Bridging the divide: Design's role in improving multi-modal transport.

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1.0 Introduction

For a public transport user to experience an efficient journey, the transport system should demonstrate the network effect (Mees 2000; Nielsen et al. 2005); combining available modes in a network to achieve their best capacity. The transport planning process exhibits an excellent opportunity to foster the network effect, displaying refined intelligent use of the available statistical information. However, there are limitations in the reach of planning alone. Statistical information is prone to disregard some finer points of transport operation; by viewing the world through a quantitative lens we can lose focus on users overlooked by our correlations and percentiles.

Incorporating issues outside the scope of statistical analysis leads to an informal design process within planning. These issues are generally unnamed in the literature; Vuchic (2005) alludes to the existence of "minor factors", parallel to potential travel demand that contribute to influencing transit travel. Usability is a significant contributor to the success of any product, including successful public transport. Physical, psychological and social barriers are evident in transport implementation (Bendixson 1974), and are difficult to predict and combat through planning with only quantitative data. In practice, the qualitative factors are analysed using a descriptive process; one role of design is to provide a proven framework for such a process.

The design process offers planners a means to identify and resolve a range of problems from a variety of viewpoints, beyond the constraints of traditional planning and its immediate theoretical boundaries. Following the design process in the planning stage, design will also contribute in the physical sense, as a product. Often dismissed as purely aesthetic, design content embodies information and solutions from disparate fields, whilst in contemporary ergonomic literature aesthetics is recognised as being integral to usability (Norman 2004). The product of design could be implemented as a partner to the planning outcomes, or as the embodiment of a specific solution. The authors recognise the informal existence of design in the planning process, the intention being to formalise and expand on its possible contribution with a focus on user-centric issues. Key to this exploration is the suitability of different stages in the design process to deal with multi-modal transport problems of differing maturity; pre-planning to post-implementation.

2.0 Background

2.1 A design process

Planning a transport system could also be described as *designing* a transport system. For purposes of clarification, we are concerned with the design process as it exists within the broader task of planning a transport system or part thereof; either as new or more commonly as a modification or expansion project. Discussing the evolution of the design process is beyond the scope of this paper; models of a specific design process showing the same fundamental stages continue to be published for application to specific disciplines. For instance, Green and Bonollo (2002) present a simplified model identifying these stages in a professional context, as shown in Figure 1.

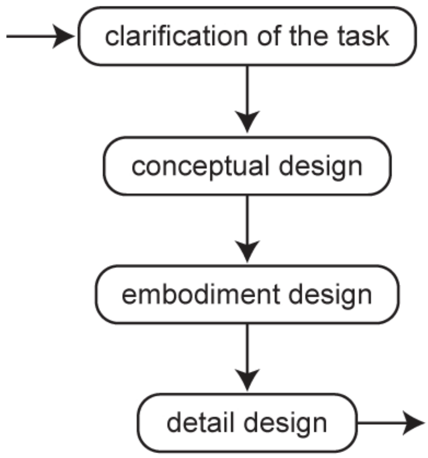

Figure 1, An example of a generic, professional design process.

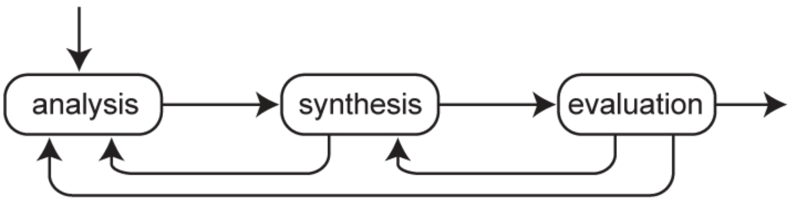

Figure 2, A generalist design process.

Further to this professional process model, Lawson (2006) identifies that any design process is not exclusive to a design or engineering profession but is a function of human nature; and although professionally formalised, the design process is exhibited by non-professionals and professionals alike. Lawson (2006) offers several design process models, an example shown in Figure 2, clearly exhibiting their cyclic nature and not limiting their application to any discipline.

As illustrated in the specific and general examples above, a design process can be utilised in a variety of different ways; as the impetus for research, for the interpretation of different data forms, distilling a particular problem and creating and testing suitable solutions. *The* design process does not exist; when confronted with an opportunity for its application a person or group would select and modify *a* design process.

When applied to a specific problem encountered in transport planning, the design process in any of its guises gives us tools for problems of a complex nature. Stakeholders at a variety of levels (for instance operator, passenger and maintenance engineer) might be represented in a specific problem. Here, a natural design process is cultivated in order to interpret demands into tangible planning and design inputs. The design process is flexible enough to offer an appropriate level of depth to a given problem, which may or may not require formalisation to achieve a satisfactory outcome.

2.2 The multi-modal problem

There exists a range of issues surrounding successful implementation of the network effect for any transit system, brought together by the overall theme of compatibility. In the user-oriented context, all transported journeys are multi-modal; the majority of which concern the user transferring a number of times from foot to motorised or mechanical means of transport and back again. Transfer is the core problem; through it multi-modal travel amplifies service inadequacies for passengers, and exacerbates incompatibilities between vehicles and environments. More positively, these problems present great opportunities for design input.

Travel by a single mode requires a certain level of accessibility for the passenger. It would be easy to accommodate the majority of passengers in the population, however this is a recipe for failure, as the principles of Universal Design (Connell et al. 1997) dictate that a successful products will accommodate the needs of *all* users, actions benefiting the whole spectrum of our user base. Fundamentally, transport must be accessible to users in every sense – a reasonable service provision, user access to the travel nodes with a navigable interior and a cognitively accessible system for which the node provides a connection.

In order to be successful, multi-modal travel must build on the above issues. The transit modes must now become accessible to one another while maintaining user accessibility. Literature identifies the potential gains to be made from slight increases or changes refining the service; encouraging routes to support each other through connections. What is often overlooked is that to be functional these connections must do more than exist; they must stimulate, or at the very least facilitate patronage through effective design. The network becomes a complex machine, more susceptible to failure because of the sheer number of moving parts. The importance of the relationship between these parts should not be underestimated.

3.0 Design input as process

As a precursor to physical products, or as an investigative tool in its own right, the design process has a natural ability to complement the transport planning process. Illustrated through an example, we discuss where the input might be required, in which ways it is appropriate to utilise such a tool, and some practical examples of specific process tasks. Three main points of design process are identified for application in the planning process.

3.1 The necessity for design process input

It would be rare to assess a situation and think '…we need a design process here…' the process is more likely to be naturally incubated as previously discussed. Where planning will benefit is by recognising the necessity for design (or design-like) processes in certain situations, and the rewards this will have for the project outcomes.

The necessity for utilising the design process as a planning methodology is most evident in tasks that represent many stakeholders; and therefore many foreign data points; ideas, concepts and points of view that are not normally represented by a conventional data set. Whether data is 'foreign' to an individual or not is a relative matter, the important point is that a design process allows synthesis of the information. For example, the task of encouraging transfer between two particular bus and tram routes has to carefully interpret requirements from two operators and two types of infrastructure whilst also representing passenger needs. The design process will enable clarification of what needs to be achieved – through research, and how the task can be performed – by interpreting and prioritising needs.

Less noticeable to some would be the design process requirement in a project of analysis; for example a study of pedestrian congestion while transferring in railway stations. The requirement for a design process in this instance, a refined task of study, is identical to that above, dealing with a foreign factor (human behaviour) in an otherwise controlled data environment; that of movement capacity, waiting space, information etc. The congestion situation is accurately represented by information of a more mathematical fashion, but representing the cause and possible solution is likely to be more complex than adding more space or another escalator. Application of a design process encourages divergent thinking and discovery, a present yet under-utilised tactic when processing mathematical data.

The two examples above exhibit different origins. The first, in addition to being multi-faceted, is a proactive project; we are aiming to achieve a goal that we believe will be a positive feature of the transport network. The second example of studying passenger congestion is more reactive, a direct investigation of a known phenomenon. There are differences in the data available for our analysis of the problems.

3.2 Interpretation of data

An important feature of a design process is that it provides the means to interpret different data types. If drawing exclusively on quantitative data, whilst the model will be accurate in so far as data points are concerned, this is prone to oversimplify the fluid nature of multi-modal travel by not illustrating the details which cause the data to occur.

Analysis of quantitative data can very quickly identify a problem and the declared solution. A good example of this is the aim in Melbourne to increase the share of public transport journeys to 20% of motorised travel by 2020 (Department of Premier and Cabinet 2001). The problem scope is very well defined through quantitative data, as is the point where success would be declared, yet the solution is much more complex and involves data foreign to the problem's definition. Synthesising foreign data is one strength of the design process; it enables us to assess information on a level playing field; simply put - how the information contributes to the given situation. Representing the needs of operators and users in a multi-modal environment is one example where this can be applied.

1. *The investigative design process interprets between the two types of data by breaking the project down into process stages, helping resist the temptation to skip ahead to premature conclusions. Definition of the stages is somewhat contradictory to their adaptive nature, but may be tentatively defined with reference to both Figures 1 and 2, as:*
    - *Indicator*
    - *Investigation*
    - *Action*
    - *Evaluate result*

The example in Figure 3 is a peak period morning bus being consistently late, and passengers missing their connecting suburban train – this is reflected in the quantitative data evident on the operator's time register; the bus arrives after train departure. Supporting this, other data shows that the bus is running at above expected capacity and the delay is caused by a hindrance of passengers' ability to join and alight from the service, especially the fact that almost all passengers alight at the railway station. While the data is accurate, there is information missing from the model that holds the answer; that the route often takes passengers whose destination is a long distance rail terminal, and that most mornings a luggage obstruction forms, blocking the exit foot-well near the door. The long distance passengers do not alight at the suburban railway station and therefore, cause the delay to the majority of other passengers who are alighting. In this case, quantitative data has successfully identified the problem, but an investigative process has identified qualitative information and effectively incorporated it into the project. An initial reaction to the quantitative data might have been to add services, or alter the timetable to cope with what looked like additional demand. In this case, the problem is of an entirely different nature, a possible solution being to substitute the vehicle for another in the fleet with a luggage rack.

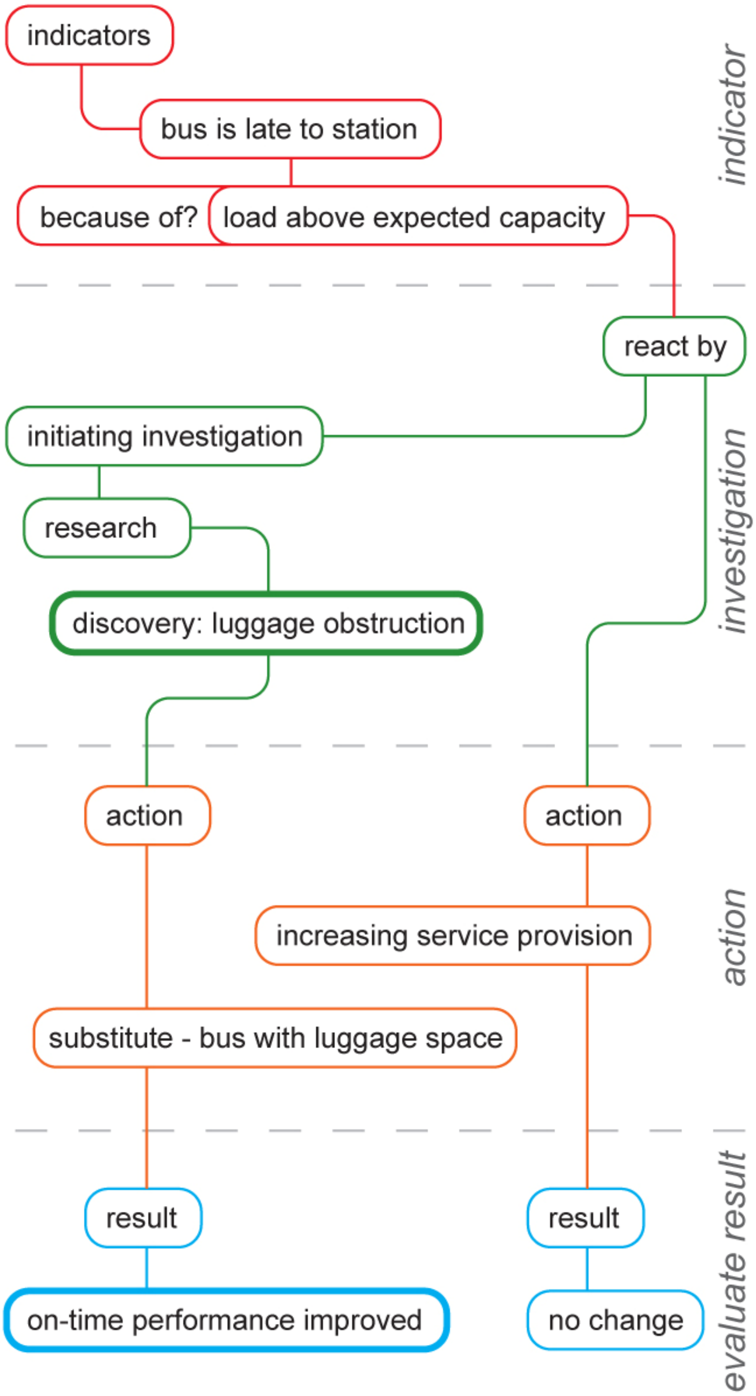

Figure 3, Quantitative data with qualitative solution.

When applied to this simplified example, the design process dictated that a complete discovery of contributing factors was necessary. Though the issue was defined in the quantitative sense of passengers arriving too late for their train, the core of the problem was qualitative – by clarifying the issue from 'the bus is late' to 'the passengers are blocked' we discovered the solution.

2. *The design process of clarification or analysis encourages professional curiosity and necessary caution of data, motivating discovery of the precise nature of a situation.*

3.3 Test processes

The design process can also be more of an analytical tool. There are tests which can be applied by translation from other design processes, and any design process also encourages self-analysis. These may be applied as part of an internalised design process as discussed above, or as an autonomous, objective method for assessing the suitability of solutions.

Firstly, an inherent feature of an applied design process is its cyclic nature (as shown in Figure 2.), representing a facility to self test. At any stage in a project, the current concept or idea can be compared back to the original problem for validation.

An important stage in the product design/development process is usability testing (Green 1997), a scientific process whose desired outcomes translate to a theoretical perspective, making it more appropriate to the transport planning process. The rigorous methods employed for usability testing adapt to what might be called 'user testing' of a transport plan; taking the position of one or many potential stakeholders or users, and analysing the proposal against their performance criteria. This can be applied in further stages to simulate a range of viewpoints in the multi-modal situation before the physical embodiment of a plan.

3. *The ability to foresee potential issues and identify positive characteristics of a concept while still engaged in planning would more than likely improve quality in a cost and time effective manner.*

4.0 Design input as product

Following on from the process-based input discussed above, the input of products contributing to multi-modal travel is typically conceived as a physical *solution*, rather than of design for its own sake. Design as product represents the physical embodiment of a decision making process, a matter of substance that incorporates the common misinterpretation of design as 'styling', yet reaches far beyond (Wijsenbeek 2003). It is very likely that the product contribution would follow on from the process contribution seen in part 3.

Developing and introducing new modes or systems to solve network, organisational or financial deficiencies is identified as an incorrect justification for new product development (Vuchic 1981). Whilst the authors uphold this view, there is little guidance in the literature for *correct* implementation of new design. This section illustrates possible methods showing how design can successfully contribute to multi-modal travel by examining some specific issues and suggesting design briefs. Whether the brief is embraced is a matter of what is set out to be achieved on a particular project, within obvious constraints such as time and budget.

We should look at the whole journey in the sense of a product. Many elements combine to form the *experience* of the trip (Bunting 2004), some of which we have more control over than others. Transport should be assessed in an overall "product" sense, if only in order to discover the parts which are failing the system as a whole. The individual parts, be they vehicles, components thereof, way finding systems or routes, for the purposes of this section are seen as products in their own right.

4.1 Transfer

A network comprised of many intersecting routes requires transfer points to make these intersections functional. A functional intersection (from a network view), or transfer node (from a passenger view) would unite two key factors; that the modes available create a desire to transfer, and that the facilities provided are conducive to that end. Horowitz and Thompson (1994) identify the myriad interrelating attributes of such an environment;

12 objectives for the successful implementation of a transfer site in order of importance:

1. Safety/Security
2. The Transfer
3. Access
4. Efficiency
5. The Passenger
6. Coordination
7. Environment, Physical
8. Environment, Nonphysical
9. Finance
10. Space/Site
11. Modal Enhancement
12. Architecture/Building

Although this list forms an instructive framework for implementing a new transfer environment, it dramatically understates the contribution that design can have in such an agenda. From a design perspective it is also somewhat contradictory, placing the importance of the environment (seventh and eighth) before architecture and building at 12th, arguably the same factor. Such a list serves to illustrate the tacit, if not at times overlooked, role design plays in any transport network. With the exception of network dependent factor six - coordination, design as product is positioned to contribute on all of these points - they are a matter of the quality of the built space and how this can impact on the usability, appeal and uptake of the transfer environment (Ittelson et al. 1974; Norman 2004). It should be noted that the above list can also read as possible sources of transfer penalty, a passenger's *perceived* value of transferring expressed as a constant time value (Currie 2005).

An analysis of contributors to the safety and security of public environments is outside the scope of this paper; suffice it to say that as per the principles of Crime Prevention Through Environmental Design (CPTED) (Cozens 2002) and the field of Environmental Psychology (Ittelson et al. 1974), the desire and need for quality, safe, secure public environments is universal. The CPTED principle however is prone to sacrificing other environmental attributes to achieve outcomes – going against our premise of approaching problems holistically. Under factor two - the transfer - design must react to the intricacies of each mode, and form an interface between both. The effort required in the process of disembarking from a train to meet a tram, a common occurrence in Melbourne for instance, is enough to make the transfer penalty too great for some, especially the uninitiated such as visitors and new arrivals. There are physical barriers; the transfer site is often stretched over 100 metres, cognitive barriers; decoding the local area maps, route, timetable and fare information, and psychological barriers; unfamiliarity with the area. At present, the two modes are incompatible in the same environment, yet design as product could bridge the divide.

Design of the site encompasses access issues, making ingress and egress easier for all users, especially users with any disability who may experience a greater transfer penalty. Universal Design literature documents these issues well, but is let down by not being enforced. Disability Discrimination Act (DDA) compliance occupies space on the opposite end of the spectrum; the principles are not as sound but they are implemented by law, providing the necessary encouragement for adoption.

Much emphasis has been placed on the station for the transfer to occur; as is often the case vehicles are interpreted as an unyielding factor in the network scheme. Examples such as low floor trams and buses, new tram stops and train rolling stock with wider or more doors have contributed to reducing transfer penalty and show that physical elements can change for the better, however slowly. Perhaps more quickly and easily realised gains are expressed through the network and the design of suitable timetables.

4.2 Mode combination intricacies

Vehicles exhibit limitations to multi-modal travel, especially when we consider the incorporation of personal modes into the transport network. For example Nielsen et al (2005) suggests that the catchment area of a public transport node, say bus stop or railway station, can be increased by ten times if the conveyance to the node is changed from walking to cycling. They offer the practical suggestion that comfortable, attractive routes and adequate storage should be provided if such gains are to be made. This suggestion, while accommodating the trip *to* the pick up point, ignores the onward journey, where there is no bicycle available once the train or bus arrives at its destination. Design of vehicles can, and in several instances has alleviated this problem by allowing bicycles to be carried on buses in order to encourage mode combination (ACTION Authority 2006; Martens 2007).

More commonly modes are combined with walking, a mode in itself requiring no additional equipment in the majority of cases, and very few restrictions on ability. Walking is also highly complementary to public transport (Wright 1992). Vehicle accommodation has come to a stage however where it is assumed that passengers only require the amount of space associated with walking. Issues arise when our walkers begin carrying luggage, wheeling shopping buggies, carrying and caring for children or have difficulties in moving unaided. Certain routes at peak periods are practically jammed with schoolbags, the vehicle having been designed for human occupants but not their personal effects. Fear of discrimination litigation has stimulated solutions for some of these more pressing user issues, but these 'self inflicted' yet completely reasonable handicaps such as shopping remain largely ignored. What is required is increased versatility of the occupant space inside the vehicle, enabling it to adapt to a variety of user needs. The difference in the usage of a train carriage for commuting and weekend travel is another important mode combination. A single vehicle needs to be capable of accommodating travel for different purposes, mirroring the behaviour and desires of potential passengers.

4.3 Cross fertilisation of positive modal attributes

The lines separating different modes are ever blurring; for example buses operating in a fashion evocative of light rail through Bus Rapid Transit, or guided through city centres by rails laid in the street in Guided Light Transit. The design methodology of transferring positive characteristics from one mode to another is well demonstrated by these examples. Distinctive modal qualities identified in the literature include permanence, familiarity, reduced pollution and environmental issues (Newman & Kenworthy 1991), accessibility, modal right of way, passenger interface and adaptability (Griffin et al. 2005). Each represents design opportunities for interpretation into other modes, improving the strength of the individual mode and through it, the network.

The permanence of a mode has three important implications; visibility, reliability and land use. Modes such as metro rail display high degrees of permanence by virtue of their necessary infrastructure. The visibility of a metro allows passengers to locate services by the large stations and just as importantly the combined rails, rights-of-way and overhead wires strung between them. The infrastructure also prominently displays the level of commitment the planning process has undertaken, and so lends an element of reliability to the services within. Permanence of transit also affects land use, with activity centres attracted to transport nodes. Bus routes in the same city might be equally permanent in planning and demand terms to the metro lines (Hensher 1999), but they have very few outwardly visible permanence characteristics. Bus stop signs spaced at 800 metres give the potential passenger - who might be at the other end of the street - little indication of the route proximity. Dedicated quality bus lanes that have been painted are generally done so to alert road traffic to the nature of the lane, but have a flow on affect for visibility to potential passengers, an advantage - if a costly one - of tram infrastructure over bus.

Familiarity of a particular mode is relative to the individual passenger, yet design as product can contribute to the overall look and feel of a mode to make it consistent across the mode choice spectrum. Refined through another attribute; passenger interface, the contribution of design can unite the modes, making them all familiar. This is more commonly expressed in corporate identity and integrated ticketing systems which make good business sense, but should be carried further into vehicle livery and fit out to achieve greater usability.

The 'sparks effect' (Newman & Kenworthy 1991); the increased passenger appeal of electric over diesel energy, is caused in part by a reduction or elimination of localised atmospheric pollution. From a global perspective, reduced pollution is seen as a positive step for transport modes. More immediate gains can be made for multi-modal travel if we identify the challenges evident in bus interchanges compared to electric tram interchanges. The main difference is the lack of localised pollution; otherwise they are street-based with similar architecture. With careful design and appropriate resources, bus environments could be made more appealing, the investment paying off with the increased suitability for development, normally associated with rail interchanges.

A more holistic attribute is adaptability. We have already discussed the capability of a mode to adapt to various personal effects and journey types in section 4.2 which examines usability issues. Further adaptability of modes brings forward manufacture and implementation issues such as evolutions in technology or hybrid power sources seen on duo-buses. Adaptability of a mode in this sense is a key factor in all the above examples, an ability to adapt to new methods of improving transport.

5.0 Discussion: Bridging the divide – Design as mediator

This paper has put forward some new ideas that will assist the planning process in more closely achieving its goals. There exist a range of factors that are acknowledged by the planning process, but understandably under-utilised in their input. This is not to say that the goals are simple or even easy to define, quite the opposite; we have discussed only some of the major contributors to successful multi-modal transport. These constituent parts can be theoretical, physical or both; and the contribution of design is to equip us in 'bridging the divides' that lie between them.

5.1 Theoretical divides, process solutions

There is a separation evident between planning and the end-user of a transport system. Although the statistics of population, movement, ridership, et cetera are based on the very users we plan for, the sum does not represent its parts. When we plan we design, yet the designing needs to be taken to a finer level to support and encourage the desired, planned, outcome. As networks are designed primarily for users, they will necessarily also be designed for supporting secondary perspectives to achieve this end such as daily operations, the systems' construction, and possible expansion; a dependence that furthers differing of perspectives of what constitutes an 'ideal' transport system. This is the type of problem that we can address in the process area.

Staying with process, the next gap is between the data types we have at our disposal. The design process offers a system of assessment for qualitative and quantitative data against the original projects' criteria. Demonstrating the cyclic nature of the design process that can be invoked whenever necessary, this method can be employed regardless of data input, in a situation where it is wise for a project to self test and refine before moving on to implementation.

5.2 Practical divides, product solutions

The direct, physical issues that exist in multi modal travel can be divided into two groups; System and Human. This division is proposed as a means of separating the core issues within the design product. Vehicle scale represents compatibility issues between modes, buildings and environments. Human scale refers to issues that arise from human interactions with their environment, usability and psychology.

On the system scale, moving towards a network effect confirms differences between modes. Of course different modes are necessary to provide service to a range of situations, but there is a chasm of compatibility in transfer environments. Once we begin to think not of individual modes but of the *system* we can more easily conceive of the products required to realise the network goal. These will be new products, as the experiences and statistics of our potentially transferring passengers tells us that simply having a bus terminate near a railway station is an insufficient conduit to multi-modal travel. What might be seen as detail in this situation is just as important as establishing the transfer point in the first place. There is no transfer without an effective environment, way finding systems, simplicity of fares and an understandable mapping model of the system our user is engaged with.

The different modes present in the network are evolving. As products, these vehicles are expensive, are acquired in an institutional fashion and have long life spans, making the evolution process comparatively slower than consumer products. One divide that can yield a positive outcome is the physical differences between these modes. Modes can and should take advantage of successful technologies and ideas from others where appropriate. The literature is quick to point out that modes should work together in an operational sense, but this needs to be extended more deeply into the design of product.

On a human scale, we are dealing with usability of the network. There are gaps evident between a transport user's intentions and what it is possible to achieve. This also applies to the theoretical planning side in section 3, but here we are concerned with usability. There is a requirement in all transport systems for an accurate, practical representation of the system so that our user may most effectively use it to their advantage. Once the user has their travel plan in mind, it is also our duty to facilitate its execution in as pleasant a way as possible. Design products, in conjunction with planned network superiority will empower the symbiotic relationship between user and network.

6.0 Directions

In contrast to their individual attributes, in a collective sense transport users, and *public transport* users in particular are not simple customers. Additional to this complexity, we have such a range of options in the form of modes with which to accommodate these needs that the planning process can easily become clouded in its intentions. Design presents a methodology to implement simple principles in this complex situation. The authors have identified the inputs of the design process and of design products in order to offer a new or refined set of tools to make the planning process more human-centric, and to more easily recognise and interpret the gaps between a desired outcome and its successful delivery. While acknowledging the current role of design in the planning process, there is call for its utilisation in managing projects, testing and refining their outcomes and recognising all possible forms of product input that have the capacity to improve multi-modal transport.

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