Cargo Hitching as a tool to transform the urban mobility system. Integrating passengers and goods transportation towards a more sustainable, desirable and efficient mobility

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Abstract: Mobility in cities is facing growing challenges. Urbanization trends, growing complexity of stakeholders scene, e-commerce and increasing fragmentation of freight transport all have negative impacts on congestion, safety, environment and quality of life in general. Authorities have developed uncoordinated policies and regulations in an effort to tackle such issues, often resulting in minor or even counter-productive effects only. The *Green Paper on Urban Mobility*, issued in 2007 by the European Commission, first explicitly mentioned the integration between passengers and freight mobility as a solution for increasing attractiveness and efficiency of the overall mobility system in urban areas, starting a new research branch. This paper presents passengers and freight transport challenges and regulation attempts and further discusses Cargo Hitching , that is the combination of people and cargo flows (cargo that hitches a ride on a vehicle transporting persons or persons hitching a ride on a vehicle transporting cargo), as an approach to promote sustainable, efficient and socially desirable passengers and goods mobility in both dense cities and shrinking peri-urban and rural areas. The potential and some limitations of Cargo Hitching will be discussed and results of a modeled application in Venice (Italy), case-study city in the Novelog project, will be presented. The focus will specifically be put on achievable operational, socioeconomic and environmental benefits and on the need of a fully renewal of governance and of the normative approach, key to the management of the mobility system as a whole in compliance with sustainability and efficiency objectives imposed on the one hand by market requests and on the other by the growing sensitivity of the various authorities and stakeholders.

Keywords: shared mobility, public transport, urban logistics, sustainable mobility

Introduction

Passengers and goods mobility is facing growing challenges: urbanization trends, growing complexity of stakeholders scene, e-commerce and increasing fragmentation of freight transport all have negative impacts on congestion, safety, environment and quality of life in general. Authorities have come up with uncoordinated policies and regulations in an effort to tackle such issues, often resulting only in minor or even counter-productive effects. This paper first shortly discusses urban mobility and logistics challenges, both in dense urban cores and in rural or peri-urban areas with lower densities, and hints at strategies which have been pursued with little or no positive results. It then introduces a new paradigm for integrating passengers and goods transportation, referred as "Cargo Hitching" (CH), according to concept that was first mentioned by the European Commission in its "Green Paper on Urban Mobility". The work, published in 2007, suggested how strong integration could improve mobility and logistics efficiency and sustainability (from environmental, operational and socioeconomic perspectives) while at the same time promoting a socially acceptable approach, responding to authorities' needs and indications. Basic principles, best practices to explore the origins, and the potential of CH are presented and drivers for both success and failure are discussed, focusing in particular on achievable operational, environmental and socioeconomic benefits and improvements, as well as on regulatory and operational constraints that currently interfere with the promotion of the management of the mobility system as a whole. The last section of this work is dedicated to the presentation of results of a CH simulation for the North Lagoon of Venice (Italy), case-study city in Horizon 2020's Novelog project. The area was chosen because of its peculiar mobility system and because, as it configures itself as a low-density semi-rural area located in between powerful attractors (Venice, Mestre and Marco Polo Airport) and relevant mobility and logistics flows, it is a perfect test terrain for CH. Despite the introduction of various constraints, reflecting operational reality, the simulation has proven to have high potentials in both obtaining environmental and operational benefits and in improving the socioeconomic situation of peri-urban shrinking, remote and scarcely populated islands, thus highlighting how CH, a solution originally designed for relieving pressure on congested urban cores, can ease long-term issues in suburban transport as well.

Logistics and mobility: challenges and hindrances to coexistence

It is important to be familiar with current challenges of logistics and passengers mobility to understand the need of growing integration and innovative practices. With decreasing densities, therefore in peri-urban or rural shrinking areas, public passenger transport faces increasing spare capacity and significant anti-economical operations, often resulting in poor service offer or no service whatsoever and therefore in transport-related social exclusion. Similarly, goods carriers might experience higher costs as demand is low and therefore offer limited service, increasing the areas' isolation (McDonagh, 2006; Jansen, 2014). Dense urban cores, on the other hand, suffer from congestion and negative externalities generated by city logistics operations, as it will be discussed more in detail. As the world is seeing a growing urbanization trend (e.g. Taniguchi et al., 2001; Savelsbergh and Van Woensel, 2016) which will result in an urban population of around 9 billion in 2100, both urban dense areas and shrinking rural or peri-urban areas will grow in number and size, bringing whole new challenges in many sectors, including that of urban logistics (Taniguchi et al., 2001). City logistics is therefore a complex systems which operates in a complex environment, involving many active (impactful) and passive (impacted) stakeholders, such as authorities (national, regional/state and city level), carriers (transporters and warehouse companies), receivers (shopkeepers and retailers, consumers, intermediaries), residents (consumers), shippers (manufacturers, wholesalers, retailers) and traffic participants, all of which make use of the same scarce resources available in the urban areas (Kant et al., 2016; Taniguchi et al., 2001). The phenomenon of city logistics is not new and has actually been tackled at various levels, as can be seen in the Law of Caesar on Municipalities, ever since 44 BC (Savelsbergh and Van Woensel, 2016). As the world has changed since roman times, so has city logistics, which is in fact a very dynamic sector, operating in the constantly mutating urban environment, on which it has both positive effects and major negative effects, such as contributing to congestion, creating safety concerns, participating in lowering the environmental quality of the city. The most recent major change happening to urban freight transport is the rapid development of e-commerce, which on one hand emphasizes the fundamental role of city logistics for the economic development of urban areas but on the other hand contributes to enlarging its impacts on social and environmental qualities of cities (Taniguchi et al., 2001; Anderson et al., 2005). City logistics is facing various challenges, which can be attributed to three major “channels”:

- Market requests: the conformation of today’s dynamic market leads to challenges for the urban goods distribution system, which has to respond to stimulations such as just-in-time requests, a high fragmentation in space and time of retailers and consumers, corporate policy such as the choices to only use company-owned and branded delivery vehicles (e.g. Coca Cola Company and soft drink producers in general). All of this adds constraints to the city logistics flow, often resulting in partial inefficiency due to low vehicle load rate, high mileage per vehicle, longer working shifts, higher number of deployed vehicles, etc.) (e.g. ENCLOSE Project Report, 2014).

- Policy and regulation: many authorities, particularly at local level, have come up with policy regulations that try to tackle some of the most invasive impacts of freight transport, such as noise, pollution, and usage of space (both for loading/unloading and while driving), sometimes even generating counter-productive effects due to forcing vehicles to take long detours, idle for longer times, etc. Such initiatives include time windows, restrictions for polluting, noisy or heavy vehicles, spatial restrictions, and so on (Munuzuri et al., 2004).

- Physical constraints/real time urban situation: congestion, pollution, noise are both partially generated by freight traffic and are affecting freight traffic, especially in terms of social acceptance by residents and, even more, by ruling authorities (which might lead to the adoption of some of the above mentioned measures) and in terms of inefficiency generated by extended operational time and related costs increases.

Starting from the described challenges, it becomes clear how the ultimate goal of urban logistics is (or should be) to reduce the clash between the interests of logistic companies and those of other stakeholder groups involved in urban mobility (Munuzuri et al., 2004), so that future policy and regulation on the topic can meet the interests of all parts and pick up the opportunities that are offered by technology advances. As it has been pointed out, though, it is increasingly difficult to provide “good service”, meaning managing to get the right product at the right time and at right place, at a low cost. It is also not possible to invest in transportation (infrastructure) capacity, either because of lack of space for expansion or because of the prohibitive costs that the operation would imply (Savelsbergh and Van Woensel, 2016). What is therefore needed is coordination of flows of goods, consolidation of freight volumes, and multi-organizational cooperation. It is needed to promote and inject innovative concepts at all levels: design, planning, execution, remembering that no pre-designed theoretical model can fit to real-life city logistics (Savelsbergh and Van Woensel, 2016). The solution to this has been approached in different ways from various authors, but it is recognized that cooperation between public intervention and company-driven efforts, a locally based strategy and a mix of technical/technological solutions (such as alternative fuel vehicles, use of real-time fleet management data, etc.), logistical solutions (such as supply chain collaboration etc.), and policy solutions is needed (Kant et al., 2016; Savelsbergh and Van Woensel, 2016). Besides exploring the theory of policy and planning, many authors provide numerous examples of possible policy and physical interventions to tackle the issues of urban freight transport, which will not be extensively reported here for synthesis reasons but which in short have as keystone the creation and support of consolidation facilities and practices to achieve Joint Delivery Systems, aided by normative and economic pushes towards cleaner operations and innovative practices. For more details and examples see among others Van Binsbergen and Visser (2001), Munuzuri et al (2004), ENCLOSE Project Report (2014), Taniguchi (2014), Savelsbergh and Van Woensel (2016). It must however be said that despite a discrete amount of available literature on the weaknesses of urban logistics not much has been written on measured impact of radical improvement strategies, and this is mostly because those strategies often fail to take off (e.g. because of their complexity) while independent measures that have been promoted and tested have repeatedly proven ineffective (such as, for example, investments in urban consolidation centers). All reviewed sources, however, stress how only an increasing capacity to integrate freight transport and other urban activity and to cooperate among stakeholders, regardless whether public or private and whether impacted or impacter, can lead to a more economically and environmentally sustainable urban logistics system. The following section of this written work concentrates on CH as a way to put in practice this stated level of integration and coordination, while improving the urban mobility system from the perspective of economic stability, user acceptance, environmental performance and resilience.

Cargo Hitching: definition and basic principles

Cargo Hitching, or the combination of people and cargo flows, is a newly explored research and activity field in what regards urban freight transport and its relationship with the urban mobility system in general and with the key stakeholders in city management and economy: public administrations, those involved in the trading system (such as shopkeepers, carriers, manufacturers, etc.), residents. CH is "the combination of passengers and goods transport flows so to increase efficiency and efficacy of operations in both central and peripherical areas" (Bracale, 2016). Its main objective is "to design integrated people and freight synchromodal transportation networks and related planning and scheduling policies to enable efficient and reliable delivery of each parcel and retail delivery" (Jansen, 2014). Both definitions allow to reason on basic principles of the CH model: first, as discussed it is an integrated system, in which passengers and goods share vehicles, infrastructures, urban space or more than one of these at the same time. Both reported definitions concentrate of efficiency and efficacy (or reliability) of the proposed model: the idea is that CH, despite implying some investments, is more efficient than current business models and more effective in operations. This means lower costs for all stakeholders, more care for environmental issues, high social value. A following paragraph will discuss CH's potential in terms of social value, discussing dynamics in central areas as well as in peripherical situations with shrinking population issues. Jansen's definition provides other fundamental sparks: the first one is that CH is about building a network. It can't therefore be said that it is just a modal quota shift to other means of transport: it's a proper turnaround of the business model of both transit agencies and operators and of stakeholders of the cargo sector. The second key point that Jansen highlights is that the creation of the "network" must be accompanied by consistent policy and coherent planning. As it will be seen, regulatory and policy aspects are crucial in determining success of CH projects and currently constitute the biggest barrier to its diffusion. Before discussing the potential of Cargo Hitching it is important to underline that is not a completely new phenomenon. The idea of outsourcing part of the delivery process, in this case using public transport with a surplus in capacity, has already been around for decades for what concerns – for example – long-haul air and rail operations, where mixed usage of one aircraft or train is nothing unusual (Bakker, 2015; Ghilas et al., 2013). The innovative aspect of Cargo Hitching lies therefore in the fact that it studies and proposes the usage of overcapacity of public transport to carry freight for short-haul operations, mainly in urban or peri-urban areas but without forgetting the potential for areas with shrinking population (Bakker, 2015; Jansen, 2014). The first hints about a shift towards a shared passengers and freight urban transport system was given by the European Commission in 2007, when they made the following statement: "Urban freight distribution could be better integrated within local policy-making and institutional settings. Public passenger transport is usually supervised by the competent administrative body while freight transport distribution is normally a task for the private sector. Local authorities need to consider all urban logistics related to passenger and freight transport together as a single logistics system" (European Commission, 2007; Bakker, 2015). Trentini and Mahene (2010) quickly reacted to this by producing a comprehensive list of ongoing or past projects that have been focused on sharing "public transport services, public road space or existing urban areas", which can be considered as precursors of the CH model. CH in fact requires, for its implementation, a complete change of the operational model, including the way scheduling works, the fare system, the whole pickup, transfer and delivery process, and last but not least physical changes to assets (vehicle and infrastructure). Before deciding to implement such a complex and resource-taking strategy it is therefore important for local administrations and for public and private companies (goods manufacturing and delivering companies, passengers transport authorities, service management agencies,…) that the local context is carefully and exhaustively studied. The next paragraphs will first highlight CH's theoretical potential in both central and peripherical areas and then discuss drivers which could bring the model to a failure at current state.

Cargo Hitching's drivers for success in urban vs rural areas

CH, as said, has been developed to allow shared goods and passengers transport in short haul operations. In dense, urban areas, benefits from such a model are clearly perceivable. In shrinking, peripherical areas, the discourse is more complex and expands a bit from transport operations only. In central areas, benefits from CH are mainly financial (minor expenses), environmental (less pollution and more efficient fleet use), and related to governance (more acceptable policy and regulations). In peripherical areas, however, a new fundamental tile joins in: the intrinsic social value of CH. Cost reductions to provide transit services and goods deliveries, in fact, makes desirable or anyways possible the provision of services otherwise considered anti-economic, such as for instance additional, more frequent bus or postal services, thus interrupting or relieving the feeling of growing isolation which many shrinking areas face. this kind of dynamics increase areas' attractiveness, allowing the retention of existing population levels and fighting growing isolation and alienation. This aspect is specifically important for the case study that will be discussed later in this work. Available literature, despite the topic having developed only recently, undoubtedly demonstrates through the analysis of real or simulated business models the potential of CH. Ghilas et al. (2013), Jansen (2014), Spoor (2015) andi Li (2016) coherently present results from different studies that show how the freight sector as a whole (manufacturers, shippers and carriers, and receivers) generally gains economic advantage from loads consolidation and CH. They moreover agree in saying that public transport operators, both fixed-schedule (typically transit agencies) or not (typically taxi and cab companies), also obtain economic advantages when making their spare transport capacity available for transporting parcels and/or small goods units. Finally, analyzed literature sources underline that public authorities can benefit from increased sustainability of transit operations, which will need lower subsidies. Absolutely not secondary are benefits related to the social sphere: as hinted, less onerous transport operations pave the way for additional, otherwise anti-economical delivery and passengers services, better serving shrinking areas and therefore increasing their attractiveness for current and future inhabitants. Those aspects are discussed in details by, among others, Jansen (2014) and Bakker (2015).

Cargo Hitching: drivers for failure. The inadequacy of the regulatory setting

CH, however, implies a significant change in today's operations and theoretical approach to urban mobility. Among the drivers which are keeping its diffusion to a hold, Jansen (2014) stresses that in most cases the regulatory and legislative systems (at all levels, from European to local) are not shaped to incentive such advanced sharing initiatives. Cargo and passengers transport are not only considered by governments and separated systems, but they are also referred as this by the law, they are regulated by different authorities, they are subject to different rules and guidelines, different work contracts etc. Spoor (2015) notes that regulatory constraints contribute to elevate the costs of the delivery chain. Ghilas et al. (2013) recognize the system as a very complex one, in which many stakeholders interact – namely "passenger door-to-door transportation, package transportation and public fixed line services,, - and produce different scenarios considering different integration levels, thus underlining that capacity to establish profitable cooperation is a necessary condition for the success of a Cargo Hitching process, but takes time and lots of political effort to achieve. The co-operation process becomes even slower due to the indecisiveness of corporation which are reluctant to "drop" their identity in delivery operations while consolidating deliveries. This phenomena is easily observable, according to literature, in the case of soft drink companies, for which the delivery with branded trucks is part of the marketing strategy. Many different constraints, moreover, complicate both the research phase and the physical application of Cargo Hitching theories. A different set of issues has to be included in research models and then transposed into practical operations, with obvious time and cost-related effects. Timing-related issues, like for example the fact that passengers are very sensible to travel times and must therefore have priority over goods, the time-limited availability of stores for receiving delivery, just-in-time deliveries and the management of just-in-time orders through web platforms, are a significant constraint to worry-free Cargo Hitching implementation. All read authors - and among those which have not yet been cited are Ghilas et al. (2013), Trentini et al. (2012) and Fatnassi et al. (2015) - have included time constraints in their research, even though they all have looked for a balance between relevance to reality and feasibility of the study. Other relevant constraints are related to spare transport capacity during certain times of the day or periods of the week, to flexibility of scheduled transportation, and to reverse logistics. None of the authors has included reverse logistics operations in their research to avoid excessive complexity of models, but it is clear that in real-life operations the problem is relevant and should be considered. This involves both waste management (which though could be outsourced to a different authority) and the return of empty rollers and containers, which is usually dealt with by shippers. A further slowing driver is the strong necessity for both public and private investments and adaptation: starting a Cargo Hitching project requires to make available at least one consolidation facility and pick-up and delivery locations at selected transit hubs, to purchase new low impact vehicles for last mile delivery (e.g. tricycles or more sophisticated solutions such as electric light vehicles, which then introduces the problem of charging facilities), to strongly intervene on the existing public transport fleet to make it usable for easy and quick(especially in loading/unloading operations), reliable, safe for goods transport. All considered authors present this aspect as a big challenge, also considering that no regulation at the moment determines which investments should lie in the responsibility of the public sector and which should be covered by private stakeholders. One last significant braking factor for Cargo Hitching's success is the necessity of constant monitoring and adaptation of the running integrated system, so it can be kept attractive for passengers and effective for goods operators, while being in the meantime socially acceptable for residents and administrations. This involves facing problems related to ITC costs and to research costs and timing. Literature has not really widely discussed this aspect yet, because there is still no fully implemented system to analyze. To sum up and conclude, it can be said that future research should take as primary objective that to propose an acceptance model for Cargo Hitching (addressed to public administrations, private and public companies, stakeholders part of the transportation and logistics systems in general) to be merged with an integrated and broad business model, which should take into account all phases of the innovation process (from theorization and planning, to implementation, to monitoring and evaluation). The main point is – to be clear – to find a way to make the transition to the integrated system happen smoothly, thus solving regulatory issues in the first place while taking into account all other discussed aspects as well. Funding by public authorities and the design and implementation of pilot initiatives are fundamental elements in the development strategy for Cargo Hitching: small-scale applications (e.g. in a restricted sector of an urban agglomeration or in a limited-size rural area) could be the key to test proposed models thus allowing to build an appropriate and reliable set of indicators and operational model to facilitate future broader diffusion of Cargo Hitching which – as it must be reminded – available research identifies as a key process to build a more economically and environmentally efficient integrated transportation system not only in dense areas but particularly in more rural areas suffering phenomena like shrinking population and service quality decrease, thus entrusting a strong social value to transport operation.

CH for the Lagoon of Venice. Setting and business model.

This paragraph summarizes the setting and most notable results of a simulation of a Cargo Hitching shared transport system in the Venice area, Italy. The chosen area is set in the North Lagoon of Venice, and was chosen for multiple reasons: first, Venice is case-study city for the Novelog Project, meaning that some scientific contributions have been developed on the topic, including the one which is here synthetized. Second, the North Lagoon has two main itineraries, which are easily identifiable and which are used for both goods and passenger transport, carrying in both cases significant volumes. Those two main itineraries are coincident with the vaporetto/waterbus (ACTV) routes 12 and 13, from Fondamente Nove (Venice) to Murano, Burano (line 12) or Sant'Erasmo (line 13) and on to Treporti (connection with the mainland) (Figure 1).

Figure 1: ACTV lines 12 and 13, chosen for CH implementation. Own elaboration

In order to limit the overall complexity of the case study and to produce a realistic model, capable of immediate acceptability from sectorial stakeholders (of both goods and passengers transport), from the workforce and from the public, it is necessary to fix some constraints and starting hypothesis. Whereas some of these constraints have been set in the academic environment, most depend directly from the results of a confrontation with the abovementioned categories, where different scenarios were proposed for the study of CH system and the most realistic possible situation was outlined. The most important fixed constraints include:

- the choice of the study area, limited to the itineraries of ACTV routes 12 and 13, due to service frequency and volume and to its overlapping with major freight transport axes, as recognized by COSES (07/2002 report);
- the decision to simulate the worse possible scenario, using winter transit schedule (lowest offered level of service) and meanwhile the highest yearly recorded freight volumes. Moreover, prudent correction factors have been applied for loading capacity and spare capacity of ACTV waterbuses;
- the limitation of freight categories to include in the simulation to "Conto terzi" of the most frequent categories, as defined by the Chamber of Commerce, due to excessive unpredictability of transport demand of other categories;
- the decision to maintain a goods delivery window from 4 am to 11 am, corresponding to current delivery times. Public transport schedules were therefore only considered in this frame.

Table 1 synthesizes the results of data collection and elaboration regarding public transport offer, freight transport demand, and number of circulating vessels. It moreover presents the sizing of freight loads onto transit vessels, in both square and cubic meters and in percentage of available volume and surface, calculated according to the process of overlay of offer and demand. Figure 2 graphically shows the impact of goods loads into cabins of transit vessels in service on lines 12 (capacity: 325 passengers) and 13 (capacity: 218 passengers). As Table 1 and Figure 2 have helped to graphically show how volumes could be redistributed, it is now useful to describe the functioning of the proposed CH system. Two consolidation hubs would be needed, one west , intercepting freight fluxes from Venice-Tronchetto and the mainland- San Giuliano (in Murano or F.Te Nove) and one east (in Treporti). Those facilities would serve as consolidation of goods deliveries into standard-size rolls (715x805x1800 mm) and for their transfer on ACTV's boats. The design of those facilities was not in the scope of this paper, however it must be said that current volumes do not impede to basically use standard ACTV floating pontoons, part of which could be dedicated to goods. Loading and unloading, as well as last-mile goods distribution on the islands, would occur in line with today's operational model.

Table 1: offer, demand and freight volumes on public transit vessels according to the proposed CH system. Own elaboration.

	Line 12 (carrying capacity: 325 passengers)				**Line 13 (capacity 218 pax)**	
	Murano-Burano	Burano-Murano	Burano-Treporti	Treporti-Burano	S.Erasmo-Treporti	Treporti-S.Erasmo
Offer						
# runs before 11am	15	12	12	11	6	6
# vessels in service	4				2	
Capacity pax	4875	3900	3900	3375	1308	1308
Sqm offered before 11am	1218.8	975	975	893.8	327	327
Maximum declared usage (%)	35	35	35	35	37	37
Security factor (%)	10	10	10	10	10	10
Spare capacity (%)	55	55	55	55	53	53
Sqm used	548.4	438.8	438.8	402.2	153.7	153.7
Sqm available	670.3	536.3	536.3	491.6	173.3	173.3

Cubic meters available (security factor 10%, height=2m)	1072.5	858	858	786.5	277.3	277.3
Demand						
Freight volumes	556	366	237	163	140	87
# vessels used	22	21	13	12	6	7
Real-size freight loads						
Cubic meters on each service	37.1	30.5	19.8	14.8	23.3	14.5
Sqm on each service (height=1.8m, with security factor 20%)	20.6	16.9	11	8.2	13	8.1
Load size (side 1)	4	4	4	4	2	2
Load size (side 2)	5.1	4.2	2.7	2.1	6.5	4.0

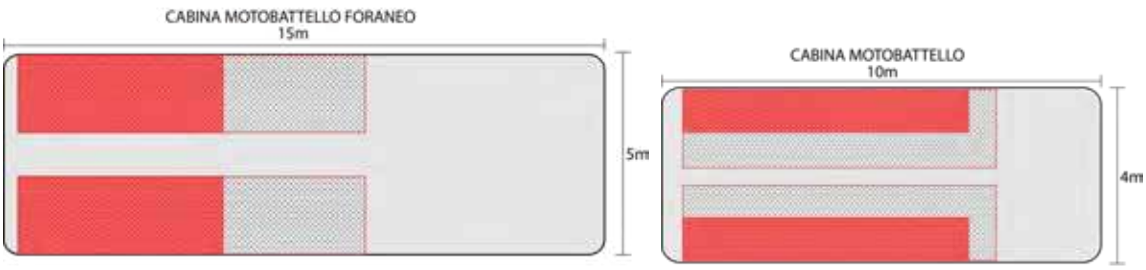

Figure 2: ACTV vessels cabins (big: line 12, small: line 13). In plain gray, space available for passengers. In dotted gray, maximum theoretic freight load (based on spare capacity). In red, maximum real freight load (based on volumes to be carried). Own elaboration.

CH in Venice. Open critical issues.

The proposed system leaves some critical aspects open; aspects which is necessary to highlight for both future research and for next on-field operative steps in the context of the city's mobility policy and practice evolution towards further integration. A first set of criticisms is represented by CH's intrinsic limits, as hinted already. In particular, it must be reminded that as today freight transport on vehicles – vessels in this case – designed and type-approved for public transportation is hardly frameable in the classic regulatory set nor in the competences which the law recognizes as proper of public transit agencies and/or operators or in sector contracts for their employees. It would therefore be necessary to strongly act on the local, national and European regulatory structure in all interested sectors, on contracts and labor deals, on plans and strategies, with the goal of allowing and even promoting, if not enforcing, goods/passenger integration. This is a first relevant issue, which has been brought to interested stakeholders in the case of Venice and is currently under discussion in the parts of competence of local institutions and enterprises. A second critical aspect is the acceptance of CH by usual transit customers. In this particular case commuters on ACTV routes 12 and 13 might experience minor schedule dilations due to longer dwell times and higher load of vessels (meaning lower cruise speeds). Passengers could moreover experience less comfort due to higher intensities in the use of PT vessels capacity. Before implementing the CH system, therefore, further studies on social acceptability should be conducted in the interest of the public administration and of ACTV. It must however be noted, on the other hand, that in the context of the Lagoon of Venice transit is in the unique position of being in most cases the only available alternative to move. In this sense, it would be easier to force the implementation of the CH system – in case the public administration would decide so – even in case of mixed feelings from the users' side. Some more critical aspects are related to the constraints which have been introduced in the model: future research should include reverse logistics operations and additional goods categories, and should further discuss consolidation hubs.

Caro Hitching for Venice: performance evaluation

This paragraph is dedicated to an evaluation process of the proposed CH system for the venetian lagoon. This is an innovative element not only for the specific geographical context object of study, but for the whole literature body about CH. Only recently, in fact, the problem of evaluating mobility performance rose, and such an approach was, to the author's knowledge, never applied to real or simulated CH operations before. The evaluation process is conducted through a set of performance indicators (KPIs) which until now, outside of the Novelog project, have never been used with reference to the transport sector.

CH for Venice: evaluation results

Before describing the chosen indicators and the results of the evaluation process, it is necessary to highlight that in the process itself all constraints which have been set during the description of the case study have been maintained. Moreover, compared to the originally considered time window (4 to 11 am), the indicators have been calculated for a restricted time window of 3 hours only (7 to 11 am), as PT offer during those hours revealed itself to be sufficient to deliver the totality of considered freight while at the same time minimizing economic, operational and environmental impacts. The first analyzed evaluation dimension is that of operational impacts, considering efficiency and efficacy of the combined transport system and confronting obtained values with the current situation, in which the two systems are run independently. Part of this category are indicators concerning total operating hours, covered distances and load factors. A second group of KPIs investigates environmental impacts. This is an extremely important field of evaluation also for what concerns social acceptability of the integrated system: environmental benefits could be a persuasive tool to increase stakeholders' consent on the project. The third and last evaluation dimension concerns economic impacts, specifically related to costs of energy and costs of workforce. Aggregated results from each calculated KPI are available in Table 2.

Table 2: evaluation through KPIs and results. Own elaboration.

Indicator (code + name)	Description (if needed)	Evaluation results
A1 – Traffic variation	Traffic variation (# of boats)	Traffic drops from 323 to 242 daily operating boats. Average reduction is therefore **-25%**
A2 – Distance variation	Distance variation (kms operated)	Compared to today's 640 daily kms, with CH a reduction of 432 kms would occur. **-67.5%**
A3 – PT load factor	Public transit vessels load factor	CH would rise load factor to max **78.2%**, still leaving spare capacity to absorb unusual peaks
A4 – Frequency/Level of service		There is **no change** in level of service from PT users' perspective.
A5 – Engines operating hours	Hours of total operations of vessels' engines (PT+freight)	Reduction from 50,6 hrs/day to 16,3 hrs/day. **-68%**
B1 – Carbon Dioxide Emissions		A daily saving of over 1.5 Tons of carbon dioxide is allowed, which means **-38%**
B2 – Energy consumption		Energy consumption reduction **-38%**
C1 – Cost of energy	Includes fuel costs	Cost of energy drops: **-42.5%**
C2 – Cost of workforce	Includes all human resources	Cost of labour is reduced by **-38.1%**

The evaluative process has highlighted incentivizing results, especially when considering that it was conducted with several limitations as to better adapt to the context's reality. According to the findings, therefore, CH proves to be a suitable solution for the discussed case study and it would be meaningful to continue the already started discussion with the various involved stakeholders so to identify common guidelines to first produce needed policy/regulatory changes and then implement the shared system. The inadequacy of the regulatory framework is, indeed, the biggest slowing driver towards high integration, in Venice more than elsewhere. It is of absolute priority to identify appropriate strategic and operational instruments to legitimate and promote integrated passengers/goods transportation. In Venice in particular the strategic reference plan could be the SUMP (Sustainable Urban Mobility Plan) which has not yet been prepared but will need to be discussed soon. From a tactic perspective, instead, the most interesting instrument for the context of study seems to be that of the tender or bid. Practically speaking, the administration should prepare a tender which includes and regulates the integrated transport system, establishing clearing rules and giving all operators time to organize and compete accordingly to their competences. In this scenario, the implementation of the CH system would be on one side supported by a powerful strategic planning instrument (the SUMP) and on the other side promoted by the operators which would compete to affirm their role within the new system, thus lowering the risk of otherwise likely protests.

Conclusion

This paper has discussed some of the issues related with short-haul logistics, particularly in dense and congested urban environments. Given that current trends show growing urbanization and an increasing fragmentation of goods deliveries, it is obvious that the situation will grow worse. Authorities and governments have at times tried to tackle major issues (congestion, noise, pollution) by promoting restrictive and punctual measures, which have proven not effective or even counter-producing. Based on the EU Commission push for further integration between goods and passengers transportation, this paper presents Cargo Hitching, namely the combination of people and cargo flows, as a possible solution for achieving higher efficiency and sustainability standards for the overall transport system in both dense urban areas and in peripherical or rural shrinking contexts. After discussing the basic principles of CH and some of its main success and failure drivers, this article reports the setting and results of a CH simulation conducted for the venetian lagoon within Novelog Project. The evaluation process, conducted using KPIs for the first time for a CH application and innovatively for the whole transport sector research, has highlighted incentivizing results, with major operational, environmental and social obtainable benefits. Taking advantage of the participation of Venice into the Novelog project, next steps towards an integrated transport systems have been identified and discussed with the sectors' operators and other involved stakeholders. In this regard, a major issue has been highlighted in the inadequacy of the governance and regulatory systems and a proposal for a two-folded legitimation strategy (strategically, through the Sustainable urban mobility plan, and operationally, through a tendering process) has been prepared. Such a strategy should, according to the simulation's results, strongly be promoted in order not to waste the innovative push and the undoubtable potential which a CH system has with regard to themes which are or should be keystones in the political debate, particularly in the venetian area, as for instance the reduction of environmental impacts (on the lagoon itself as well), the necessity to maintain attractiveness and competitiveness not only of the historic city but of the islands as well, the will to make economically competitive and sustainable public transport and the mobility system in general, and the requirement to lighten the pressure on the lagoon generated by transport operations.

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References

Anderson, S., Allen, J. and Browne, M. (2005). Urban logistics how can it meet policy makers sustainability objectives? Journal of Transport. Geography, 13(1), 71-81.

Bakker J., 2015, Increasing delivery efficiency by Cargo Hitching: a case study. Master thesis, TU/e School of Industrial Engineering.

Bracale A., 2016, Politiche innovative per il trasporto delle merci nella laguna di Venezia: prime simulazioni di Cargo Hitching. Thesis, Università IUAV di Venezia.

European Commission, 2007, Green Paper on Urban Mobility.

European Commission, 2014, ENCLOSE Project Report.

Fatnassi E., Chaouachi J. and Klibi W., 2015, Planning and operating a shared goods and passengers on-demand rapid transit system for sustainable city logistics. Transportation Research Part B, No. 81 (2015),p. 440–460.

Ghilas V. et al., 2013, Integrating passenger and freight transportation: model formulation and insights. Working Paper, TU/e Eindhoven.

Ghilas V. et al., 2016, The Pickup and Delivery Problem with Time Windows and Scheduled Lines. Information Systems and Operational Research, Vol.54, No.2, pp. 147-167.

Jansen T.A.M., 2014, Development of a design model for integrated passengers and freight transportation system. Master Thesis, TU/e School of Industrial Engineering.

Kant, G., Quak, H., Peeters, R., & Woensel van, T., 2016, Urban freight transportation: Challenges, failure, and successes. In H. Zijm, M. Klumpp, U. Clausen, & M. Ten Hompel (Eds.), Logistics and Supply Chain Innovation: Bridging the Gap between Theory and Practice (Vol. 3, pp. 127-139).

Li B., 2016, Optimization of People and Freight Transportation – Pickup and Delivery Problems Variants, PhD Thesis, TU/e Eindhoven.

McDonagh J., 2006, Transport policy instruments and transport-related social exclusion in rural Republic of Ireland. Journal of Transport Geography 14, pp.355-366.

Munuzuri J. et al., 2004, Solutions applicable by urban administrations for urban logistics improvements. Cities, Vol. 22 , No. 1 (2005), p. 15–28.

NOVELOG, 2016, Deliverable D.3.2 Evaluation Tool.

NOVELOG, 2016, Deliverable D.8.2 Toolkit.

Savelsbergh, M. W. P. M., & van Woensel, T., 2016, City Logistics: Challenges and Opportunities. Transportation Science, 50(2), 579-590.

Spoor J.M., 2015, Replenishing nanostores in megacities for a consumer packaged goods company. Master Thesis, TU/e School of Industrial Engineering.

Taniguchi E. et al.., 2001, City Logistics. Network Modelling and Intelligent Transport Systems (Emerald).

Taniguchi E., 2014, Concepts of city logistics for sustainable and liveable cities. Social and Behavioral Sciences, No. 151 (2014), p. 310 – 317.

Trentini A. and Mahene N., 2010, Towards a Shared Urban Transport System Ensuring Passengers & Goods Cohabitation. Working Paper, Trimestrale del Laboratorio Territorio Mobilità e Ambiente, Dipartimento di Pianificazione e Scienza del Territorio, Università degli Studi di Napoli Federico II.

Trentini A. et al., 2012, A shared “passengers & goods” city logistics system. 4th International Conference on Information Systems, Logistics and Supply Chain, Quebec, Canada, Aug 2012, 10p. hal-00861728.

Van Binsbergen A. and Visser J., 2001, Innovation steps towards efficient goods distribution. Delft University Press.