

Sustainable mobility: “exchange poles” between transport networks and urban structure

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Abstract

An intermodal hub can be defined as a place where transportation networks are organized to facilitate intermodality between different modes. Intermodal hubs should intrinsically have an urban dimension and be globally designed as “plug flows”, being interfaces between transport networks and territory, being an element to create “urbanity”. Intermodal hubs focus technical, social, urban, transport, service aspects and they play a multi-modal, multi-service, multi-operator role. Several studies highlight the need to “measure the interdependence” among the various aspects of urban problems, avoiding too specific methodologies. The increasing congestion in urban centres and urban parking problems encourage mobility managers to increase “exchange poles” for the interconnection between private and public transport to out of city centres. Several authors consider the “exchange poles” as planned around three roles: “transport”, “urban” and “service” function. The first is considered for the articulation of networks, the second through the integration of its close environment and the “service” for association with the movement of travellers and the information. These poles are located in large open areas, away from downtowns, easing the separation of city spaces and the concentration of desire lines, but it limits the urban inclusion of these important poles. Primarily, these nodes are scheduled to organize and ease the matching between bus lines, helping the expansion of the transport networks, to become a preferred entry point for the users. In addition, they must be places that fit the urban context with architectural quality and design, taking into account the surrounding environment. Finally, the improvement of information and users' comfort should be considered developing commercial actions to integrate urban entertainment.

Keywords: intermodal hub, transport network integration, territorial planning.



1 Introduction

With the evolution of transfers, mobility places have evolved and grown to reach a complexity incompatible with the positive fruition by the traveller.

The attention of collectivity and operators on the exchange nodes is changed: traveller, transport and services supply are the core of the problem already in the planning and organizational phase of these places.

The relationship between node-places and urban displacements is being researched for twenty years and can be studied from three points of view: of the operator (space, infrastructuring and interpretation of places), of the transport service (performance and commercial requirements for the exchange pole), of the architects and planners (urban insertion from any point of the network).

The establishment of an inventory of exchange poles is a part of these research activities. It allows you to face with more knowledge, the issue of urban organization and inclusion of these infrastructures and of the possible comparison of places chosen as elements for the interface between mobility and the wide spectrum of activities undertaken by citizens in moving in the city.

Use of the collective transport system is encouraged by providing a quality service, characterized by a number of components that influence users' choices in various ways.

Among these components, the creation of interchange poles for mobility is essential to facilitate the transfer between different transport modes and/or within the same mode. So the modal integration includes various options for the by different interchange points of view in terms of technology (motorized and non-motorized means of transport, road-rail), travel contexts (urban-rural) and functional characteristics generally attributed to individual mobility reasons (commuters, leisure, service and family trips, neighborhood trips and long distance connections).

The functional integration between the systems can be one of the most suitable models to exploit the advantages and vocations of each type of vehicle and encourage new travel behaviors with the aim of curbing the use of the private mean (Parkhurst and Richardson [1]).

The inventory of urban exchange poles should primarily be directed to the spatial organization of the affected areas, through the representation of a set of characteristics, which refer to the overall regional situation (suburban areas, medium and large cities), to the involved different modes of displacement (urban and extra-urban buses, metro, trams, trains, private cars, two wheelers and pedestrians) and to the interface requirements of these modes with their surrounding environment in terms of connection level with road network and accessibility (Amar [2]).

According to the planning logics of local authorities, the road network aims to ensure that the transiting traffic flows smoothly and safely, and to facilitate the exchange traffic serving poles of particular interest in different crossed territorial contexts.

The involvement of the community into the problem above mentioned has as aimed objective those related to the connection between the downtown of the

city and neighborhoods that can be physically marginalized or developed (or redeveloped) for high quality urban use of the space.

On the one hand, the complete road network plays a structural role in the urban territory.

On the other, it allows to connect periphery with the inner part of the city, making it possible to serve several significant attraction poles created by the phenomenon of urbanization.

The road network links the hinterland with its basin of influence and it offers a potential for urbanization of the surrounding and geographically widespread areas, leading to a reduction of access time to the farthest urbanisable spaces.

The investigated theme becomes more complex when we give answers that can be adapted to the urban settlement types, especially depending on the size criterion and on of displacement the policies that are adopted. If well organized, in these cases the exchange nodes become crucial elements to promote sustainable intermodal mobility and the growth of life quality and mobility of citizens, by offering differentiated services. The latter should reduce, as much as possible downtimes.

2 The territorial development of the city

It seems important to understand the properly epistemological dimension of the choice among compact and diffuse city.

The defenders of the compact city highlight the benefits of a strong density of population that limits the use of land, allows the mix of functions, reduces motorized travel and allows the significant use of collective transport.

While supporters of diffused city argue that, starting from a certain threshold, the compactness of the urban tissue involves congestion phenomena and, hence, an increase in air pollution and a deterioration of life quality.

They also add that the land prices prevent to a large proportion of the population to solve the housing problem in densely populated areas.

The cities are now associated to the phenomena of urban dispersion and fragmentation. The development of suburban trade centers, the proliferation of entertainment poles, the extension of business areas, the search for isolated habitats in a rural areas lead to a disperse city, space consumer and shifts generator.

In the industrialized nations, the development of technical networks has accompanied urban growth.

The large systems built to empty the city in emergency situations, for distribution and circulation of flows (water, power and telephone distribution networks, sewerage network, road and transport network, information system networks, etc..) constitute the armor of cities and they underlie its operativity. They allow maintaining and developing the livability of the city.

In the early '70s, the marginalization of certain neighborhoods began to be perceived as a political and urban element of great importance. On the one hand the cities attract the peripheral areas, while on the other they show the need to specialize themselves by function (residential, commercial, administrative, etc.).



Often but not always these districts are recent large urban agglomerations one where mono-functional characteristic dominates.

This mechanism over time produced considerable transportation area criticalities causing severe impacts and influences over territory, over inhabitant's conditions and a strong impact on environmental quality.

Traffic problems and an excessive use of private transport means, in fact, have generated significant repercussions on the environment sustainability, on climate changes, and also economic and social negative impacts (Borzi [3]).

In the economic field, the functioning of local real estate market suffers a mechanism that determines the devaluation of the social image of the neighborhood and of the buildings, the transfer of the most successful families, the property degradation, and the increase of unemployment rates.

The social life of the impoverished neighborhood, the neighbors do not communicate with each other and they cower in their homes, the xenophobic reactions multiply, the associative tissue moves, marginal and aggressive behaviors arise.

From considerations of the importance of exchange nodes emerges. They should not be seen as mere car parks, where "leave the car" to take the first available public transport mean, but as integrated transport and services nodes. They have become aggregation places for meeting, recreation and leisure of the community, attracting different services (trade, health, administrative, public safety activities).

They must also be equipped with an auxiliary equipment and services to lighten the weight of the pending or transfer time perceived by users and to become almost necessary (but wanted) phase shifts within the users' the chain. So the urban passenger interchange node assumes a fundamental value within the service quality perception measurement and the estimation of links that connect the same node and the entire city (Gandit [4]).

3 Exchange nodes: promotion of a multimodal and sustainable mobility

This paper examines the factors that affect the service level of an interchange node in terms of relationship between the space (and services) related to same node and the users' quality perception.

The user's flows interact dynamically, with variable behavior, according to their typology and density, occupying the spaces of the entire node.

The need to study the organizational and dimensional setting that best suits the users' needs becomes crucial, creating an efficient, attractive and sustainable urban environment. To achieve these objectives it is important to act on:

- the extension of the network of paths and travel times for travel within the node, because a connection between the offered supply of services and the possibility of covering the entire area by foot or by using special movement equipment (mobile stairs, treadmill, etc.) should be created, providing users with information about routes and travel times;



- the connectivity between the nodes and the attraction basins through offered the transport services having regard to these infrastructures on the one hand as central hubs in a polarized vision of urban shifts, while on the other like access doors to the city for extra-urban and hinterland users. The competitiveness of integrated supply of public transport plays a key role in this last field. It should be an effective alternative, with the slow mobility for a real modal rebalance.

In addition to the geographical location and to the working data, the theme of spatial organization of the exchange node can be explained using some important elements:

- the historical analysis of the temporal development of the site chosen to build a new interchange node or the place already become a multimodal center;
- the public space of the node, or rather a vision of the exchange pole through the surfaces (and relative services) for travelers and generally for potential users;
- the interrelationship between the multimodal node and the surrounding urban tissue and the identification of possible and effective ways to ensure properly the interface between the afferent transport networks, the same node and the city (Offner and Pumain [5]).

The historical analysis of the site reveals constraints that are associated with organizational aspects. The presence of past existing infrastructures (road networks, rail lines, buildings, etc.) may constitute a system of constraints to be respected, on which the expected developments must engage.

On the other hand, a pre-existing infrastructure allows directing the organization of the node to its future form with a clear vision of its detailed and global aspects.

The overlapping of spaces creates a vision problem of the spatial organization and of the overall intelligibility of the exchange node. The location of urban bus stops (or a bus terminal) in the peripheral zone of the multimodal pole contributes to its spatial extension.

But the pedestrian paths that lead to collective urban public transports (stops or terminals) should have important characteristics of continuity (i.e. no interruption and indication signals).

The same considerations can be made for locations for taxis. They must appear as a logical continuation of the mobility space of the traveler.

The integrity and harmony of the space dedicated the passenger are negatively affected by operating constraints related to the activities, management activities of transportation and other services, which take place into the exchange pole.

The dismemberment of the development of multimodal nodes temporally, spatially and during the course of the activities done by individual operators is always achieved against the coherence of the exchange pole complex (Table 1).

Evidently, the intermodality is the crucial element of the birth of an exchange pole by the functional point of view.

The intermodality can find its fulfillment in the spatial multimodality creation, so considering the coexistence of different transport modes in a certain place and time.

Table 1: Multimodal exchange poles - surfaces and equipment assessment.

Sizing of facilities dedicated to the “passengers” activities of transport	
Type of facility	Measurement unit
Railway Station	
Rails	Number
Loading/unloading docks	Number (and/or linear meters)
Surface necessary for passengers	Square meters
Ticket windows	Number (and/or linear/square meters)
Information office	Number (and/or linear/square meters)
Ticket machines	Number (and/or linear/square meters)
Baggage and lost and found offices	Square meters
Toilettes	Number (and/or square meters)
Commercial activities	Number (and/or square meters)
Food and beverage places	Number (and/or square meters)
Maintenance and technical areas	Square meters
Bus Station or terminal	
Parking lanes	Number
Information office	Number (and/or linear/square meters)
Ticket windows	Number (and/or linear/square meters)
Surface necessary for passengers	Square meters
Toilettes	Number (and/or square meters)
Commercial activities	Number (and/or square meters)
Food and beverage places	Number (and/or square meters)
Taxi terminal or lanes	
Loading/unloading docking lanes	Number (and/or linear meters)
Medium number of waiting taxis	Number
Permissions	Number
Private car and two-wheelers parking areas	
Short-term stops	Number (and/or linear/square meters)
Long-term stops	Number (and/or linear/square meters)
Toll parking	Number (and/or linear/square meters)
Free parking	Number (and/or linear/square meters)
Bike parking	Number (and/or linear meters)

The spatial translation of intermodality is expressed in terms of spatial pathways. Each of the main transport modes (private car, collective urban transport, taxis, trains, pedestrians) has a spatial location, which may suffer of conflict zones in its performance.

The pedestrian mode, with its quite unpredictable behavior, is characterized by multiple generators points (bus stops, subway gates, entrances to buildings, etc.). While the pathways associated with automobiles are complex and frequently interfere with pedestrian accessibility. Thus the study of such

pathways (hence the attraction pairs) of the different categories of involved users becomes an important aspect (table 2).

Table 2: Typology and attendance of multimodal exchange poles.

	Kind of user	Kind of displacement	Attraction area
Railway station (or terminal)	Workers and students	Daily (home-workplace or school)	Downtown, metropolitan area and school-dedicated areas
Bus urban station (or terminal)	Middle-high school and university students	Daily	Downtown and metropolitan area
Global trend	Middle-high school and university students	Daily (home-workplace or school)	Downtown and metropolitan area

4 The exchange nodes as structuring elements of the urban territory

The network is often a synonym of “interconnection” into the “continuous” space of the city, because it creates connectivity. The interconnection should be understood as an organization principle of a network, as a set of nodes that are present at the intersection of more modal networks and more levels.

The role, the functions and the attributes of these nodes are the result of the shape planning of the network. They are the backbone of the network. The interconnection should be also understood on one side as an accessibility multiplier to the node, on the other as a process of spatial enhancement (Pucci [6]).

But the territory is also the creator of the network node, since it is the instrument through which the station, for example, becomes a public space, a city appendix where each (rail, bus, taxi etc., terminal becomes an extension of the place that serves the mobility.

The interconnection can be achieved only if it enhances each of the connected networks, representing a multiplier of accessibility. The concept of “accessibility” recalls the notion of interrelation and elimination of physical or temporal constraints removal into users' displacements and attractiveness of a certain area in relation to the satisfaction of given needs. It is linked to the concepts of space and place, functions and time.

The concepts of space and place are closely related to the concept of “node”. They are important for the creation of modern transportation modes. Moreover, they represent the city, the networks and the nodes (Kohler [7], Amoroso *et al.* [8]).

During the last years, a transformation of the form and the articulation of urban space have occurred. It was influenced by the activities taking place into

the city and by the regional planning processes. Moreover, the processes of construction with a low-density distribution have expanded the contemporary city into an open-ended, unstable and fragmented space. New neighbourhood are fragmented into a myriad of buildings.

They represent the result of incremental dynamics: they are apparently devoid of settlement planning, with heterogeneous and changeable “geometries” of the built environment. So the city has lost its “borders”. The general disorder of the urban periphery and the chaotic distribution of the spatial activities have produced waste, consumption and soil artificialisation. Moreover, they have changed the urban accessibility conditions, substantially increasing the private wheeled mobility, with a consequent raise in the hypertrophy of the global transport system. In other words, the new models of diffuse settlement outside the dense city and the decentralization of (residential, commercial, industrial and tertiary) functions in the suburban areas (which are not adequately served by public transport means) have led to an explosion of metropolitan mobility, utilizing the private vehicle. Infrastructural and service deficits are clear, particularly concerning the management of large intra- and inter-city mobility basins. This is most commonly by analyzing the connections between the nodes of the international and interregional transportation systems (airports, high speed railway stations), regional and local ones. A fact that characterizes all Italian macro-areas is the poor organization of the urban mobility system. It is unable to “create network” developing and managing the different transport modes. The mobility in urban and metropolitan areas involves issues related to the efficiency and competitiveness of the city and the life quality of citizens.

5 The exchange nodes: flows management and multimodality

The exchange pole should be “globally” conceived as a “connector flow”, having an intrinsically urban dimension. It is also an element that “creates urbanity” and a place where the interface between the transport (and people) networks and urban territory.

The extension of displacements by private motor-vehicle, the congestion of the urban areas and also downtown parking problems encourage public administrations to multiply the space out of city limits that can connect private with public transport and to decrease the motorized traffic into the core of the same cities.

So some of these mentioned spaces (the poles) involve movement, on the contrary of the points. They are places with a polarity that attracts. The pole attracts customers and migration flows: these polarized areas of the city are central places where fields of attraction converge.

Instead the point is turning to itself. It is animated and lives depending on itself.

The term “exchange” is a double referred to: the commercial activities and the organization of flows. These places have an important role in promoting multimodality, but also as structuring and accessibility basics for downtowns and/or sub-urban areas. Their creation is no longer the result of a purely technical

discussion, but it is one of the keys to a sustainable development and for the repression of car use (Rodrigue [9]).

Attractiveness of areas of exchange nodes is predominantly local zones (city or hinterland), so pedestrian and urban public transport are the dominant modes of attraction. Generally exchange nodes are organized around three principal functions: the “transport”, the “urban” and the “service” function. The “transport” one is used for the articulation of networks; the “urban” one through the integration in to its surrounding environment, and the “service” function for the possible association with commercial activities and information for the displacement of the traveler.

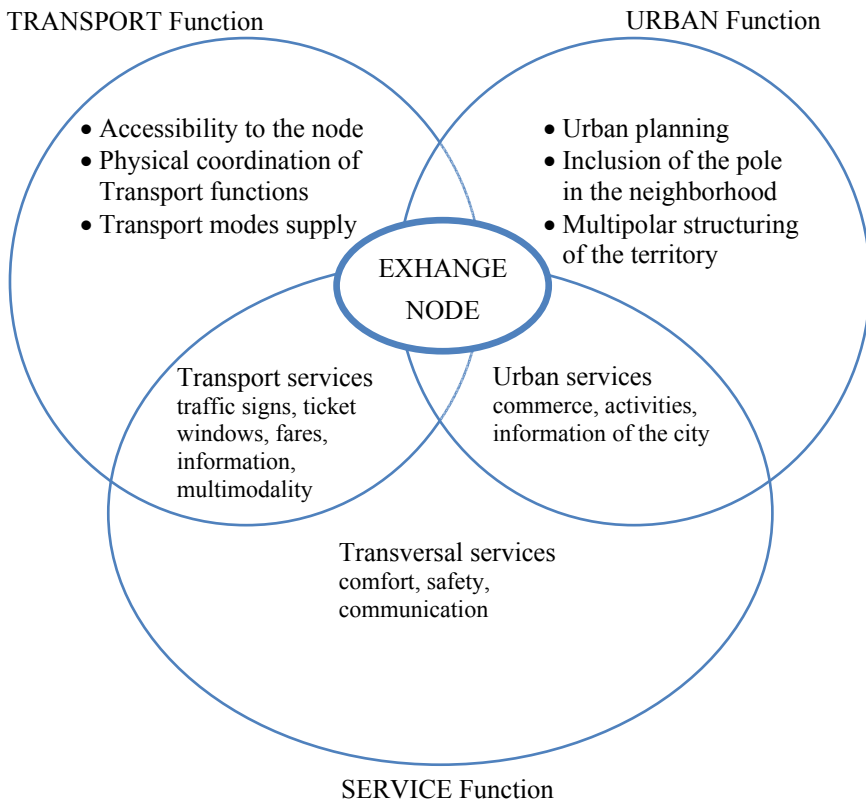


Figure 1: Three functions of an exchange node.

The diagram of figure 1 evidently confirms that the interaction between these three functions provides the fully explains the effectiveness of the exchange pole (Bavoux [10]). However, these different functions are often separated from each other into the management of an exchange pole. The poles of exchange that can be considered as a real interface between transport and urbanization are few. The presence of different modes of transport, different operators (with their services

that cannot be only transportation-related services), economic and/or complementary activities supportive to mobility processes, should be viewed in spatial terms. Interior spaces of different terminals (train, metro, taxi and bus station) should be known and, consequently, managed. This statement is also valid for external spaces assigned to transport modes used to collect passengers, as private cars, buses and taxis.

The assignment of spaces by type of activity is often a complex problem. The concept of exchange pole is related firstly to the purpose of integration of the different incident transport modes.

So the aim to reach the flows' fluidity has to be obtained as the total readability of the node structure and the limitation of the interchange times between different transport modes.

This objective is not easily and always reached: a typical example is the exchange parking area that is high space consumer; it needs an appropriate planning, design and the presence of bus, metro or train stops for the use of other transport modes. But the fact that the various and specific terminals are excessively diffused on the territory obviously prevents the concentration of parking supply.

The cause of these structural defects may be related to the temporal overlap of interventions required to adapt the territory to the evolution of transport supply.

The internal organization of the areas destined to different transport operators is tightly connected with the traffic volume of each mode.

The commercial supply on one side is related to the transport users and on the other depends on the degree of inclusion of the exchange pole in the urban tissue.

So the multimodal pole can be seen only as a poor transit point for some users connecting two separate areas of the city or a place where also occur commerce and activities connected to the daily life of the community.

6 Conclusions

The 7th Framework Programme requires funds directed to the design and creation of exchange nodes into the Research and Development field:

- to improve the coordination between different transport modes and their managers,
- to propose a model of innovative economic exchange hub,
- to establish the governance scenarios of the exchange poles, involving local communities, transport operators, private operators and services users.

The future of the exchange poles is strictly linked to a regulation of European harmonization process of the rules and their organization.

The European project "Link" recommended the creation of quality standards to apply to all exchange poles (CEN/TC 320). A strong collaboration between the railway operators, which are the main leaders of national and local transports, and CEN is required.

The creation of a design practical guide would be important for decision makers in order to dispose a help instrument for plan exchange poles.



From the economic point view it is necessary that the design of exchange pole is connected to a future vision in terms of financial impact of the infrastructure, potential growth of the city, of mobility and urban services expectations.

The associations of transport users censure their marginal status in relation to transport projects and to the organization of exchange poles.

But passengers are the principal actors using these infrastructures. So their interests can conflict with private operators' ones.

The most part of surveys conducted in different European cities evidenced the common user's discomforts in exchange poles: the dissatisfaction for service, cleaning and maintenance quality, the absence of equipment and services (WC, shops and refreshment).

Users depends by private motorized transport means because of the absence of a strict relationship between the collective transport modes involved in their displacements, especially in terms of quality for the provided information.

The necessity for the control authorities of urban transportation system to frequently check the quantity and the quality of level of services offered in the exchange poles is important for improving the user-mobility relationship. It is often overlooked, encouraging other carried out activity sectors (commercial and consumption centers).

Users who daily use the exchange poles are the main users of these sites. So the latter should primarily be public places opened to more and larger activities and services.

The adoption of standards-graphic representations characterized by a predetermined codes and scales to achieve these objectives, can be an important tool to foster users' urban movement (promoting knowledge of the exchange places) and to help the research universe: planners, managers, decision makers and technicians may find into these documents a set of practical guidelines to plan these places, their morphological structuring and sizing according to a number of discriminating themes (such as accessibility, intermodality, location of the modal of flows, and the quantification for the target surfaces).

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