U.S. DOT, FL DOT, MIAMI-DADE EXPRESSWAY AUTHORITY, CITY OF SWEETWATER, FIU

UniversityCity Prosperity Project

http://UC.FIU.edu

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Principal Investigator: **Dr. Naphtali Rishe**

**Informed Traveler Program and Applications**

Plan for Phase 1 – Design and Development

Revision 3, October 2016
Abstract

The Informed Traveler Program and Applications (ITPA) is an advanced consumer-oriented, predictive, and multimodal transportation management software system being developed by Florida International University's High Performance Database Research Center (HPDRC) and partners under the umbrella of National Science Foundation's Industry-University Cooperative Research Center for Advanced Knowledge Enablement at FIU (NSF I/UCRC CAKE, [http://CAKE.FIU.edu](http://CAKE.FIU.edu)).

ITPA will provide customized real-time and predictive information to individual ITPA users about multimodal and intermodal transportation conditions and options in the UniversityCity region so as to disperse informed travelers in time, place and mode. It will also make available innovative decision support for parking and transportation providers. As an electronic wayfinding system that provides a large-scale transportation demand management services, ITPA will enable the individual users to make optimum route and mode choices and enable the service providers to help efficiently and effectively manage individual traffic, transit, transport, and parking decisions.

With input from the Lehman Center for Transportation Research (LCTR) personnel and other FIU staff assigned to the ITPA development, HPDRC faculty, students, staff, and partners under the umbrella of NSF I/UCRC CAKE (collectively referenced as the ITPA Team) have been in the process since February 10, 2014 of planning, designing, and developing ITPA and will deploy Phase 1 of ITPA in 2017, with funding of US DOT TIGER-2013, through its use by the UniversityCity Transportation and Management Association of Sweetwater, Inc. (UTMA).

This document describes ITPA Phase 1 design and development. After a general introduction on the system's scope and the underlying assumptions (Section 1), the functional requirements to the software are listed (Section 2). This is followed by an overview on the general architecture and the utilized technologies and processes (Section 3) and descriptions of the goals of the two major design and development phases (section 4). The document concludes (Section 5) with an identification of the roles in ITPA Phase 1's design and development process.

This version 3 of the Plan for Phase 1 – Design and Development presents updates to Revision 2 presented to the FHWA in March 2016, which in turn was an update of the initial version from September 2014. All versions are posted at [http://cake.fiu.edu/TIGER2013/](http://cake.fiu.edu/TIGER2013/).
1 Introduction

The 2013 TIGER Discretionary Grant-awarded UniversityCity Prosperity Project consists of:

1. An infrastructure component to improve pedestrian-oriented transit access, including:
   - Plazas, sidewalks, walkways, and transit stop improvements on Florida International University's (FIU) Modesto A. Maidique Campus (MMC)
   - A signature pedestrian-oriented shared-use bridge connecting MMC and the neighboring City of Sweetwater (Sweetwater)
   - Complete streets improvements on the "Main Street" of Sweetwater (SW 109th Avenue) north of US 41 and associated plaza improvements west of SW 109th Avenue in Sweetwater

2. Phase 1 design and development of ITPA software and technology as described below

3. Acquisition, rebuilding, repairing, and enhancing of community transit vehicles for feeder bus services within and between FIU and Sweetwater and to and from FIU and Sweetwater and specific related destinations such as Miami International Airport (MIA) and Miami Intermodal Center (MIC) so as to enhance customer experience and to reduce fossil fuel emissions. These vehicles will be operated by UTMA and will be connected to ITPA using wireless technology.

ITPA is an advanced customer-oriented software package which will provide customized real-time and predictive information to improve multimodal and intermodal trip decisions and travel outcomes in the UniversityCity region. ITPA will enable individual users to improve schedule, route and mode choices with the aim to reduce travel times, costs, and greenhouse gas emissions, as well as provide decision support for community transit and parking providers. The ITPA software will address individual motorized and un-motorized traffic movements, access to public transit, and parking availabilities. It will be developed to be interoperable with and to receive information from various locally deployed technology systems. ITPA will therefore aim to provide best possible solutions from both a local and global point of view, enhancing both efficiency and effectiveness of individual traffic, public transit and parking decisions. It will thus yield a significant economic benefit derived from such better travel decisions and provide for large-scale transportation demand management as applied to the UniversityCity region by dispersing travelers in time, place, and mode as well as to alternate destinations.

The UniversityCity region shall be defined so as to include trips in and between: FIU’s MMC, Biscayne Bay Campus, and the Engineering Center; significant Sweetwater destinations; smart parking garages, lots and street parking locations; MIA; and, MIC.

This document describes the work planned to design and develop the ITPA Phase 1 software on schedule and on budget. ITPA Phase 1 is the first installment of ITPA, to be deployed in 2017, funded by the 2013 TIGER Discretionary Grant.
ITPA Phase 1 Scope

ITPA Phase 1 will focus on providing parking availability information and management support, as well as transit information and management support. To accomplish this, it will display to individual users' smart-phones and to service providers' operations centers various customized views of the:

1. Guidance to users with respect to FIU parking garages and parking lots and Sweetwater street parking, including occupancy estimation, crowdsourced occupancy status, navigational directions to the available parking locations

2. Transit vehicle locations, routes, estimated times of arrival, navigational directions by foot, by bicycle and by car to transit stops, accounting for access time and estimated stop time; integration of County transit and FIU transit data

3. Access to messages posted by authorities and by the ITPA operations personnel, with the user’s ability to select relevant messages along the route and to discard types of messages that are uninformative for the user

4. Ability for the user to query data on local business and landmarks and navigate thereto via various modes

5. Hardware-agnostic video feeds from selected FIU buses and privileged users to the operations center and certain users, with the possibility of map correlation of live video stream and map-correlated playback of archived video streams

6. Capability to preview navigational routes via intelligent stitching of the available archived videos

7. Provide detailed data on most houses in UniversityCity, including multi-angular oblique and orthogonal aerial views of the house

Personal mobility is a highly dynamic, exciting field. With a multitude of community transit options, short-term car and bicycle rentals, and private last-mile transportation providers like Uber and Lyft arising in just a few years, ITPA Phase 1 has to be ready to adapt quickly to new services. It will therefore be designed to interface to third-party last-mile transportation providers to enable its users to request transit by entering origin, destination, and desired time of service. Another innovative feature will be the estimation of parking availability based on crowd-sourced and historic data acquired from sensors.

ITPA Phase 1 will serve as a platform to develop and lay a foundation for additional functions in future phases, such as: navigation to available parking; extended dynamic transit routing based on real-time user demand; and more overall decision support with redundancies for transit and parking management and operations. Over time it is expected that ITPA will decrease the cost of operation of transit, increase passenger convenience and satisfaction, improve commuters’ options for transit vs private vehicles, grow the number of trips undertaken as pedestrians and bicyclists, decrease congestion and cost of operation on the road network; and, thereby, lower fossil fuel emissions. To that effect, development during Phase 1 will have an immediate
deliverable as specified herein and will also produce software modules beneficial to later phases.

**ITPA Phase 1 Budget**

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<tr>
<th>Account: TIGER</th>
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<tr>
<td><strong>Total ITPA</strong></td>
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**Pre-requisites**

The ITPA development plan makes several assumptions the prior fulfillment of which is essential for the completion of the ITPA Phase 1 software according to schedule and budget. Efforts to fulfill these pre-requisites are therefore not part of the work described in this document. Barring the fulfillment of the prerequisites, certain functionality may be adjusted.

1. Transit and parking management and operations will be provided by the UTMA, which was established in 2015 by the City of Sweetwater and will be fully operational by or before October 2016. This pre-requisite has not yet been fulfilled and therefore, for as long as UTMA is not operational, some of the described features might be tested preliminarily with FIU Department of Parking and Transportation's transit vehicle fleet.

2. FIU Department of Parking and Transportation (P&T) will use $168K out of the TIGER match budget to provide camera-based data acquisition modules for FIU's parking garages. P&T will co-operate with NuPark or a similar provider, which will make available to the ITPA software a stream of real-time data on parking availability by December 31, 2016. P&T also install TransLoc vehicle tracking and occupancy estimation technology for its transit vehicles by December 31, 2016. By September 1, 2016, no complete and reliable real-time parking availability data streams have been made
available and we will now expect to get real-time data directly from Parking and Transportation in order to meet an end of 2016 deadline.

3. Vehicle interaction modules will be installed on three transit vehicles in first quarter of 2017 (one to be purchased Moto Electric vehicle identified as MPV-2, one Sweetwater owned 2008 Ford Van/#5667 identified as SW-1, and the small rubber tire trolley identified as SW-7) subject to a budget amendment to move TIGER match funds from the community transit component budget to the ITPA component budget. The necessary devices themselves, as well as customization work for on-board sensors or cameras, information and communications equipment and software will be undertaken such that they function in coordination with TransLoc technology to the extent possible. The UTMA current plan is to use Transloc data to track buses and occupancy until such time as ITPA is fully operational and provides such functionality as TransLoc. ITPA-enabling technology will be installed in the community transit vehicles. The installation and monitoring of sensory devices will be done with Department of Mechanical and Materials Engineering (MME) personnel and third-party vendors.

4. The FHWA-approved vendor Pirouette Software will deliver a working prototype of its StreetSmart parking availability estimation module by the end of 2014 and a finished product by the end of 2015. (The time frame for the prototype deployment was extended to April 1, 2016)

5. Miami-Dade Transit (MDT) will make available to the ITPA software a stream of the real-time position of its vehicles by mid-2015. Only information about vehicles with streamed real-time positions can be included into the ITPA software.
2 Functional Requirements

1. ITPA Phase 1 shall provide information and management support related to transit by:
   a. Tracking transit vehicles by processing data on:
      i. Transit vehicle positions
      ii. Transit passenger occupancy estimations
      iii. Special events reported by community transit drivers
   b. Providing schedule and route information via a smart-phone app that provides:
      i. User position
      ii. Transit information on a map-based view
      iii. Information on transit routes and schedules
      iv. Current transit vehicle positions
      v. Estimated transit vehicle arrival times for each bus stop
      vi. Lists of next available transit vehicles for each bus stop
      vii. Event notifications from the transit operations center
      viii. An option for users to request last-mile transportation
   c. Providing management support for a transit operations center that:
      i. Reports vehicle positions on a map-based view
      ii. Reports transit occupancy for many FIU buses
      iii. Provides a knowledge base for making route recommendations for transit route planning
      iv. Aims to fulfill feasible last-mile transportation requests by interfacing to adequate third-party transportation providers
      v. Reports system usage statistics
      vi. Includes video playback facilities providing historical information for management review and analysis

2. ITPA shall provide information and management support related to parking by:
   a. Tracking parking availability and collecting diverse data:
      i. vehicles entering and leaving FIU parking garages
      ii. vehicles entering and leaving FIU parking lots
      iii. vehicles entering or leaving parking spaces in Sweetwater
   b. Providing parking availability information via a smart-phone app regarding:
i. Parking availability information and estimates at FIU parking garages

ii. Parking availability information and estimates at FIU parking lots

iii. Parking availability information and estimates in Sweetwater

c. Providing operations center information as to:
   i. Parking availability on a map-based view
   ii. Usage statistics for parking garages and parking lots
   iii. System usage statistics
   iv. Video playback facilities providing historical information for management review and analysis

3. ITPA shall meet other requirements as outlined in this section to:
   a. Allow for a secure log-on to all of its components
   b. Provides information to authorized third-party devices
3. Architecture and Technologies Overview

While the detailed composition of ITPA Phase 1's modules will be designed at the start of development, a plan for its general architecture is already in place. ITPA Phase 1 design and development will leverage the technologies of HPDRC TerraFly, IBM MobileFirst Platform, Pirouette StreetSmart, Spring Framework, and possibly others, and will establish an agile software development process.

General Architecture

The ITPA Phase 1 software will consist of front-end and back-end modules, and will interact with stationary data acquisition modules and vehicle interaction modules on board of transit vehicles. A computational transportation research team will design the complex algorithms for its more advanced requirements.

Front-end – The front-end will consist of the smart phone application and the operations center module.

The smart phone App will run on most popular devices and will not be restricted to one single platform like Android or iOS. It will display customized information to individual users and will allow them to interact with the system.

The operations center module will run on a regular work station, typically also connected to wall-mounted screens. It will display customized information to operators and will allow them to interact with the system. The operations center hardware will be provided to the UTMA along with other ITPA software and technologies embedded in the improved community transit vehicles.

Back-end – The back-end software will run on a dedicated server or will utilize cloud computing services. These will include a parking availability module, a transit tracker module, and also service modules for user interaction, vehicle interaction, parking management interaction, system usage statistics and database services.

Figure 1: Architecture and Technology
Research – Several features in the areas of parking availability estimation and management, and transit analysis and management require advanced and computationally complex models and algorithms. A computational transportation research team will research and design those models and algorithms.

Technologies

ITPA Phase 1 will utilize a set of technologies and products.

TerraFly – While the back-end will utilize TerraFly’s geospatial databases and moving object tracking technology, the front-end will utilize its methods to display aerial imagery and street maps, including the platform-neutral next-generation viewer with dynamic depiction and queryability of transportation, being developed for the needs of ITPA.

Multi-Platform App Development – By utilizing a framework like Cordova, Ionic/Angular or IBM Mobile First Platform major parts of the front-end app code can be re-used on the dominant mobile platforms, particularly iOS and Android; and supplemental data will be viewable on most web browsers. Using one of these frameworks, many parts of the actual smart-phone and operations center applications are coded in non-proprietary programming technologies (e.g., JavaScript, HTML5 and CSS3).

Pirouette StreetSmart – StreetSmart is a crowd-sourced parking availability estimation software currently in development by Pirouette Software. It will enable ITPA to provide users and service providers with parking availability information for UniversityCity’s on-street parking based on historical availability and real-time data.

Spring Framework – Utilizing an enterprise application framework like Spring Framework will enable efficient back-end development. It provides extensive services in areas like user authentication, remote access, transaction management and testing.

Other technologies to be used include CSS3, HTML5, Java 7 Enterprise Edition, Python, JavaScript, JSON, MySQL, and SQLite.

Processes

An agile scrum\(^1\) software development process will be established for ITPA Phase 1 software design and development. This software development method is especially suitable for complex projects in which requirements and solutions evolve as new information is gathered and the project’s environment changes. Its way to control complexity is to promote adaptive planning, evolutionary development, early delivery, continuous improvement and to encourage rapid and

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\(^1\) Agile scrum is an iterative and incremental framework for managing product development. For ITPA the process is documented and will be put on the Tiger Website.
familie response to change. It focuses on delivering working software with the minimum amount of work.

As user feedback is very important in the context of an agile software development process, the ITPA Team has agreed with the Honors College at FIU to recruit a significant number of Honors College students as pioneer audience and testers throughout the duration of the project. As the success of the project relies on good user response, significant attention will be devoted to user feedback from the Honors College and selected FIU and Sweetwater employees. This feedback from initial ITPA users will be used to guide further feature development. The Honors College will thus also serve as a launching pad to market the ITPA Phase 1 software to the broader universe of ITPA users: FIU student body, faculty, and staff, businesses located at FIU and their employees, and visitors to FIU; and, Sweetwater residents, Sweetwater business owners and their employees, and visitors to Sweetwater.

4 Design and development phases

Work on ITPA Phase 1 will consist of two design and development phases (Phase 1A and 1B) and a wrap-up period. At the successful completion of Phase 1A, ITPA will be a viable basic product informing a pioneer audience on real-time parking and transit. It will be used to support management and operation of FIU’s parking garages and of the UTMA’s community transit fleet, which is currently envisioned to commence operation in the first half of 2016 (UTMA commencement of operations is now planned for October 2016). At the successful completion of Phase 1B, ITPA will include estimates on parking availability, basic last-mile transportation support, and other ITPA Phase 1 functionalities. At the successful completion of the wrap-up period all ITPA Phase 1 related documentation will be complete.

<table>
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<tr>
<th>ITPA Phase</th>
<th>Planned Start</th>
<th>Planned End</th>
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<tbody>
<tr>
<td>Phase 1A</td>
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<td>Phase 1B</td>
<td>11/01/16</td>
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<tr>
<td>Phase 1 Wrap-up</td>
<td>4/1/17</td>
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ITPA Phase 1A

Assuming that all pre-requisites described in Section 1 are met, ITPA Phase 1A will result in a viable commercial grade product which satisfies a significant subset of ITPA’s functional requirements as stated in Section 2. This product will be tested, documented and ready to ship to a pioneer audience. It will enable users to navigate on a map of the University City region, which also yields information about bus routes, bus stops, current position of buses and expected times of arrival (ETAs) at the respective next bus stops. It will include basic information on the availability of parking in some FIU parking garages and parking lots.

The schedule for Phase 1A assumes - as stated above - that UTMA will install vehicle interaction modules on FIU and Sweetwater buses in parallel with this effort and that MDT publishes or
delivers the real-time position of its vehicles. It also assumes that at least one parking garage will have a sensor-based data acquisition module by October 1, 2016, and that Pirouette Software delivers a working prototype of its parking availability estimation module by October 1, 2016.

In the following, “UC buses” refers to FIU buses and the ITPA system shall enable the inclusion of UTMA buses when those are deployed. At the successful completion of ITPA Phase 1A, the smart-phone app will:

- Allow users to create an account and log in to the system
- Show a map of the user's surroundings
- Show the user's position on the map
- Allow for scrolling of the map
- Show UC and MDT bus stop locations
- Show UC bus routes
- Show the current position of UC buses
- Show ETA of UC buses at stops
- Show MDT bus routes
- Show current position of MDT buses
- Show ETA of MDT buses at stops
- Show parking garages color-coded according to occupancy
- Show parking lots color-coded according to occupancy
- Send the user's position to ITPA server
- Show messages from the operations center module

At the successful completion of ITPA Phase 1A, the server will:

- Administer user account data
- Deliver map data requested by apps
- Deliver bus route and bus stop data requested by apps
- Deliver UC bus positions requested by users
- Deliver MDT bus positions requested by users
- Deliver parking garage occupancy data requested by users
- Deliver parking lot occupancy data requested by users
- Track the user's position and movement
- Track position of UC buses
- Track position of MDT buses
- Accumulate parking garage traffic flow data provided by FIU Department of Parking and Transportation
- Accumulate parking lot occupancy data provided by FIU Department of Parking and Transportation
- Accumulate ETAs of UC buses
- Accumulate ETAs of MDT buses
- Administer messages for users from the operations center module
• Collect statistic data on ITPA system usage

At the successful completion of ITPA Phase 1A, the operations center module will:

• Show a map of UniversityCity region
• Show the current position of UC buses
• Show the current position of MDT buses
• Show UC bus routes
• Show MDT bus routes
• Show statistical data on UC buses
• Show parking garages color-coded according to occupancy
• Show parking lots color-coded according to occupancy
• Show the estimated number of available parking spaces in parking garages
• Show the estimated number of available parking spaces in parking lots
• Show the position of individual ITPA users (anonymously)
• Show statistical data on ITPA system usage
• Allow for messages to be sent to a smart-phone app

At the successful completion of ITPA Phase 1A, it is assumed that the vehicle interaction modules developed and installed by the FY2015-2016 FDOT Service Development Grant project “UniversityCity Transit Improvements” will:

• Track the vehicle’s current position
• Send the vehicle’s current position to the ITPA server via mobile data

ITPA Phase 1B

Assuming that all pre-requisites described in Section 1 are met, ITPA Phase 1B will result in a software system fulfilling the functional requirements stated in Section 2. It will be tested, documented, and ready to be deployed to UniversityCity TMA.

At the successful completion of ITPA Phase 1B, the smart-phone app will:

• Show list of scheduled UC transit vehicle departures at bus stops, attributed by ETAs
• Enable querying for third-party last-mile transportation options to a given destination
• Enable requesting third-party last-mile transportation to a given destination
• Enable users to query routes from given origin to a given destination
• Enable users to obtain information and recommendation as to parking at a parking garage
• Enable users to obtain information and recommendation as to parking at a parking lot
• Enable users to obtain information and recommendation as to parking adjacent to a given destination
• Show users estimated available parking in Sweetwater
At the successful completion of ITPA Phase 1B, the server will:

- Show passenger occupancy data received from transit vehicles
- Make available transit information to third parties, e.g. dynamic message signs at stops
- Provide interface to enable users to request third-party last-mile transportation
- Allow to query and playback videos recorded by transit vehicles for management review. This hardware agnostic capability will allow acceptance of videos recorded by dashcams and/or in-bus camera and/or smartphones/tablets.
- Estimate best available parking in participating parking garages
- Estimate best available parking in participating parking lots

At the successful completion of ITPA Phase 1B, the operations center module will:

- Show passenger occupancy data and statistics for UC transit vehicles
- Show messages from authorities and ITPA operations
- Show last registered entry and exit events for parking garages
- Show statistical data on entry and exit events for parking garages
- Show usage statistics on participating parking garages
- Show usage statistics on participating parking lots
- Enable operations center personnel to query and playback videos recorded by transit vehicles
- Administer Parking Garage and Parking Lot Data

**ITPA Phase 1 Wrap-up**

ITPA Phase 1 Wrap-up will result in a complete documentation of ITPA.
5 Personnel

To complete the stated features in the time frame of ITPA Phase 1 the software design and development team will consist at least of the following personnel:

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<tr>
<td>• TIGER P.I. and ITPA Project Director</td>
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<td>Expertise in directing large Federally-funded R&amp;D projects in the areas of geospatial data management and computational transportation; Director of NSF I/UCRC CAKE and HPDRC, Professor of Computer Science.</td>
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<tr>
<td>• TIGER ITPA Project Manager</td>
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<td>Significant experience in project management, team management, design and development technologies, object-oriented design and design patterns (industry professional level).</td>
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<tr>
<td>• Team Lead/Architect</td>
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<td>Significant experience in research management, team management, design and development technologies, object-oriented design and development, design patterns, data structures and complex algorithms (post-doctoral or industry professional level).</td>
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<tr>
<td>Back-end design/development:</td>
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<tr>
<td>• Senior Software Engineer</td>
<td>full</td>
<td>Significant experience in enterprise application development, database management, object-oriented design and development, knowledge of design patterns, data structures and complex algorithms (industry professional level).</td>
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<tr>
<td>• Junior Software Engineer</td>
<td>part</td>
<td>Experience in enterprise application development, object-oriented design and development, data structures and standard algorithms (comp. science graduate level).</td>
</tr>
<tr>
<td>• Assistant Developer</td>
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<td>Knowledge in object-oriented design and development (comp. science student level).</td>
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<tr>
<td>Front-end design/development:</td>
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<tr>
<td>• Senior Smart-phone Application/Website Developer</td>
<td>full</td>
<td>Significant experience in mobile application development, web development, deep knowledge of design patterns (industry professional level).</td>
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</tbody>
</table>
- Junior Smart-phone Application/Website Developer full
  Experience in mobile application development, web development (comp. science graduate level).

- Interaction Designer/Graphic Designer part
  Significant experience and deep knowledge in graphic design for web sites and mobile devices, experience in interaction design for mobile devices and corporate identity creation (industry professional level).

Research and Expertise – Public Transit:

- Senior Computational Transit Researcher part
  Significant experience and deep knowledge in computational transportation research, especially transportation modeling, simulation and optimization, general computer science, data structures and complex algorithms, academic writing (at least post-doctoral level).

- Computational Transit Researcher Full
  Deep knowledge in transit modeling, simulation and optimization, general computer science, data structures and standard algorithms (at least PhD student level).

Research and Expertise – Parking:

- Researcher Full
  Deep knowledge in parking modeling and management, data science, data structures and standard algorithms (at least PhD student level).