Digital Transport for Africa: Mapping of Alexandria

Final Report – Outline

Final Report v2

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Produced by:

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For:

World Resources Institute

Digital Transport for Africa

Title picture: Public Minibus in Bahary Terminal, Alexandria (2022)

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Glossary

Acronym	Term
GTFS	General Transit Feed Specification
AFD	French Development Agency
WRI	World Resource Institute
TfC	Transport for Cairo
AAST	Arab Academy for Science and Technology
AASTMT	Arab Academy for Science, Technology & Maritime Transport
UPGRADE	Urban and transportation regeneration for reducing automobile dependency in MENA area
DT4A	Digital Transport for Africa
OSM	OpenStreetMap
GIS	Geographic Information Systems
PT	Public Transport
NAT	National Authority for Tunnels
BRT	Bus Rapid Transit
GKMA	Greater Kampala Metropolitan Area
NGOs	Non-Governmental Organizations
APTA	Alexandria Passenger Transportation Authority
LTRA	Land Transport Regulatory Authority
GPS	Global Positioning System
GIS2GTFS	Geographic Information Systems to General Transit Feed Specification
FR	Field Research

Executive Summary

Alexandria is Egypt's second largest city, with a rich history and diverse cultures the city is also considered a hot spot for internal and external tourism. These facts along with the ongoing mass transit projects implementation such as Abu Qir's metro and Raml Tram rehabilitation, prompted DT4A to target the city for digital mapping and capacity building of one of the city's prominent universities, AAST.

This report details the mapping exercise done, how the project was designed, the methodology followed, the tools used, the devised field research plan, the mobilization and monitoring of the field research, and finally the outcomes of the field research exercise. Three surveys were conducted:

1. Identification surveys: to build an "index" for the operational routes in the city by geographically capturing their points of origin (terminals), their mode and their destination
2. Onboard surveys: to trace the routes itinerary, points of boarding and alighting, their speed profiles, and fare
3. Frequency surveys: to estimate an average headway for each route and further compliment the services' temporal data

104 routes out of 126 initially identified were successfully mapped, with 80 AAST students doing 56% of the surveys and 4 hired FRs doing the remaining 44%. The data deliverables consist of GIS layers describing the transport network (routes, stops, and terminals). GIS data was converted to a GTFS feed that enables trip planning and analysis.

The deliverables also consist of map visualizations for the data and analysis, the material used during the students' capacity building sessions, a recording of the seminar presenting the students with the data outputs and findings from the data. and this report.

1 Background & Objectives

1.1 Project Aim

The project is part of the "Beyond Mapping" project, led by the World Resource Institute (WRI) and sponsored by the French Development Agency (AFD) as part of the DigitalTransport4Africa (DT4A) initiative.

"Beyond Mapping" aims to support multiple African cities with existing digital data on their transport networks to use this data in planning and passenger information applications, basically to leverage the use of digital data within the public sector. The project also aims to do a mapping exercise for two cities, where there is no data yet. One of the two African cities chosen is Alexandria.

There are two main objectives for the mapping of Alexandria:

1. Build the capacity for senior college students to be able to:
    a. Understand the importance of digital transport data
    b. Understand the parameters of this digital data and where each parameter fits into the bigger planning picture
    c. Continue mapping public transport themselves after the project

2. Build the first database on Alexandria's public transport network

1.2 Why Alexandria?

Being Egypt's second most populated city with over 5 million inhabitants[1], not to mention a touristic hub for foreigners and Egyptians alike, Alexandria's transport is seeing a lot of investment, especially in recent years. Alongside road infrastructure changes and the building of overpasses, the city is currently working on two major public transport projects, namely:

- Rehabilitation of the Raml tram line, the oldest tram in Africa[2]
- Abou Qir Metro Line, the second Metro system in Egypt after Cairo's[3]

Both projects are estimated to cost close to 1 billion euros combined[4]. With the current lack of digital data on the rest of the transport network, the need for the data in planning is more dire than ever.

Another important aspect of digital data integration in planning is the constant advocacy for using it, whether to the public or private sector stakeholders involved in projects. That is why the existence of Transport for Cairo (TfC), the technical implementation team, in Egypt is key to building on the mapping exercise and making sure the outputs are sustained in the future.

Figure 1: Bakous Tram Line in Alexandria

1.3 Stakeholders

- **Digital Transport for Africa (DT4A) Network:** is an initiative funded by Agence Française de Développement (AFD) and led by the World Resources Institute (WRI). DT4A aims to create a movement for open transit data across the African region. DT4A represents a diverse network of city governments, civic technology companies, collectives, residents, universities and international development organizations. The network is now scaling up efforts in data collection, mapping, analysis, and capacity building with the aim of reaching 10 additional cities across Africa. The DT4A resource sharing platform is also moving beyond mapping just data on public transport in cities, but seeks to inform planning, creation of tools, and meaningful research on actions to improve sustainable mobility.
- **French Development Agency (AFD):** is a public financial institution that implements the policy defined by the French Government. It works to promote sustainable development and fight

[1] Official 2021 estimate, Central Agency for Public Mobilization and Statistics, Egypt
[2] NAT, http://www.nat.gov.eg/LocationActivity.aspx?id=2112
[3] NAT, http://www.nat.gov.eg/LocationActivity.aspx?id=2111
[4] Egypt Independent, 2022. https://egyptindependent.com/eib-to-finance-transport-projects-in-egypt-at-1128-bln-euros/

poverty. AFD Group finances and supports development projects in; energy, urban development, education, climate, agriculture, health, water and sanitation, digital technologies, biodiversity and sport. AFD is one of the main sponsors of the DT4A intiative.

- **World Resource Institute (WRI):** is a global research non-profit organization that works on tackling multiple global challenges including mobility in cities. WRI-Africa is currently leading the DT4A project implementation and have hired Transport for Cairo as technical support consultant
- **Transport for Cairo (TfC):** TfC provides data, tools, and research to improve urban mobility in emerging cities, primarily in Africa. They are the technical support consultant responsible of the project implementation. Namely to undertake mapping and going beyond mapping projects in Alexandria, Egypt; Kumasi, Ghana and Maputo, Mozambique
- **AAST - Erasmus UPGRADE+:** The academic partner is one of the most distinguished universities in Alexandria: the Arab Academy for Science and Technology (AAST).
  Trainings and field research activities were integrated with AAST's UPGRADE program. UPGRADE is an Erasmus Joint Regional Project, aimed at capacity building in the field of Higher Education. The project consortium comprises the departments of Architecture, Urban Planning, and Civil Engineering in 8 highly reputable Higher Education Institutes and one Research Center from 6 different countries

The diagram in Figure 2 depicts the above-mentioned stakeholders and their relationships. A connection between two stakeholders denotes direct coordination between them.

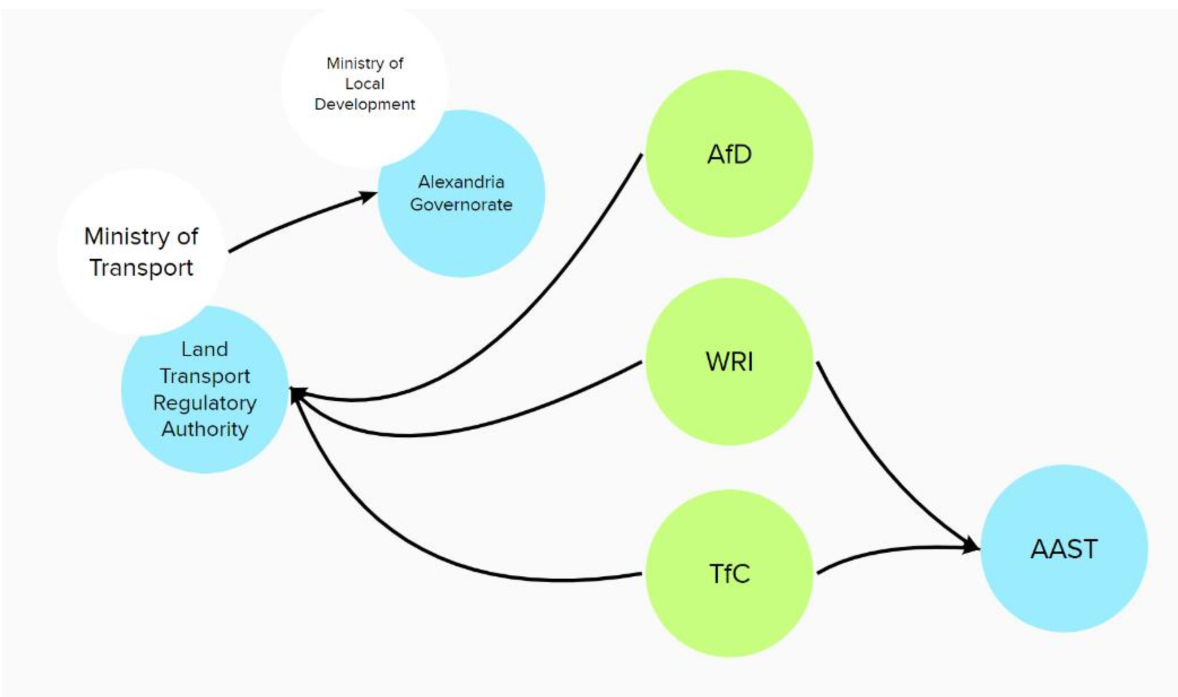


Figure 2: Project Stakeholders

2 Methodology

2.1 Design: The Addis Experience

The project's design is similar to the mapping project of Addis Ababa in 2018. As shown in **Error! Reference source not found.**, the mapping of Addis Ababa was led by WRI with technical support from TfC, same as this project. The mapping was done by students from Addis Ababa University's Urban planning and computer science departments, under the sponsorship of the city's transport authority.

This approach of grassroots and government sponsorship has proven successful. The data was later on used for planning purposes by the authority, and later on used for the city's first journey planning application.

With WRI's remote management, and TfC empowered with more experience and mature digital tools, the project aim was to replicate the success of Addis in Alexandria. The process can be shown simplified in the following diagram.

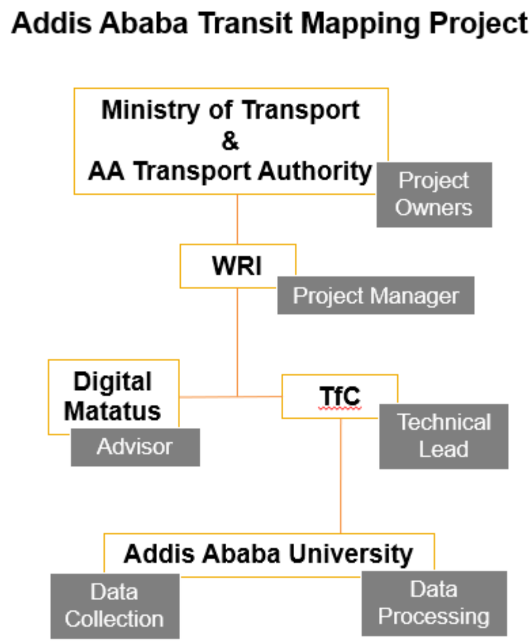
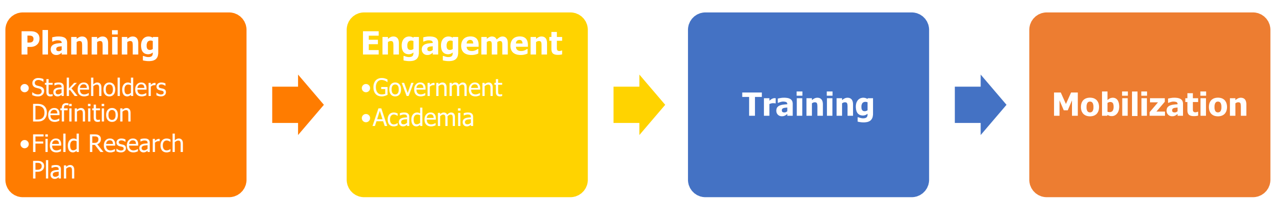


Figure 3: The model for mapping Addis Ababa's public transit systems?



2.2 Engaging The Government

To gain government support and sponsorship for the project, TfC initially reached out to the main regulatory authority within the Ministry of transport, the Land Transport Regulatory Authority (LTRA) with the help of AFD's Egypt office.

LTRA could not officially sponsor the project, even though they support the data collection, due to DT4A being an "international" project by definition and thus requires its own due process to be acceptable for sponsorship by a government agency. However, LTRA expressed readiness to support data collection activities that fell within the scope of ongoing AFD projects in Alexandria.

2.3 Engaging Academia

TfC leveraged existing partnership with the UPGRADE+ Erasmus team from the Arab Academy for Science, Technology & Maritime Transport (AASTMT) university to host the mapping exercise academically.

The Upgrade team proved exceptionally cooperative and dedicated to the project. Through direct communication between TfC and Upgrade, both teams were able to plan for the students' field research capacity, decide on training course material, dates and logistics, and most importantly how the exercise will fit within the students' courses curriculum and how the professors of each course would get on board with the project.

There was potential in getting Alexandria University, which is the main public university in Alexandria, to join the exercise, but given the size of the managing team and the scope of the exercise adding another university of this size would have entailed more complexities in both administrative and logistical aspects. However, the potential remains for future similar exercises to engage with Alexandria University, especially their renowned engineering and computer science faculties.

2.4 Transit Mapping Methodology

Over the course of previous paratransit mapping activities managed by TfC, the used methodology has evolved and consolidated in the form of Routelab Observer, the tool used in this project. This methodology includes the raw data needed from the field to get to a valid GTFS feed. GTFS is widely used standard for digital representation of transit networks. It is a relational model of entities, such as routes, trips and stops, each describing a component of the transit system. Figure 4 is an overview of the essential GTFS entities and their relationships. Other entities exist in the specification to augment the basic entities but are not essential.

The trip is the central entity in a GTFS feed. Every trip has a set timestamp or a headway (for frequency-based trips). Every trip has a set of stops with corresponding "stop_times". A trip belongs to a route. Routes are distinguished by name and transit agency.

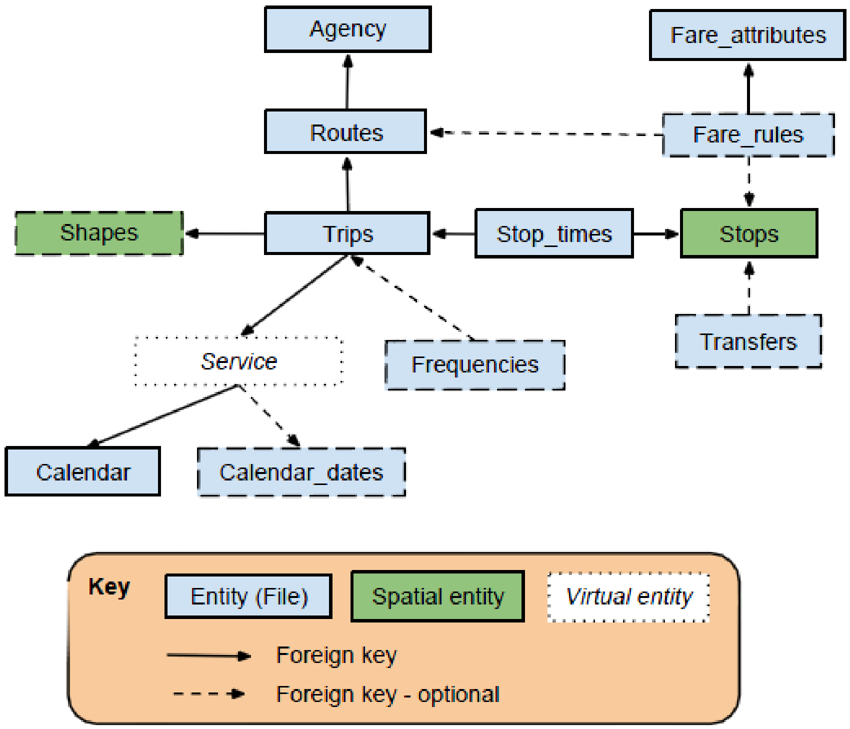


Figure 4: GTFS Entity-Relationship Diagram

2.4.1 Methodology Overview

2.4.1.1 Identifying Routes and Terminals

The first step of the methodology is a high-level mapping of the transit network in the form of routes and terminals. A route in GTFS is identified by name and agency. Terminals, a common element in informal transit networks, are gathering points for public transport at the start or end of trips. Vehicles may have a designated parking area, or they could be parked informally in an empty space or outside of busy areas.

A route is then identified by a start, end terminal, and an "agency", which is used to denote transit mode.

2.4.1.2 Onboard Survey

In an onboard survey, a field researcher boards a trip from origin to destination and records the trip's GPS trace and stop locations with passenger counts along the trip. The trip fare is also captured.

Raw data from onboard surveys, when cleaned and aggregated, is used to create the trips, shapes, fares, stops and "stop_times" entities in the GTFS feed.

2.4.1.3 Frequency Survey

The methodology utilizes frequency-based trips in the GTFS specification to model informal transit trips. Despite not having an accurate headway, they tend to have consisted of headway ranges based on demand in different timeframes of the day and the week. Such behavior modeled through an estimated headway value.

The raw data for trip frequency is captured in the frequency survey. A field researcher observes a specific route at its origin terminal and records every vehicle's arrival and departure time.

2.4.2 Sampling

Informal transit services are dynamic and exhibit varying patterns for frequency and demand for different periods of the day. Depending on the scope of a mapping project, the above-mentioned surveys can be repeated for different periods of the day and on different weekdays to capture a larger sample.

In this mapping activity, maximum coverage of the city's network was higher priority than a large sample for a subset of the city's network. Hence, each route leg was sampled **once**. Surveys were only conducted on **weekdays**, to keep the sample purely representative of demand during weekdays.

2.5 TfC's Transit Mapping Tools

The methodology explained in 2.4 has been translated into a dedicated software suite built by TfC with the name of "RouteLab".

It includes "Observer", a mobile application and a rich dashboard that work together to enable conducting onboard and frequency surveys. The application sends the collected to the server in real-time, where it can be directly inspected and validated on the dashboard by a field research manager.

2.6 Field Research Plan

Strategy is to do a basic mapping of public transport routes in Alexandria working with students as field researchers, with the minimal amount of time taken from each student, namely one and a half days, half a day for training and one day for field research.

The main risk affecting different aspects of planning was that of the relatively low capacity of the students to perform the field research, due to both lack of time available -1 day for field research- and lack of experience.

Working with AASTMT Students:

Field Researchers experience is crucial for performing successful field research projects. The task of surveying public transport is often regarded as a task with too small of a learning curve. While this may be true in some cases, it depends on the level of data quality required and the complexity of the services being surveyed.

In the case of Alexandria, it was estimated from the start that the team will need to complement the surveys done by the students with some person-days from experienced hired field researchers. This was due to the low amount of time spent onboarding each student on the activity (half a day) and their general inexperience using public transport as most students drive their own cars or take private transport modes such as taxis and Uber.

Generally, working with students should be always viewed in the light of the tradeoff between data quality and the more strategic added value of the capacity building.

Our go-to metric for assessing the effectiveness of the capacity building is by reviewing the quality of the data received. Quality checks include the numbers of recorded passengers boarding and alighting, the GPS trace coincides with the actual route assigned and not something else, and the number of vehicles departing within a frequency survey is reasonable compared to the duration of the observation.

2.6.1 Students Capacity

The staff at AAST connected the team to professors of several engineering courses who were willing to contribute to the exercise. To the question of students' capacity, the professors and the TfC team concluded we could dedicate two days for the project for each student, one day for the training and one day? for the field surveys.

This limitation in time comes from the approach of wanting to make the exercise somewhat obligatory for the students. This would mean they get marks and attendance in a specific course by participating in the exercise from start to finish, but that would also mean we can't take too much time from the overall course curriculum, hence the two-day-per-student limitation.

Thus, the training day agenda had to be compressed and optimized. For the sessions to remain interactive, we split the day into two identical workshops for two batches of students. The session's main objective should be to get the students excited about the exercise and see the potential, and to get training on the actual field research and how to use the data collection app to capture data accurately.

A site visit has been conducted by the TfC team to the AAST campus to meet the faculty staff in person and visit the facilities. The visit was beneficial in determining which lecture hall would fit the workshop best, and where in the campus the team could conduct the simulation field research with the students using the "RouteLab Observer" data collection app The team also finalized some contractual and administrative details with the staff.

During the visit, logistics were also discussed, most importantly the TfC team would describe the nature of the exercise from a societal standpoint and the staff would correspond that to the nature and background of the students. For example: which bus terminals would be suitable to which students? Should female students be assigned different routes than male students?

Two important conclusions from this meeting were:

1. Female students would go into groups of two working on the same assignment, to ensure safety. This would mean that the female student's capacity will be half compared to what was expected.
2. Some routes were considered problematic due to having both their origins and destinations in areas that were too remote or deemed unsafe. Those would be excluded from the students' assignments but would be assigned to the professional field researchers hired later by the TfC team.

2.6.2 Estimating Scope

To determine how many person-days is required to accomplish the mapping, there are two determining factors:

1. **The network parameters**: How many routes operate within the network, the average length and trip duration of the routes, how scattered the terminals are from one another. All those parameters affect the estimation of how many person-days are needed.
2. **Sampling Strategy**: How frequent should each route be surveyed? For how many intervals across the day should headway and travel times be measured?

To estimate network parameters, the team relied initially on Alexandria Passenger Transport Authority's (APTA) website to get a list of formal bus routes and scraped news articles about the microbus services which had some poorly photographed lists of some microbus routes.

الخطوط الداخلية مسافات طويلة و متوسطة المسافة من (٤٠) كيلو إلى (٦٠) كيلو و بيانها كالتالي:

م	الخط	تعريفة ٢٠١٩	التعريفة الجديدة	النسبة المئوية
١.	الموقف / برج العرب	١٠,٠٠	١٠,٥٠	٥
٢.	الموقف / مراقيا	٩,٧٥	١٠,٢٥	٥,٢

الخطوط الداخلية مسافات طويلة و متوسطة المسافة فوق ال (٦٠) كيلو و بيانها كالتالي:

م	الخط	تعريفة ٢٠١٩	التعريفة الجديدة	النسبة المئوية
١.	الموقف / الغربانيات	١١,٥٠	١٢,٢٠	٦,١
٢.	الموقف / قرى البنجر	١٣,٥٠	١٤,٤٠	٦,٦

Figure 5: Snippets from documents showing old and new tariffs for microbus routes, photographed by reporters[5]

This approach was later subsided in favor of the more reliable approach of field identification surveys. TfC hired one field researcher on a one-week mission to Alexandria to go to every bus terminal mentioned in the news articles and from APTA to (a) locate the terminal locations geographically and (b) identify which bus routes operate from each terminal.

One limitation of the identification activity is that the field researchers would go and identify bus routes in each terminal staying for about 40 minutes. This is not necessarily enough time to capture services with low frequency and so there could be some bus routes that were missed.

Moreover, large terminals or those consisting of multiple locations would need several identification sessions. There is no certain method of determining the percentage of routes captured to the missed ones, but it's a safe assumption that most active routes were captured.

[5] El Yom Newspaper, 2022, https://el-yom.com/%D8%A7%D9%84%D8%A5%D8%B3%D9%83%D9%86%D8%AF%D8%B1%D9%8A%D8%A9-%D8%AA%D8%B9%D8%AA%D9%85%D8%AF-%D8%AA%D8%B9%D8%B1%D9%8A%D9%81%D8%A9-%D8%A7%D9%84%D8%B1%D9%83%D9%88%D8%A8-%D8%A7%D9%84%D8%AC%D8%AF%D9%8A/

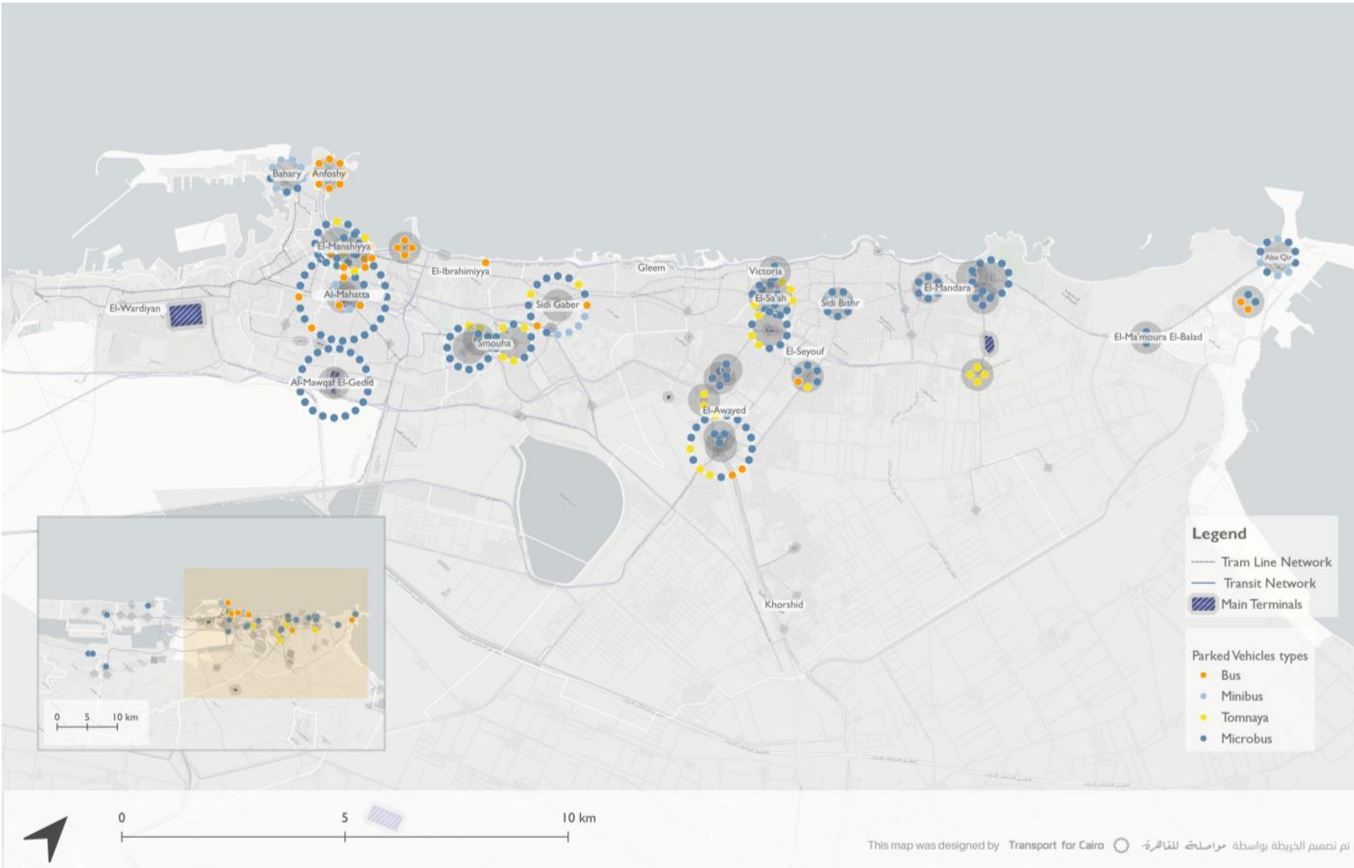


Figure 6: Identified routes at terminals, colored by different modes

The result was 126 bus routes operating from 58 terminals. This list of routes would be converted into the list of individual assignments for students to do the survey. The student would receive the exact location of where to take the bus from, what type of vehicle operates on the route and bus number if any.

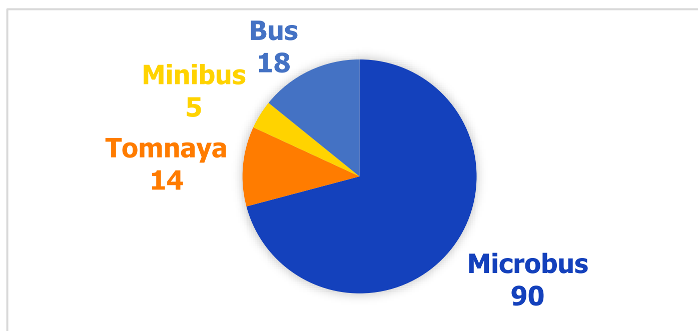


Figure 7: Number of Identified Routes per Mode

Public transport modes in Alexandria constitutes of the following:

- **Tram**: The first tram in Africa, with around 16 lines. The tram wasn't included as part of the mapping due to existence of some data already online that could be digitized via desk research. However, the level of operation for each of those lines is unknown and subject to variability.
- **Microbus**: Same as the capital Cairo, 14-seater microbuses are the dominant mode in Alexandria, especially given the city's narrower streets.
- **Tomnaya**: The small 8-seater focuses more on peri-urban or areas with high traffic congestion such as popular markets.
- **Bus**: The APTA operated buses are the main formal mode of transport

- **Minibus**: The newest addition to the city, those are a bit smaller with around 35 passenger capacity. Those are licensed by the Land Transport Regulatory Authority (LTRA).

(a)

(b)

(c)

(d)

Figure 8: PT modes in Alexandria (a) APTA Bus (b) Tomnaya (c) Microbus and (d) Minibus

The tram seemed to share traffic with the rest of the vehicles in some portions of the lines where the rails are in between the road with no barriers, decreasing its efficiency.

2.7 Field Research Mobilization

2.7.1 Student List

The AAST staff compiled a list of the students enrolled in the courses in which the mapping exercise would be embedded. The initial list amounted to 120 students and included additional information for each to help with the planning, namely:

- Student ID
- Name
- Gender: to calibrate safety when assigning routes
- Phone Number
- Personal phone Operating System: "Observer" Mobile app is Android-based
- Email
- Residence Area: to give preference to nearby assignments when assigning routes to survey

The first thing the team noticed is that over 65% of students were females, this automatically meant focus had to be shifted to assessing the safety of origin and destination terminals.

Most students also seemed to carry IOS phones and couldn't borrow an Android phone to do the task. This prompted TfC to rely on existing stash of Android phones from previous projects. Around 40 phones were updated, indexed, and made ready to distribute to students during the training day.

2.7.2 Communication

The WhatsApp group for the students was used to make announcements and communicate media, and later on to receive and give feedback to the students during the field research activities.

The group was used to send an online form for students to fill and subsequently receive an email with a link to the Observer app and credentials to log in. This way we could link on scale the students to their field researcher's user accounts on Observer.

The students received the "Field Research Protocol" document on the group before going into the field as well. This document is a guidebook to how to behave and collect data from the field, it goes into detail for each type of survey.

2.7.3 Training Day

Training day with the students was the official kick off for field research activities on the 4th of December 2022. The day started early in the morning with the AAST staff organizing the location of the lecture and the split of students into two batches, one for the morning workshop and the other for the afternoon.

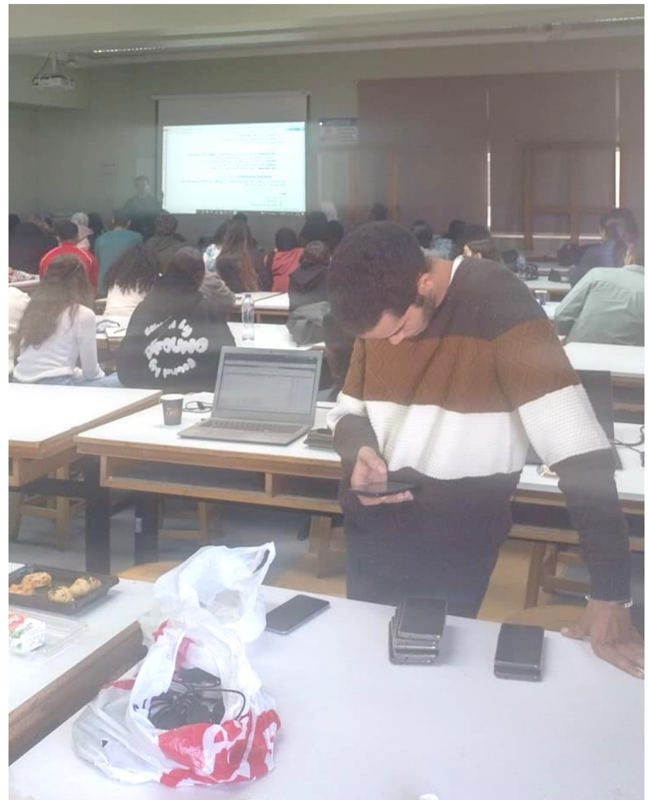


Figure 9: TfC tech team setting up mobile phones during the Field Research Protocol session

The TfC team was divided into two functions: (a) Lecturing & orientation and (b) Assignment and mobile phones management.

More details about the day's agenda can be found in section 3.1. The workshop was divided between theory and application, and aimed to get the students motivated for the assignment and to explain to them how to capture the data correctly from the field.

Training on data collection would include not only using the "Observer" mobile app but also understanding the social aspect of public transport and its practical dynamics from a passenger perspective. The latter was necessary to expand upon as the majority of involved students, being completely dependent on private cars, had no previous experience using public transport. That part of the training included details on topics like navigating public transit terminals and safety concerns. They were explained through the "Field Research Protocol" document.

A simulated exercise for onboard and frequency surveys was done on the university campus with batches of students.

Afterwards the students commenced with their assigned surveys within the time window communicated by TfC, mentioned in 2.7.4.

2.7.4 Monitoring

The student field work activity occurred between the 4th and the 10th of December 2022. Survey assignments were done between 08:00 and 17:00 during workdays only, weekends were excluded.

80 out 120 students who attended the training ended up participating in mapping in the field.

Monitoring tools could be listed as follows:

1. RouteLab Dashboard: The web user interface to monitor surveys being done in real time and check on the validity of the data.
2. WhatsApp Group: Free group chat to communicate between the TfC, AAST teams and the students.

3. Phone calls: Directly to TfC's research lead for urgent problem solving and troubleshooting.

Knowing which student has which user account on RouteLab meant that researchers from TfC are able to receive verbal or textual feedback from students and relate that to the data received on the Dashboard. This would be very useful in validating the data as well.

For example, an onboard trace being cleaned was found to start from intended trip origin but ended up at a different terminal station than what was in the assignment. Based on verbal communication from students, we discovered that this destination terminal is used as a proxy for the originally intended terminal in times of traffic congestion.

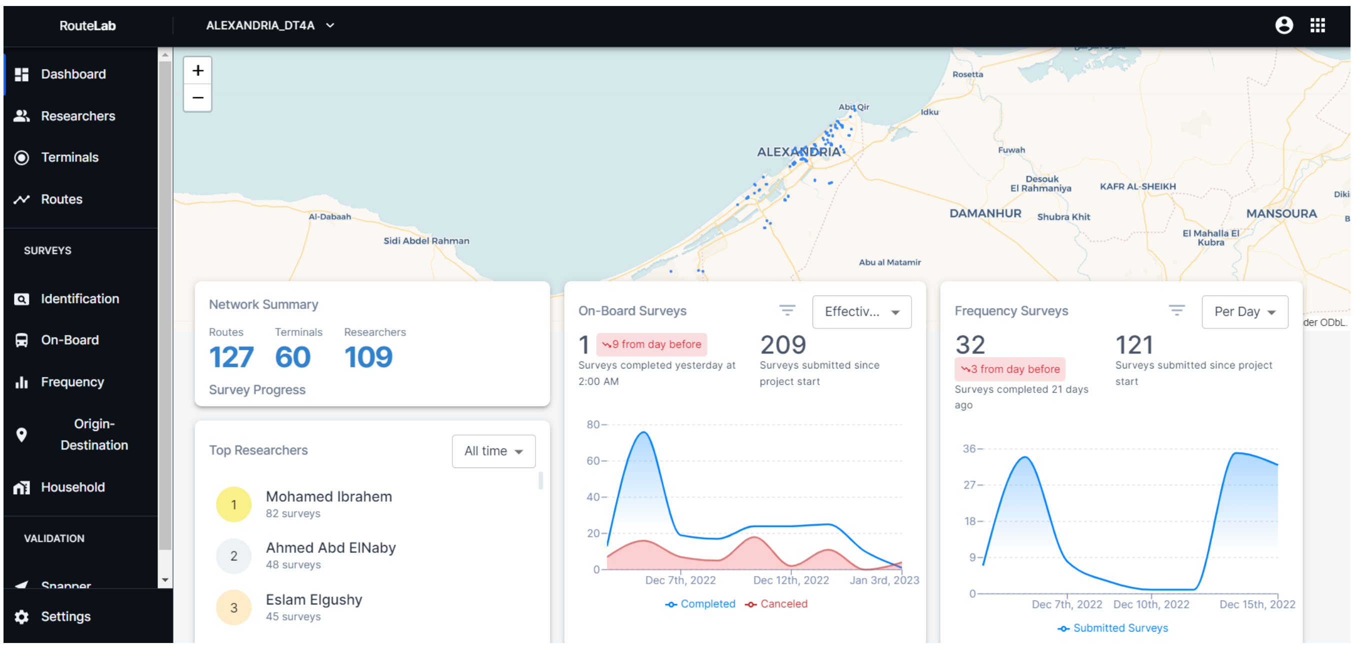


Figure 10: RouteLab's monitoring Dashboard for the Project

Throughout the field research, questions would be asked freely by students on the main WhatsApp group. Questions that were deemed useful to have for the rest of the students were answered in the main group, while specific questions or troubleshooting would be done in private chat.

Given the large number of students, it was expected that the monitoring team should be ready to deal with different types of personalities and try to deduce the best method to respond to each. For example, one student would be stuck with one of the steps on the Observer app and would try their utmost to resolve it themselves without conveying urgency to the team, while another might give the impression of urgency by consistently calling and asking questions that at best could be labelled "precautionary".

2.7.5 Hiring Field Researchers

AAST students were able to conduct 125 onboard surveys and 53 frequency surveys. After that, 4 professional field researchers who have extensive experience with RouteLab Observer were hired for 4.5 full time working days to complete as much as possible of the remaining surveys to cover the planned total of 126 routes. They completed 83 onboard surveys and 68 frequency surveys.

2.7.6 Field Research Outcomes

In total 104 routes out of 126 initially identified were successfully mapped, with AAST students doing 56% of the surveys and hired FRs the remaining 44%. The expenses budget for the project was exhausted to hire the professional field researchers. The remaining 22 routes were not mapped.

The difference between the contribution of students and professional FRs is explained by the difference in experience and the limited time dedicated to the activity per student, as mentioned in 2.6.1.

2.8 Data Quality Control and Processing

This section describes the quality control process for managing collected raw data and processing it into the output GIS and GTFS datasets.

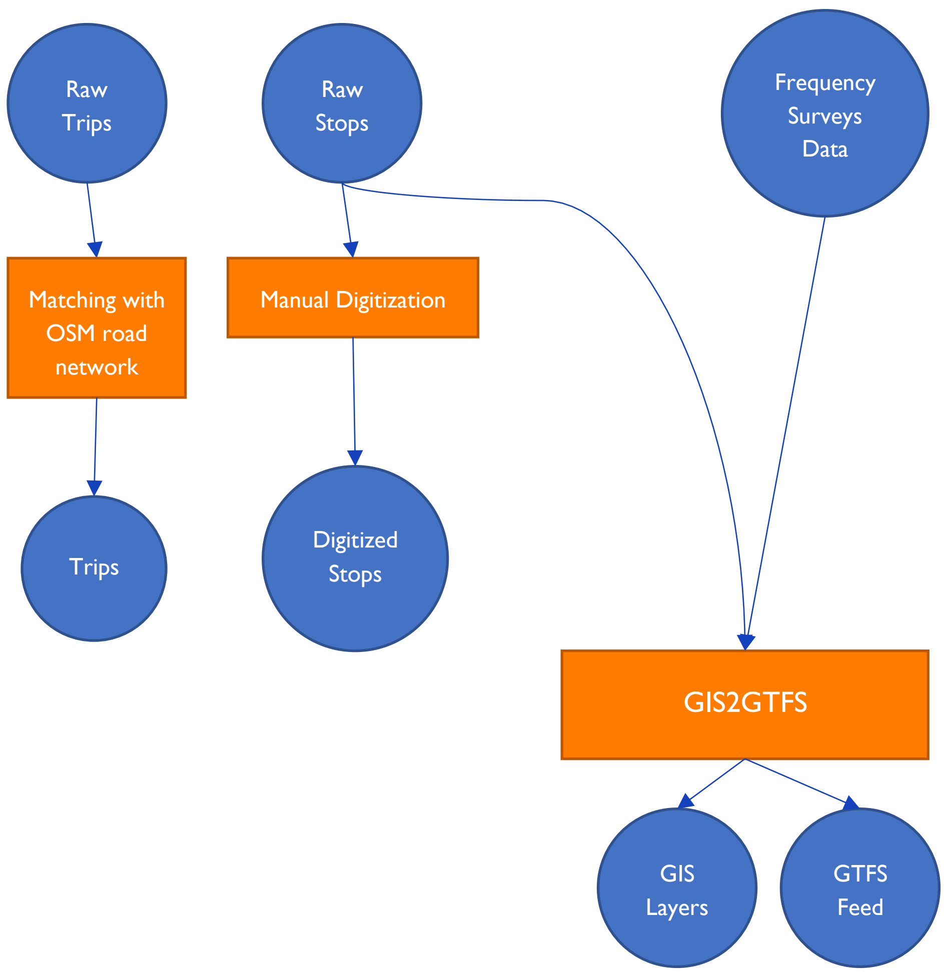


Figure 11: Raw data transformation steps

2.8.1 Processed trips

First the trips data is validated after meeting certain criteria. A trip's raw GPS trace had to (a) match the origin and destination assigned, (b) be readable with as little gaps as possible, and (c) cover the full trip length. If there criteria were not met, the raw trip is deemed invalid and is eliminated from any further processing or cleaning. Next step is the digitization of "Raw Trips", which is the process of aligning the valid raw traces received from the field to the OSM road network to form the processed trips. This step was done after the data collection, using "Snapper", a tool developed by TfC as part of the RouteLab software suite.

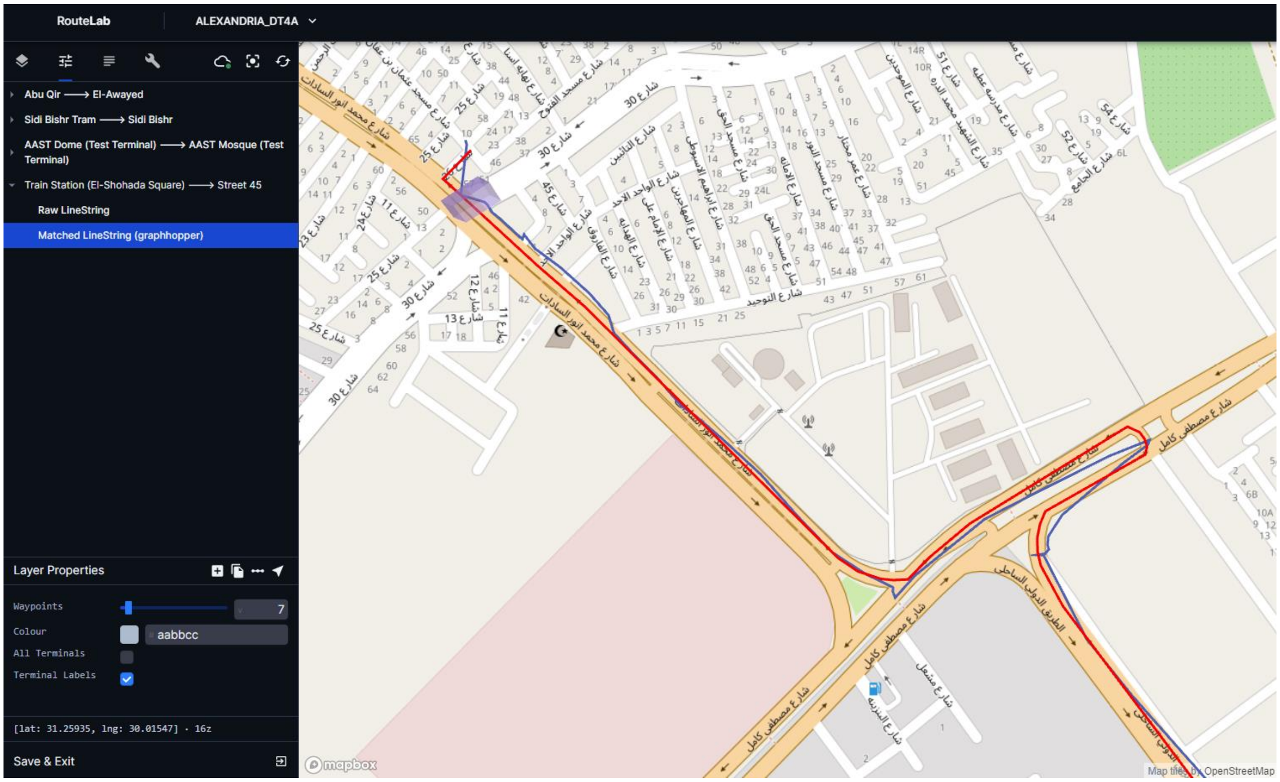


Figure 12: Snapper tool in use.

2.8.2 Stops Digitization

In this processing step, "raw stops" collected during onboard surveys are consolidated into a *representative* set of stops across the network. Such stops are created to comply with the GTFS specification. In reality, transit services in Alexandria usually don't adhere to certain stops; passengers board and alight anywhere along the trip's route. The raw stops usually form distinct clusters at intersections or entrances of neighborhoods where many people usually board and alight.

Stops are digitized through a manual process. Figure 13 shows a map of a subset of the raw stops (in red) and processed stops (in green).

Every stop created is assigned a location and a name, based on the following approach

- **Location:**
  - Location of created stops is based on the spatial clusters of raw stops
  - Created stops need to be at least 250 meters apart, with some exceptions in especially dense urban areas.

- The decision of where to place a stop was done consciously based on various factors such as the density of raw stops, proximity between the stops and the passenger activity (boarding/alighting)recorded with raw stops

- **Name:**
  Identifying the most frequent name occurring in a cluster is chosen. If no name is identified, the nearest landmark or the team's local knowledge is used.

Through the process explained above, a set of 441 stops were manually created from 2057 raw stops.

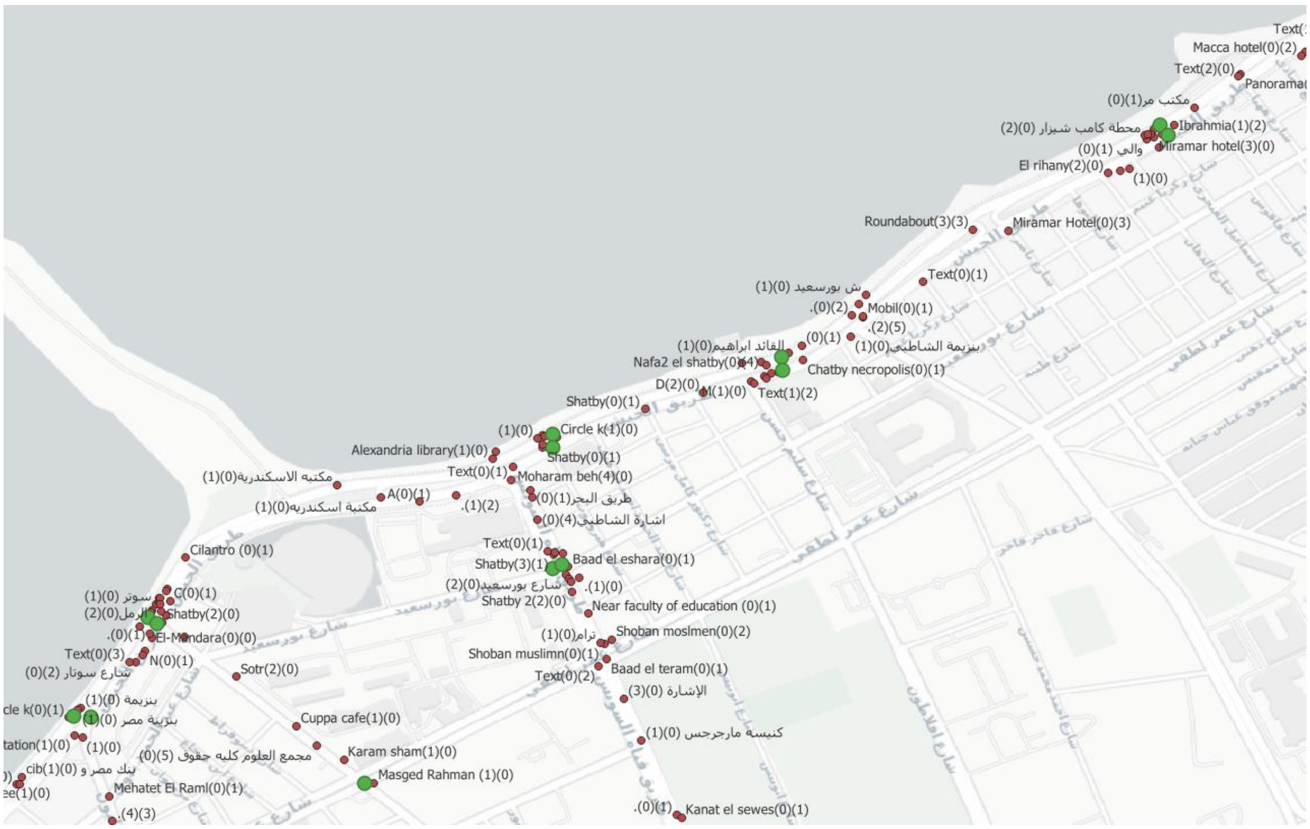


Figure 13: Red is raw (actual) stops; Green is processed (representative) stops

2.8.3 GTFS Transformation

The output of the data processing step comprises a reduced set of trips and stops that make up the transit network. Using the script "GIS2GTFS", developed by TfC, the data in GIS format is transformed into a valid GTFS feed.

2.8.3.1 Aggregating Temporal Data

The raw data comprises onboard and frequency surveys. Onboard survey data include timestamped GPS track points, stop locations and fares. From these inputs, vehicle speeds can be aggregated by trip or transit mode.

2.8.3.2 Estimating Headway

Trip headway is a required component of a valid GTFS feed. Average headway for each trip is estimated from the raw frequency survey data. In this project, one frequency survey was done for each trip. For 28 out of 192 trips, frequency surveys were not conducted, due to some students not completing their assignments. Those trips were assigned the average headway for the corresponding mode.

2.8.3.3 A Virtual Network of Stops

In the Egyptian transit context, the norm, except for a few services, is that passengers can board or alight at any point along the trip's itinerary. The GTFS standard supports this using the dedicated fields 'continuous_pickup' and 'continuous_dropoff' for the "route" entity. All the routes in the Alexandria GTFS use these fields. Therefore, the stops are not strict boarding and alighting points; they are a *virtual* network of stops that represent the locations with most dense boarding and alighting patterns based on the raw data.

Following from the previous point, the method that we use to create the "Stop Times" is to spatially join the stops and trip geometries. The stops are ordered based on the spatial order, and duration between stop pairs are aggregated from raw track points.

3 Outputs

3.1 Capacity Building Session 1: Field Research

The first capacity building session was focused on Field Research, namely, how to collect digital data on popular and formal public transport modes that otherwise are invisible.

Main target audience were the AAST students, and the teaching staff of AAST were also included as both audience and facilitators. The students turn-out to the session was considerable, around 120 students in total attended over the course of two batches, 80 of which would go on to do the mapping.

The workshop was repeated two times during the day, once for each batch of students. Each workshop consisted of four sessions, as described in Table x below.

Table 1: Field Research Workshop Agenda

Session Title	Objectives
A brief introduction to the DT4A project	• Who is DT4A, TfC, and AfD? • What activities will we conduct? • Defining some terminologies used in Public Transit mapping • Why is this work important? • Applying our learnings: Case 1, TfC's Transit Map for 6th October City • Applying our learnings: Case 2, Measuring Accessibility • Applying our learnings: Case 3, Predicting traffic better than Google • Applying our learnings: Case 4, Hotspot analysis reduces the risk of marginalized populations • Applying our learnings: Case 5, Journey planning with Google Maps

Digitizing Informal Transit Networks, a peek behind the curtains	• Why do we need a Transit Information System? • What types of data do we collect? • How do we go about collecting each data point? • What is an Identification, Onboard, & Frequency Survey? • How does each survey contribute to our understanding of the network? • What are some Open-Source tools for Data Collection? • What is the advantage of using RouteLab? • RouteLab Demo
Briefing on the FR Protocol	
Hands-on Data Collection with RouteLab & Observer	

The first session, titled "Introduction to the DT4A project" was focused on making students understand the importance of having transit data in a standard digital format to make data driven decisions in order to attain the ultimate goal of bringing sustainable transit systems in African cities. the session introduced the DT4A project and how regional mapping efforts could overcome the challenges associated with unavailability of transit data in a standard format…. giving a brief background on ongoing transport projects in Alexandria and how this contrasts with the lack of data in the city. The session also focused on real-world examples where data, like the outputs of the data collection exercise they are about to undertake, was used to make change.

Figure 14: Session 1 Proceedings

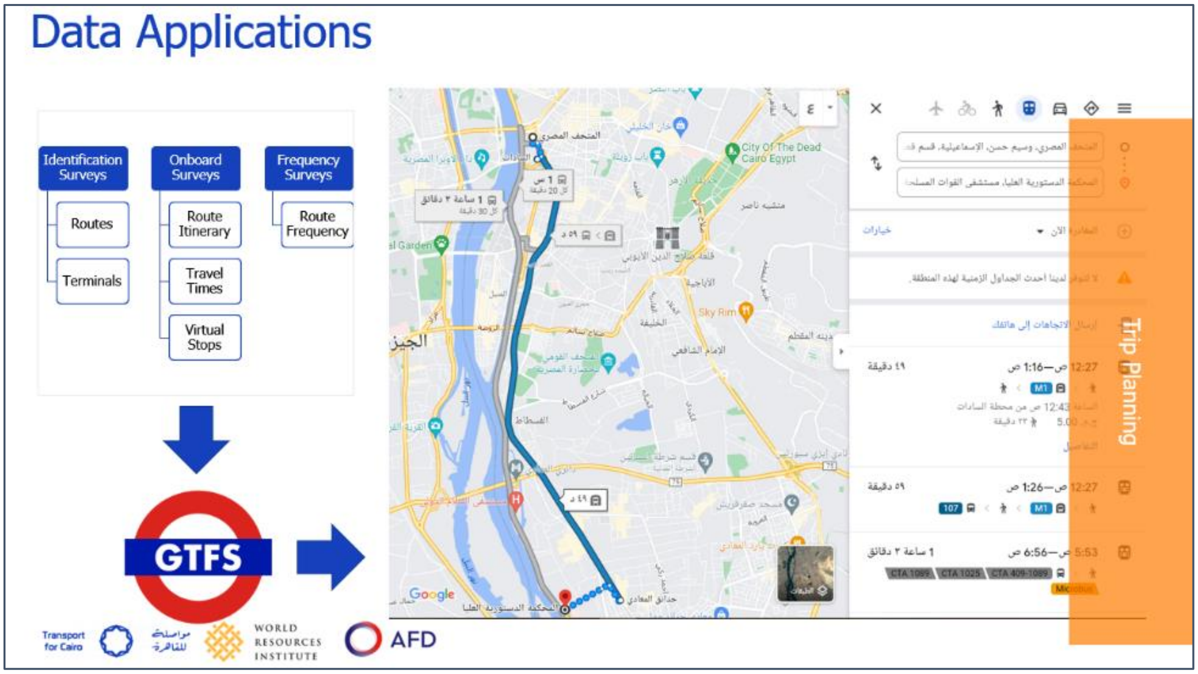


Figure 15: Excerpt from the First Session Use-cases Slides

The second session was focused on the use of digital tools, specifically the "RouteLab" software suite, in collecting data on popular transport modes. The session starts with a theme similar to the end of the first session where the attendees are shown numbers of mode share and how public transport affects people's everyday lives. The first half of the session is interactive, and students were asked questions such as "What's the percentage of households in your city, you think own a private car?" and other stimulating questions. The session then delves into describing RouteLab and the different types of surveys they're going to be doing.

Description of the surveys includes the different data outputs of each survey and how those are useful and goes specifically into how those surveys can be collected using the "Observer" mobile app, part of the RouteLab suite.

Third session focused on the logistics of field research and on the specifics on how to capture data and how to prepare for and behave in on? the field. The main material for the session was the "Field Research Protocol" which is a small guidebook for the field researchers to carry around in their phones.

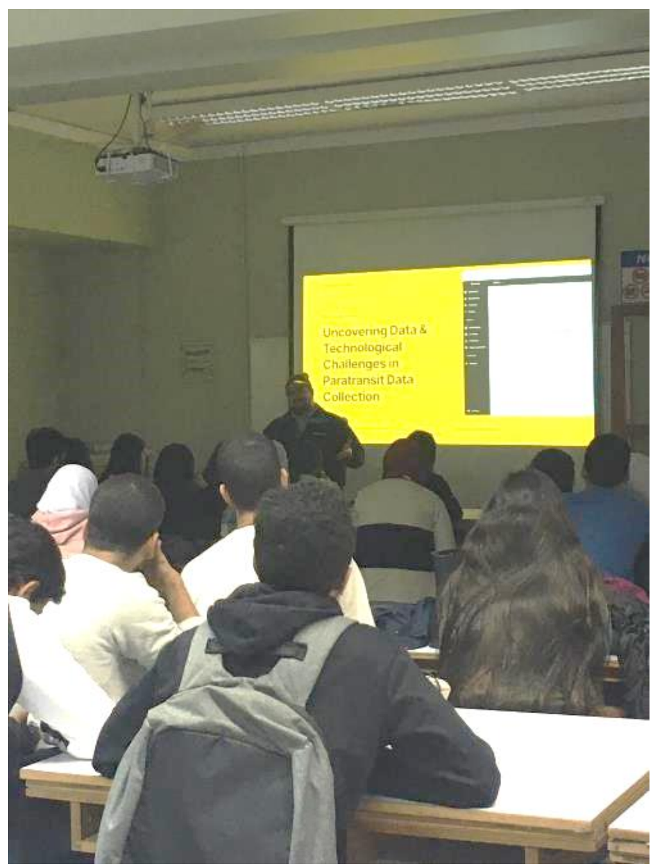


Figure 16: Session 2 proceedings

The protocol is slightly updated to match different contexts. It's divided into a general guidelines section, a section describing the public transport system and modes within the city, a section on how to prepare, behave and capture data for each type of survey, and a section about COVID precautions.

The session also contained an interactive portion where TfC gathered feedback and questions from the students on what they've heard so far and measure their understanding of the task.

Figure 17: TfC and AAST giving the students an overview on the Field Research Protocol

Finally on the fourth session "Hands-on Data Collection", the students are divided into two batches, the first of which had their phones ready to attend the practical training, while the other still had to set up and troubleshoot the app on their phones.

The session went as follows:

1. The first batch, divided further into two groups with two trainers, went to do simulated data collection activity. Two dummy terminals were created within the university campus with an imaginary route going between them. The trainers got a chance to simulate a real-life public transport vehicle and reiterate key points from the field research protocol. The students used the app first-hand and their questions were addressed by the trainers.

2. The remaining students were divided into two other trainers in the classroom to get their phones set up and fix any configuration needed for the app to function correctly. This time was also used to assign specific surveys (i.e. tasks) to each student.
3. After the first batch of students got done with the field research simulation, they were asked to move to a classroom where they get all their phones completely set up and receive their tasks, while the second batch of student do the field research simulation.

Figure 18: TfC giving a hands-on field research demo on the AAST campus

3.2 Data

3.2.1 List of Output Data

Both raw and processed data, as described in 2.8, are exported and provided as outputs. Table 2: Index of Datasets shows a full list of data outputs. Figure 20 shows the visualization of the network's stops, main terminals and trips, along with the existing tram lines, whose data is exported from OSM.

The datasets are mostly in GIS format except for the tabular "Frequency Observations" and the GTFS feed itself.

Table 2: Index of Datasets

Survey	Dataset	Description	# Of Features	Attributes Included
Identification	Identified Routes	Point location of bus queues operating on a specific route, parked within a terminal	126	• Origin Terminal • Destination Terminal • Operating Agency
	Terminals	Bus terminals, any point of origin or destination for bus routes	58	• Name
Onboard	Track Points	GPS points for the tracked route	80,000+	• Timestamp
	Raw Stops	Point location of boarding and alighting throughout onboard surveys	2057	• Number of people boarding/alighting • Timestamp

	Raw Trips	Linestring representation of an onboard survey trace	206	• Trip Fare • Timestamps for vehicle's boarding time in, departure, and arrival at destination
	Processed Trips	Cleaned routes itinerary	194	• Bus number • Operating Agency • Fare
	Processed Stops	Manually digitized stops, based on locations of regular boarding and alighting	441	• Name
Frequency	Frequency Instances	Point location of a finished frequency survey	121	• Average headway
	Frequency Observations	Tabular record of every vehicle's departure for a specific route observed during a survey		• Timestamp of departure • Average passenger load
NA	GTFS	General Transit Feed Specification, based on cleaned data from surveys.		

		Uses raw data to get travel time and headway estimates		

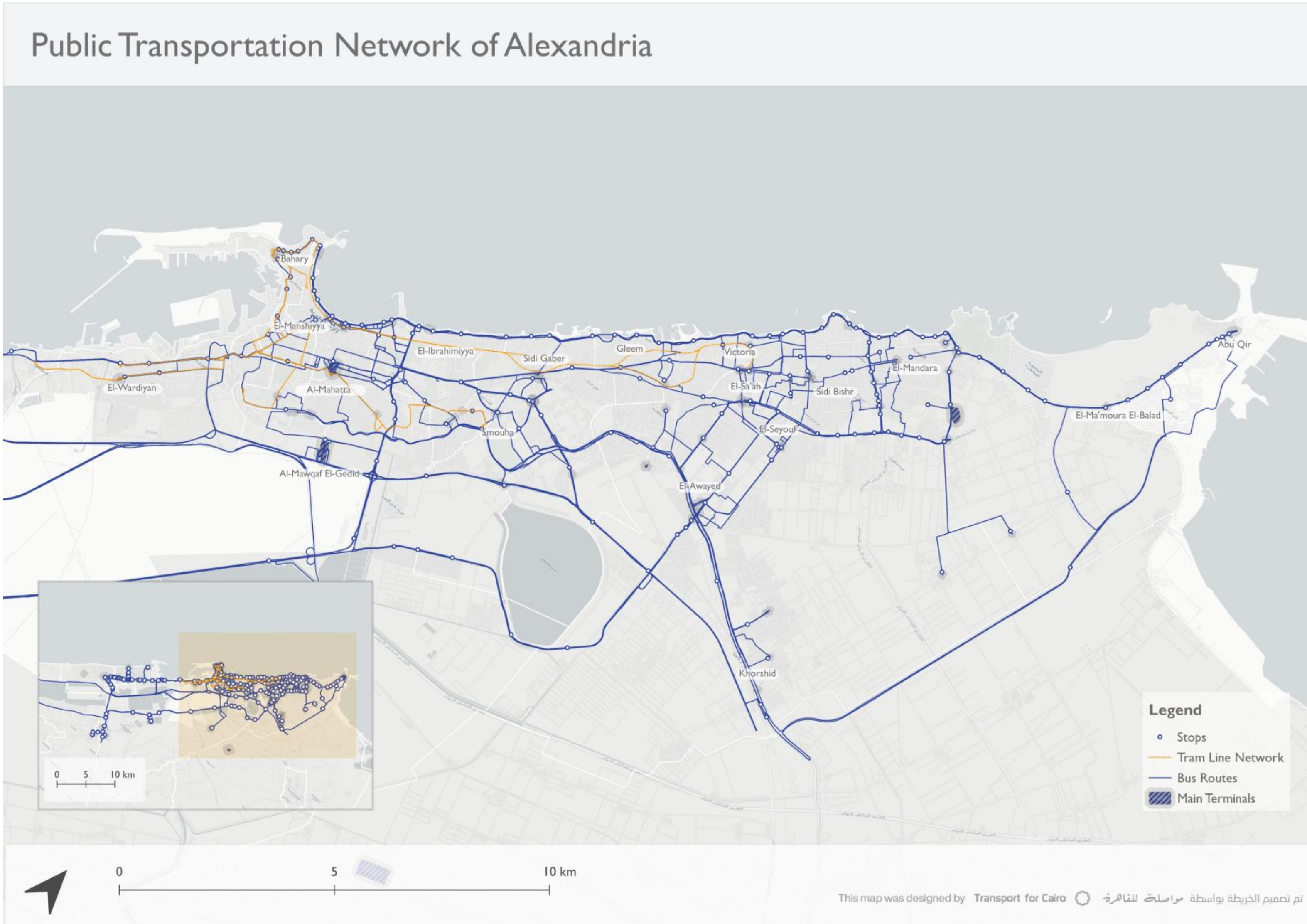


Figure 19: Public Transport Network of the City

3.2.2 Data License

The data -along with documentation- is released publicly under a CC-BY-NC 4.0 license and could be published on any platform with the proper license and attribution. Data is hosted mainly on the **DigitalTransport4Africa** resource center, it can also be viewed and downloaded from the TfC data portal.

3.3 Analysis & Findings

3.3.1 General Observations

3.3.1.1 Network Coverage for Different Modes

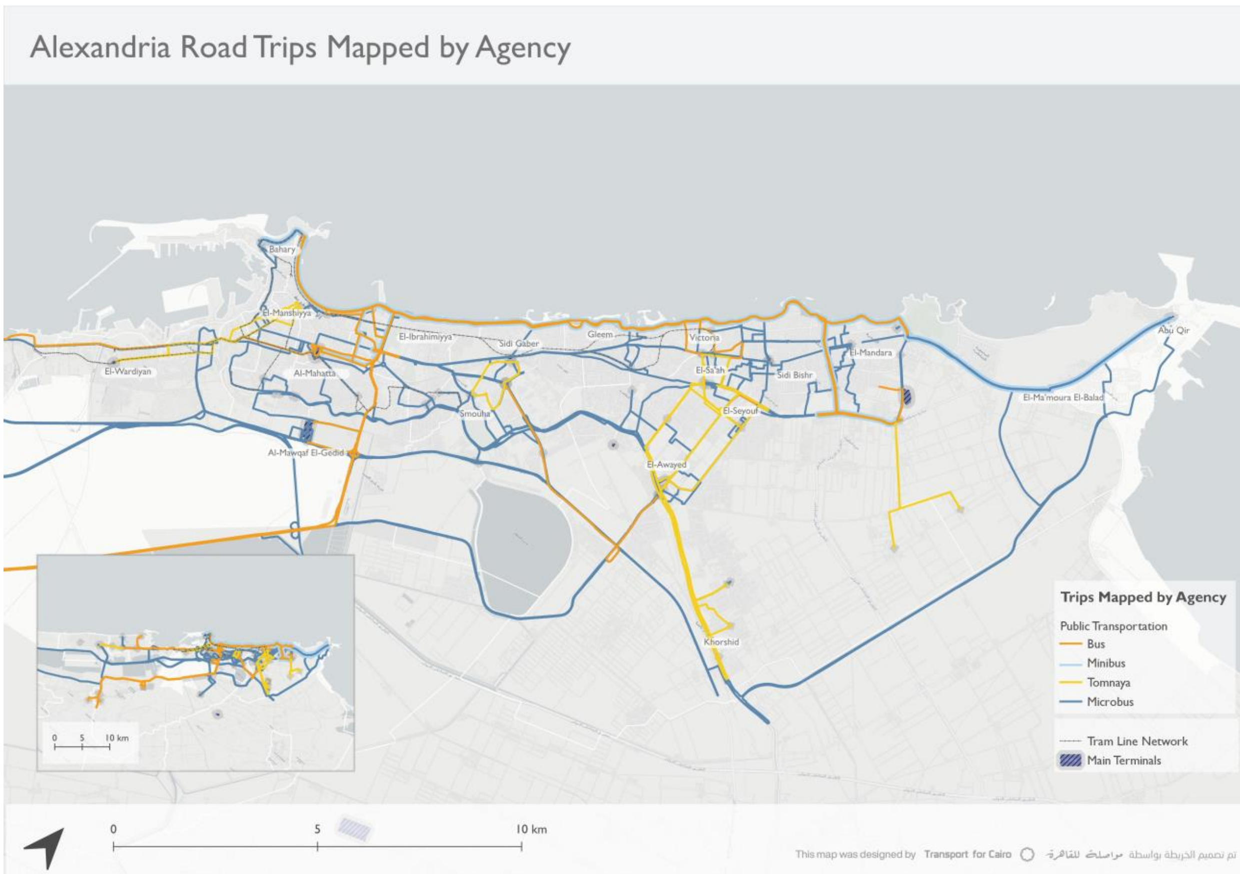


Figure 15: Mapped Trips by Agency

First, we look at the trends in network coverage for each mode. Figure 15 shows a map of all trips, differentiated by "agency", which represents in this project the main four modes in Alexandria: Bus, Microbus(16-seater), Minibus (28-seater) and "Tomnaya" (8-seater).

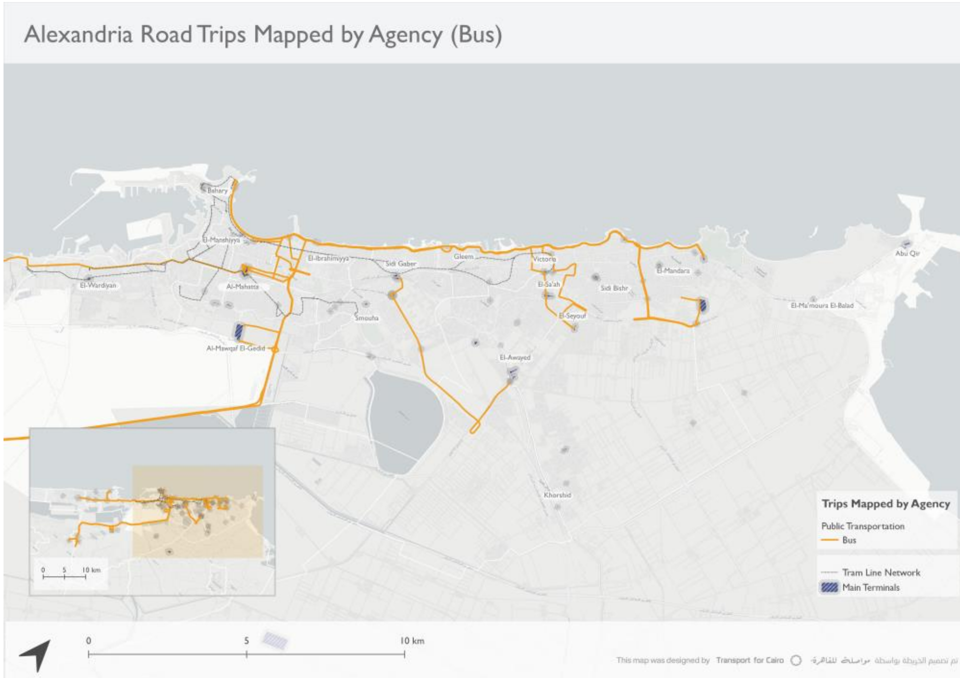


Figure 20: Mapped bus trips

We can observer from Figure 20 that bus trips in Alexandria tend to cover primary corridors and highways. It's apparent from the boarding and alighting patterns for bus trips that these locations are usually are at least hundreds of meters apart. This shows that passengers whose destination lies further into the city's neighborhoods would take a last-mile trip towards their destination, using a different mode.

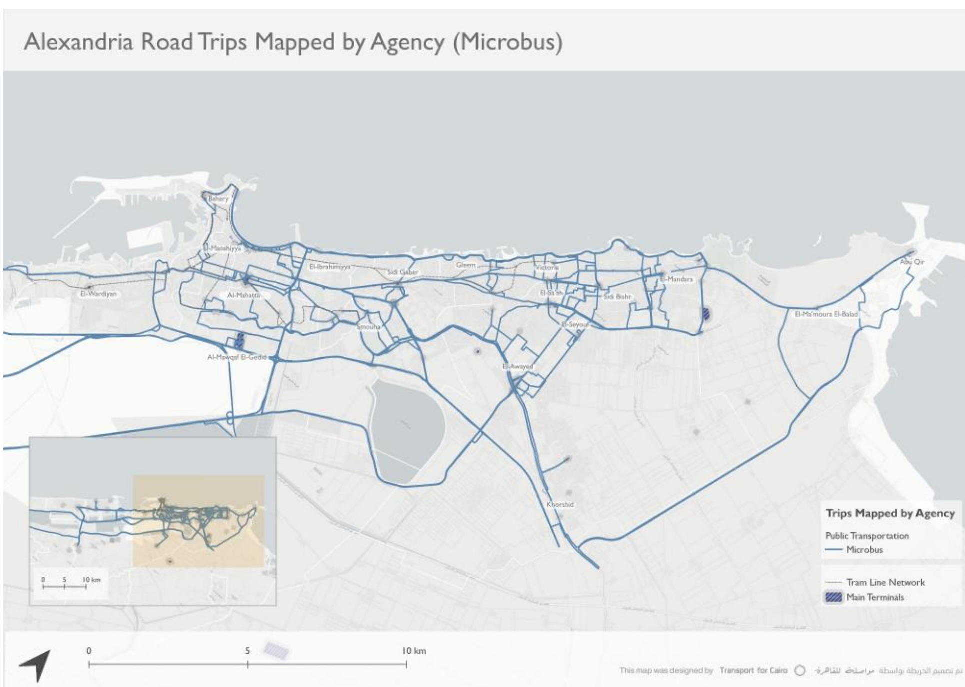


Figure 21: Mapped Microbus trips

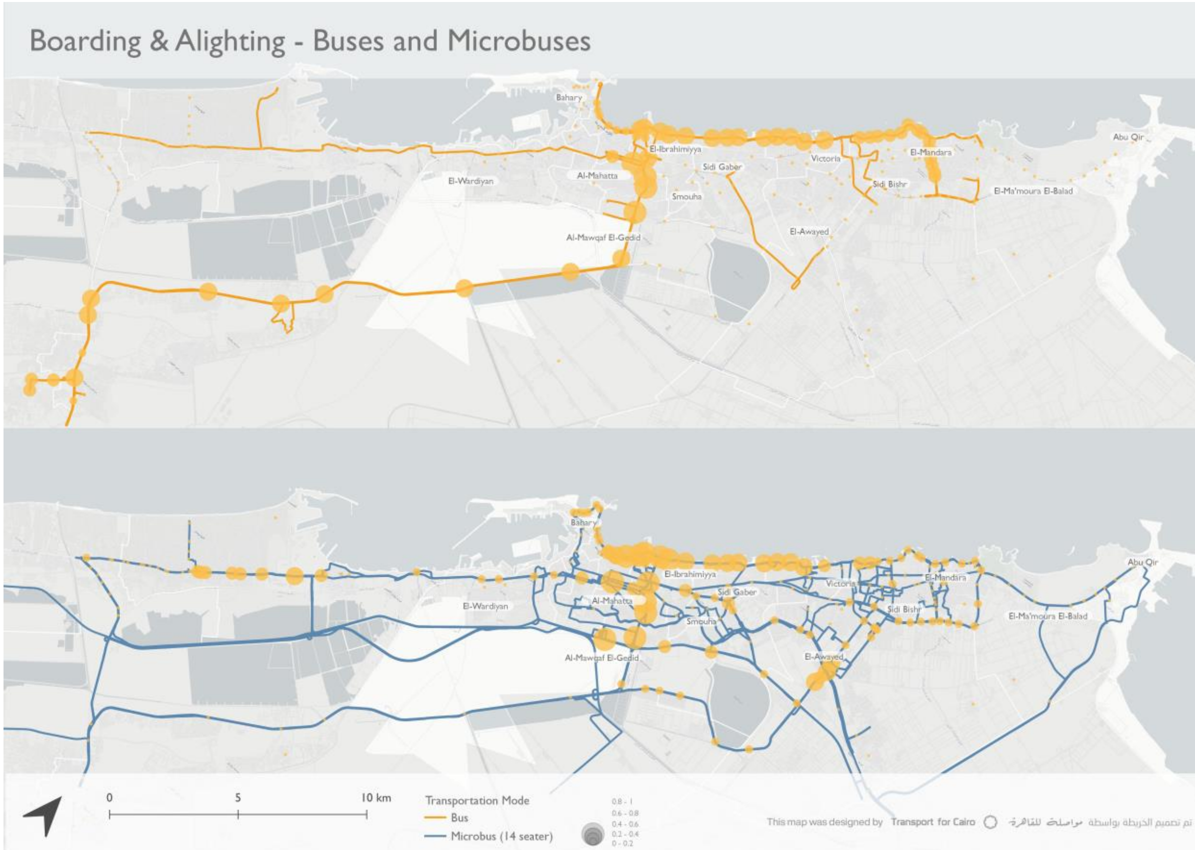


Figure 22: Relative boarding and alighting counts for bus and microbus

As opposed to limited coverage of bus trips. Figure 22 shows how microbuses dominate the network in terms of number of trips and geographic coverage. They offer both long-distance trips and short trips with densely clustered boarding and alighting locations.

One way to explain the different trends for bus and microbus trips is the nature of the road infrastructure in different parts of the city. The corniche road is wide enough to accommodate all modes, while many of the city's internal roads are much narrower, presenting challenges for large vehicles like 49-seater buses.

3.3.1.2 Vehicle Speed Profiles

Vehicle Speed profiles are aggregated from the timestamps from raw onboard survey data. In Figure 23, the average speed on each road segment across all modes is visualized.

Figure 23: Average Vehicle Speeds for all modes (km/h)

Most inner-city roads have an average speed of 5-15 km/h. The average speed across the corniche generally falls between 5 and 30 km/h and we can see that highways with 60+ km/h speeds are on the outskirts of the city. Both observations are to be expected given the nature of Alexandria's planning with dense urbanization and roads with few lanes.

Two road segments stand out in the speed profiles map with average speed of less than 5 km/h: one near Al-Mahatta north-west of the city and one at Sidi Gaber near the center of the city. This can be explained by the fact that they are both train stations and host major hubs/terminals for other modes, especially microbuses. Section 3.3.2 explores, in more detail, the density of passenger and vehicle flow there in Al-Mahatta terminal.

3.3.1.3 Continuous Boarding and Alighting Along Trips

It's quite common in transit systems dominated by paratransit that passengers board and alight at arbitrary points along trip itineraries. Figure 24 visualizes this phenomenon using the raw data collected during onboard surveys. Alighting locations are almost evenly distributed all over the network, where passengers choose to alight at the nearest point to their destination. Passengers are used to this characteristic of the transit services they use.

On the other hand, boarding locations are observed to be much more clustered into distinct hubs that serve nearby neighborhoods.

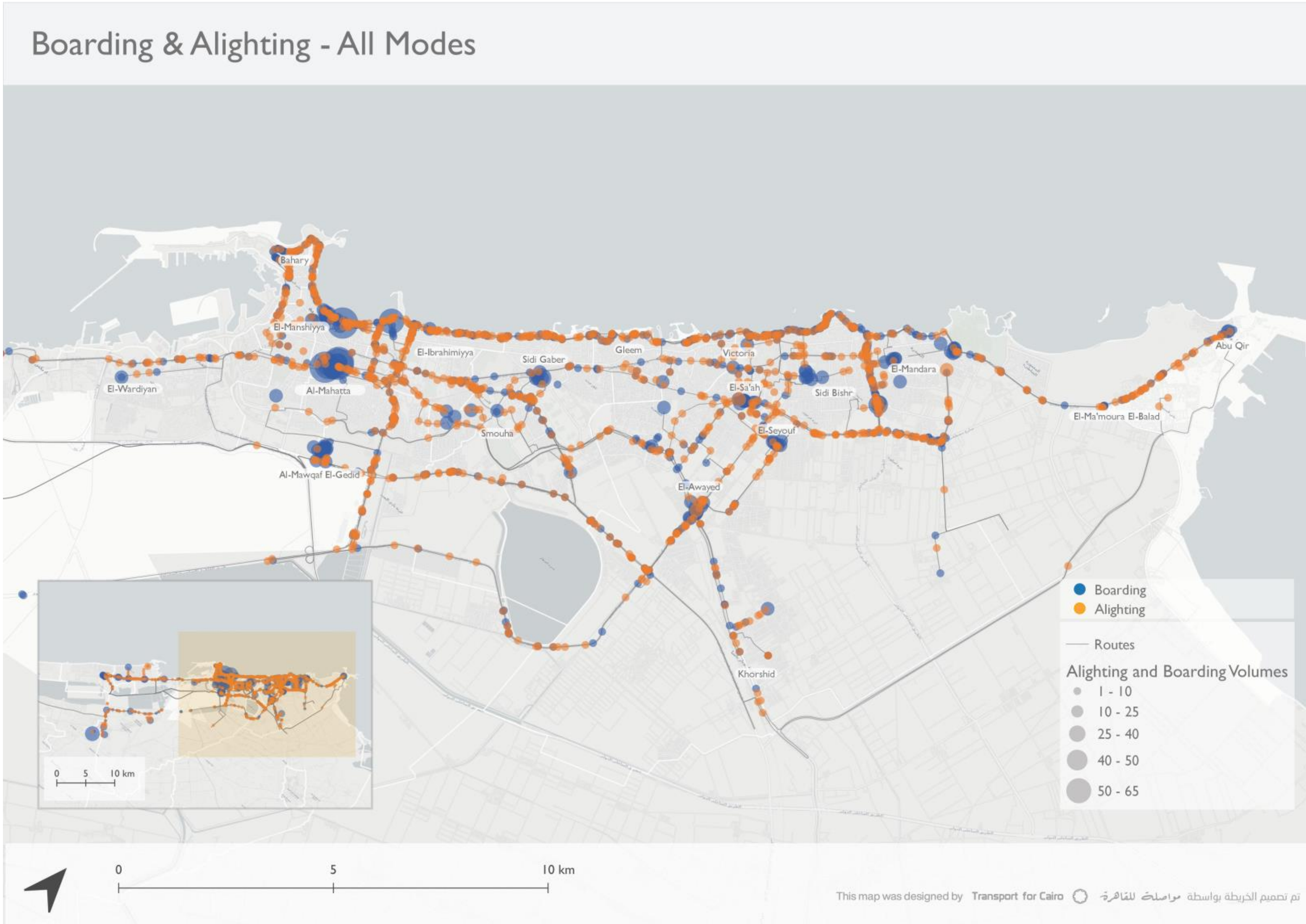


Figure 24: Raw Boarding and Alighting Data Points

3.3.2 Al Mahatta Station & Alexandria's Railways

Following from the previous section, we further explore a specific terminal that stands out in Figure 24 as the densest in passenger activity— Al-Mahatta terminal in the northwest. The densest cluster of boarding and alighting activity is at this terminal, which is explained by its proximity to the main railway station in Alexandria. Figure 26, as well, shows the highest flow of passengers at this terminal. We can expect that the transit services at this terminal primarily serve railway passengers, taking them to the railway station and back into different parts of the city.

Figure 25: Relative Passenger Flow on Road Network Segments

It is, however, an interesting finding that the busiest terminal is one that primarily offers not intra-city trips for residents, but to and from the railway station. It could well be possible that both types of trips heavily overlap at this terminal, given the dense urbanization around it, as shown in Figure 26. Further investigation would need more on-site data, but from satellite imagery it is clear the extent of informal markets surrounding the terminal which would mean more pedestrian activity and slower traffic flow for vehicles.

Figure 26: Google Earth Snapshot of Al-Mahatta Terminal

When comparing this preliminary insight with the forthcoming Abu Qir Metro plan (stretching from Abu Qeer in the far north east of Alexandria to Km 21 in the far west beyond El Wardiyan), shown in Figure 27: Planned Abu Qir Metro Itinerary, source "Moustafa Rizk" on LinkedIn, it is interesting to note that the existing passenger flow does not necessarily coincide with the line's itinerary. That doesn't mean the metro shouldn't alleviate the public transport traffic from congested corridors to the north and south but would mean that vertical feeder services would probably pop up to connect passengers vertically to areas of demand.

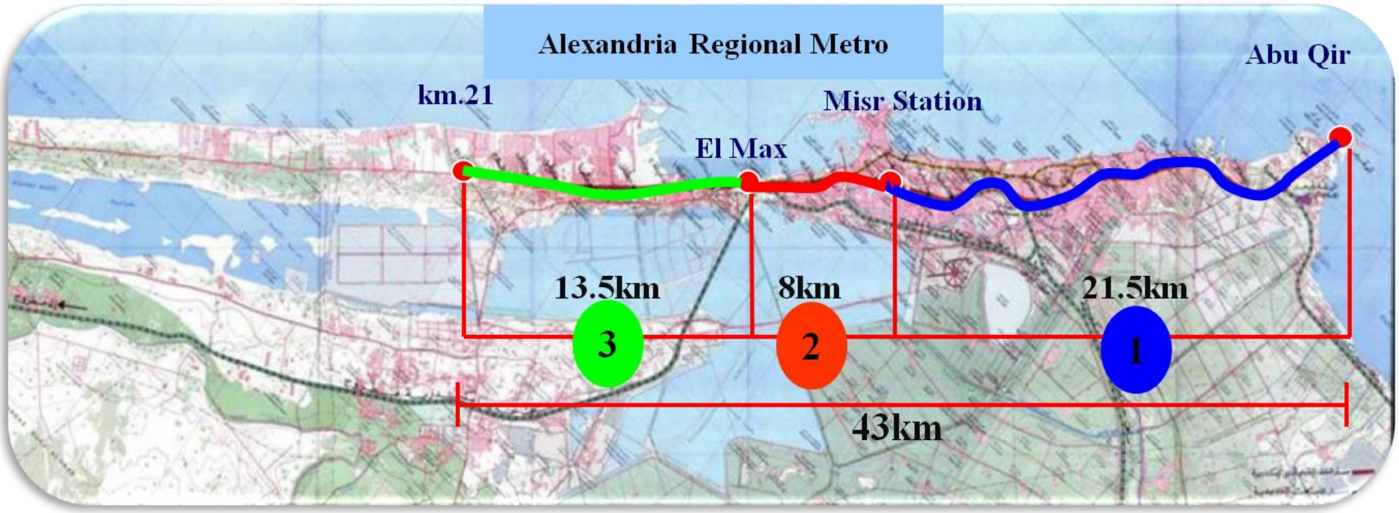


Figure 27: Planned Abu Qir Metro Itinerary, source "Moustafa Rizk" on [LinkedIn]

3.4 Capacity Building Session 2: Results & Use-Cases

3.4.1 Activity Description

The final activity in the project was an online session with the following objectives:

1. Present the raw and final data to the students and show them their achievement
2. Display some findings from the previous section in a simple manner
3. Raise the students' awareness *data-driven decision making* and the many potential uses of this dataset
4. Open discussion to hear the students' impressions and how they see this work can be taken forward

The session was conducted on 26th January 2023. A total of 14 students and faculty staff attended.

3.4.2 TfC's Presentation

The session was started with a re-iteration of the motivations and benefits of transit data. Such points were addressed in the first capacity building session.

Then, visualizations from 2.8 were presented to the students with an explanation and examples of the research and policy questions that the transit data can be leveraged to answer, like the one shown in Figure 28. For example, identifying bottlenecks of vehicle flow, and comparing transit supply and demand on important corridors. Aligning with objective number 2 in the previous section, the presentation only lightly touched on each question in the favor of presenting more ideas for uses of the data. Transit data is even used beyond research in making digital art.

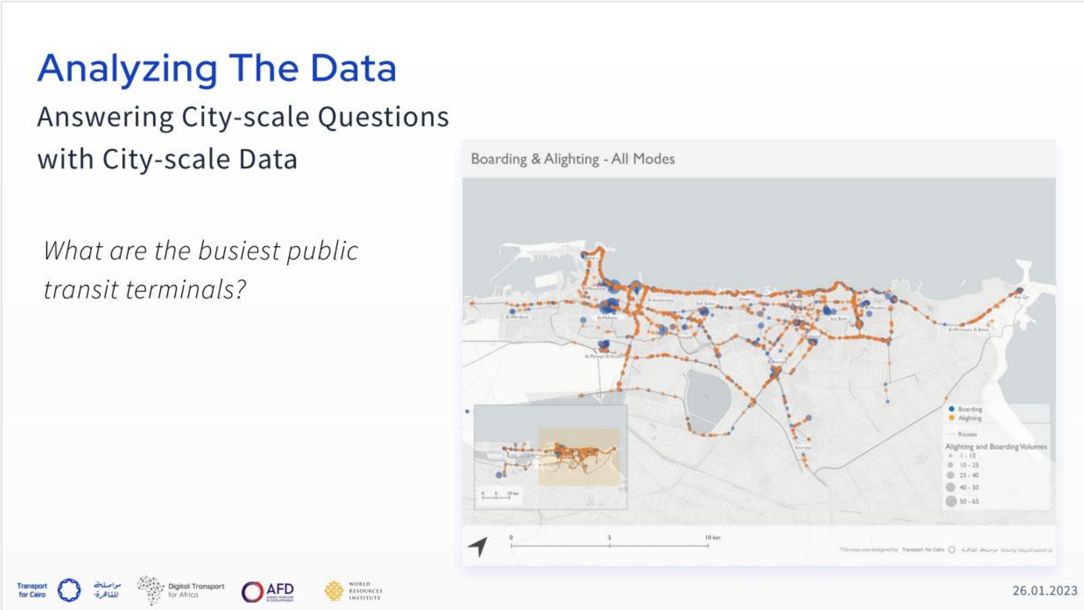


Figure 28: A slide from the seminar's presentation

Then stories of the impact of transit data in other African cities were briefly told, namely in Cairo, Egypt and Kumasi, Ghana.

Finally, the topics presented throughout the presentation were grounded in the present reality of Alexandria by relating them to the currently in-progress Raml Traam Rehabilitation project and Abu Qir Metro. Published estimates of the total investments and the number of passengers to be served were used to convey the large scale of these projects, with their impacts covering the entire city. We aimed, through that, to heighten the sense of ownership that the student felt towards their work and get them invested in the future of these projects.

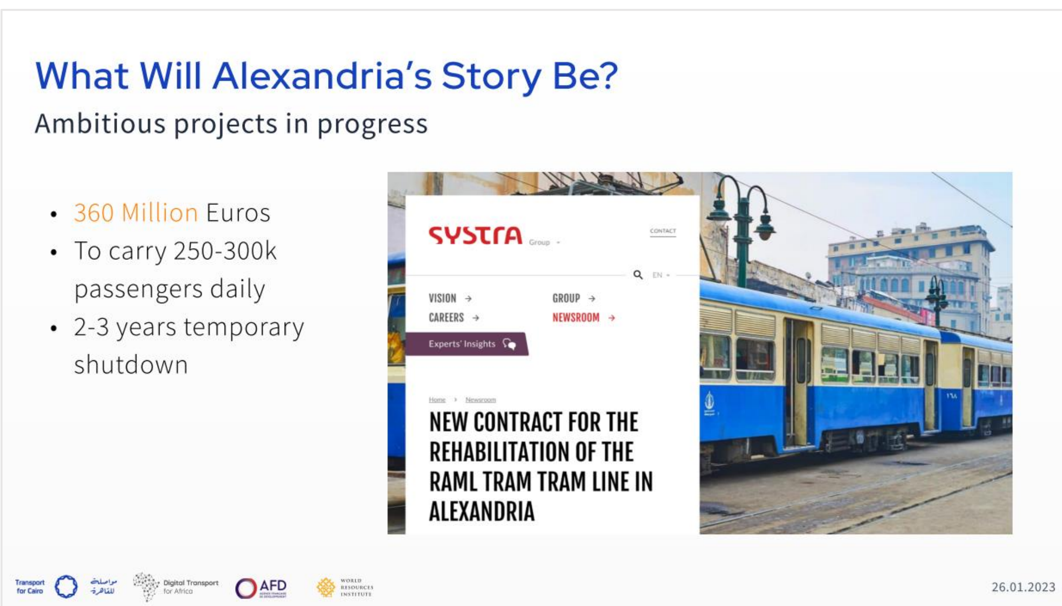


Figure 29: Presentation slide showing projected cost and capacity for the completed Raml Tram Line

3.4.3 Feedback From Open Discussion

A high level of engagement was observed in the open discussion. A postgraduate student stated that she has already started using the data in her research. Other students expressed the shift in awareness they had experienced regarding the impact of transit and transit data on urban planning. One student actively inquired about ways to take the outcomes of the project forward.

TfC encouraged the audience to use the data and promote its use in their circles, so it evolves based on the needs of the city.

4 Next Steps

The first logical step to build on the work done, is to continue mapping the rest of the city's routes. With the initial mapping exercise done, there is now a clear "index" of routes in the city, and with the upcoming mass transit projects, digital transport data is more important than ever.

Best approach to keeping the data sustainable is by using it in practice, some of the feasible usages in the near future would include:

1. Building Alexandria's first journey planning app: using the GTFS feed output and open-source white labeled apps such as the "transit" API.
2. Identify opportunities for network optimization: This requires more comprehensive mapping and public sector intervention. Already from the data captured, it is visible that Alexandria's public transport network suffers from a lot of overlaps in the city's main corridors (e.g. The courniche) and could use better planning
3. Design replacement transport during ongoing construction of projects: Al Raml Tram, a mode which is used by Alexandria's inhabitants on a daily basis, is about to shut down for 2 to 3 years. Finding a proper replacement requires data to assess the current demand and design a replacement that accommodates that, along with future demand

Transport for Cairo, along with WRI and DT4A partners are going to leverage their networks and online presence to promote the work done, and make sure it is used for the benefit of the city and it's people.

5 Annex A: Project Plan