LIFE GreenYourRoute: A European innovative logistic platform for last mile delivery of goods in urban environment

Deliverable B5.1: *Report on integration activities*

Partner responsible for this report: UTH

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Contents

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Abbreviations

GYR	GreenYourRoute project

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List of Figures

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Abstract

GYR technical team implemented the integration of GYR service into the business environment of the demonstrators of the project, as it was initial foreseen. The GYR service was integrated into the business environment of 4 3PL companies. In addition, APIs of GYR service was integrated into the business environment of a routing planning provider. Both integrations were implemented smoothly with some delays due to COVID pandemic. The integration was fully implemented and the demonstrators of the project were ready for the real life practice of GYR service.

1 Introduction

GreenYourRoute service uses several APIs to provide green vehicle routing planning as well as to report the environmental footprint including GHG and non-GHG emissions of the provided routing plans.

The developed APIs include database API, vehicle routing optimization algorithm API, Map data API, Cost matrix API, and Map tiles API as presented in the Figure 1. In addition, GreenYourRoute service uses two external APIs necessary for the optimal green routing planning. These APIs are the Traffic API and the Weather API provided both by external services.

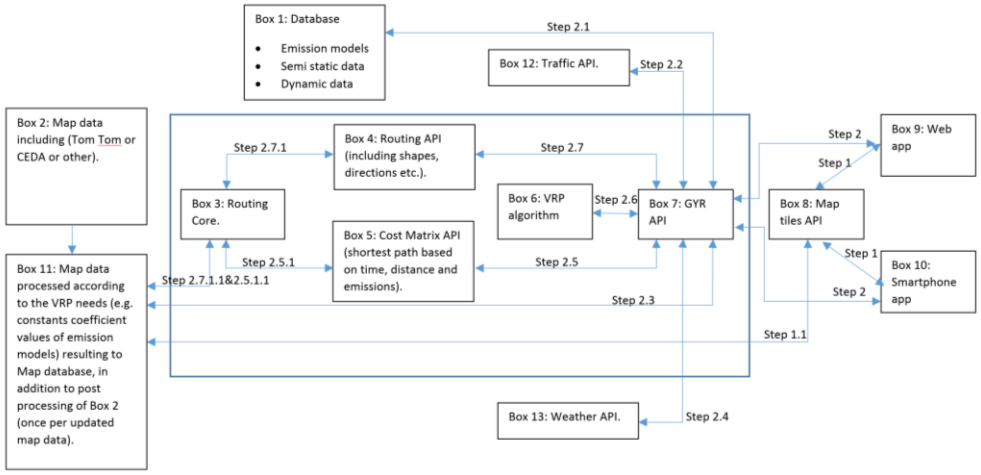

Figure 1: GreenYourRoute structure

Using GreenYourRoute service, one can plan a set of routes for his/her delivery/pick-up fleet to efficiently serve a set of points. GreenYourRoute service provides to the users the option to a)edit the suggested routes by the optimization algorithm using a drag-and-drop vehicle editor, b)analyse them in various ways, and c)investigate different scenario where different fleet of vehicles and/or different visiting points should be served. Additionally, GreenYourRoute service inspects the suggested or revised routes in a map and exports the final routing plans to the mobile devices of the drivers.

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The integration of GreenYourRoute service into the business environment of the demonstrators, was made with a cyclic way as shown in Figure 2 based on the iterative development of GreenYourRoute platform and its application.

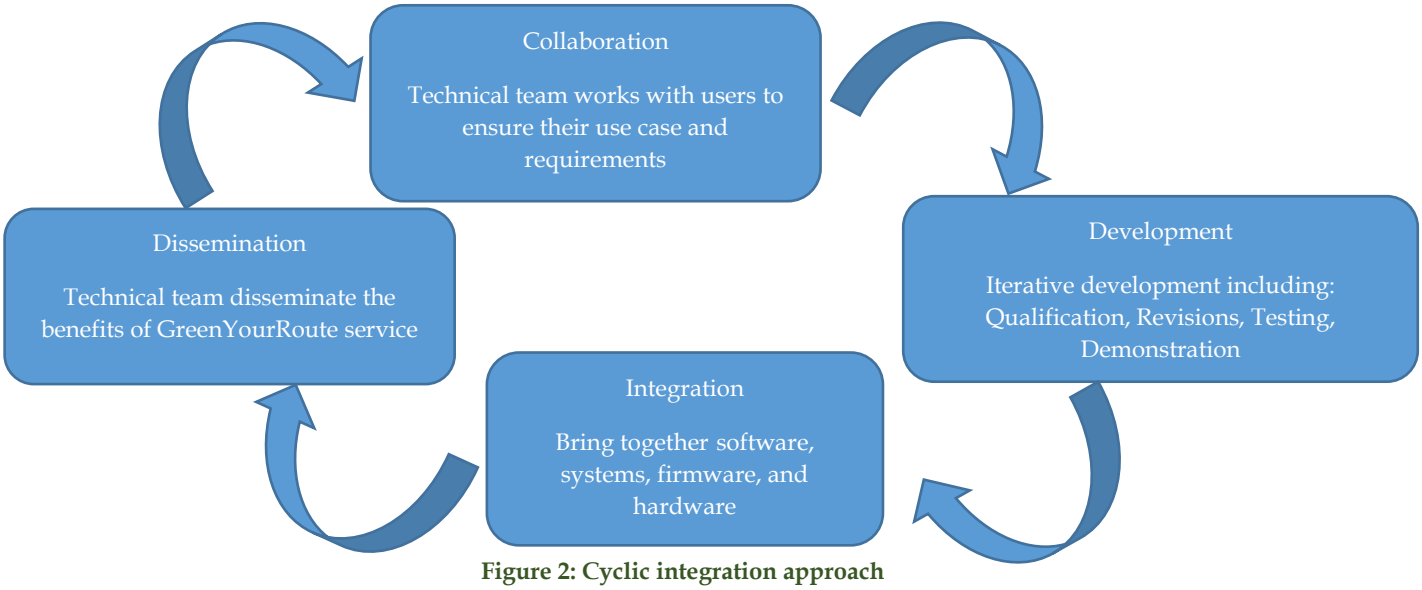

Figure 2: Cyclic integration approach

The cyclic integration approach includes *Collaboration*, *Development*, *Integration* and *Dissemination*. The collaboration included the collaboration of the technical team and the users to ensure their use case and the satisfaction of their requirements and the requirements of the potential future users. The development included the iterative development presented in *Deliverable B4.2: Testing and evaluation report of GYR platform*. The integration brought together several software components, different systems, firmware and hardware. Finally, the dissemination focused on the benefits of GreenYourRoute service, showing to the perspective users its plethora functionalities.

The main reasons for choosing this cyclic integration approach were:

- User-centric approach supporting convergence towards fulfilling the requirements of the users;
- Improved the visibility of GreenYourRoute service benefits;
- Promotes trust between GreenYrouRoute developers and users;
- Continuous inspection and improvement of GreenYourRoute service;
- Maintain successfully GreenYourRoute service;
- Controlled the integration of new tools into GreenYourRoute service;

2 GreenYourRoute service integration

The integration of GreenYourRoute service into the business environment of 3PL companies was the compass to combine software, systems, firmware, and hardware to work together as one routing planning service.

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GYR was integrated into the business environment of 4 3PL companies (i.e. ATHINAIKI, PLUS, KOUKOUZELIS, a 3PL company customers of CEDA) and into the business environment of a routing planning service provider (i.e. ITACA) to be used by 3PL companies.

2.1 Integration of GreenYourRoute service into 3PL environment

The integration of GreenYoruRoute service into the business environment of the 3PL companies participating to the project was based mainly on 1) the user manual developed for the web and mobile apps and 2) the step-by-step integration manual of the web and mobile apps.

2.1.1 Collection of information and demo examples

During the Integration process, the questionnaire presented in Deliverable B5.2 was given to the demonstrators of the project, working in a bi-directional way. On the one hand, GreenYourRoute technical team introduces the demonstrators to the integration procedure by giving a first short idea of the information and data that are needed by the GreenYourRoute technical team on the one hand but also vice versa; the demonstrator given a first idea to the GreenYourRoute technical team of the type of the needs that it had. The information gathered through the questionnaire regarded general information about the demonstrator, the routing planning methodologies, and the data used on daily basis by the demonstrator.

The questioner has mainly 4 sections. The 1st section includes general information about the demonstrator such as name, website, email, contact person, average daily number of trucks used, orders served, orders served per truck, volume & weight transported, kilometers travelled, the orders type, packages type, potential time windows, and service time. Then based on the 2nd section of the questioner, the technical team collected information related to the existing routing planning approach. The demonstrators were asked to explain the way that they were creating the routing planning before the use of GYR service and the time they were spending in a daily base. Additionally, info about their ERP were gathered in order to find the best way to introduced the daily routing needs into GreenYourRoute database. Then the technical team spent significant time at the 3rd section of the questioner in order to analyze the digitization level of each demonstrator as well as the format followed by the ERP system to store daily routing data. Finally, the technical team using the questions of the last section of the questioner defined with details the daily routing planning approach adopted for each demonstrator. The technical team recorded the main restrictions of the routing planning problem of each demonstrator such as packages restrictions, trucks restrictions, customers restrictions, and transportation network restrictions. Then information about the shifts followed by the demonstrators were defined as well as information of the environment footprint recorded (if any).

After the completion of the questioner, the technical team requested by the demonstrators to prepare and send 4 files in excel or cvs format including information about a representative working day referred to as demo day:

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- Full information about the orders of the day including type of product, weight, volume, time windows, type of order pickup/delivery/requisition, customer associated with the orders.
- Full information about the customers of the day to be served including name, email, phone number, street, city, postal code, latitude, longitude, ERP ID.
- Full information about the available trucks of the day including brand name, plate, engine type, fuel type, category, contract type.
- Full information about the routing plan prepared (without the use of GYR service).

The above information were used by the technical team as demonstration examples. The data included into the files, were introduced into the GYR database and the GYR service was used to prepare the routing plan of the demo day. The obtained routing plans referred to as demo routing plans were analyzed by the manager of each demonstrator in order to:

- check the quality of the obtained routing plan;
- check the applicability of the obtained routing plan;
- compare the demo routing plan and the plan already implemented;
- investigate the potential environmental and socio-economic benefits by using the GYR service.

After the full analysis of the demo routing plan, GYR technical team requested additional demo examples from each demonstrator which corresponded to different conditions. Demo examples of high season period, demo examples of low season period, demo examples of week days, demo examples of Saturdays, demo examples of different cities and demo examples with different availability of trucks.

GYR technical team introduced these demo examples into the GYR database and used GYR service to prepare the routing plans. The analysis continued with the comparison of these examples with the routing plans implemented in practice. Note these demo examples was part of the example used to define the baseline scenario necessary for the environmental and socio-economic assessment of the project's results.

The main outcomes of this integration step were:

- The revisions of the routing optimization modeling and solution approach to satisfy additional requirements of the demonstrator;
- The revisions of GYR service's UX and UI;
- The definition of the level of digitization of the demonstrator;
- The capabilities of demonstrators' ERP;
- The environmental and socio-economic benefits using GYR service convincing GYR demonstrators to fully integrate GYR service into their business operational environment.

2.1.2 Integration of demonstrator data into GYR database

The process of the collection of the data which are reused for the daily routing plans, contained the 7 groups of data. In every step, the GYR technical team provided the necessary instructions and supports to the demonstrators for any issue raised. The project team, if needed, adjusted

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the already developed templates for data collection so that they fitted in the specific requirements of each demonstrator taking under consideration the specific tools used (i.e., ERP software), the quality of the data and other relative factors (e.g. format of data). At the each step of the data collection, the project technical team inspected the obtained dataset to check the quality of the data. If the quality of the data meted the desired standards, then the project team continued with the next step of data collection. If the quality of the data were poor, then, the project team proceeded to making some corrections in the obtained dataset. Therefore, a close corporation of GYR technical team with the demonstrators was needed to ensure that the corrections made increased the quality of the dataset to meet the necessary requirements.

Group 1: GYR technical team collected from each demonstrator the data regarding its customers by filling up the corresponding sheet of the template (i.e. the template i.e. file GYR_Setup_Template.xlsx is attached to Deliverable B5.2). The data requested included:

- The unique id for each customer registered into its ERP system.
- The name of each customer.
- The telephone number of each customer.
- The fax number of each customer.
- The unique id for each address of the customers.
- The address of each customer.
- The postal code of each customer
- The city of each customer.
- The latitude of each customer.
- The longitude of each customer.

Group 2: GYR technical team collected from each demonstrator the data regarding its trucks that are used for the routing process by filling up the corresponding sheet of the template. The data requested included:

- The plate of the truck.
- The brand of the truck.
- The engine type (i.e. EURO type) of the truck.
- The fuel type of the truck.
- The description of the truck.
- The type of the license that a driver needs to have to drive the truck.
- The contract type of the truck.
- The total Kg that the truck can carry.
- The total m3 that the truck can carry.
- The total number of pieces that the truck can carry based on the package types that can be carried by the truck.
- The abilities of the truck based on the demonstrator's requirements.
- The restrictions of the trucks based on the demonstrator's requirements.

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Group 3: GYR technical team collected from each demonstrator the data regarding the package types that are served by the demonstrator by filling up the corresponding sheet of the template. The data requested included:

- The name of the package type.
- The weight of the package type in Kg.
- The volume of the package type in m3.
- The loading service time of the package type.
- The unloading service time of the package type.
- The width of the package type in meters.
- The height of the package type in meters.
- The length of the package type in meters.
- The description of the package type.

Group 4: GYR technical team collected from each demonstrator the data regarding the material tags that are served by the demonstrator by filling up the corresponding sheet of the template. The data requested included:

- The name of the material tag.
- The description of the material tag.

Group 5: GYR technical team collected from each demonstrator the data regarding its depot by filling up the corresponding sheet of the template. The data requested included:

- The name of the depot.
- The telephone number of the depot.
- The address of the depot.
- The postal code of the depot.
- The city of the depot.
- The latitude of the depot.
- The longitude of the depot.

Group 6: GYR technical team collected from each demonstrator the data regarding its drivers by filling up the corresponding sheet of the template. The data requested included:

- The last name of each driver.
- The first name of each driver.
- The email of each driver.
- The telephone number of each driver.
- The address of each driver's home.
- The postal code of each driver's starting point (e.g. home).
- The city of each driver's starting point (e.g. home).
- The latitude of each driver's starting point (e.g. home).
- The longitude of each driver's starting point (e.g. home).

Additionally, based on the data provided by the demonstrators the technical team created for each driver, a user account.

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After the collection of the above data, GYR technical team after consultation with each the demonstrator created 3 additional datasets:

Dataset 1: Based on the requirements of the demonstrator, GYR technical team created the dataset of abilities of trucks. This dataset included:

- The name of the ability (e.g. bulk products)
- The description of the ability (e.g. the ruck could deliver only bulk products).

Dataset 2: Based on European and national legislation and other rules implied to the region where the demonstrator serves its customers, GYR technical team created the dataset of restrictions of trucks. This dataset included:

- The name of the restriction (i.e. city center).
- The description of the restriction (i.e. only Euro IV or higher could enter the area)

Dataset 3: Based on the package type, the material tags and the abilities of truck, GYR technical team created the dataset of compatibility matrix and restrictions of trucks. The vehicle routing algorithm uses the compatibility matrix to ensure that the truck based on the ability of the truck to carry the package type or the material tag can carry an order with a package type or a material tag.

GYR technical team inspected the collected data to estimate their quality. To be able to do this, GYR technical team developed a series of tools and methodologies to prepare the data for the integration.

For the dataset of the customers, GYR technical team developed a tool that separates the customers based on the results of the geolocation of the addresses. This process ensured that the quality of the data of the customers and especially of the addresses were the expected one. If the quality of the addresses was poor, GYR technical team continued with a second tool that transformed the data of the addresses to the expected form. The developed tools are attached in Deliverable B5.2.

For the dataset of the trucks, GYR technical team ensured that the combination between the engine type, the fuel type and the description of the Truck of the demonstrator provided a class_id that can be used for the calculation of the emissions. GYR team communicates with the demonstrator if the information of the trucks were not the expected one.

For the dataset of the drivers, GYR team ensures that the addresses of the starting points of the drivers are correct and could be geolocated. GYR team communicates with the demonstrator if some of the addresses cannot be geolocated or the information of the addresses is not the expected one.

2.1.3 Integration of data and cost matrix calculation

After the necessary corrections and revisions in the datasets, GYR technical team continued with the actual integration of data into the GYR database. GYR team had developed the necessary tools to transform and import the data with the most efficient way. The tools developed optimize the total time of the integration and ensure that the data imported

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correctly. After the import, GYR technical team with the support of the demonstrator ensured (with manual methods by selecting random datasets) that the data had been imported correctly and ensured the integration.

In order to optimize the required time for the integration of data GYR team developed a series of tools. These tools are attached in Deliverable B5.2 and they include several scripts: 1) a script that imports the vehicles of the demonstrators to GYR database automatically based on the data provided and revised (if necessary), 2) a script that imports the semitrailers of the demonstrators to GYR database automatically based on the data provided and revised (if necessary), 3) a script that imports the package types of the demonstrators to GYR database automatically based on the data provided and revised (if necessary) and 4) a script that imports the material tags of the demonstrators to GYR database automatically based on the data provided and revised (if necessary).

After the integration of these data, GYR technical team integrated the data of the customers to create the necessary cost matrix including static data for each pair of visiting points i.e. distance, time, elevation, type of road, historical data of vehicle speed. In order to maximize the user experience, minimize the delays and the on-the-fly calculation time of the cost matrix, GYR technical team has developed a tool that can calculate the cost matrix between the already uploaded customers.

2.1.4 Training

The final part of the integration of GYR service into the operational business environment of the 3PL companies (i.e. demonstrators of the GYR project) was the training of the managers on how to use the GYR web application and the training of the drivers on how to use the GYR mobile application.

2.1.4.1 Training of the managers

The training started with the delivery of login information to the web application dedicated to the managers of the demonstrators, the one responsible for the routing planning of their companies. The training of the managers took place in three steps.

The first training step included the setup of the account with additional to the above presented data in section 2.1.2. The manager of the demonstrators trained on how to

- add a new customer manually;
- add several new customers importing a file with specific format;
- edit the info of a customer;
- show the customer on the map;
- add a new truck;
- edit the info of an existing truck;
- add a new ability for trucks;
- edit the info of an existing ability for trucks;
- add a new restriction for truck;
- edit the info of an existing restriction for trucks;
- add a new semi-trailer type;

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- edit the info of an existing semi-trailer type;
- add a new driver;
- edit the info of an existing driver;
- add a new shift type;
- edit the info of an existing shift type;
- add a new package type;
- edit the info of an existing package type;
- add a new material tag type;
- edit the info of an existing material tag type;

The second training step included the creation of the routing plan based on the data presented in section 2.1.2 and the data inserted in the first step. The manager of the demonstrators trained first on how to select a shift for which the routing plan should be prepared and on how they could create an empty routing plan for this specific shift.

After the creation of the plan, the managers was trained on how to import into the GYR database the orders of the shift that they were planned to create the routing plan. GYR team presented the manual and automatic (using an excel file) approach to import the orders into the GYR database. For the creation of the routing plan, it is important to give a visual representation of the orders on a map. GYR technical team trained the managers on how to present the orders of the day on a map for visual assessment. Then, the planning procedure starts with the selection between the available trucks which would be part of the routing plan. The managers were trained how to select the trucks, how to revise the default details of the trucks (i.e. starting point, ending point, working hours, driver) which are defined in the previous steps of the integration approach.

One of the most time consuming part of the training was the presentation of the three available approaches for the creation of the plans. The managers was trained on how to create the routing plan fully manually, how to create the routing plan fully by requesting a routing plan from GYR platform and how to create the routing plan with a hybrid approach i.e. pre-assign orders to specific trucks and then request by GYR platform based on these pre-assignments to create the final routing plan. Several examples were presented to the managers in order to make clear the advantages of each approach as well as the potential disadvantage in case the three approaches are not used properly.

After the creation of the routing plan, the managers were trained to revise (if necessary) the obtained (manually, automatically, or hybridity) routing plan before it release to the drivers of the trucks.

The third training step included the monitoring of the implementation of the created routing plans. Initially, the home monitoring screen was explained to the managers with its functionalities. The managers were trained on how to display the order and their statues (e.g. delivered, picked-up, canceled etc.). After the training of the managers to the main functionalities of the monitoring mode of the GYR service, the GYR technical time trained them on how to revise a route under implementation in case a new event occurred (e.g. new order, cancelation of an order etc.).

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Finally, GYR team delivered to the managers, the user manual of the web app as well as the video developed for its use.

2.1.4.2 Training of the drivers

GYR technical team trained the drivers of the truck on how to use the mobile app for the implementation, revision and monitoring of their routing plan. The drivers were trained on how to start the app and how to select their routing plan. Then the drivers were trained on how to confirm a delivery, a pick-up, or the cancelation of an order. GYR team explained to the drivers the way to use the routing direction functionality of the mobile app in order to optimize their movement from one visiting point to another visiting point. The GYR technical team run several examples of this functionality in order to convince further the drivers to use it for the implementation of their routing plan. Finally, the drivers were trained to use several functionalities of the mobile app such as the display of their visiting point to a map, the available option to contact the customers (e.g. the shop to deliver a box), and the possibility to revise the remaining of their routing plan (e.g. change the visiting sequence).

Finally, GYR team deliver to the drivers, the user manual of the mobile app as well as the video developed for its use.

2.2 Integration of GreenYourRoute into ITACA routing planning system

The integration of GreenYourRoute APIs into the routing planning system of ITACA included the integration of the Routing API and the Cost Matrix API where emissions are estimated.

The technical developing team of UTH, CEDA & CHAPS and the technical team of ITACA followed specific integration steps.

1. GYR technical developing team install the two APIs to specific urls (e.g. http://194.177.201.70:8080/emissions/). The urls were prepared to provide responses by making a POST request to the emissions calculation models and optimization algorithm.
2. The following step included the authentication. The token is obtained from http://194.177.201.70:8080/api-token-auth/ by making a POST request with {"username": "myusername", "password": "mypass"}. Afterwards included in every request a header with the following: Authorization: Token <my-obtained-token>. Username and password were provided by GYR technical team through communication.
3. The developing technical team and the technical team of ITACA defined the parameters necessary for the integration of the APIs. The parameters included the following in the body of the request:
   - vehicle_id (integer): An id that is assigned based on engine type, fuel type and vehicle description.
   - emission_id (integer): An id that is assigned for each type of emission.
   - traffic_mode (string): The amount of traffic there is, on the vehicle's traveling road.
   - speed (float): The current speed of the vehicle in km/h.
   - occupancy (float): The percentage that the vehicle is loaded.

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- road_age (integer): The age of the road that the vehicle is traveling to.
- road_gradient (integer): The percentage of the gradient that the road has, on which the vehicle is traveling to.
- heat_index (integer): The air condition of the area the truck is traveling.
- wind_speed (float): The affection of the wind 's speed on the traveling vehicle.
- visiting_point_longt(float): The longitude of visiting point.
- visiting_point_ lat(float): The latitude of visiting point.
- visiting point_pickup_delivery(float): the type of visit such as delivery, pick-up or requisition.
- visiting_point_volume(float): The volume of the product to deliver or pick-up to a visiting point.
- visiting_point_weight(float): The weight of the product to deliver or pick-up to a visiting point.

The obtained response was defined by the two teams in JSON format and the metrics of the returned emission in gr/km, order of visiting points, km travelled. See the request examples below for the case of emissions estimation.

Request examples as the following one were delivered to ITACA technical team. Python language is used for making the request examples.

1. Request for calculating the emission:

url = "http://194.177.201.70:8080/emissions/" payload = {

'vehicle_id': '95',

'emission_id': '2',

'traffic_mode': 'No - Low traffic',

'speed': '35',

'occupancy': '0',

'road_age': '1',

'road_gradient': '0',

'heat_index': '67',

'wind_speed': '0'} headers = {

'Authorization': 'Token <obtained token>'

}

response = requests.post(url, headers=headers, data = payload)

Response:

{

"emissions": 265.45445284770597,

"fuel_type": "Diesel"

}

Request for calculating the final emission:

url = "http://194.177.201.70:8080/emissions/" payload = {

'vehicle_id': '95',

'emission_id': '2',

'traffic_mode': 'Medium traffic',

'speed': '35',

'occupancy': '50',

'road_age': '5',

'road_gradient': '1',

'heat_index': '75',

'wind_speed': '10'} headers = {

'Authorization': 'Token <obtained token>'

}

response = requests.post(url, headers=headers, data = payload)

Response:

{

"emissions": 1291.2422519954835,

"fuel_type": "Diesel"

}

The 1st request example happened when the caller needs the emission that isn't affected from the absence of one or more parameters. The result is based on vehicle_id, emission_id, speed etc. and the rest parameters are being ignored if they are not available. The 2nd request example is used, when all parameters are available.

The result of the request should be multiplied with the distance is being traveled by the vehicle.

4. The developing technical team with ITACA technical team defined the information about parameter calculations. Prerequisites that will be needed are:

- Access to a Weather API from which the below values are necessary:

- Temperature: metrics doesn't matter as long it can be converted to Fahrenheit
- Humidity: in percentage (1 to 100)
- Wind speed: in km/h
- Wind direction: in values of "N", "E", "S", "W" etc., although need to be converted to the mainly used for calculations, degrees.

5. The developing technical team informed technical team of ITACA the approach followed to access to the Map API:

- vehicle_id: Make a GET request to http://194.177.201.70:8080/vehiclemeta/?engine_type=<engine_type_id>&fuel_type=<fuel_type_id>&vehicle_description=<vehicle_description_id> to retrieve the correct vehicle id or remove the query parameters for the full list. Query parameters:
- engine_type_id: make a GET request to http://194.177.201.70:8080/enginetype/ to get the list of the correspondence between ids and engine types.
- fuel_type_id: make a GET request to http://194.177.201.70:8080/fueltype/ to get the list of the correspondence between ids and fuel types.
- vehicle_description: make a get request to http://194.177.201.70:8080/vehicledescription/ to get the list of the correspondence between ids and vehicle descriptions.
- emission_id: Make a GET request to http://194.177.201.70:8080/emissiontype/ to get the list of the correspondence between ids and emission types.
- traffic_mode: is assigned only 3 values, with the exact format there is below: "Heavy traffic", "Medium traffic", "No - Low traffic".
- road_age: Values are assigned: 1 to 15 years. Should be able to be provided by the city/country planning services.
- road_gradient: Values are assigned: -20 to 20. Values with minus(-) represent downslope. This information is most commonly found in Map APIs. If this data is not available then an alternative is to find the difference of the elevation between 2 points, divide it with the distance and multiply by 100.
- heat_index: Values are assigned: 67 to 110 Fahrenheit, can also be assigned values below 67 and above 110 but the result will be the same as if the value was 67 or 110, correspondingly.

6. GYR technical team provided several examples to ITACA technical team for testing and integration purposes. A quick example is:

- Trucks direction: N or 0 degrees Wind speed: 5 km/h;
- Wind direction: NE or 45 degrees => final wind speed: -5km/h;
- Wind direction: SW or 225 degrees => final wind speed: +5km/h;
- Wind direction: E or 90 degrees => final wind speed: 0km/h;

7. The final step included the suggested emission calculation approach from point A to point B. Given a route from point A to point B, should be split in segments (which are straight lines) depending how long in kilometers the route is. The smaller the segments are, the more precise the calculation of emission is. To comprehend this in depth, several examples are given:

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- Assumed a route from point A to point B of 20 km, if the user splits the route in 4 then 5km segments is used and the final emission will be:
    - Route's emission = emission in segment A • 5km + emission in segment B • 5km + emission in segment C • 5km + emission in segment D • 5km. That way there is, the least or even none at all, loss of data in the emission's calculated parameters.

3 Conclusion

The integration of GYR service into the business environment of 3PL companies and the business environment of a routing service provider was implemented smoothly. The only issue raised during the integration was the format and quality of data. GYR team developed a series of software to overpass this issue and the integration was completed properly. After the integration phase, the real life practice period started and the GYR service and its APIs were used and tested in fully operational environment for more than a year resulting significant environmental and socio-economic benefits.

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