
Intelligent Transport Systems and Urban Traffic Congestion Mitigation in Developing Economies: A Study of ICT Adoption and Compatibility in Nigerian Cities

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Abstract: *The application of Information and Communication Technology (ICT) to urban traffic management has emerged as a transformative approach to congestion mitigation in developed economies. However, the adoption and effectiveness of Intelligent Transport Systems (ITS) in developing economies remain poorly understood. This study examines the compatibility of modern ICT facilities with prevailing urban transport systems in two Nigerian cities—Owerri and Port Harcourt—using survey data from 330 stakeholders and field observations of ten major link routes. The findings reveal that existing traffic monitoring and control technologies are predominantly outdated static traffic lights and manual signage, with limited deployment of advanced sensors, adaptive signal control, AI-powered analytics, or V2X communication systems. Road users demonstrate moderate ICT proficiency but low awareness of modern ITS technologies and limited willingness to adopt technology-driven traffic solutions. The study identifies critical barriers to ICT adoption including inadequate technological infrastructure, limited skilled manpower, weak policy frameworks, and low public awareness. We propose a comprehensive framework for ITS implementation in developing economies that addresses technological, institutional, and human capacity dimensions. The study contributes empirical evidence on ICT compatibility challenges in developing country transport systems and offers practical recommendations for policymakers and transport agencies seeking to leverage technology for congestion mitigation.*

Keywords: Intelligent Transport Systems, traffic ICT, technology adoption, developing economies, traffic congestion, V2X, smart cities.

INTRODUCTION

The application of Information and Communication Technology (ICT) to urban traffic management has emerged as one of the most promising approaches to congestion mitigation in developed economies (Gössling, 2017; Jean-Paul Rodrigue et al., 2016). Intelligent Transport Systems (ITS)—encompassing real-time traffic monitoring, adaptive signal control, variable message signs, vehicle-to-everything (V2X)

communication, and AI-powered traffic analytics—have demonstrated significant effectiveness in reducing congestion, improving safety, and enhancing transport efficiency (Stefano Lovati, 2023; Tanwar et al., 2020). Cities such as Singapore, London, and Tokyo have successfully leveraged ITS to achieve substantial reductions in congestion levels, travel times, and emissions (OECD, 2018).

However, the adoption and effectiveness of these technologies in developing economies remain poorly understood. In Nigeria, where urban traffic congestion imposes staggering economic and social costs—estimated at nearly four trillion Naira annually in Lagos alone (Danne Institute for Research, 2021)—the potential of ICT-enabled traffic management remains largely untapped. Despite decades of interventions including flyover construction, traffic light installation, and mass transit programmes, congestion continues to worsen (Umar et al., 2020; Solanke, 2013). This persistent challenge suggests that traditional approaches are inadequate, necessitating a paradigm shift toward technology-driven solutions.

The rapid urbanisation experienced by Nigerian cities has exacerbated the congestion challenge. With urbanisation rates exceeding 5% annually and motorised transport accounting for over 90% of urban trips, the demand for efficient transport systems has outpaced infrastructure development (Alhaji & Amadu, 2017). Cities such as Lagos, Port Harcourt, and Owerri have witnessed explosive population growth, with corresponding increases in vehicle ownership and usage. The average traffic speed in Nigerian cities against the speed capacity of 40 kilometres per hour (kph) has fallen to 10-15 kph, with much lower speeds in many parts of these cities.

The Compatibility Challenge

The successful adoption of ITS in developing economies requires careful consideration of compatibility with prevailing urban transport systems. Compatibility encompasses multiple dimensions: technological (hardware and software infrastructure), institutional (policy frameworks and organisational capacity), human (skilled manpower and user awareness), and cultural (user acceptance and behavioural adaptation) (Rogers, 2003). Understanding these compatibility dimensions is essential for designing effective ITS implementation strategies.

In Nigerian cities, the prevailing urban transport systems are characterised by several distinctive features that present compatibility challenges for modern ITS. These include fragmented and uncoordinated transport operations, predominantly private and profit-oriented transport services, poorly maintained and aging vehicle fleets, limited mass transit infrastructure, manual rather than computerised operations, poor inclusion of pedestrian and cycling infrastructure, and unsustainable institutional frameworks. These characteristics create a significant gap between the technological sophistication of modern ITS and the operational realities of Nigerian urban transport systems.

Problem Statement

Despite growing interest in ITS applications in developing economies, significant gaps persist in understanding the compatibility of modern ICT facilities with prevailing urban transport systems. First,

limited empirical research has examined the current state of traffic ICT deployment in Nigerian cities. Second, the compatibility of modern ITS technologies with prevailing urban transport systems has not been systematically assessed. Third, barriers to ITS adoption in Nigerian contexts remain poorly understood. Fourth, frameworks for ITS implementation in developing economies are underdeveloped.

These gaps are particularly significant given the potential of ITS to address the chronic congestion challenges facing Nigerian cities. The persistence of congestion despite decades of interventions suggests that traditional approaches are inadequate and that technology-driven solutions offer a promising alternative. However, without a clear understanding of compatibility issues and adoption barriers, ITS implementation efforts risk failure.

This study addresses these gaps by examining the compatibility of modern ICT facilities with prevailing urban transport systems in two Nigerian cities—Owerri and Port Harcourt. Specifically, we seek to: (1) identify existing traffic monitoring and control technologies on selected link routes; (2) evaluate road users' acceptance and proficiency with modern ICT facilities; (3) assess the level of utilisation of traffic ICT facilities by road users; and (4) ascertain the compatibility of modern traffic ICT facilities with prevailing urban transport systems.

Objectives of the Study

1. To identify the present traffic monitoring and control technologies on selected link routes in Owerri Urban and Port Harcourt Metropolis.
2. To evaluate the level of acceptance of these technologies within the country by road users.
3. To assess the level of utilisation of modern traffic ICT facilities by road users.
4. To ascertain the level of compatibility of modern traffic ICT facilities with the prevailing urban transport systems in the country.
5. To develop a comprehensive framework for ITS implementation in developing economies.

Research Questions

1. What are the existing traffic control and monitoring measures implemented in the country and these urban areas in particular?
2. To what extent have these measures adopted in the country been able to solve the menace of urban traffic congestion?
3. Which other approach could be implored to augment these measures?
4. Does Nigeria have adequate policy framework needed to tackle urban traffic congestion problem?
5. What are the key barriers to ICT adoption in Nigerian urban transport systems?

Justification of the Study

This research is prompted by the search to discover sustainable approaches to curbing the experienced traffic bottleneck invading urban centres as a result of high influx of people, private car ownership, and

improper urban land use, amongst others. It shall proffer a comprehensive solution to the menace through the adoption of adequate road pricing/allotment approach, adequate urban land use planning, among other measures. It shall also awaken the smart city approach, a situation where technological innovations/advancement are meticulously implored in information and data gathering, processing, and dissemination to guide in optimal utilisation of the city's resources.

The study shall constructively x-ray the direct and indirect cause and effect of urban traffic congestion. This study shall be relevant to transport policy makers, town and urban planners, commuters, transport agencies, researchers, urban dwellers, and government as a guide towards sustainable planning and economic development in the African region and other developing economies.

LITERATURE REVIEW

Intelligent Transport Systems and Congestion Mitigation

Intelligent Transport Systems (ITS) represent the application of information and communication technologies to transport system management, encompassing a wide range of applications (Geenhuizen, 2009; Wilson et al., 2019). The concept of ITS emerged in the 1990s as a response to growing congestion problems and the recognition that traditional infrastructure expansion alone could not solve urban mobility challenges. Today, ITS has evolved into a comprehensive ecosystem of technologies that enable real-time monitoring, analysis, and control of transport systems.

Traffic Monitoring Technologies:

Traffic monitoring technologies form the foundation of ITS, providing the data necessary for informed decision-making and control. These technologies include:

In-road sensors: Inductive loop detectors, piezoelectric sensors, and magnetic sensors embedded in road infrastructure detect vehicles by their metallic mass, generating voltage signals when compressed, or detecting changes in the Earth's magnetic field. These sensors collect data on traffic volume, speed, and occupancy (Khisty & Lall, 2008).

Above-ground sensors: Video image processing (VIP) systems use cameras and computer vision to analyse live video footage for incident detection, vehicle counting, speed monitoring, and traffic flow analysis. Radar sensors send out radio waves and measure reflections to determine vehicle speed and distance, effective in various weather conditions. Infrared (IR) sensors detect vehicle heat signatures, while ultrasonic detectors use high-frequency sound waves (Wilson et al., 2019). Drones (UAVs) equipped with cameras and sensors offer flexible and mobile traffic monitoring, especially for assessing accidents or monitoring large areas.

Connected device technologies: GPS tracking devices in vehicles transmit speed and location data for aggregated traffic flow monitoring. Bluetooth and Wi-Fi sensors detect signals from in-car mobile devices

Publication of the European Centre for Research Training and Development-UK
to estimate travel times and track traffic flow. Vehicle-to-Everything (V2X) communication allows real-time data exchange between vehicles (V2V), infrastructure (V2I), and other network elements to provide a comprehensive view of the entire transportation system (Demba & Möller, 2018).

Traffic Control Technologies:

These systems use data from monitoring technologies to actively manage traffic flow and improve safety:

Intelligent signal control: Adaptive Traffic Signal Control (ATSC) systems dynamically adjust traffic light timings based on real-time traffic demand from sensors and cameras, reducing delays and congestion at intersections. Intelligent traffic light systems are IoT-enabled traffic lights that can communicate with one another and a central system to optimise flow across a network (Tanwar et al., 2020).

Driver information and communication: Variable Message Signs (VMS) are digital signs along roadsides and highways that display real-time information such as travel times, warnings about accidents, and road closures. Mobile applications provide drivers with real-time traffic updates, navigation, and alternative route suggestions (Pesic & Kojic, 2017).

Work zone and incident management: Automated Flagger Assistance Devices (AFADs) are robotic systems with stop/slow paddles that control traffic in work zones. Queue detection systems alert drivers and work zone personnel to slow-moving or stopped traffic ahead. Automated traffic management systems use algorithms and data analytics to respond to incidents, manage lane usage, and optimise signal timing automatically.

Advanced and predictive control: Artificial intelligence (AI) and machine learning algorithms analyse traffic data to predict congestion, identify incidents, and proactively adjust traffic control measures (Fakhimi et al., 2021). The convergence of technologies like AI, IoT, and V2X allows for comprehensive management, enabling data from multiple sources to be used to coordinate traffic lights, update dynamic message signs, and communicate with connected vehicles simultaneously.

Research has demonstrated significant congestion reduction benefits from ITS deployment. Tanwar et al. (2020) developed real-time traffic light controlling systems that reduce queue lengths. Pesic and Kojic (2017) proposed applications combining GPS, WiFi, GSM, and Google Maps for real-time congestion information and route guidance. Wilson et al. (2019) demonstrated ICT-improved solutions for traffic queue management. Cipriani et al. (2019) found that ITS-enabled congestion pricing policies increased sustainable transport modes by up to 25%, reduced emissions by 0.7%, and reduced congestion costs by 2%.

V2V, V2I, V2P and V2X Technologies

For a long time, vehicles have been relatively insular, but recently, vehicles have become 'connected' to enhance functionality. This interconnectivity has provided enhanced navigation and streaming services.

However, advanced communication is becoming central to vehicle operation as automakers see this as a way of delivering enhanced road safety, increased efficiency/economy and an improved experience for driver and passengers—eventually leading to fully autonomous vehicles (Demba & Möller, 2018).

Vehicle-to-Vehicle (V2V) Communication:

Vehicle-to-vehicle (V2V) is the inter-vehicular application of telematics and vehicle-to-everything (V2X) technology, in which vehicles connect with one another using anything from dedicated short-range communications (DSRC) to 5G, so that they form an IoT on wheels. With V2V technology, all forms of road transport (cars, lorries, buses, vans, and motorcycles among others) will be able to communicate directly with each other to share and collaborate on traffic conditions, road issues, and other forms of hazards and delays in the transport network.

V2V is based around a peer-to-peer mesh network where each element of the network (a vehicle) is able to generate, receive and relay messages. With this approach, an expansive network can be created in populated areas without the need for expensive infrastructure. Typically, each vehicle would be able to transmit information about their speed, direction, location, braking and turning intent—although this list is likely to expand over time.

Vehicle-to-Infrastructure (V2I) Communication:

V2I refers to a wireless exchange of data between vehicles and roadway infrastructure. V2I technology enables vehicles to communicate with the infrastructure around them, such as traffic lights, signs, and road sensors. This communication allows for the sharing of real-time information, such as traffic conditions, weather, and road hazards. V2I provides immediate value and numerous benefits:

- Emergency vehicles can arrive faster to save lives, safely passing through red lights.
- A smart intersection can detect a pedestrian crossing the road or other road users that can impose a danger, and alert vehicles approaching the intersection.
- Public transportation can be prioritised when approaching the traffic light.
- V2I is critical for autonomous vehicles, for knowing without doubt the upcoming traffic lights state.

Vehicle-to-Pedestrian (V2P) Communication:

V2P involves direct communications between a vehicle and a pedestrian or multiple pedestrians within close proximity. In addition, communication can be to other vulnerable road users, such as cyclists. It will facilitate warnings to be provided to the pedestrian of an approaching vehicle, and warnings to the vehicle of vulnerable road users. The Vehicle to Pedestrian network establishes direct communication between a vehicle and the pedestrian, focusing on keeping the most vulnerable on the road safe.

Vehicle-to-Everything (V2X) Communication:

Vehicle to Everything (V2X) technology enables vehicles within a particular range to communicate with one another and their environment. V2X is revolutionising road safety by enabling drivers to know about dangers ahead without visibility. It can see around corners and through any obstacle or obstruction in a radius up to a mile. V2X technology connects all users to one safety network, thereby, improving road safety and mobility.

V2X is based on peer-to-peer direct communication between objects that are using or approaching the road in an environment of up to 2 km. The technology's range is at least 600 metres on the highway and 200 metres in an urban intersection. The technology does not depend on the cellular network, as it can operate in hybrid mode or in parallel to the mobile infrastructure.

Key Benefits of V2X Technology:

1. **Enhanced Road Safety:** V2X enables vehicles to communicate with each other and the infrastructure around them, providing real-time information about other vehicles and potential hazards.
2. **Increased Efficiency:** V2X can reduce traffic congestion and improve traffic flow, leading to more efficient road network use, reduced fuel consumption and lower emissions.
3. **Enhanced Mobility:** V2X can help drivers reach their destination more quickly, safely and cost-effectively.
4. **Improved Transportation System Management:** V2X enables real-time data sharing among vehicles and infrastructure, which can help transportation agencies better manage the road network and respond to incidents more quickly.
5. **Better Accessibility:** V2X can enhance accessibility for drivers with disabilities or other mobility challenges.
6. **Reduced Emissions:** Traffic flow management strategies like communication with traffic signals can reduce idling and other contributors to automotive-related emissions.

ICT and Transport Demand Relationships

The relationship between ICT and transport demand is complex and multifaceted (Gössling, 2017; Salomon, 1986). ICT can substitute for travel by enabling remote activities (telecommuting, teleshopping), complement travel by facilitating new trips, modify travel patterns through real-time information, or have neutral effects (Senbil & Kitamura, 2003; Aguilera et al., 2012).

Line et al. (2011) found that ICT becomes embedded in everyday routines, allowing for re-scheduling and adjustment of activities in time and space. Social media expands social networks and generates invitations to social events, potentially increasing travel demand. Aguilera et al. (2012) found that ICT changes the nature of transport demand by adding "new value to physical presence," with travel no longer addressing only instrumental needs but making up for "relational deficits."

Advances of Internet platforms, smartphone and tablet applications, and the rise of social media platforms are becoming increasingly relevant in transport contexts, as they facilitate travel, allow for co-presence in the sharing of distant lives, while also generating new forms of social and network capital (Germann Molz, 2012). Cohen, Prayag and Moital (2014) found that social media had gained considerable importance for tourism behaviour and mobility patterns, as a result of opportunities to communicate travel patterns.

In developing economy contexts, the relationship between ICT and transport demand may differ significantly due to infrastructural limitations, lower technological penetration, and different mobility patterns (Umar et al., 2020). Understanding these contextual differences is essential for effective ITS implementation.

Smart City Concept and Traffic Management

A smart city is a technologically modern urban area that uses different types of electronic methods and sensors to collect specific data. Information gained from that data is then used to manage assets, resources and services efficiently; in return, that data is used to improve operations across the city. The smart traffic-management system is an effort to work together with smart digital infrastructure such as Internet of Things (IoT), sensors, and Radio Frequency Identifications (RFIDs) to streamline traffic flow (Fakhimi et al., 2021).

According to Jack Williams (2021), smart cities depend on multiple services working with a singular purpose on common objectives—with data being the foundation. The four pillars of a smart city are:

1. **Connectivity:** A smart city must rely on the internet and a stable, fast network to exchange important data. Real-time information is of paramount necessity in order to have a working Internet of Things (IoT) environment.
2. **Mobility:** Sensors and the IoT are able to collect real-time data of traffic, which can then be analysed and interpreted by artificial intelligence to make the best decisions for every situation.
3. **Public Engagement:** It promotes the active collaboration between citizens and local authorities, to create a more enjoyable, safe and efficient urban environment.
4. **Cyber Security:** These cities are relying on data—and often also sensitive data. Every device needs to be protected in this environment, from sensors and mobile devices to the communication network itself.

In the context of traffic management, smart city applications enable dynamic traffic management, vehicle information services, real-time road navigation, travel guides, real-time public transport information, public parking, digital signboards, and emergency priority traffic lights for public transport, fire trucks, and ambulances (Amir Hoshang Fakhimi et al., 2021). Proper traffic management avoids unnecessary traffic, encourages the use of public transport fleets, and reduced travel times will greatly reduce CO₂ emissions and thus protect the environment.

Barriers to ICT Adoption in Developing Economies

Literature identifies multiple barriers to ICT adoption in developing economy transport systems. The Technology Acceptance Model (TAM) and Diffusion of Innovation Theory provide frameworks for understanding these barriers (Rogers, 2003; Davis, 1989). Recent studies have applied these frameworks to ITS adoption in developing countries (Oluwayemi-Oniya Aderibigbe, 2024; Springer, 2025).

Technological Barriers:

- **Inadequate Infrastructure:** Limited internet connectivity, unreliable electricity supply, and poor road networks hinder ITS deployment. Many Nigerian cities face significant obstacles including inconsistent power supply, poor road networks, and insufficient public transportation systems (LinkedIn, 2024). The lack of reliable power supply is particularly critical, as ITS systems require continuous power for sensors, cameras, and communication equipment.
- **Lack of Compatible Hardware and Software Systems:** The absence of standardised hardware and software platforms creates interoperability challenges. Different systems may not communicate effectively, reducing the overall effectiveness of ITS deployment.
- **High Cost of Technology Acquisition and Maintenance:** The capital-intensive nature of ITS deployment poses significant financial challenges for developing economies with limited budgets. The cost of sensors, cameras, communication infrastructure, and control systems can be prohibitive.
- **Limited Local Technical Support and Maintenance Capacity:** The absence of local technical expertise for system design, installation, and maintenance creates dependency on foreign vendors and increases operational costs.

Institutional Barriers:

- **Weak Policy Frameworks and Regulatory Environments:** The absence of comprehensive ITS policies and standards creates uncertainty and inhibits investment. Many developing countries lack the regulatory frameworks necessary to guide ITS deployment and ensure interoperability (Umar et al., 2020).
- **Limited Institutional Coordination among Transport Agencies:** Fragmented institutional structures with overlapping responsibilities create coordination challenges. Different agencies may have competing priorities, reducing the effectiveness of ITS implementation.
- **Inadequate Budgetary Allocation to Transport Technology:** Limited government budgets for transport infrastructure and technology constrain ITS deployment. Transport often competes with other sectors for limited resources.
- **Lack of Standards and Interoperability Frameworks:** The absence of technical standards for ITS components creates interoperability challenges and limits the potential for system integration.

Human Capacity Barriers:

- **Limited Skilled Manpower for System Design, Implementation, and Maintenance:** The shortage of trained professionals in ITS design, implementation, and maintenance constrains deployment. This includes engineers, technicians, and system operators with specialised knowledge.
- **Low Public Awareness and Understanding of ITS Benefits:** Limited public awareness of ITS capabilities and benefits reduces demand for technology-driven solutions. Many road users are unfamiliar with the potential of ITS to improve travel efficiency and safety.
- **Resistance to Technology Adoption and Behaviour Change:** Cultural resistance to new technologies and reluctance to change established behaviours create adoption barriers. This is particularly evident in contexts where manual systems have been in place for decades.
- **Limited Training and Professional Development Opportunities:** The absence of training programmes and professional development opportunities constrains the development of local ITS expertise.

Cultural Barriers:

- **Low Trust in Technology-Driven Solutions:** Limited trust in technology reliability and effectiveness creates adoption barriers. This is particularly relevant in contexts where infrastructure quality is poor and technology failures are common.
- **Preference for Familiar Manual Systems:** Comfort with established manual systems and reluctance to adopt new approaches create resistance to ITS implementation.
- **Limited Willingness to Adopt New Technologies:** Cultural factors, including perceptions of technology as complex or unnecessary, reduce adoption willingness.
- **Cultural Norms Affecting Technology Acceptance:** Cultural norms regarding technology use, authority, and individual behaviour affect acceptance of ITS. For example, norms regarding compliance with traffic regulations may affect the effectiveness of enforcement technologies.

Theoretical Framework: Technology Acceptance Model

The Technology Acceptance Model (TAM), developed by Davis (1989), provides a theoretical framework for understanding technology adoption. TAM posits that two primary factors determine technology acceptance:

1. **Perceived Usefulness (PU):** The degree to which a person believes that using a particular system would enhance their job performance. In the context of ITS, this relates to perceptions of how technology can improve travel efficiency, safety, and convenience.
2. **Perceived Ease of Use (PEOU):** The degree to which a person believes that using a particular system would be free of effort. This relates to perceptions of how easy ITS technologies are to learn and use.

TAM has been extended and applied to various technology adoption contexts, including transport. Recent studies have applied TAM to ITS adoption in developing countries (Springer, 2025; IEEE, 2025). These studies have identified additional factors influencing adoption, including infrastructure quality, technology access, socioeconomic status, and policy support.

The study by Springer (2025) on ITS adoption in Kinshasa, Democratic Republic of Congo, found that factors such as perceived usefulness, perceived ease of use, social influence, and facilitating conditions significantly influenced the adoption of intelligent public transport systems. The study highlighted the importance of context-specific factors in developing country settings.

The study by IEEE (2025) on factors influencing travellers and motorists acceptance of ITS applications found that the Technology Acceptance Model (TAM) effectively explained acceptance intentions. The study, using PLS-SEM with 500 respondents, found that perceived usefulness and perceived ease of use were significant predictors of behavioural intention to use ITS applications.

METHODOLOGY

Research Design

The study adopted a mixed-methods research design combining quantitative and qualitative approaches. The quantitative component involved survey administration, field observations, and traffic counts. The qualitative component involved interviews with transport stakeholders and analysis of policy documents. This mixed-methods approach enabled triangulation of findings and provided both statistical rigour and contextual depth (Creswell & Plano Clark, 2018).

Research Context

The study focuses on two Nigerian cities: Owerri Urban and Port Harcourt Metropolis. Owerri is the capital of Imo State, with a metropolitan population of approximately 1,064,000. Port Harcourt is the capital of Rivers State, with a metropolitan population of approximately 3,794,000. Both cities are rapidly growing urban centres experiencing chronic traffic congestion due to rapid urbanisation, high vehicle ownership rates, infrastructural deficiencies, and limited public transport integration.

The selection of these two cities enables comparative analysis of ITS compatibility across different urban contexts. Owerri represents a medium-sized city with moderate congestion levels, while Port Harcourt represents a larger city with severe congestion challenges. This variation allows for examination of how city characteristics affect ITS compatibility and adoption.

Data Collection

Field Observations:

Ten major link routes (five in each city) were selected based on their strategic importance and high traffic volumes. The selection criteria were:

- **Road Function and Network:** Arterials, collectors, local roads, connectivity to key destinations and areas with planned development.
- **Traffic Characteristics:** High traffic volumes, congestion prone, specific vehicle types, and diverse modes.
- **Geographical Locations:** Land use connectivity, ability to offer the needed congestion metrics, and coverage of reasonably greater portion of the entire city.

Field observations recorded: traffic lights (number, type, functionality), traffic signs and signals, markings, presence of traffic officers, and any advanced technologies (sensors, cameras, variable message signs).

Survey Instrument:

A structured questionnaire was administered to 330 stakeholders including private car drivers (57.6%), public/commercial drivers (15.2%), and commuters (27.3%). The questionnaire captured:

- **Section A:** Respondent profile (sociodemographic characteristics)
- **Section B:** Vehicle/Operational information
- **Section C:** Awareness, usage, and acceptance of traffic ICT facilities

The questionnaire items were measured using five-point Likert scales (1=Strongly Disagree to 5=Strongly Agree) and categorical response options.

Interviews:

Semi-structured interviews were conducted with transport agency officials, traffic managers, road safety officials, and technology experts to understand policy frameworks, implementation challenges, and future plans for ITS deployment.

Sampling Technique

The sampling technique adopted for this research is stratified and purposive sampling methods to achieve the desired representations. This method is considered because of the different categories/stakeholders within the target population of the study.

The population under study is unknown; the Andrew Fisher's formula was used for the calculation of the sample size at a confidence level of 95% and Z-score of 1.96, and standard deviation of 0.5 (most suited for unknown population).

$$n = (x)^2 * (s(1-s)) / h^2$$

Where:

- n = sample size
- x = Z-score
- s = standard deviation
- h = confident interval

$$n = (1.96)^2 * 0.05 * (1-1.96) / (0.05)^2$$
$$n = 0.9604 / 0.0025 = 384.16$$

A total of 396 copies of questionnaire were administered, with 330 completed and returned (83.3% response rate).

Analytical Approach

Quantitative Analysis:

Data were analysed using descriptive statistics, cross-tabulation, and inferential statistics. Descriptive statistics summarised respondent characteristics and technology awareness, usage, and acceptance. Cross-tabulation examined relationships between variables such as education and technology awareness. Inferential statistics tested for significant differences between groups.

Qualitative Analysis:

Interview data were analysed using thematic analysis: familiarisation, coding, theme development, and interpretation. The software used for qualitative data analysis was NVivo, which facilitated coding, theme development, and management of qualitative data.

Compatibility Assessment:

A compatibility assessment framework was developed to evaluate the compatibility of modern ITS facilities with prevailing urban transport systems across five dimensions: technological infrastructure, technical capacity, policy framework, user awareness, and cultural acceptance. Each dimension was scored on a 5-point scale based on the collected data.

RESULTS

Existing Traffic Monitoring and Control Technologies

Table 1: Existing Traffic Monitoring and Control Technologies (Port Harcourt Link Routes)

Link Route	Traffic Lights	Traffic Officers	Flyovers	Traffic Signs/Markings	Advanced Technologies
Trans Amadi Road	19	16	3	Present	None
Uniport to Onne	21	15	3	Present	None
Rumuokoro to Borokiri	25	17	5	Present	None
PH Airport to Rumuola	15	9	3	Present	None
Oyigbo to Lagos Bus Stop	30	14	4	Present	None

Table 2: Existing Traffic Monitoring and Control Technologies (Owerri Link Routes)

Link Route	Traffic Lights	Traffic Officers	Flyovers	Traffic Signs/Markings	Advanced Technologies
FUTO to Atta Junction	6	10	1	Present	None
Orlu Road	3	6	1	Present	None
Egbu Road	5	5	0	Present	None
Wetheral Road	5	3	0	Present	None
Douglas-Aba Road	3	3	0	Present	None

Key Observations:

1. **Predominant Technologies:** Traffic lights (static, non-adaptive) and manual traffic officer direction are the primary traffic control mechanisms. All traffic lights are outdated, non-intelligent systems without real-time adaptive capabilities. The traffic lights are not smart and intelligent, and some intersections are without traffic lights at all (e.g., Hospital Junction along Link Route F, several intersections along Link Route G).
2. **Absence of Advanced Technologies:** No advanced sensors (inductive loops, cameras, radar), data analysis platforms (with AI and computer vision), or control systems (with adaptive signals) were observed. IoT sensors, GPS-based tracking, and V2X systems are completely absent. The road networks are still operating with outdated ICT signalling facilities.

3. **Inconsistent Coverage:** Many critical intersections lack traffic lights entirely, relying solely on manual officer direction. This creates inconsistencies in traffic management and contributes to congestion.
4. **Outdated Infrastructure:** Traffic signs and markings are worn, faded, or missing. Variable Message Signs (VMS) and real-time information displays are non-existent. The road networks do not have the following requirements: intelligent signal control, driver information and communication systems, work zone and incident management systems, or advanced and predictive control systems.
5. **Limited Technology Sophistication:** Despite the present traffic monitoring and control installations, the congestion index is relatively high on all these roads. For example, link route I (Wetheral Road) despite being the shortest distance recorded the highest congestion time index of 3.82. Link route F (PH-Okigwe Road) has traffic lights at six intersections, one fly-over, ten intersections with traffic personnel, traffic signage, and markings, but with a very high congestion time index. This indicates that these measures fall short of the expected congestion mitigation solution.

Road User Characteristics

Table 3: Socio-Demographic Characteristics of Road Users

Category	Frequency	Percentage
Type of Road User		
Commuter/Passenger	90	27.27
Private Driver	190	57.58
Public Driver	50	15.15
Total	330	100
City of Residence		
Imo	200	60.61
Port Harcourt	130	39.39
Total	330	100
Age (Years)		
26-36	10	3.03
36-45	210	63.64
46-55	90	27.27
56-70	20	6.06
Total	330	100
Gender		
Male	240	59.17

Category	Frequency	Percentage
Female	90	40.83
Total	330	100
Usage Intensity		
Occasionally (about twice a week)	40	12.12
Regular (over 200 days yearly)	210	63.64
Moderate (between 100-200 days yearly)	80	24.24
Total	330	100
Education		
Primary	48	14.55
Secondary	98	29.70
Tertiary	150	45.45
No formal education	34	10.30
Total	330	100

Key Observations:

1. **High Private Vehicle Usage:** The predominance of private drivers (57.6%) indicates high car ownership rates and limited public transport usage. This contributes to congestion through high vehicle volumes.
2. **Regular Usage:** The majority of respondents (63.6%) are regular road users (over 200 days per year), indicating high exposure to congestion and potential familiarity with traffic conditions.
3. **Educational Profile:** While 45.5% of respondents have tertiary education, ICT proficiency and awareness of traffic technologies remain limited. This suggests that education alone does not guarantee technology awareness or adoption.
4. **Age Distribution:** The majority of respondents (63.6%) are in the 36-45 age bracket, representing the working population most affected by congestion during peak hours.

Vehicle Technology Capabilities**Table 4: Vehicle Model Distribution**

Vehicle Model	Percentage	ITS Capabilities
2023-2018	8.2	Limited (GPRS, basic navigation)
2017-2012	22.4	Very limited
2011-2006	31.5	None
2005-1999	24.8	None
Pre-1999	13.1	None

Key Observations:

1. **Aging Vehicle Fleet:** The majority of vehicles (69.4%) are from 2011 or earlier, lacking any ITS capabilities. Most vehicles plying through the surveyed roads are relatively old with non or less modern V2V, V2I, and V2X facilities. They cannot communicate with each other.
2. **Limited Technology Integration:** Only 8.2% of vehicles are from 2018 or later models that may have basic ITS capabilities. The vast majority of vehicles lack any form of advanced driver assistance systems or connectivity.
3. **Technology Gap:** There is a significant gap between the technological sophistication required for ITS implementation and the capabilities of the existing vehicle fleet. This creates a compatibility challenge for V2V and V2X technologies.

Road User Awareness and Acceptance of ICT**Table 5: Awareness and Adoption of ITS Technologies**

Technology	Awareness (%)	Usage (%)	Willingness to Adopt (%)
GPS Navigation	78.5	62.4	85.2
Real-time Traffic Apps	34.8	18.2	67.9
Traffic Light Cameras	45.5	-	72.4
Speed Limiters	52.1	18.8	68.5
V2V/V2X Systems	12.1	1.8	45.5
AI Traffic Analytics	8.5	0.6	38.2

Key Findings:

1. **Low Awareness:** Awareness of modern ITS technologies is very low (8.5-12.1% for advanced systems), with most road users familiar only with basic GPS navigation. The low awareness levels suggest that road users are largely unfamiliar with the potential of ITS to improve traffic conditions.
2. **Low Adoption:** Adoption rates for advanced ITS are extremely low (<2% for V2X systems). Most vehicles (69.4%) are from 2011 or earlier, lacking any ITS capabilities. This reflects both limited vehicle technology and limited user engagement with traffic ICT.
3. **Moderate Willingness:** Willingness to adopt ITS is moderate (45.5-67.9% for various technologies), suggesting potential for adoption if awareness and accessibility improve. The willingness-adoption gap indicates that barriers beyond awareness, such as cost and infrastructure availability, constrain adoption.
4. **GPS Navigation Dominance:** GPS navigation has the highest awareness (78.5%), usage (62.4%), and willingness to adopt (85.2%). This suggests that road users are most familiar with and accepting of consumer-facing technologies that provide direct personal benefits.

5. **Limited ICT Proficiency:** Despite 45.5% of respondents having tertiary education, ICT proficiency and awareness of traffic technologies remain limited. This suggests that education alone is not sufficient to drive technology adoption in the transport context.

Barriers to ICT Adoption

Table 6: Barriers to ICT Adoption

Barrier	Percentage Agreeing
Inadequate Infrastructure	82.4
High Cost of Technology	78.2
Limited Technical Skills	76.1
Low Awareness/Benefits	74.5
Weak Policy Frameworks	71.8
Limited Maintenance Capacity	69.7
Low Trust in Technology	58.2
Cultural Resistance	52.1

Qualitative Insights from Interviews:

"The traffic lights we have are outdated and often malfunctioning. We need modern systems that can adapt to traffic conditions, but we don't have the infrastructure or technical capacity." — Transport Agency Official

"Most drivers don't understand or trust the traffic lights. They rely on what the traffic officers tell them, even when it contradicts the signals." — Traffic Officer

"The cost of installing modern traffic systems is prohibitive. We need international support and private sector investment to make this happen." — Transport Planner

"People are used to doing things the old way. Even if we install modern systems, changing behaviour is a major challenge." — Road Safety Official

"Inconsistent power supply, poor road networks, and insufficient public transportation systems hinder progress in implementing smart city technologies in Nigerian cities." — Technology Expert

Key Findings:

1. **Infrastructure as Primary Barrier:** Inadequate infrastructure (82.4%) is the most frequently cited barrier, reflecting the critical importance of reliable power, connectivity, and road networks for ITS deployment.
2. **Cost Constraints:** The high cost of technology (78.2%) is a significant barrier, particularly for developing economies with limited budgets. This includes both initial capital costs and ongoing maintenance costs.
3. **Capacity Gaps:** Limited technical skills (76.1%) and maintenance capacity (69.7%) highlight the human resource constraints affecting ITS implementation.
4. **Awareness Deficit:** Low awareness of benefits (74.5%) indicates the need for public education and communication campaigns to build support for ITS.
5. **Policy Gaps:** Weak policy frameworks (71.8%) reflect the absence of comprehensive ITS policies and standards to guide implementation.
6. **Trust and Cultural Factors:** Low trust in technology (58.2%) and cultural resistance (52.1%) indicate the importance of addressing behavioural and cultural dimensions of technology adoption.

Compatibility Assessment

Table 7: Compatibility Assessment of Modern ICT Facilities

Dimension	Assessment	Score (1-5)
Technological Infrastructure	Inadequate power supply, limited connectivity, poor road networks	2.1
Technical Capacity	Limited skilled manpower, weak maintenance capabilities	2.3
Policy Framework	Weak legislation, limited funding, absence of ITS standards	2.0
User Awareness	Low awareness, limited understanding of ITS benefits	2.5
Willingness to Adopt	Moderate willingness for basic systems, low for advanced	3.2
Cultural Compatibility	Moderate cultural acceptance, some resistance to change	2.8
Overall Compatibility	Low to Moderate	2.5

Compatibility Challenges:

1. **Power Supply:** Unreliable electricity supply is a critical barrier to technology operation and maintenance. Many Nigerian cities face inconsistent power supply, which affects the reliability of traffic management systems (LinkedIn, 2024).
2. **Connectivity:** Limited internet connectivity, especially in suburban areas, constrains real-time communication systems. The absence of reliable broadband infrastructure limits the potential for connected vehicle technologies.

3. **Technical Capacity:** Limited skilled manpower for design, implementation, and maintenance of advanced ITS creates dependency on foreign vendors and increases operational costs.
4. **Financial Constraints:** High costs of technology acquisition and maintenance relative to budget allocation constrain ITS deployment. Transport competes with other sectors for limited government resources.
5. **Policy Gaps:** Absence of comprehensive ITS policy frameworks and standards creates uncertainty and inhibits investment. Nigeria lacks the regulatory frameworks necessary to guide ITS deployment and ensure interoperability.
6. **Awareness Deficit:** Low public awareness of ITS benefits and limited understanding of technology operation reduce demand and support for ITS implementation.
7. **Infrastructure Quality:** Poor road networks and insufficient public transportation systems hinder progress in implementing smart city technologies (LinkedIn, 2024).

DISCUSSION

Theoretical Implications

The study extends understanding of technology adoption in developing economy transport systems by identifying critical compatibility barriers. The findings support the Technology Acceptance Model (TAM) by demonstrating that perceived usefulness and ease of use influence adoption willingness (Davis, 1989). The moderate willingness to adopt ITS technologies (45.5-67.9%) suggests that road users perceive potential benefits but face barriers to actual adoption.

However, the findings also reveal that technology adoption in transport contexts is shaped by broader institutional and infrastructural factors beyond individual user perceptions, consistent with Institutional Theory (North, 1990; Scott, 2014). The high proportion of respondents citing inadequate infrastructure (82.4%), weak policy frameworks (71.8%), and limited technical skills (76.1%) as barriers indicates that individual-level factors alone cannot explain adoption patterns. This suggests that ITS adoption requires addressing systemic barriers at multiple levels.

The results align with Diffusion of Innovation Theory (Rogers, 2003), which emphasises the role of relative advantage, compatibility, complexity, trialability, and observability in adoption decisions. Low awareness (34.8% for basic applications, <12% for advanced systems) indicates that potential adopters lack knowledge of relative advantages. Compatibility challenges across multiple dimensions (infrastructure, capacity, policy, culture) create barriers that slow adoption. The low adoption rates for advanced ITS (<2% for V2X systems) reflect the cumulative effect of these barriers.

The study also extends understanding of the relationship between ICT and transport demand in developing economy contexts (Gössling, 2017; Aguilera et al., 2012). The low awareness and adoption of ITS technologies suggest that the potential for ICT to substitute for travel or modify travel patterns is currently limited in Nigerian cities. This contrasts with findings from developed economies where ICT has significantly influenced transport behaviour.

Comparison with Other Developing Countries

The findings from this study are consistent with research on ITS adoption in other developing countries. The study by Springer (2025) on ITS adoption in Kinshasa, Democratic Republic of Congo, found similar barriers including fragmented public transportation, limited funding, and weak institutional frameworks. The study highlighted the importance of context-specific factors in developing country settings.

The study by IEEE (2025) on factors influencing travellers and motorists acceptance of ITS applications found that the Technology Acceptance Model (TAM) effectively explained acceptance intentions. The study, using PLS-SEM with 500 respondents, found that perceived usefulness and perceived ease of use were significant predictors of behavioural intention to use ITS applications.

Research on smart city technologies in African cities (Aderibigbe, 2024) has identified similar challenges including inadequate infrastructure, limited technical capacity, and weak policy frameworks. The study highlighted the need for context-specific approaches to smart city development in the Global South.

Practical Implications

For Policymakers:

1. **Develop Comprehensive ITS Policy:** Establish national and state-level ITS frameworks with standards, funding mechanisms, and implementation timelines. This should include technical standards for interoperability, data sharing protocols, and cybersecurity requirements.
2. **Invest in Infrastructure:** Prioritise investments in power supply, connectivity, and technological infrastructure that enable ITS deployment. This includes improving electricity reliability, expanding broadband connectivity, and upgrading road infrastructure.
3. **Strengthen Technical Capacity:** Invest in training programmes, professional development, and institutional capacity building for ITS design, implementation, and maintenance. This includes partnerships with academic institutions and technology providers.
4. **Promote Public Awareness:** Develop communication campaigns to increase awareness of ITS benefits and promote technology adoption. This should include demonstrating success stories and providing hands-on experience with ITS technologies.
5. **Address Institutional Coordination:** Strengthen coordination among transport agencies, technology providers, and other stakeholders to ensure coherent ITS implementation. This includes establishing inter-agency coordination mechanisms and shared governance structures.

For Transport Agencies:

1. **Phased Implementation:** Adopt a phased approach to ITS implementation, starting with basic systems and progressing to advanced technologies as capacity develops. This allows for learning and adaptation while building institutional capacity.

2. **Pilot Projects:** Initiate pilot projects to demonstrate ITS benefits, build institutional capacity, and generate evidence for wider deployment. Pilot projects should include rigorous evaluation to inform scaling decisions.
3. **Public-Private Partnerships:** Leverage private sector expertise and investment through public-private partnerships for ITS deployment and operation. This can help address financial constraints and access technical expertise.
4. **Integrated Planning:** Integrate ITS planning with broader urban and transport planning to ensure alignment and maximise benefits. This includes coordinating ITS with land use planning, public transport development, and infrastructure investment.
5. **User-Centred Design:** Design ITS systems with user needs and capabilities in mind, ensuring that systems are accessible, understandable, and useful for diverse user groups.

For Road Users:

1. **Awareness and Education:** Increased awareness of ITS benefits can promote adoption and usage. Road users should seek information about available technologies and their potential benefits.
2. **Skill Development:** Developing ICT skills can enhance ability to utilise technology-driven traffic solutions. This includes learning to use navigation apps, traffic information systems, and other ITS applications.
3. **Behavioural Change:** Willingness to adopt new technologies and adapt behaviour is essential for effective ITS implementation. Road users should be open to trying new technologies and adapting their travel behaviour.

Policy Implications

Regulatory Framework:

1. **ITS Standards and Guidelines:** Establish national standards and guidelines for ITS deployment, including technical specifications, data standards, and interoperability requirements.
2. **Data Governance:** Develop frameworks for data collection, sharing, and privacy protection in ITS systems. This includes defining data ownership, access rights, and security requirements.
3. **Enforcement Mechanisms:** Strengthen enforcement of traffic regulations through technology-enabled monitoring. This includes automated traffic enforcement systems and electronic ticketing.

Funding Mechanisms:

1. **Government Budget Allocation:** Increase government budget allocation for ITS deployment and maintenance. This should be part of broader transport sector investment.

2. **International Development Assistance:** Leverage international development assistance and multilateral funding for ITS projects. This includes partnerships with development banks and international organisations.
3. **Private Investment:** Create enabling conditions for private investment in ITS infrastructure and services. This includes public-private partnerships and investment incentives.

Institutional Coordination:

1. **Inter-Agency Coordination:** Strengthen coordination among transport agencies, technology providers, and other stakeholders to ensure coherent ITS implementation.
2. **Capacity Building:** Invest in training and professional development for transport agency staff to build ITS expertise.
3. **Stakeholder Engagement:** Engage road users, transport operators, and other stakeholders in ITS planning and implementation to build support and ensure relevance.

CONCLUSION

Summary of Findings

This study examined the compatibility of modern ICT facilities with prevailing urban transport systems in two Nigerian cities—Owerri and Port Harcourt. The findings reveal significant gaps between current deployments and modern ITS requirements.

Existing traffic monitoring and control technologies are predominantly outdated static systems with limited advanced capabilities. Traffic lights are non-adaptive, and there is a complete absence of advanced sensors, AI-powered analytics, and V2X communication systems. The road networks lack intelligent signal control, driver information and communication systems, work zone and incident management systems, and advanced predictive control systems.

Road users demonstrate low awareness and adoption of ITS technologies despite moderate willingness to adopt. Awareness of advanced ITS technologies is very low (8.5-12.1%), and adoption rates are extremely low (<2% for V2X systems). The majority of vehicles (69.4%) are from 2011 or earlier, lacking any ITS capabilities.

Critical barriers to ICT adoption include inadequate infrastructure (82.4%), high cost of technology (78.2%), limited technical skills (76.1%), low awareness of benefits (74.5%), weak policy frameworks (71.8%), and limited maintenance capacity (69.7%). The overall compatibility of modern ICT facilities with prevailing urban transport systems is low to moderate (score 2.5 out of 5).

Contributions to Knowledge

Theoretical Contributions:

1. Extends Technology Acceptance Model (TAM) to developing economy transport contexts by identifying additional contextual factors affecting adoption
2. Demonstrates the importance of institutional and infrastructural factors in ITS adoption, extending beyond individual-level factors
3. Contributes understanding of compatibility dimensions in technology adoption in developing countries
4. Integrates diffusion of innovation and institutional perspectives to explain ITS adoption patterns

Empirical Contributions:

1. Provides empirical evidence on ITS deployment in Nigerian cities
2. Identifies critical barriers to ICT adoption in developing economy transport systems
3. Assesses user awareness, acceptance, and willingness to adopt traffic ICT
4. Provides baseline data for future ITS deployment assessment and monitoring
5. Documents the current state of traffic monitoring and control technologies

Practical Contributions:

1. Provides evidence-based guidance for ITS policy and planning
2. Offers a comprehensive framework for ITS implementation in developing economies
3. Identifies priority areas for investment and capacity building
4. Provides recommendations for addressing compatibility challenges

Limitations and Future Research

Limitations:

1. **Two-City Focus:** The focus on two cities may limit generalisability to other Nigerian cities or developing country contexts with different characteristics.
2. **Cross-Sectional Design:** The cross-sectional design provides a snapshot of current conditions but does not capture changes over time or the dynamics of technology adoption.
3. **Self-Reported Data:** The reliance on self-reported data may introduce response bias, social desirability bias, and common method bias.
4. **Limited Technology Assessment:** The study assessed current technology deployment but did not evaluate the effectiveness of different ITS technologies in the Nigerian context.
5. **Sample Size:** While the sample size (n=330) is adequate, larger samples would enhance statistical power for subgroup analysis.

Future Research Directions:

1. **Longitudinal Studies:** Longitudinal research tracking ITS deployment and adoption over time would provide insights into the dynamics of technology diffusion and the effectiveness of interventions.
2. **Comparative Studies:** Comparative studies across multiple African cities with different characteristics would enhance understanding of contextual factors affecting ITS adoption.
3. **Technology Evaluation:** Research evaluating the effectiveness of specific ITS technologies in developing country contexts would provide evidence for investment decisions.
4. **Intervention Studies:** Studies evaluating the impact of specific interventions (policy changes, awareness campaigns, infrastructure investments) on ITS adoption would inform implementation strategies.
5. **User Behaviour Studies:** Research on how road users interact with ITS technologies and how this affects travel behaviour would inform user-centred design.
6. **V2X Technology Research:** Research on barriers and facilitators for V2X technology adoption in developing countries, including infrastructure requirements and user acceptance.
7. **Smart City Integration:** Research on integrating ITS with broader smart city initiatives, including data sharing, interoperability, and governance.

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APPENDIX A: COMPATIBILITY ASSESSMENT FRAMEWORK

Dimension	Indicators	Scoring Criteria
Technological Infrastructure	Power supply reliability, internet connectivity, road network quality	1=Very Poor, 2=Poor, 3=Moderate, 4=Good, 5=Excellent
Technical Capacity	Skilled manpower availability, maintenance capabilities, training programmes	1=Very Poor, 2=Poor, 3=Moderate, 4=Good, 5=Excellent
Policy Framework	ITS policies, standards, funding mechanisms	1=Very Poor, 2=Poor, 3=Moderate, 4=Good, 5=Excellent
User Awareness	Public awareness of ITS, understanding of benefits	1=Very Poor, 2=Poor, 3=Moderate, 4=Good, 5=Excellent
Willingness to Adopt	User acceptance, willingness to use ITS	1=Very Poor, 2=Poor, 3=Moderate, 4=Good, 5=Excellent
Cultural Compatibility	Cultural acceptance, resistance to change	1=Very Poor, 2=Poor, 3=Moderate, 4=Good, 5=Excellent

APPENDIX B: SURVEY INSTRUMENT (EXCERPTS)

Section B: Vehicle/Operational Information

7. Type of Vehicle: (a) Car, (b) Truck, (c) Bus, (d) Earth Moving Equipment, (e) Others (Specify).
8. Grade/generation of your vehicle: (a) 2023-2018 model, (b) 2017-2012 model, (c) 2011-2006 model, (d) 2005-1999 model, (e) Manufactured before 1999.
9. Which of the following V2V, V2I, V2P and V2X technologies installations is operational in your vehicle?

(a) Auto-drive, (b) GPRS Receiver, (c) Speed limiter, (d) Crash avoidance mechanism, (e) Congestion hotspot detector, (f) V2V, V2X compliant, (g) Others.

10. How often do you break the traffic? (a) Often, (b) Occasionally, (c) None, (d) Unavoidably, (e) Counter directive from traffic warders.
11. What constitutes your reasons above if a, b, d or e?
 - (i) It possess delay, (ii). it doesn't worth waiting for, (iii) it's confusing, (iv) it is malfunctioning/unreliable, (v) I don't understand it, (vi) the warders always instruct otherwise.