

## Station Access and the Modern Transit System

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### Abstract

*A discussion of new starting points for better, more proactive station access planning approaches.*

Station access planning is re-emerging as a vital component of the overall suite of initiatives needed to make public transport systems work effectively. Without proactive access planning and access infrastructure improvement, the overall travel experience for public transport users is invariably diminished, and it may be that significant ridership potential is also forgone. It is only through a view that supports and enhances the “total journey” (including access and egress) that transit can compete with private travel alternatives.

The paper analyses figures for station access and egress in the BART network (of the San Francisco Bay Area) – and uses these figures to develop station access “typologies” or “categories”. Interpretation from the figures and the categories is then delivered with a view to informing new efforts in access assessment, planning, design, and infrastructure provision.

Advanced station access planning approaches would look at multi-modal and transit transfer questions, but also address pedestrian and bike access elements. But a first step may be to clearly *understand* actual access/egress usage, in order to then determine how planning and infrastructure development should proceed, based on preferred outcomes.

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## 1. Introduction – the centrality of access for improved public transit

This paper analyses and interprets station access performance in a notable rail system in order to offer new insights into the future of mass transit. Beyond the figures themselves on access modes, a reasonably radical concept is put forward here – namely that a transit agency or transit stakeholder’s own interests extend significantly beyond the boundaries of its engineering system, properties, and realms of immediate policy influence. Perhaps transit agencies are *not* at the mercy of “external” or “endogenous” influences only with regard to their ridership figures, and the view of customers and non-customers alike about the desirability of their transport offering.

We know from the established literature that transport journeys are a choice, made on the basis of the competitiveness and attractiveness of a “whole-of-journey experience” involving transit-based legs or components, versus a “whole journey” utilising other modes (mainly the car) (Brons et al 2009; Givoni & Rietveld 2007; Hine & Scott 2000; Martens 2007; Mees 2010; Semler & Hale 2010; Wardman 2004). This choice is often put forward by specialists as an *economic* trade-off, in which the generalised cost of alternatives can be compared (DePalma et al 2008, ch16; Litman 2011; O’Sullivan 2007, ch10; Wardman 2004) – and to a large degree this appears to be a useful abstraction. But our understanding of the “cost” of the various components of transit-based trips is still evolving. It often involves the simplification of assuming that the “cost” of a journey to-and-from a mass transit station is simply a function of time taken. At times the additional “cost” of “walking time” or “transfer penalty” is also brought into the equation (Litman 2011; Wardman 2004). Again, these are usefully simplified assumptions. But the detail and complexity of the access component of journeys is often lost. The comprehensive meta-analysis performed by Wardman (2004) suggests that most existing studies simplify rail access into “walk time”, and disregard other access modes (or actual walking *conditions* for that matter). Potential options for *improving* the “generalised cost” and competitiveness of public transport-based trips can be and *are* missed in much of the literature. It appears that the long-term dominance of modelling in the science of transport engineering is leading to analyses in which options for change are de-emphasised in favour of abstracted attempts at developing predictive models (see Ruesser et al 2008; Debrezion et al 2009 for examples).

An entirely different view of mass transit as a business could be centred very practically on the *potential access catchment* of individual stations (Brons et al 2011; Vuchic 2005, ch5). This would include access possibilities by walking, cycling, feeder transit (Brons et al 2011; Mees 2010), and the car (where appropriate). In this sense, a transit agency’s ridership would be a function of the familiar exogenous “macro” factors like population and economic wealth, but the *connectivity of catchment populations and markets to existing stations* would be brought into the endogenous realm – where transit agencies and other stakeholders could plan, intervene and act in order to purposefully improve connections and grow ridership (Brons et al 2011). Presumably, once taking this path, agencies and supportive stakeholders would concentrate on the most cost-effective investment options for improving connections and growing ridership (Brons et al 2011). Better access outcomes and growth would presumably be founded on evidence-based understandings and planning processes. Better connections to stations would surely involve better journey conditions to-and-from surrounding areas (Brons et al 2011; Green & Hall 2009). Conditions of arrival, entry, transfer, wait-time and more within stations could be seen as access-related issues *to be improved* (TCRP100, ch4) - not just as elements of an abstracted “generalised cost” (as per Wardman 2004). This implies a need for improved design of stations to facilitate these journey elements – but also the idea (under-developed in the literature, but reasonably obvious) that the design of stations should be *a function of existing and desired access contexts* (see Queensland Rail 2010 for a recent example of a station design guidance document that treats access as a largely peripheral issue). In simple terms – a park

and ride station has its own needs and components, so does a station where high rates of bus-rail transfer are encountered, and the design possibilities and needs for stations with strong walking and cycling access are a different thing again. A step beyond this is to consider whether transit agencies may wish to alter the dominant access paradigm over time toward a more sustainable and cost effective outcome through planning, design and infrastructure (e.g.- BART 2003; WMATA 2008). Some studies have recently suggested that despite the problematic “cultural” effect of access conditions being considered “external” to the transit agency, enhancements and changes in access remain among the most productive and cost-effective ridership-generation options available to those agencies (Brons et al 2011). Through this paper, new steps in this direction are advocated, based on a clearer initial view of prevailing access *conditions*, usage patterns, and performance.

## 2. BART and the Bay Area – a mini case study of access & egress

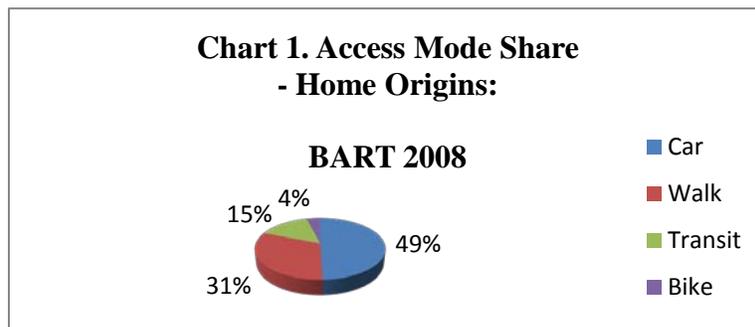
In the United States, BART of the San Francisco Bay Area provides a useful example in which solid data on access modes at station can be contextualized against well-developed access planning frameworks and policy contexts. For the bulk of this paper we use BART, its access conditions and policy contexts, as a case study for mobilising a better understanding of station access planning futures.

### Planning context and settings

BART champions an access planning approach based on a clear hierarchy of modes (BART 2003, esp ch2). The “active” modes of walking and cycling sit at the top of this stated hierarchy, with feeder transit at the next tier, and park and ride access afforded lowest emphasis in forward planning. But as with any planning policy or framework, BART’s access hierarchy does not exist in a vacuum – and must be seen as a response to existing conditions and pressures in order to be fully understood and engaged-with. In this sense, our first port of call in statistical terms should be an overall breakdown of daily station access across the BART system.

### BART - System-wide access & egress by numbers

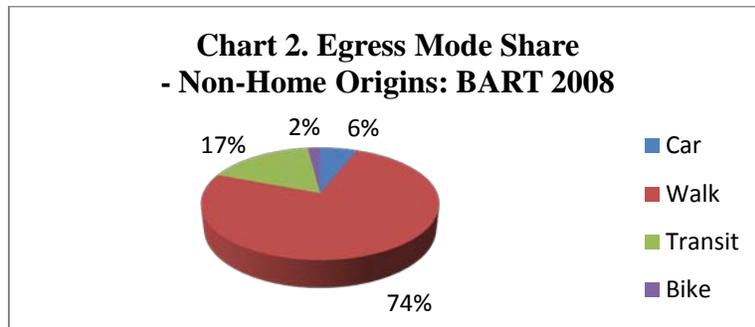
The figures below (chart 1) provide an insight into the work needed to shift access mode shares from prevailing conditions in order to meet the stated access hierarchy goal over time.



Through this initial and most over-arching breakdown of home-origin access figures (from BART 2008), we see that as at 2008, BART was a system heavily-reliant on car-based access – with around half of all access occurring by this “least preferred” mode (in policy terms). These figures can be interpreted as an outcome of BART’s *network concept* – of its status as a rail network primarily providing connections from suburban dormitory suburbs to urban CBD-type

destinations (in San Francisco, Oakland, and perhaps Berkeley). Equally, it can be interpreted as a logical outcome of the access planning approaches mobilised during the initial development of BART during the 1960s and 1970s – a period that saw heavy car parking provision at suburban stations as a default access infrastructure approach. Actual conscious planning intent during that period is an interesting and perhaps non-resolvable philosophical question, but it is apparent that for the most part, BART was planned with cars in mind as a primary home origin to station access mode. Certainly, the infrastructure actually *provided* suggests that the primary intent was to facilitate car-based access for morning commute journeys from suburban locations to employment centres via BART.

Another aspect of interest might be the recent change dynamic in overall access mode shares. Figures (BART 2008) show that rates of car-based access for BART remained constant between 1998 and 2008, that walking has increased its mode share from 26% to 31%, and that transit-transfer access shares have fallen from 23% to 15% (this is perhaps the most notable and assumedly challenging change dynamic for BART planners). Rates of bike access have remained relatively static with a 1% increase from 1998. If an overall picture from this change dynamic is to be interpreted – it might be suggested that BART has remained firmly car-centric over a 10 year period, while feeder transit has fallen perhaps worryingly (in percentage terms), and a latent demand for walking-based access appears to be asserting itself. Finally, in terms of over-arching figures, the question of egress mode shares may also warrant interpretation.



As the figures above demonstrate, egress is inherently a journey component more oriented to walking and connector transit services. It remains to be seen whether new international views on dual mode transit/bike journeys (via facilitation of on-train carriage of bikes, and hire bike schemes perhaps) allows biking to play a greater role in station egress in years to come. But at this stage, bike-based egress options are marginal for BART. Recent historic trends (1998-2008) show that car-based egress has fallen (by 3%), walking has increased (by some 7%) and a fall in usage of connector transit (of 5%) has been recorded (BART 2008). Bike usage for egress remained static.

**Current status and potential futures**

In summary, based on the figures demonstrated here, BART faces significant work to move over time from a car-based access reality into a paradigm focused primarily on walking, cycling and feeder transit access as preferred and dominant modes. In this sense, the stated station access planning goals exist in a challenging setting. At the same time, egress figures demonstrate the degree to which walking is an inherently logical and important mode of connection between stations and activity-generators. Biking remains in a minority for both trip components – but one with significant potential if we cross-reference BART’s stated access planning aims to the mode shares that are achieved in international systems (e.g. – the Netherlands, as discussed in Martens 2007), and perhaps at certain individual stations within the BART network itself.

### 3. Using BART’s figures to develop typologies of station access

Moving on beyond an overarching system-wide view, clear and dramatic variation is observable in the prevailing or dominant modes of access at individual stations. The station-by-station mode share figures for access and egress to BART are used in following sections of the paper for two purposes: firstly, to develop an early-stage series of access “typologies” based on observed access mode split paradigms in a notable rail system; and secondly, to provide greater focus on actual performance and future potentialities for access to BART itself. This case study can then perhaps be generalized to other locations or cities. The analysis below describes access and egress *usage*, which is clearly based on a variety of factors. Some discussion of access condition factors will be engaged later on, but the primary aim of the paper is to pioneer new methods to *describe* usage. This may seem at first obvious - but is an important and original research program, in that clear descriptors for observed access and egress usage have not emerged in the literature so far.

It should be noted that the analyses below deal with access “vectors” – and either home (H) or non-home (NH) access journey origins (hence vectors) are nominated, based on the specifications of BART’s data. Data for this analysis comes from BART’s 2008 “Station Profile Study”, and readers interested in the survey method employed should refer to the original document, where approach is outlined in greater detail (BART 2008). But in summary, these input figures come from data accumulated across some 50,000 respondents, who were randomly approached at BART station entrances. While there are undoubtedly a variety of issues surrounding any survey approach, this author recommends that readers accept the figures provided as *broadly indicative* of usage patterns.

**Table 1. Proposed access/egress usage categories & performance thresholds**

<b>Category</b>	<b>P&amp;R</b>	<b>Mega P&amp;R</b>	<b>Motorised</b>	<b>Transit transfer</b>	<b>Active</b>	<b>Transit oriented</b>
<b>Key threshold proposed</b>	<b>50% - 64% car-based access/egress mode share</b>	<b>65% + car based access/egress</b>	<b>50% + mode share for combinations of car-based &amp; transit based access/egress</b>	<b>30% + mode share for feeder transit access/egress</b>	<b>50% + mode share for combinations of walking and cycling-based access/egress</b>	<b>50% + mode share for combinations of walking, cycling, &amp; transit-based access/egress</b>
<b>Discussion</b>	50% + represents a majority/dominant car-based access paradigm – but most BART P&R stations see far more car-based access than this threshold	Large numbers of BART stations see far beyond the 50% mark for car-based access/egress – hence this stand-alone category is proposed.  The antithesis of BART’s stated hierarchy	Identifies stations where infrastructure for P&R & transit transfer logically dominates.  Includes ~ 10% mode share minimum stipulation for transit modes.  These stations presumably draw from a geographically broad rider catchment	Identifies scenarios where substantial transfer is occurring, hence specific infrastructure probably required.  Presumably a relatively favoured outcome in BART’s hierarchy	One of the more interesting usage patterns where observed.  Indicates favourable built-form context. Also points to “what is possible” with strong active mode infrastructure	Demonstrates a favoured usage pattern based on BART’s own access hierarchy and policy goals.  Existing conditions reflected – but BART is <i>actively seeking to develop this usage pattern</i> over time.

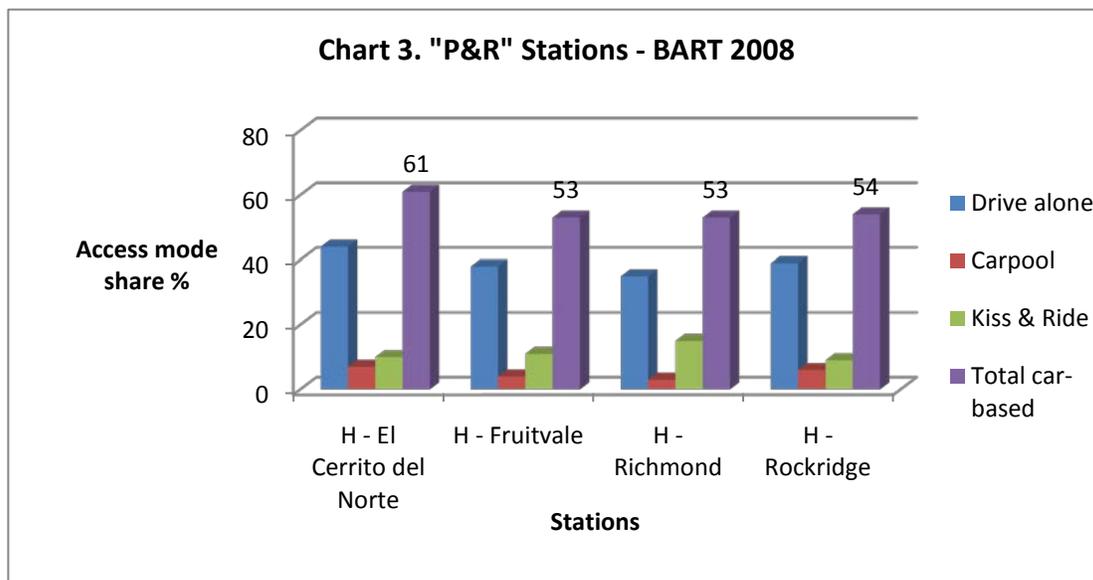
### Categories & Thresholds

The table above describes the *thresholds* that emerged during initial analysis, which were then consolidated into six proposed station access *categories* representing recognizable paradigms. A 50% “starting point” has generally been auctioned as a threshold - as it seems to represent the *dominance* of particular access dynamics, but in other instances different thresholds have been improvised. Readers should remind themselves throughout that at this stage of the research, the thresholds and categories are proposed for consideration and discussion, rather than insisted-on as conclusive parameters.

## 4. Categorisation analysis across the BART network

### Park-and-ride stations

Two typologies have emerged for parking-dominated stations from observance of BART access figures. These are “P&R” (park-and-ride) – for stations where at least 50% of access appears to be by car) and “mega-P&R” for stations that are *overwhelmingly* dominated by car-based access, with at least 65% of access by private vehicle. The car-based access mode share figures listed in chart 3 are an accumulation of figures for access by “drive-alone”, “carpool” and “kiss-and-ride” as per BART’s own statistical approach.

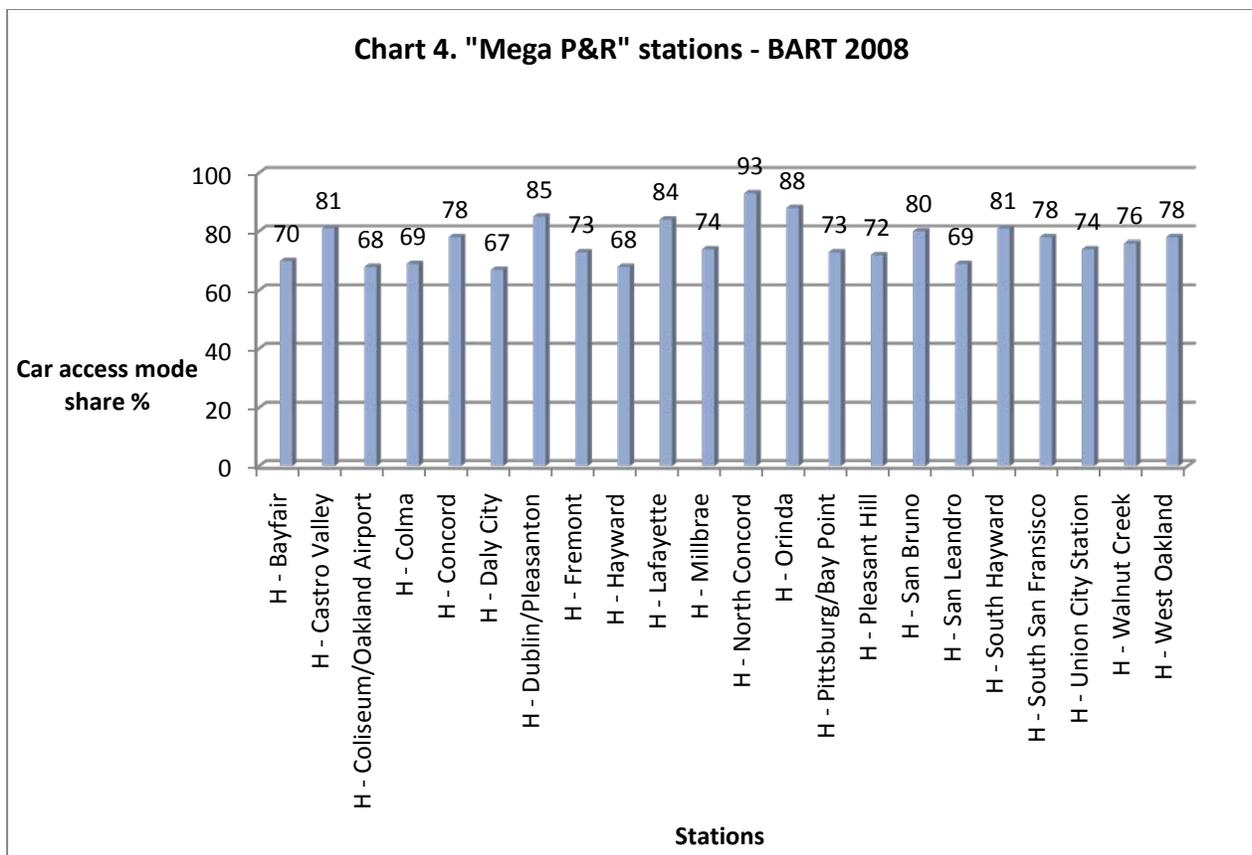


As we can observe here, a limited number of stations could be labeled “park and ride dominated” if we accept a tentative “P&R” typology of 50% - 64% access mode share to cars. We also observe the relatively limited and reasonably constant level of access by carpool and kiss-and-ride. But perhaps more interesting is the number of stations (or access vectors) in the BART network where an even greater level of car-based dominance is observable than appears in this listing of four stations.

At first, it was assumed that a “Park & Ride” category would be logical, and that a 50% threshold represents a useful categorization, based the dominance of car-based access usage at those locations. But during analysis, it emerged that the bulk of P&R dominated stations were seeing

rates of P&R far beyond the 50% threshold - hence two P&R categories seemed logical, and are auctioned and proposed for reader’s consideration.

We witness in Chart 4 the very large set of vectors (all home-origin access trips) to BART stations in which what could be described as *extremely high levels* of park and ride dominance is occurring. Overall, there are 26 stations in the BART system that could fit into either the “P&R”, or “Mega P&R” typologies. This appears to apply to access vectors for a large proportion of all BART stations, and this early diagnosis of “car-based access dependency” is borne-out by the overall level of car-based access system-wide, the suburban-to-urban nature of the BART system, and simple on-the-ground observation. It remains to be seen in future iterations of this research program how typical or atypical the car access dominance of the BART system is when compared to other US or international systems. But in simple terms – BART’s stated access hierarchy policy of emphasising sustainable mode-based access (BART 2008) exists in a very challenging context, based on existing conditions such as these.

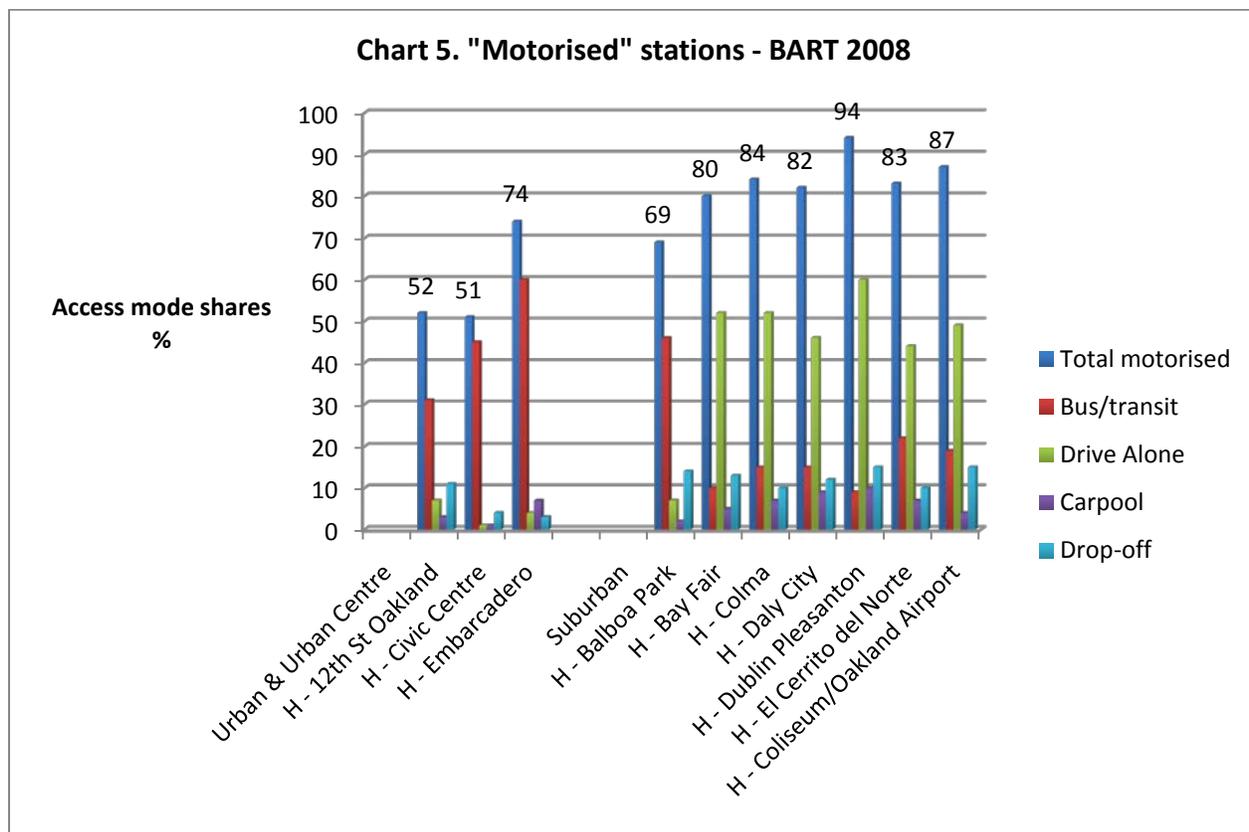


**Motorised Stations**

The next proto-typology that emerged formatively, based on BART mode share observations, is the “motorised” station type. This station type is suggested to be one where a *combination* of cars and transit-based access is observably dominant. In the BART context, transit-based access is primarily light rail and bus routes, with some lower-volume “feeder bus” services also in operation at specific locations.

Different typologies presumably demand varied access infrastructure, design and even station configuration treatments – so it is believed that the ready and accurate apprehension of the

prevailing access/egress dynamic at particular stations can provide a step forward in planning terms. “Motorised” access conditions are indeed a unique set of conditions – but this concept has so far not appeared to any great degree in previous literature or research.

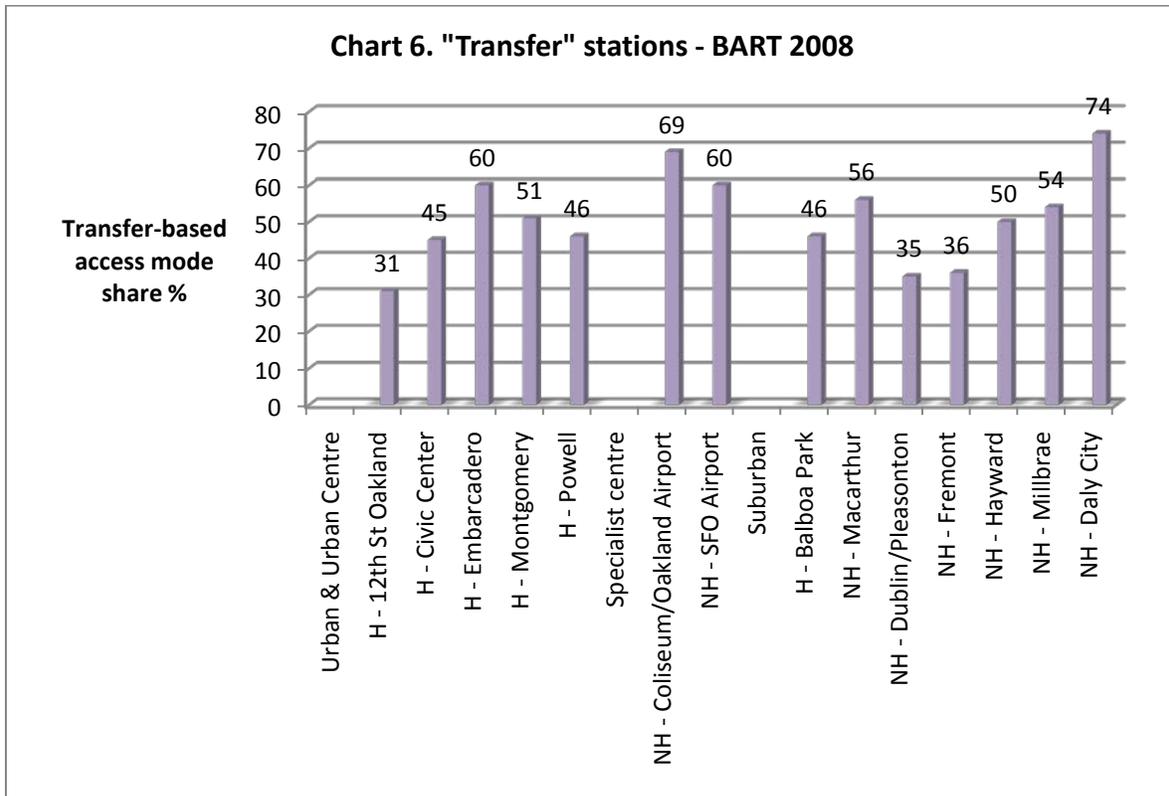


Grouping BART stations into a “motorised” category based on observation of 50%+ mode share to a combination of car and transit-based access modes, inclusive of a minimum of around 10% transit-based access, produces this interpretively intriguing chart. Here we see a solid set of suburban stations that can be labeled as “motorised”, plus three primary urban stations in San Francisco and Oakland whose transit-based access dynamic renders them highly motorised. Again, an early-stage interpretation or recommendation might be that these station types are distinct – and deserve a distinct access planning treatment, whether to grow access levels at existing mode splits, or to “grow and shift” concurrently into a more sustainable, feeder transit-based access paradigm. We might again begin to raise the question of station design or facility design after viewing these figures. It would seem that stations with a highly “motorised” access paradigm demand particular design treatments.

**Transfer stations**

A newly-proposed “transfer” categorisation provides another interesting, and perhaps somewhat more familiar insight - by grouping stations with similar characteristics of strong access by transit modes other than heavy rail. These could be light rail, “standard” bus, or “feeder bus” in the BART context. Here, a 30% + mode share for transit-based access has been nominated and used as a benchmark level of attainment for stations to enter the “transfer” category. It is surmised that this level of transfer activity is (broadly) sufficient to require specific infrastructure treatments.

Interestingly here, a significant set of stations seem to be working with access vectors that are strongly transit-access based. These include several home-origin (H) journey types via downtown San Francisco and Oakland stations. Equally (and very logically and expectedly given the internal airport shuttle services) the two major airport stations stand out as having strong non-home (i.e.- airport-origin) transfer-based vectors.



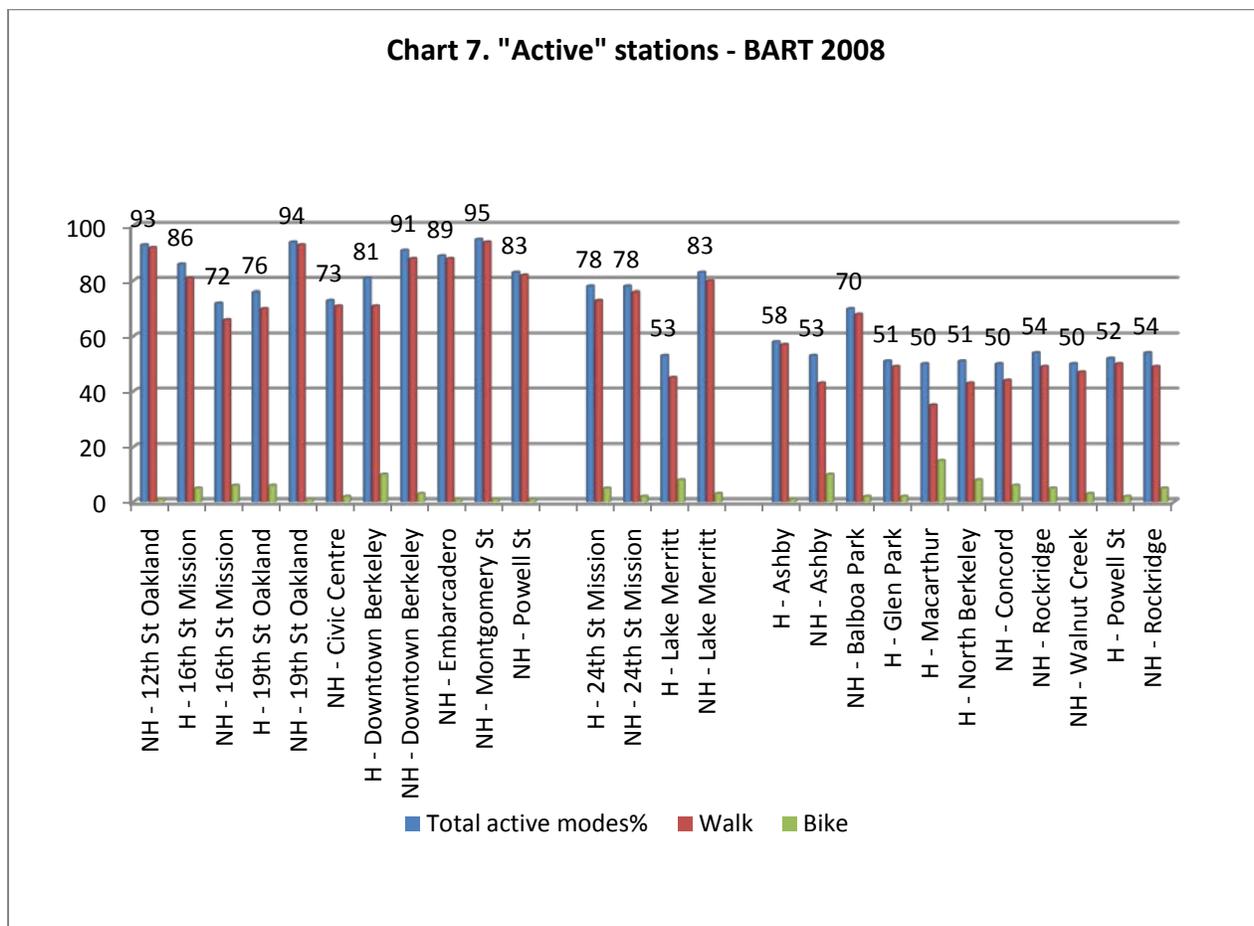
But perhaps of most interest are the suburban locations that see high rates of transfer-based access, especially it appears for journeys with non-home origins. In a practical sense, it can be assumed that these are often journeys involving bus or light-rail access from a work origin (probably in the PM peak). But equally, it can be (almost) assumed that there is some aspect of localised *quality-of-service* for transit-based transfers onto BART that facilitates the high rates of transfer occurring at these stations. Balboa Park features Muni light rail interchange opportunities, but the remainder are bus-based – including the specific “feeder”-type services offered at a station like Macarthur. While infrastructure and route structure would be presumed aspects of “service quality”, frequency of feeder transit services would be another contributing factor from the operational side. In simple terms, high rates of transit-based access can only occur where levels-of-service for transit-transferability are strong enough (for some reason or other). One potential interpretation from these figures would be that *transfer occurs robustly where it is offered as a convenient and workable option* – and the obverse is probably equally true. BART’s “transfer” stations may offer clues for planning and operational efforts in other locations – in that prevailing conditions are conducive to transfer, and possibly worth replicating.

A next step in interpretation and recommendation might be to suggest that stations with this access paradigm would logically require specific design treatments to facilitate ease-of-access. From on-the-ground observation it is clear that downtown San Francisco stations such as Civic Center, Montgomery, and Powell offer “internal” transfer opportunities “within” the same station facility (between Muni light rail and BART). But the quality of design treatments for facilitating inter-modal transfer at the suburban stations in this list is open to critical interpretation in many cases. In many of

these examples it may be level-of-service from the feeding transit mode(s) (i.e frequency, service span, route effectiveness), rather than level-of-service in the design of the station's *transfer facility* that is leading to robust transit transfer mode shares.

**Active stations**

Another emergent typology is the “active” station, which has been based on a 50% + majority for access by walking and cycling in observed access/egress vectors. The Active stations listed below are interesting because of their diversity – a mixture of urban centres, urban locations, and suburban locales is represented, and a fairly even mix of home and non-home origins emerges.

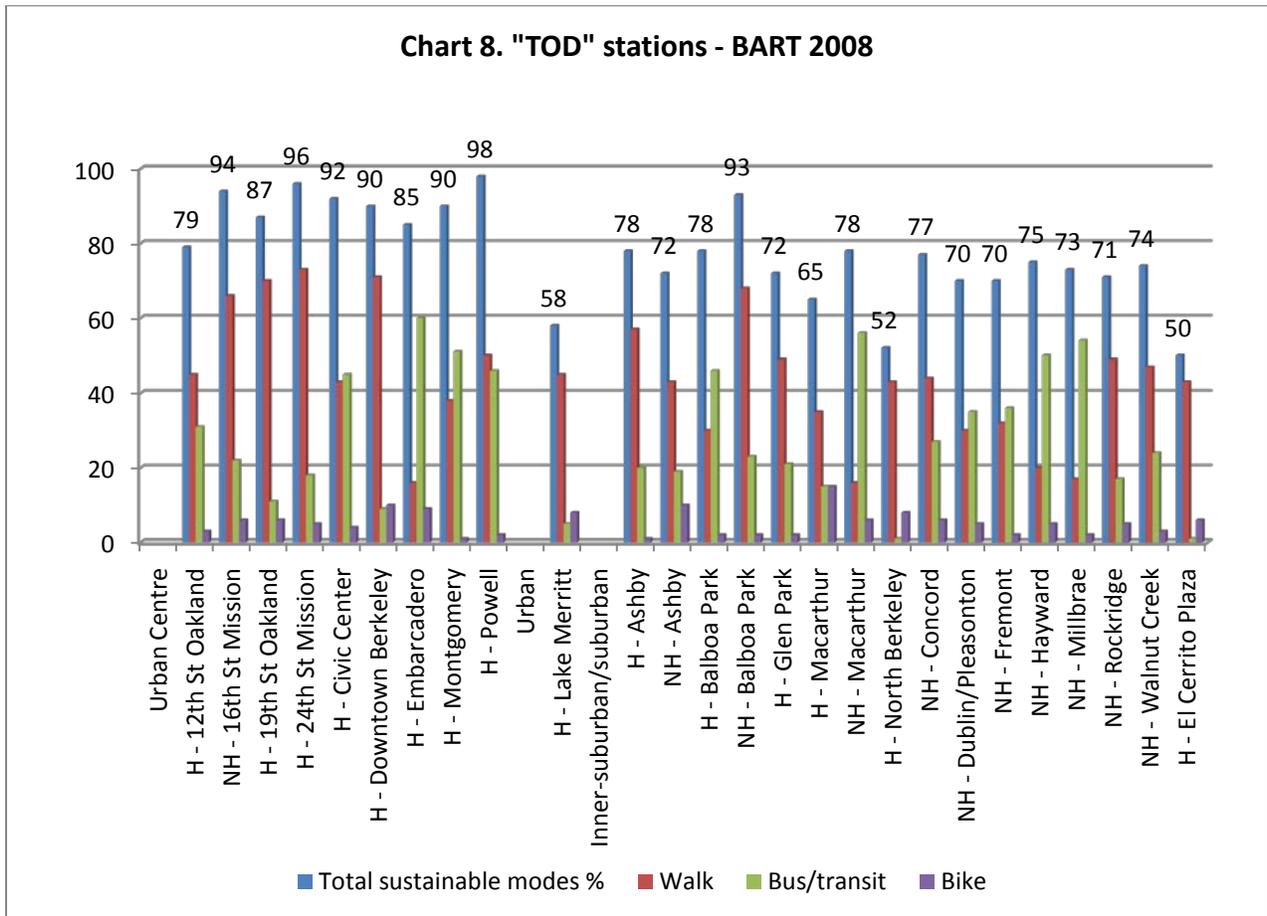


Biking appears here to be an under-developed access mode across the BART system, including in many station settings where high rates of walking-based access would tend to suggest relatively benign conditions for bike-based access. BART has undertaken a roll-out of bike access and egress infrastructure (including lockers and hire bike stations) during 2009 and 2010, and the impact of these changes is yet-to-be determined until the next iteration of BART's access studies occurs (apparently every 10 years at this stage with the next possibly due in 2018). But there is not much evidence currently of any large-scale roll-out or planning process for European-style protected bike lanes in the Bay Area. All things considered, the primary aspect of interest here is the large number of access vectors for which active modes are not only well-represented, but overwhelmingly dominant (even if walking does subsume biking). This tends to suggest the deeply-rooted need for both BART, and other rail systems, to take access planning, design and infrastructure issues for active modes very seriously – perhaps more seriously than has been the case during the life-cycle of the BART system

to-date since earliest phases in the 1960s and 1970s. Built form conditions clearly contribute substantially to walking and cycling outcomes, and conditions in the “active” stations listed here should be observed and re-worked wherever higher sustainable and active access is pursued.

**“Transit-oriented design” (TOD) stations**

A final emergent typology worthy of discussion is the “transit oriented” station, which has been based on the surpassing of a benchmark of 50% for access by a combination of walking, cycling and feeder transit. These stations appear to be a mix of urban centres (as expected), and suburban locations – many of which have experienced transit oriented planning, design and development (in the now-established Bay Area tradition) at some point in the past 10 years. A mixture of home and non-home origin access vectors is observable, and the overall number of stations fitting into this “desirable” typology is quite encouraging (from sustainability and design points of view), as are the very high percentages of sustainable mode access journeys in many of these examples. Again, biking appears to be under-developed to some degree.



Based on these figures, we may speculate what might be achieved with sustained transit oriented design or sustainable access planning and infrastructure efforts for stations that do not appear in this grouping. Another interpretation might be to re-state the importance of access planning, infrastructure, and design work in and of themselves – because access *conditions* are clearly playing a role in determining whether stations end up in either the “TOD” grouping or the “P&R” and “Mega P&R” groupings. Benign access conditions may lead to stronger access outcomes by sustainable means, but improving access conditions is entirely within the toolkit of medium and even shorter-term planning. These efforts should be connected-in to the broader momentum for ridership growth on BART (or rail systems more generally – see Walker 2008 for discussion).

## 5. New directions in analysis and planning of station access

In this paper, figures for station access across the BART network have been analysed and interpreted, with a view to understanding BART as a system, but also to generate a better understanding of access to rail more broadly, and to understand the relationship of rail to its surroundings. A new selection of station “typologies” has been offered based on access paradigms reflected in access mode share figures. It is felt that reviewing stations via a typology labeling system should assist with ease-of-understanding as to their prevailing conditions and needs. The research effort represented by this paper is attempting to focus on provision of rich information utilising benchmarking as a basic quantitative approach. In this sense, the paper is deliberately positioned in contrast to other efforts that have favoured relatively complicated quantitative methods in an effort to present single figure “answers” in the form of correlation co-efficients - which appear to be near-useless for practical planning and design-based applications (see examples such as Brons et al 2009; Debrezion et al 2009; Reusser et al 2008).

It is difficult to escape the interpretation that the access mode share figures seen at various stations throughout the BART network (and in other rail systems) are a function of planning as much as any other cause - and the analysis from our correlation-based research colleagues tends to support this view. From a distance and at a macro scale, we might be tempted to view a system like BART as “inevitably” more dependent on car-based access than its European or Asian equivalents. But a close-up view of the variation between stations in dominance of various access mode splits suggests that decisions, design, infrastructure, and built form conditions play a very strong role. These aspects all vary and change over time considerably, and all are within the purview of medium-term planning. Some might suggest the counter-argument that an agency such as BART (or other transit agencies) are not directly responsible for access conditions beyond their property boundaries. But this would tend to underplay the opportunities offered by partnerships, the ability of transit agencies to fund design and infrastructure change, or the option to simply support access planning-related work by local governments and other stakeholders. Good transport is built on multi-stakeholder partnerships - and any desire to act alone appears increasingly old-fashioned. Ryan and Frank (2009) suggest a carrot-and-stick approach where transit agencies would direct service improvements toward local governments actively supporting better sustainable access infrastructure. But overall, we need to be clear that *transit agencies* are the player with the most direct vested interest in ridership generation via improved access conditions.

A view that access conditions are “not the responsibility of transit agencies” now appears outdated and non-constructive - and essentially suggests that the agency is not interested in its own ridership markets and catchments. But BART stands as one of the more enlightened agencies because of its willingness to identify a policy platform for access that includes enhancing sustainable modes as a priority. For better or worse, access *is* a responsibility of transit agencies. This responsibility extends into the need to develop new methods for assessing the level-of-service for access by various modes, so as to assist in identifying design and infrastructure options for access improvement. Further iterations of the research program represented by this early-stage paper will increasingly grapple with the assessment methods available for developing a better understanding of specific station access infrastructure qualities. Hopefully this will include providing tools for access quality-of-service assessment more practically useful than correlation-based modelling. The assessment tools will need to be founded on analysis of existing and prevailing access mode shares, but also on a view that at certain locations the overwhelming dominance of car-based access may need to be treated over time. It also implies that the design of stations themselves will increasingly need to be directly informed by detailed understandings of existing and preferred access conditions.

Station access now presents itself as one of the great frontiers of mass transit research, design, planning, and infrastructure development for this century.

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