Innovative Transportation Services – Research Gap Analysis

The committee of the Innovative Transportation Services sees as its main purpose encouraging research, developing, and implementing the advanced technologies to improve and extend the provided mobility services to the end-user. To this end, the committee will provide both the research community and the transportation practitioners with a road map of the research and main activities conducted in this field as well as identifying promising directions for future investigations. The research domain under the responsibility of the committee includes but is not limited to: mobility as a service (MaaS), customize transportation services, shared, and connected mobility.

During the last few decades, we are witnessing the rapid development and implementation of innovative transportation solutions worldwide as well as continuously increasing the interest of the research community on this topic. These solutions have become affordable with the recent developments of new communication-based and automation technologies. Moreover, the implementation of these solutions has brought a significant improvement of the provided mobility services to the end-users thereby making a positive contribution to citizens' quality of life as well as reduction of the environmental burden by using sustainable transportation means.

To deeper understand this theme, we start as usual with a comprehensive literature survey. However, to perform such an analysis at first, it's necessary to decide which studies should be considered and which ones will remain outside the scope. To this end, the relevant keyword list ought to be clearly defined. Moreover, collecting the data concerning how many times each keyword appears in the journals over some time intervals (e.g., years) may certainly indicate the trends and evolution of the investigated domain (for more details see Section 1). Next, based on the outcomes of the first step, the more relevant and promising research are chosen and described in detail, as it's shown in forthcoming Sections 2-3. This is done to reveal the current gaps that in the future may constitute the research scope for academics as well as practitioners.

1. Preliminary Literature Analysis

At the first step of a literature collection, we define a boundary of the analysis. To this end, three important notes are made: (a) the analysis in this section focuses only on peer-reviewed journals that are published in English (note, that in Sections 2-3 highly contributed conference papers and reports were discussed as well), (b) the search is conducted based on the ProQuest database, and (c) the investigation focuses mainly on studies that have been published between 2015-2021.

Next, to ensure the suitability of the articles for our purposes, the keyword list should be introduced. Note, that for the efficient search, on the one hand, the keyword list should not be very short, otherwise, the result will be very narrow thereby increasing the probability to overlook some important research. On the other hand, using a very long keyword list may lead to searching results that have a very far connection with the investigated topic. For a more proper definition of it, we divide the studied domain, i.e., innovative transportation services, into the next two main sub-groups: the first sub-group incorporates the works associated with Mobility as a Service (MaaS) while the second one deals with the theme of Mobility on Demand (MoD). Recall, that the detailed description of each of these sub-groups with an emphasis on discussing the main research, will be presented in Sections 2-3, respectively.

Based on the initial acquaintance with the relevant literature, our choice of the keyword list for the MaaS stopped on: (1) mobility as a service (alternatively MaaS), (2) integrated mobility, and (3) innovative mobility services, while for the MoD these are: (1) mobility on demand (alternatively MoD), (2) shared mobility, (3) automated mobility and (4) smart mobility. Then, the search has been made in the ProQuest database. In total, for MaaS 73 relevant journals have been detected wherein for MoD this figure stands at 106. Note, that under the relevant journals we mean the papers wherein at least one of the searched words appears in the keyword section. The found results are summarized in Table 1 where each record indicates the number of appearances of the corresponding keyword in the journals over the corresponding period.

Table. 1. Search results

Sub-group	**Keyword**	**Year**					**Total**
		2015-2017	2018	2019	2020	2021	
MaaS	Mobility as a service (or MaaS)	5	8	17	22	23	**75**
	Integrated mobility	3	-	-	2	2	**7**
	Innovative mobility services	1	-	-	-	-	**1**
MoD	Mobility on demand (or MoD)	3	4	5	7	5	**24**
	Shared mobility	8	8	19	39	49	**123**
	Automated mobility	1	1	9	13	10	**34**
	Smart mobility	5	4	9	28	26	**72**

Although, the outcomes presented in Table 1 indicate that with the time increase the interest for both MaaS and MoD increases, however, the attention paid to the MoD rises faster. Such fact can be explained by the difficulty existing in clear recognition of what the MaaS is that, in turn, makes the search of this topic and the related directions harder. It is also worth noting, that inside the MoD field, the research associated with shared mobility grow quicker than others. This may be clarified by the latest worldwide trend toward sustainable development which puts the main focus on providing services and sharing the assets rather than their purchasing for individual usage. Probably, this tendency also has found its reflection in sharing the transportation means as well.

2. Mobility as a Service (MaaS)

According to [1], Mobility as a Service (MaaS) can be defined as the provision of transport as a flexible, personalized on-demand service that integrates all types of mobility and presents them to the user in a completely integrated manner. Although there is no clear consensus about what MaaS is, it is acceptable to distinguish nine core characteristics of MaaS: integration of transport modes, tariff option, one platform, multiple actors, use of technologies, demand orientation, registration requirement, personalization, and customization [2]. To help clarify an overview understanding behind the MaaS, various frameworks were proposed (see, for example, [3] and [2]). In particular, [3] used the so-called 0-4 level topology wherein zero level is associated with no integration at all. At the first level, the integration of information is located, whereas the second level integration of booking and payment is located. The third and fourth levels are occupied by the integration of service offers and social goals, respectively. Following [4], the way to the MaaS goes through improving both the public transportation (PT) system such that to increase its availability and quality, as well as changing people's travel behaviour and preferences.

2.1. Improving PT System

Improving the PT system can be addressed by the integration and cooperation of all services delivered during the entire transportation process thereby providing the user with a customized door-to-door solution. Following the topology provided by [5], this includes fare-ticketing, information, time-transfers, and physical integration. In particular, network integration aims to coordinate and connect between long-distance and local public transport networks, whereas fare-ticketing integration implies using a single fare ticket or card for numerous services which eases the transfer between modes. Information integration tends to provide the passengers with a comprehensive and easy-to-use travel guide, and integrated timed transfers give the ability to change the transportation mode with minimal waiting and transfer times. Physical integration cares about the position of stations as well as the access to the interchanges. The studies on PT integration have concentrated both on a broad framework of integration (see, [6] and [7]) as well as on developing specific types of integration. For instance, physical integration with an emphasis on terminal facilities and other physical attributes was studied in [8]. The network integration with a focus on tactical aspects and coordination among different operators found its place in the works of [9] and [10]. The importance of each integration type depends only on customer needs and perceptions. To discover the real passengers' perceptions regarding the importance of various types of integration, several kinds of research have been devoted. For instance, in [6] authors found that for the New Zealand users fare-ticketing integration is most significant. Nevertheless, the number of such studies remains at a very low level and a more comprehensive investigation is required.

2.2. Travel Behavior

On the other hand, changes in people's travel behavior are achieved by implementing reward and punishment strategies to target psychological factors such as congestion charges, taxes, and parking fees, information campaigns, and free bus passes. However, despite multiple pilots that have been initiated around the world (see, for instance [4], [11]), empirical knowledge of MaaS's expected effects on people's travel preferences and travel behavior remains quite limited [12], [13], [14] and [15]. For instance, [14] indicates a necessity to address the following matters that MaaS will face in the close future and which the private cars can address already now: traveling with luggage or shopping, traveling to the hard reached places.

3. Mobility on Demand (MoD)

According to [16], Mobility on Demand (MoD) is an innovative transportation idea where consumers can access mobility, goods, and services on-demand by dispatching, or using shared mobility, courier services, automated (or self-piloted) aerial vehicles, drones, and public transportation solutions. MoD is based on three core principles: (a) commodification of transportation, (b) embracing the needs of all users, and (c) improving the efficiency of the transportation network, and includes the following passenger services: bike/car/scooter sharing (e.g. Car2Go, ZipCar), micro-transit, ride-sharing (e.g. Uber, Lyft), shuttle services, urban air mobility (UAM), and public transportation [17]. For the delivery of the different goods, courier network services (CNS), robotic delivery, and aerial delivery (e.g., drones) are used. For instance, FedEx and UPS are developing delivery vans that are paired with drone systems, which can make short-range aerial transfers while a parcel van makes another delivery [18], [19]. A rapid growth in the number of on-demand mobility options raises the concern of the policymakers and public transit agencies regarding how the MoD will be integrated into the existing public transportation system. In the work of [17], the authors identified four possible partnership models: (a) providing first- and last-mile connections to public transit services, (b) supplying gap-filling services within low-density areas and during off-peak hours, (c) offering public transit replacement services in areas with insufficient public transit ridership, and (d) supplementing or replacing an existing paratransit service. Several studies have been dedicated to addressing these issues (see, for instance, [20], [21]). In particular, [20] developed a real-time dispatching policy for MOD services in cooperation with existing mass transit service and tested it on a real network between Luxembourg City and its French-side cross-border area.

Among the other most investigated topics in this domain we can distinguish: (a) using of electric vehicles and shared mobility (see, for example, [22], [23] and [24]) and (b) developing efficient multi-modal networks ([25], [26]). For instance, the authors in [25], developed a model to control a multi-region and multi-modal network system wherein the passenger can adapt their mode choices and the transportation traffic may evolve. While some studies have examined the impacts of MOD services on public transportation, more research is needed to better understand how geospatial and temporal dimensions impact this relationship. In particular, this includes, among the others, understanding of the exact effects of MOD on public transportation [16], [17].

3.1. Autonomous Vehicles

Recent advances in automation technologies have enabled evolving MoD services to the so-called autonomous MoD (AMoD) system [27], [28]. The research in this domain includes: (a) autonomous vehicles - AV, and (b) connected vehicles - vehicles that are equipped with internet connectivity. According to [29], there exist five levels of autonomy: up to level 2, the driver is required at all times, whereas in levels 3 and 4, deliveries from the vehicle to the driver under problematic circumstances are possible. Finally, level 5 is kept for fully self-driving vehicles. To achieve level 5, it will be required to resolve many technical, legal, and social issues as well. The technical aspects associated with automated vehicles are extensively examined today and toward solving the following problems: vehicle dynamics and control [30], parallel autonomy [31], motion planning for autonomous vehicles [32], [33]. Note that most of the discussed techniques for autonomous driving assume that future routes of other traffic members are known. However, the real-life traffic situations are more compound and include the relations among many road users whose actions are not known a priory. Thus, this problem remains unsolved [34]. Moreover, autonomous vehicles purpose to offer on-demand transportation possibly to anyone, anywhere, anytime. To attain this vision, additional advances are required in large-scale fleet management with stochastic routing and online performance (see again [34]). As technological development is in rapid progress, governmental authorities concern with how to plan transportation systems for such technologies. To address that issue, a deeper understanding of the community perceptions and impacts of the AV on travel behavior is highly obligatory (see, for instance [35], [36], and [37]). More specifically, [37] studied the potential impact that fleets of shared autonomous vehicles (SAV) might have on family vehicle ownership. They found that gender, socioeconomic characteristics, respondent commute distances, and average daily travel times are the main influence factors on the decision whether relinquishing a household vehicle in a presence of SAV or not. But, as it was pointed out by the authors, the people's perception of SAVs is not expected to be temporally stable and thus, more research are wanted in this field.

3.2. Internet of Vehicles

In turn, the connected vehicle's technologies permit vehicles to connect and the world around them. For instance, a GPS-based system embedded in the vehicle receives information on congestion or accidents. The concept behind the connected vehicle aims to provide the driver with valued data during the trip to help him/her making safer and more informed decisions. On the other hand, the transportation agencies may access vehicle data related to speed, location, and route, thereby enabling them to better manage the traffic flows and address rapidly the problem in real-time. Connected vehicles use several different communication technologies, like vehicle-to-vehicle (V2V), vehicle-to-road infrastructure (V2I), vehicle-to-pedestrian (V2P), and others, which have the big potential in refining safety and increasing traffic efficiency (see, for instance, the works of [38] and [39]). Moreover, connected vehicles are considered as the construction blocks of the emerging Internet of Vehicles (IoV), which in turn, will lead to the next generation of intelligent transportation systems (ITSs). Although adding connectivity to vehicles has its benefits, it also has challenges. For instance, there are issues with security and privacy ([40], [41]), data analytics due to the huge amount of information to be studied within a short time, and lack of standards ([42]).

4. Survey Analysis

The literature review has allowed us to shed light on the main directions and achievements of the research community done in the domain of innovative transportation services. However, to better understand the real-life requirements as well as to detect possible collaborations with practitioners and academics, an extensive survey was conducted. The obtained results of the survey have been analyzed and its main insights are further discussed in the following sub-sections.

4.1. Academic Community

The survey has been conducted among the research and academic community in Israel and encompassed about 116 respondents. Among the entire surveyed population only 24% (28 respondents) have indicated that their research interests lie in the domain which is under the responsibility of the innovative transportation committee. The distribution of the respondents between the academic institutes and faculties is represented in Figures 1-2:

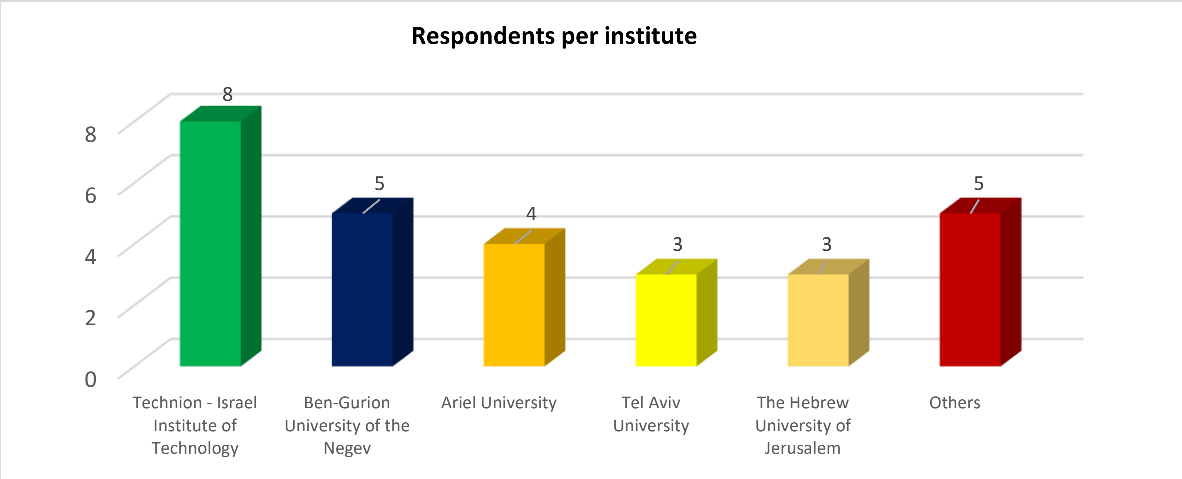

Fig. 1. Respondents per institute

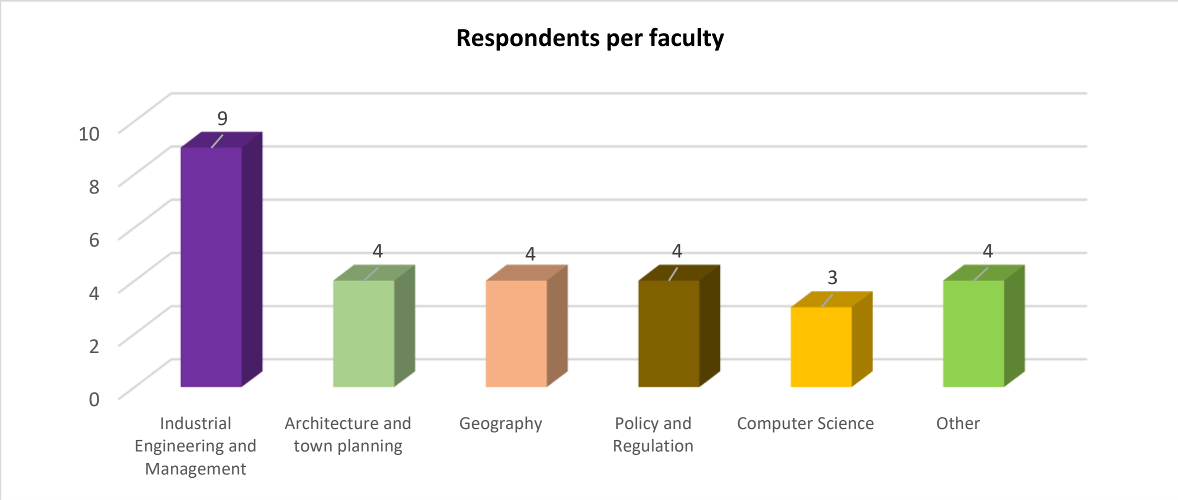

Fig. 2. Respondents per faculty

From Figures 1-2 it follows that most of the respondents come from either Technion, Ben-Gurion, or Ariel universities. Moreover, their main activities are within the faculty of industrial engineering, town planning, or geography. To better understand the research interests of the respondents, we analyzed the keywords describing their investigation scope and clustered them into the following domains (see Figure 3):

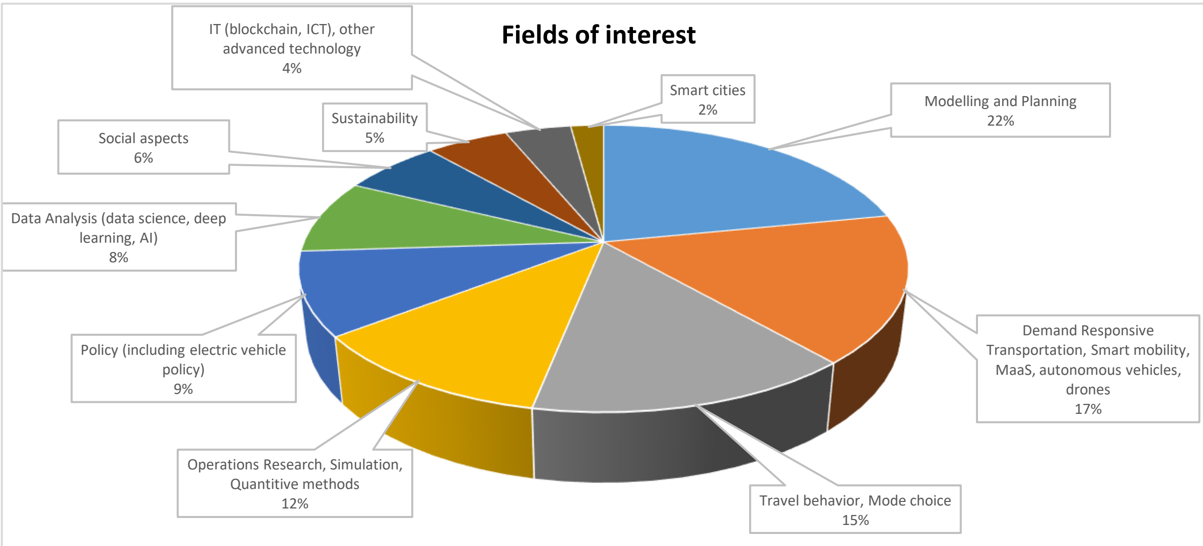

Fig. 3. Fields of interest

One can verify from Figure 3, that modeling and planning, demand-responsive transportation, and travel behavior constitute more than 50% of overall interests.

4.2. Stakeholder Community

The survey in an academic sphere has allowed us to detect the main research centers working in the vein of the committee as well as their main interests. In turn, the survey conducted among the stakeholders will permit us to better understand the real-life requirements and to identify the potential partners in the market. In this survey, 75 respondents have participated and 33 of them (44%) indicated that the field of innovative transportation services answers by their business interests. Interestingly, but along with the committee of the innovation services, the same respondents indicated their concernment with the committee of big data & data analysis, traffic management & control, and policy planning & smart cities. In turn, only fewer votes were cast to committees of mobility safety & security and automation & connectivity. In the following Table 2, we summarize the stakeholders according to the organization type, whereas the field of company practice is presented in Table 3:

Table. 2. Organization type

Organization Type	**Count**
Industry	16
Public authority	6
Research Centres	3
Associations	2
Other	6

Table. 3. Field of company practice

The field of company practice	**Count**
Consulting, Investments	6
Smart City, Smart Transportation	6
Automated Vehicles, Remote Vehicles	4
MaaS, Shared Ride	4
Other (Insurance Company, International Forum)	3
Public authority (Air Transportation Services)	2
Safety	2
Transportation Infrastructure	2
Research Authority	1
Sustainable Transportation	1
Vehicle Production (GM)	1

As it can be easily noticed from Tables 2-3, although the majority of the companies present the industry (around 50%), about 27% of their activities lie in the field of consulting and insurance. The companies which work in the domain of smart transportation, automated/remote vehicles, and shared riding constitute about 42%. Among the main challenges which the companies face in a daily manner are (a) lack of advanced and practical knowledge, (b) lack of basic theoretical knowledge, and (c) professional human resource recruitment. Together they constitute around

75% of the overall challenges. Interestingly, but having the lack of advanced and practical knowledge and lack of basic theoretical knowledge only 7 companies have indicated their concernment in collaboration with the academy. Probably this stems from the fact that either some of the firms are the research centers or already have connections with academia. The main services which are seen by the stakeholders as of high importance are: (a) identifying trends and developing a holistic view of smart transport, (b) access to a portal with expert knowledge, and (c) conferences, workshops, and seminars.

5. Gaps and Future Directions

Based both on the literature review and survey analysis we are now ready to define the main gaps which will be addressed first:

Table. 4. Main gaps

Gaps	Actions
It is highly required to define the responsibility borders of the committee of innovative transportation services plainly and holistically to avoid ambiguity with other committees	Further deeper exploring the research works as well as collaboration with academic partners detected during the survey
The conducted survey within the stakeholders provides only the first glimpse about the real requirements of the market	Based on the survey results, the focus group will be chosen and undergo a more detailed and deeper analysis (including meetings and conversations with the representatives of the firms)
The survey revealed that the number of both researchers and practitioners who are interested in partnership is relatively small	Searching for additional partners

6. Call for proposals' topics:

1. Multi-modal, integrated MaaS: the investigation of a holistic transportation provision considering traditional and innovative modes in an integrative system. The aim is to provide a smooth and easy multi-model connection for all activities taking into consideration modes, parking, information, etc..).
2. Rideshare services: conducting research promoting the shared use of private vehicles aiming at increasing the vehicle's utilization (number of passengers).
3. City logistics / last-mile distribution: researching measures and tools for decreasing logistics' urban movements. The research scope is distribution modes (conventional, non-powered, autonomous, drones), infrastructures (storage, parking, dedicated lanes), policy, public transport, and MaaS integration.

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