Problem statement 1: Tool for rationalising of transit routes and frequencies

1. Challenge Summary	Development of a solution to support transit agencies in assessing travel patterns in the city, forecasting demand, and help in planning services (routes and frequency) to match demand characteristics and maximise ridership.
2. Challenge Scenario	With the expansion of cities, the travel patterns have become complex and also constantly changing – seasonally and annually. The traditional process of collecting travel demand data through manual methods and sample household surveys are time taking, inaccurate, inadequate, and expensive. This is leading to poor planning of transit services, leading to poor patronage of buses in some areas and overcrowding at some others. This, in turn, leads to public transport becoming an unfavourable mode of transport, setting off a vicious cycle leading to increased traffic congestion and pollution.
3. Profile of the end-users	• Urban/Transit planners, who are in charge of defining routes, timetables and fares • Third-party tools which access the outputs to further create timetables and schedules • Urban authorities with responsibility of strategic planning and sustainable development • Academicians/Researchers
4. Solution requirements	
4.1 Functional requirements of the end-user	• GIS based spatial tool. • With the solution the public transport agency should be able to make informed decision in identifying new routes, level of demand along each route, frequency of service and other service parameters.

4.2 Functional & Operational capabilities	The solution could potentially have the following functionality: • Plug-ins to various anonymised passenger travel data sources (transit ticketing data, telecom/mobile app tracking, traffic cameras, etc.). • Tools to adjust the biases in the data sources to approximate the actual travel patterns and mode of travel. • Visual (heat maps, desire lines, time-lapse simulation, etc.) and analytical tools to forecast passenger travel patterns (origin-destination-demand) and their variation – seasonally, spatially and by time of day. • Ability to overlay current bus routes and frequencies to assess the match/mismatch between demand and supply. • Calculate various service level benchmarks and KPIs such as passenger access distance, access modes, wait times at transit stops, etc. • Allow for developer access to build add-ons/plug-ins that can leverage the spatial engine of this tool.
4.3 Deployment Constraints	• The solution should not be (computer hardware) resource intensive. • Could be a cloud-based solution preferably with an office utility that would allow various analysis and extraction of outputs. • The solutions should be cost effective.
5. Expected Tangible Outcomes & Benefits	• The visual and analytical outputs of the tool are expected to provide valuable insights to transit operations planning leading to increased ridership and passenger satisfaction, and reduced passenger wait times at bus stops. • Identification of lack of service coverage leading to additional investments into improving mobility in underserved regions of the city.

6. Gaps in the Current Solution	• Currently cities use manual methods of travel data collection and such route rationalisation exercises are done once in couple of years.
Other Requirements/Remarks	—

Problem statement 2: Spatial tool for digitising and managing transit (including IPT/last-mile modes) networks, timetables, fares, etc., and to compute accessibility index for an area.

1. Challenge Summary	Create a spatial tool for digitising, managing, and publishing transit (including IPT/last-mile service) networks, timetables, fares, etc., and to compute accessibility index for an area.
2. Challenge Scenario	With the expansion of cities, the travel patterns have become complex and so did the transit networks. Transit operators manage hundreds of routes and service types with timetables that vary between weekdays, weekends, and holidays. Route timetables are also updated routinely to match changing demand patterns. Currently, all of this is managed manually in excel based unstructured tables, thus making the operations quite opaque and inefficient. The solution is expected to provide a spatial tool that makes it easy to code the transit networks (stops, routes), store & manage its attributes, and publish the data to third party solutions in GTFS. The tool should further enable various analytical features including but not limited to estimate accessibility index of a place based on custom defined criterion.
3. Profile of the end-users	• Urban/Transit planners, who are in charge of defining routes, timetables and fares • Third-party tools which access transit data to provide information to passengers • Urban authorities with responsibility of strategic planning and sustainable development • Academicians/Researchers

4. Solution requirements	
4.1 Functional requirements of the end-user	• GIS based spatial tool. • Provide convenient and intuitive way of coding of bus stops and routes (by series of clicks on the map). • Tools to select, copy, and edit existing routes

4.2 Functional & Operational capabilities	The solution could potentially have the following functionality:
	• Automated name suggestions while creating bus stops.
	• Interface to enter (and copy/edit) timetables for each route in the network.
	• Ability to maintain multiple timetables for a route by date range.
	• Import/export network data from GTFS
	• Ability to import various spatial datasets (socio-economic, infrastructure, etc) to overlay over the transit network
	• Analytical tools that allow for quantitative (KPIs) and qualitative assessment of level of service, such as:
	  ○ Total transit network length
	  ○ Service coverage (by area, population, within specified distance of transit stop)
	  ○ Network length classification by frequency of service.
	  ○ Thematic representation of network links and stops based on various service parameters (frequency, routes, etc.)
	  ○ Accessibility index of a place in the city based on a customisable function.
	  ○ Thematic maps of the city on the basis of accessibility, in order to identify underserviced areas.
	• Tool to identify ideal locations for transit depots (based on fleet assignment) to reduce dead mileage,
	• Ability to integrate/connect with various third-party applications to publish static information

	by way of GTFS standard. • Being secure and hack-proof, • Ability to maintain regular back-ups and all the edit-logs to enable revert to a backup(s) in case of unintended changes. • Allow for developer access to build add-ons/plug-ins that can leverage the spatial engine of this tool.
4.3 Deployment Constraints	• The solution should not be (computer hardware) resource intensive. • Could be a cloud-based solution preferably with an office utility that would allow editing and analysis and later sync it with the main database. • Secure logins for individual transit agencies in a city to be able to create or modify their networks without effecting the others. • The solutions should be cost effective.
5. Expected Tangible Outcomes & Benefits	• The visual and analytical outputs of the tool are expected to provide valuable insights to transit operations planning and understanding level of service. • This would act as a base for many more services and solutions to be developed on such as PIS, route rationalization etc. • Creation of open-data platform that will lead to multiple apps being deployed to provide information and journey planning services to passengers. • Identification of lack of service coverage leading to additional investments into improving mobility in underserved regions of the city.
6. Gaps in the Current Solution	• None of the cities have any existing tools to digitize their transit networks.

Other Requirements/Remarks	—

Problem statement 3: Tool for scheduling of public transport buses and staff

1. Challenge Summary	Development of a solution to support transit agencies in automatically creating route timetables, bus schedules and staff duties in an optimal manner to reduce costs by utilising resources effectively, while also ensure fairer workloads and distribution of work shifts.
2. Challenge Scenario	With increasing traffic congestion in cities, the travel times along the routes varies significantly at different times of the day. It is impractical for creating timetables manually by considering such variations. Thus, almost all transit agencies create timetables with a fixed average speed, across the day. Thus, the practical operations on ground can vary quite significantly from the planned timetable resulting in poor passenger experience and reduced revenue/efficiency. Similarly, rostering of duties to staff is also done manually, which limits the ability to optimise staff working hours, thus increasing costs.
3. Profile of the end-users	• Transit planners/managers, who oversee defining routes, timetables and duty assignments.
4. Solution requirements	
4.1 Functional requirements of the end-user	• Ability to consider various inputs and constraints such as: ○ Transit routes ○ Intended headways (varying by time of day) ○ Travel times along the route ○ Available fleet (and various attributes such as type, passenger capacity, distance range, refuelling requirements,

	etc.) ○ Labour laws (working hours, salary, overtime compensation, overtime limits, etc.) ○ Staff preferences (working hours, duty days, etc.) ● Considering the various constraints, the solution is expected to output: ○ Timetable for the routes ○ Bus schedules ○ Staff duties ○ Rostering of fleet ○ Rostering of staff ● Integrate with third party applications to access input parameters and export the outputs as may be necessary.
4.2 Functional & Operational capabilities	The solution could potentially have the following functionality: ● Ability to consider constraints of depot locations, need for staff to return back to home depots within a specified number of hours, etc. ● Generate a timetable and specify number of buses and staff required (under given constraints) when a preferred frequency along routes is provided ● When the number of buses is fixed, then the tool could generate an optimal timetable with uniform headways in each time-period. ● Ability to identify multiple routes having significant overlap on the same road segment, and adjust timetables of individual routes to provide near uniform headway to passengers travelling in the overlapping route segment, thus avoiding bunching of buses. ● In case of electric bus fleet, the solution should additionally be able to handle the charging requirements and locations of the charging stations while creating bus schedules. ● Ability to calculate various KPIs such as daily bus utilisation, staff per bus, total cost per kilometre

	(based on staff salaries, overtime rates, etc.) and allow the users to select the parameter on which to optimise the results. • Keeping track of staff leave accruals and overtime payments.
4.3 Deployment Constraints	• The solution should not be (computer hardware) resource intensive. • Could be a cloud-based solution preferably with an office utility that would allow various analysis and extraction of outputs. • The solutions should be cost effective. • Detailed user manual and training material for the end-users will be required
5. Expected Tangible Outcomes & Benefits	• The practically achievable timetables with uniform headways should lead to reliable operation of bus services, thus increased ridership and passenger satisfaction, and reduced passenger wait times at bus stops. • The tool should reduce the cost and time involved in generating timetables, bus schedules and staff rostering. • The overall cost of bus operations is also reduced.
6. Gaps in the Current Solution	• Currently cities use manual methods for bus and staff scheduling which are quite cumbersome, inaccurate and inefficient.
Other Requirements/Remarks	—

Problem statement 4: Transit performance monitoring tool

NOTE: While the solution for problem statement #2 is for understanding travel dynamics of the city and helping to identify/plan potential routes and frequencies, this tool is to evaluate the actual performance (KPIs/SLBs) of the day-to-day operations, and to fine-tune the routes and timetables to maximise service availability with given fleet.

1. Challenge Summary	Development of a transit performance monitoring (data analytics) and service optimisation tool.
2. Challenge Scenario	Transit operations in cities are quite complex due to the environment in which they operate. Monitoring of their performance and optimising the available supply to match passenger demand is a very challenging. Due to the technology adoption, transit operations generate significant amount of data – from vehicle tacking using GPS and passenger travel data from the ticketing machines. However, the transit agencies haven't been able to yet leverage this data to make tangible improvements to their operations to achieve better passenger satisfaction.
3. Profile of the end-users	• Transit operators/planners/managers, who are tasked with planning and delivering transit services to passengers
4. Solution requirements	
4.1 Functional requirements of the end-user	• The solution has to integrate with the existing IT systems in the transit agency to access the static and dynamic transit data (NOTE: Different OEMs may follow different protocols for data sharing). • Should be able to process large volumes of data to generate relevant KPIs/SLBs/alerts and present them in real-time dashboards as well as

	post-process reports. • The solution can use various data processing methods, including AI/ML, to generate useful insights (with intuitive visual representations of data) and alerts that will enable the transit manager to take appropriate actions. • The tool could include a formula/report builder to allow end-user to create custom KPIs/ visualisations/dashboards as necessary. • The solution has to be scalable and function without noticeable latency.

4.2 Functional & Operational capabilities	• Some of the various insights the performance monitoring & optimising tool could:
	  ○ Ranking routes by load factor
	  ○ Ranking of drivers by
	  ■ schedule adherence
	  ■ fuel efficiency
	  ■ safe driving/ride-comfort
	  ○ Forecasting temporal variation in travel time
	  ○ Identifying opportunities for optimising routes (varying frequency in different route segments, express service, etc.)
	  ○ Computing payable kilometres and penalties based on SLA (in case of contracted services)
	  ○ Flag instances of suspected revenue leakage
	  ○ Computing various KPIs fleet-wise, route-wise, etc.
	  ○ In case of electric vehicles, monitor battery health and performance.

4.3 Deployment Constraints	• The solution should not be (computer hardware) resource intensive. • Could be a cloud-based solution preferably with an office utility that would allow various analysis and extraction of outputs. • The solutions should be cost effective.

5. Expected Tangible Outcomes & Benefits	• The visual and analytical outputs of the tool are expected to provide valuable insights to transit operations improvements, leading to increased ridership and passenger satisfaction, while also reducing cost of operations.
6. Gaps in the Current Solution	• Currently cities use manual methods of travel data analysis and most decisions are just based on revenue potential of the routes alone.
Other Requirements/Remarks	—

Problem statement 5: Reliable passenger information system with integrated multimodal journey planning & ticketing

1. Challenge Summary	Create a mobile-web platform for multimodal journey planning, real-time transit information and integrated ticketing.
2. Challenge Scenario	Cities in India have grown in size and travel distances have increased. Lack of information on transit routes, timetables and fares is forcing people to depend on private vehicles or taxis for their travel needs, thus congesting roads and worsening the quality of living. The solution is expected to gather network, timetables and fare data from existing transit agencies and IPT operators, integrate with their technology platforms such as daily duty assignment module, vehicle tracking module, fare collection module, etc., to deliver reliable information and convenient transaction to commuters, to enable both journey planning as well as in real-time.
3. Profile of the end-users	• Public transport users of different age groups, gender, and economic background • Transit operators for inputting static and dynamic data pertaining to transit operations. • Ticketing staff of transit agencies who validate the tickets purchased through the app.
4. Solution requirements	
4.1 Functional requirements of the end-user	Passengers: • Application should be able to access passengers' location and suggest the nearest transit stop (in the direction of travel)

	• Show possible travel options based on users choice of origin and destination at a given time range. • Provide multiple options for payment of fare (possibly NFC based offline wallet?) • Application should have options for users to static information in offline mode. • The information system should be ***user-friendly*** for all age groups, and the educated and uneducated people. Transit Agencies: • Connect with various static and real-time data sources. • Easy integration with existing technology systems. • Allow for developer access to build add-ons/plug-ins for integrating other passenger services such as grievance redressal, etc.
4.2 Functional & Operational capabilities	Potential Trip Planning Functions: • Show information about the stop location, frequency of services at selected bus stop. • Estimated time for completing a trip, the total cost for making a trip. • Provide transit options between selected pair of stops and show their timetable. • When multiple travel choices exist, allow user to sort by transit mode/travel duration/cost, etc. • Access timetable by providing route number instead of stop pair. • When having access to user's location, indicate the nearest bus-stop and directions to reach there. • Facilitate booking of individual tickets and different kinds of passes Potential Real-time Functions: • Travel time prediction module based on historic vehicle location data and other secondary sources to predict accurate ETA's for the fleet • Indicate the level of passenger loading in the bus (light, moderate, congested). • Alerts to the passenger about arrival of transit

	vehicle at their location. • Indicate most probable time for reaching destination in the current mode and alert passenger, along with additional instructions in case of transfer to another route/mode. • Integration with the payment management systems of individual transit operators. • Mechanism for easy validation of passenger tickets inside the transit vehicle – even in areas without mobile network coverage. • Common and secure digital payment facility • Provision for integrated ticketing and payment allowing users to cover multiple modes in a single journey. General • The platform should be scalable and modular so that any new modes that may come up in the city can plug into this platform to offer services • Multi language support (optional)
4.3 Deployment Constraints	• Functioning in poor mobile signal coverage areas ⇒ Limiting data transfer • Maximising functionality in offline mode. • Handling interruptions to vehicle tracking data (possibly compensating with passenger's mobile location tracking) • Integration with various hardware/software/ legacy systems • Transit operations is essentially loss making. Hence, the solution needs to be extremely cost effective. • Since the targeted users are from diverse backgrounds, the UI has to be extremely simple and intuitive.
5. Expected Tangible Outcomes & Benefits	• Improvement in passenger satisfaction and upliftment of brand image of transit service (measured by way of positive feedback, local and national recognition, etc.) • Increased ridership/mode share • Increasing share of digital payments • Easing workload of transit operators and

	ticketing staff
6. Gaps in the Current Solution	• Most cities don't have any solutions providing fare integration, grievance redressal and real-time travel information for the commuters.
Other Requirements/Remarks	—

Problem statement 6: Passenger grievance redressal system

1. Challenge Summary	Create a mobile-web-voice portal to register and manage user complaints/feedback.
2. Challenge Scenario	Passenger satisfaction is the key to a thriving public transport system in a city. Currently, most cities do no have an effective mechanism for collecting user feedback or a grievance management mechanism. All of this is currently handled by ad-hoc means that cause significant hassle to affected users. A streamlined and automated tool is necessary to address their concern to create a transit friendly environment.
3. Profile of the end-users	• Public transport users of different age groups, gender, and economic background • Transit operators and urban authorities for grievance redressal
4. Solution requirements	
4.1 Functional requirements of the end-user	Passengers: • A simple and easy way to register feedback/grievance. Transit/Urban Authorities: • Semi-automatic routing of complaints to concerned government department for response. • Mechanism to forward the file/complaint/issue to alternative officers/departments in case of inter-departmental issue. • Tracking process of redressal of complaint and sending updates to the user.

	• Generate reminders and escalation for issues not addressed and overdue. • Systematic way of recording and monitoring the progress or resolution of issues
4.2 Functional & Operational capabilities	The solution could potentially have the following functionality: • A chat-bot/automatic-voice-response style interactive system to respond to FAQs • Directing to live-chat/customer-service where necessary and if the authorities wish to enable.
4.3 Deployment Constraints	• Mapping the complexity of the government authority responsible for the type of grievance. • Multiplicity of authority and inter-departmental nature of issues.
5. Expected Tangible Outcomes & Benefits	• Improvement in passenger satisfaction and upliftment of brand image of transit service (measured by way of positive feedback, local and national recognition, etc.) • Increased ridership/mode share
6. Gaps in the Current Solution	• Most cities don't have any solution providing grievance redressal.
Other Requirements/Remarks	—

Problem statement 7: Monitoring of transit fleet health and managing maintenance schedules

1. Challenge Summary	Development of a transit fleet health monitoring (data analytics) and maintenance management system.
2. Challenge Scenario	Transit fleet are in continuous use and serve hundreds of passengers in a day. Any issue with the bus resulting in breakdown in between the route or a major maintenance activity result in severe inconvenience to passengers. Hence, there is a need for a solution that understands the periodic/preventive maintenance of different types of vehicles (fuel type, AC/non-AC, body style, etc.). Automobile technologies have evolved over the years to enable users/OEMs to identify problems before occurrence of a failure (predictive maintanance). However, the transit agencies haven't been able to yet leverage this data to make tangible improvements to their operations to achieve better passenger satisfaction.
3. Profile of the end-users	• Fleet maintenance managers, who are tasked with upkeep of the bus fleet. • OEMs of buses
4. Solution requirements	
4.1 Functional requirements of the end-user	• Understand the recommended routine and preventive maintenance of variety of bus fleet and create a workshop schedule along with the spares necessary. • Analyse the real-time vehicle health data to identify malfunctions and undertake predictive

	maintenance.
4.2 Functional & Operational capabilities	The solution could potentially have the following functionality: • Consider the financial impact of bus being unavailable for operations, priority of the maintenance activity, and availability of maintenance facility/spares in order to create an optimal maintenance plan that reduces the overall cost of upkeep as well as disruptions to service. • Consider the driver feedback and complaints on the mechanical issues with the bus. • Integrate with the bus scheduling solution to provide the list of buses available for operation. • Create a maintenance calendar for the workshop to provide for reasonable pre-notification and preparedness of maintenance staff. • Understand the spare parts, manpower and time requirements for a particular maintenance activity to optimally handle the disruption to service. • Maintain a vehicle log of all maintenance activities performed and calculate the cost of keeping the bus in service, in order to advise on replacing a bus with a new vehicle. • Attempt to keep the fleet maintenance budget predictable and uniform.
4.3 Deployment Constraints	• In practical circumstances, workshop/ maintenance facilities are limited and spare parts are not immediately available. • A bus has many parts/furniture other than the ones monitored by the CAN/OBU. There may be additional maintenance activity due to accidents or wear-and-tear of the vehicle upholstery. The solution should have provision to account for such needs while creating a maintenance

	calendar.
5. Expected Tangible Outcomes & Benefits	• The overall cost of maintenance of bus fleet are reduced while also minimising the disruption to the transit operations. Should result in better passenger satisfaction and brand image of the transit service among the passengers, as revealed in passenger feedback.
6. Gaps in the Current Solution	• Currently fleet maintenance activity is mostly manual and dependent on the skill of the maintenance manager to optimise/prioritise various service demands. Other than the routine preventive maintenance schedules advised by the OEMs, all other maintenance are mostly reactive or based on driver feedback.
Other Requirements/Remarks	—

Problem statement 8: IPT Aggregator & Monitoring Solution

1. Challenge Summary	Create a mobile-web platform for IPT/taxi aggregator and monitoring service.
2. Challenge Scenario	Informal transit systems add potential value to the existing transit options. However, due to its lack of accountability and organization setup there is an impact on environmental conditions, parking, travel network, congestion, etc. The city is also unable to manage and track operations of these services. Current aggregator services such as Uber/Ola have become monopolistic and as a consequence most auto-rickshaw drivers prefer not to operate under their platforms. At the same time, citizens are burdened by the over pricing of service by the existing aggregators. Thus a need for an alternative platform that will bridge the issues of passengers and IPT drivers, while also enabling cities to monitor their operations effectively.
3. Profile of the end-users	• General citizens of different age groups, gender, and economic background • Auto-rickshaw and taxi drivers which provide door-to-door travel service under contract carriage permits from the RTA. • Transport/law-enforcement authorities tasked with the monitoring/grievance redressal of users of IPT.
4. Solution requirements	

4.1 Functional requirements of the end-user	The application has to satisfy the following core criterion: • Easy way for passengers to avail a ride as per their requirement and connect to nearby/interested IPT drivers. The solution should also inform the expected price, duration of journey, the route, and the user feedback of the service provider. Once the ride is accepted, facilitate cashless payment for the service. • A monitoring framework to check and alert authorities in case of non-compliance/violation of any rules. • Analyse historic travel patterns and provide advisory to IPT providers to place themselves optimally with respect to passenger demand.
4.2 Functional & Operational capabilities	The solution could potentially have the following functionality: Passenger expectations: • Track drivers and alert when the vehicle has arrived for pick-up • Alert when driver is deviating from expected route. • Allow sharing of the live-track of vehicle with friends/family for safety. • Easy SOS alarm to alert emergency contact and law-enforcement. Driver Expectations: • Easy access to nearby passengers, to reduce dead mileage (traveling without passengers). • Prioritise assignment of trips/passengers traveling towards a preferred pre-set destination (home/other) when ending their work day. • Show heat maps of density by demand and available vehicles in real-time to avoid overcrowding/unavailability of IPT in some areas. Authority Expectations: • Highlight/alert violation of rules (speeding, parking, safety, user rating, etc.) and maintain a

	log/rank to enable decision making of renewal of permits.
4.3 Deployment Constraints	• Functioning in poor mobile signal coverage areas ⇒ Limiting data transfer • Handling interruptions to vehicle tracking data (possibly compensating with passenger's mobile location tracking) • Since the targeted users are from diverse backgrounds, the UI has to be extremely simple and intuitive. • The solution has to be scalable (1k – 50k vehicles) • Since the IPT drivers mostly are from low income groups, the solution should minimise financial burden on the drivers or the passengers and explore other revenue sources.
5. Expected Tangible Outcomes & Benefits	• Reducing dead travel for IPT drivers • Reducing wait time for passengers availing ride • Improved compliance to rules • Improved mobility in the city
6. Gaps in the Current Solution	• Ola and Uber platforms have monopolised the IPT market and there is high level of dissatisfaction among all the end users.
Other Requirements/Remarks	—