality of life, support a clean and sustainable environment and use smart systems [1]-[5]. Unfortunately, for many rail networks, a large percentage of users drive private vehicles to the nearest station, park their cars and then engage with the rail network. Reference [6] highlighted that this arrangement means that rail systems are not servicing all key areas, but rather specific locations. Subsequently, large multibillion-dollar rail transportation networks are utilized only partially. In contrast, many European nations utilize their systems to their full potential and not only have the latest rail systems, but also provide exemplarily patronage services, including many more stations located throughout their cities' areas. Nations such as England,

France, and Germany are at the forefront of dynamic rail transportation patronage services.

Outstanding timetabling, efficiencies and sensible fares are only some of the accepted best practice indicators. In addition, one positive outcome of effective rail transportation is satisfied patronage [7], [8]. A satisfied patronage outcome is central to content ridership. This paper will review some of the most crucial rail transportation patronage for Sydney, Australia. In doing so, its ridership will be investigated comprehensively and will include assessment of some of the communication system dynamics of Sydney's rail transportation network.

II. LITERATURE REVIEW

Rail transportation is one of the most important infrastructures for cities [5], [9], [10]. As such, sustainability is crucial [3], [11]. To conjoin sustainability with rail transportation infrastructure introduces many complexities. To counter these complexities, a global (universal) approach that considers both short and long-term considerations is needed [12]. Key to this approach is a long-term ridership policy. Nonetheless, the authors of [13] argued that general issues for optimal rail ridership are as follows: a) competition with personal vehicles, b) lack of overall public transportation coordination, c) limited coverage zones and areas, and d) locality and accessibility to train stations.

Gharehbaghi and Myers [14] further expanded on these issues and also included modern public transit systems such as information and communications technology (ICT) and intelligent transportation system (ITS) as an additional and important rail ridership issue. Moreover, authors of [15] argued that slow and low capacity rail systems compound transportation ridership issues. In response to such concerns, Li in [16] noted a long-term solution is required. For world leading cities, a strategy involves comprehensive patronage planning [12], [17]. Comprehensive patronage planning in-turn necessitates the careful integration of sustainable transportation infrastructure and communication systems. Such systems encompass signaling, engineering supports together with ridership experience. Fig. 1 represents the overall communication system integration for the purpose of improved of rail transportation patronage.

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Fig. 1. Communication system integration of improved of rail transportation patronage.

While the communications integration includes the general capacities, the global response, on the other hand, building rail network capacity is also required. This means that the improved rail transportation infrastructure needs to include both international communications benchmarks and innovative technologies [18]. Accordingly, policy efforts focused on incorporating a combination of national and international transportation management capabilities [19], [20]. This capacity allows for the establishment of cooperative arrangements – the alignment of government and private sector service providers [21], [22]. This association is necessary for dealing with the various global transportation sustainability issues including environmentally sustainable design and construction practices. In summary, the communications integration includes the amalgamation of two vital features:

- The circuitous ridership indicators, their advancements and encroachment including improved technologies to enhance the public transportation and related services.
- Amplified performance and functionality of rail transportation infrastructure projects.

The ridership planning phase is an example of where the integration of communication can be increased. This phase is where the underpinning communication issues are carefully prepared [23] and includes mapping various service delivery strategies and their potential shortfalls

and risks [24]. Subsequently, this phase underpins the delivery of essential rail services, economic growth, supports social needs and particularly the establishment of vital Key Performance Indicators (KPIs). For dynamic rail transportation patronage, determining ridership KPIs is central for effective communication integration of ridership outlooks.

III. RESEARCH METHODOLOGY

Using explicit system methodology and qualitative & quantitative variables, this research first carried out a comprehensive literature examination. Then, based on the findings, the research methodology consisted of determining Sydney's ridership issues through close determination of its sustainability challenges. The research method also entailed collecting primary data such as system KPIs from various technical reports, government documentations and associated recommendations. This information was scrutinized to enumerate the data and observe any particular relationships held between them. Using sustainable transportation theory as the conceptual framework, this research then investigated Sydney's communications system dynamics. Finally, since this study is qualitative in scope, the findings were consolidated through a descriptive and comparative approach to determine the Sydney's communication system requirements.

IV. SYDNEY'S RAIL TRANSPORTATION NETWORK

Generally, Sydney's rail network is its main means of transport. This is especially the case for mass populace movement [13]. Before the most crucial rail transportation patronage for the Sydney are discussed, first its ridership positions need to be established. For this mega city, ridership outlook is closely aligned with a comprehensive systematic sustainability focus. Accordingly, this city's ridership issues are entangled with its rail network's uncertainties and predicaments. As a part of appropriate ridership planning, key sustainable indicators of engineering, environmental, social and economic need to be carefully integrated. This is in response to a broader and holistic patronage planning. As a mega city, Sydney is comprised of many sprawling suburbs. Each of these cover a large area and are bordered by different surroundings. Subsequently, Sydney's rail authorities are confronted by manifold sustainability challenges, shown in Fig. 2.

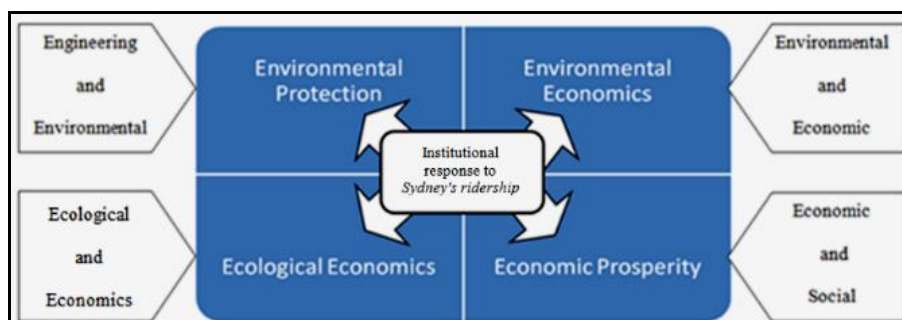


Fig. 2. Sydney's rail transportation sustainability challenges.

Fig. 2 signifies the importance of a sustainability response as a part of Sydney's broader rail transportation challenges. The sustainability approach is necessary to ensure Sydney's rail network is effectively aligned with the aspirations of the specific ecological institutions such as the Environmental Protection Agency (EPA). This alignment is necessary to further bring into line Sydney's environmental, engineering, economic and social indicators and influences. Importantly, as a part of a wide-ranging sustainability challenges, Sydney's rail network also needs to carefully align the ecological economics in terms of interdependence of monetary and natural ecosystems. Further, economic prosperity such as livability and longevity must also be considered. All in all, to ensure Sydney's rail transportation sustainability challenges are successfully met, an institutional response is required. This entails a careful collaboration of all the relevant authorities. Overall, as part of broader ridership approach, the discussed sustainability challenges effects the cities' ridership planning. To further understand such planning difficulty, Sydney's ridership issues need to be reviewed.

A. Sydney's Ridership Issues

Crucial rail transportation patronage issues facing Sydney include:

- Congestion and over-crowded network. For Sydney's urban areas, this is a particular frustrating issue. The city's continued growing population exacerbates this situation.
- Elevated fare pricing. Although, the annual price increase is generally based on the Consumer Price Index (CPI), Sydney's rail fares are among the highest in the developed world.
- Transit systems not expanding beyond the urban cores. For Sydney insiders, the rail infrastructure is adequate, however, for its outer-urban and rural areas it is some-what limited.
- Operation hours, intervals and system breakdowns. There has long been a need for 24 hours rail services for Sydney. This is necessary to bring the Sydney's rail service in-line with premium cities such as New York, London, Paris and so on.

For Sydney, such patronage predicaments not only impact its livability, but also further complicate the governance processes. In addition, the crucial patronage predicaments are primarily based on the city's future challenges and opportunities including a) population decentralization, b) lack of coverage zones and neighborhoods, and c) patron behavioral changes.

B. Sydney's Ridership KPIs

Due to on-going ridership issues, Sydney has invested considerable resources in its rail network upgrade. As a smart infrastructure, the Sydney Metro is an example, where it is assumed that the city's patronage predicaments together with the ridership issues will be effectively resolved. To this end, Sydney's efficient rail transportation patronage is central for a positive outcome. As a mega city, Sydney's rail network requires continuous ridership satisfaction reassessment through

system measurability of all requisite KPIs. For this purpose, the following ridership satisfaction rubric was developed, Table I.

TABLE I: SYDNEY'S RIDERSHIP SATISFACTION RUBRIC

Ridership KPI's	Minimum	Maximum	Notations
Safety	100%	100%	Effective incident impact assessment through precise TIM
Reliability	88%	100%	Overall process consistency
Efficiency	88%	100%	Output optimization
Improve overall quality	boost communication via smart systems, i.e. ICT, ITS		

The presented rubric can be used as Sydney's rail ridership performance KPIs. Subsequently, Sydney's relevant transportation authorities can further adopt performance measurement as a benchmark to ensure ridership issues are well restrained. To improve Sydney's ridership issues, enhanced communication systems are recommended, that is smart systems. Consequently, the remaining complex issue facing Sydney's rail transportation is the on-going and positive collaboration between all the pertinent stakeholders. Such collaboration is the epitome of meeting sustainable rail infrastructure expectations; and more importantly to ensure benchmarks are met. The Sydney's ridership satisfaction rubric is further evaluated based on actual system requirements which are presented in Fig. 3.

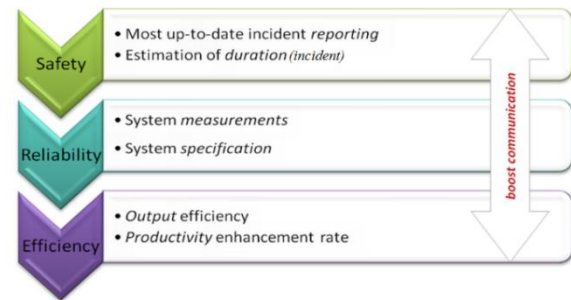


Fig. 3. Sydney's communication system requirements.

To achieve the overall Sydney's rail transportation ridership quality an improvement in the overall quality, satisfactory system requirements are a must. Fig. 3 represents the patronage the Sydney's ridership satisfaction system requirements. These system requirements are carefully aligned with Sydney's ridership outlook and the subsequent ridership performance KPIs. The proposed KPIs have the following key measures: 1) providing a safe journey, including exact incident detection and response; 2) system reliability appraisal, and 3) system efficiency evaluation. These specific system measures are all part of the Sydney's rail transportation communication dynamics which will respond to its ridership issues, such as patronage consideration. As such, the overall quality of the communication system can be boosted via advanced communications-based train control (CBTC). For the

Sydney's rail network, ITS, CBTC needs to encompass the most sophisticated smart systems including ICT, ITS etc. Obviously, all of the positive outcomes are based on available data, specific system methodologies and qualitative & quantitative variables. These matching systems elements will therefore be part of the proposed concise and reliable analytical computation process.

V. CONCLUSION

In response to Sydney's rail transportation ridership issues, this paper examined the communication system challenges as a way to improve its patronage. This research has found that Sydney's rail network is its main means of transport, and as such, required careful investigation. First, the Sydney's rail transportation sustainability challenges were discussed, highlighting some the network difficulties. Second, Sydney's ridership issues along with system KPIs were discussed. It was found, in terms of Sydney's rail transportation communication system, there are three specific requirements. Exact incident detection and communiqué together with precise reliability and efficiency setting were the backbone of the Sydney's rail transportation infrastructure. Due to its great size and system challenges, meeting these system measures can allow the Sydney's ridership issues to be further assessed and mitigated. Such findings are evidently based on available data, explicit system methodology and qualitative & quantitative variables. Finally, the findings discussed in this research can assist rail transportation planners and researchers to further assess complexities in mega networks. Subsequently, this can lead to the creation of frameworks and strategies to better plan and manage rail transportation infrastructure.

DATA AVAILABILITY STATEMENT

Some or all data, models, or code generated or used during the study were available from the corresponding author by request.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

Gharehbaghi conducted the research; Gharehbaghi, Farnes and Paterno analyzed the data and wrote the paper. All authors have approved the final version.

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