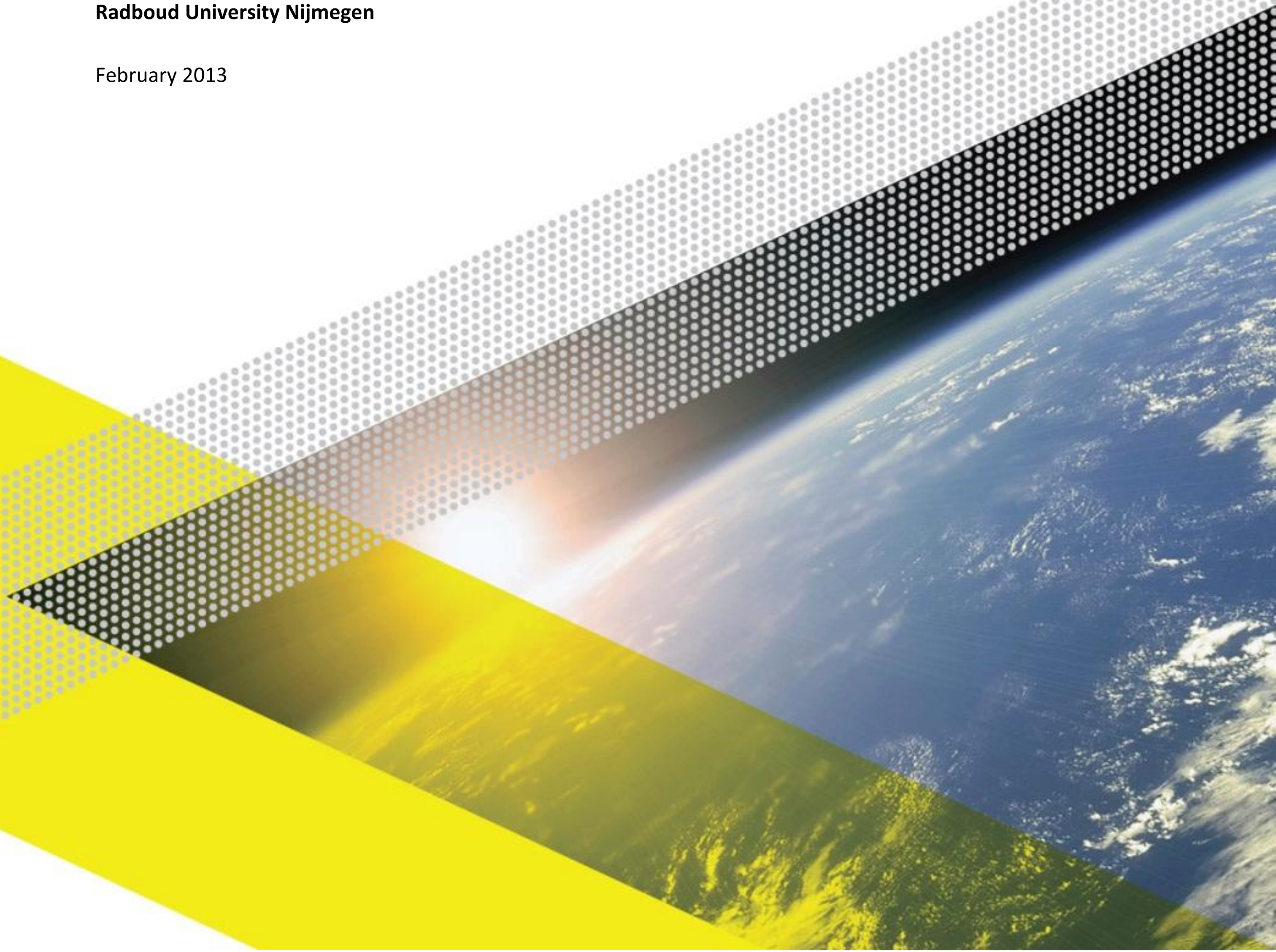
Climate Technology & Development Case study: Bus Rapid Transit

Heleen de Coninck
Radboud University Nijmegen

February 2013



Acknowledgement

The author would like to thank CDKN for their support of this project and case study, as well as Stefan Bakker, Ron Benioff, Rob Byrne, Lachlan Cameron and Ambuj Sagar for useful comments on earlier drafts.

This case study has been drafted as part of the project Climate Technology and Development, funded by CDKN and coordinated by ECN, which examines the conditions for innovation for climate-compatible development for different categories (the emerging industry, the rising middle class, the base of the pyramid) in developing countries. This report is registered under ECN project number 5.1633.

Climate & Development Knowledge Network

Contents

Executive Summary

A Bus Rapid Transit (BRT) system is "a rubber-tired rapid transit service that combines stations, vehicles, running ways, a flexible operating plan, and technology". It is often associated with high quality, customer-focused service that is frequent, fast, reliable, comfortable and cost-efficient. Implementing BRT systems in densely populated cities have been shown to have considerable benefits, including reduction of congestion, higher air quality, shorter travel times, appropriate transport for the poor, reduction of greenhouse gas emissions and higher-quality employment.

This report illustrates the technology and economic value chain around BRT and gives insight in the benefits and challenges of bus rapid transit systems. The aim is to provide a background study to the CDKN Climate Technology & Development policy briefs on what technology policies could be pursued by local and international policymakers. BRT systems are relatively well-studied, so a lot of information could be found in literature.

Of the almost 150 BRT systems in operation globally today, many are highly successful, the most famous example being Bogota's TransMilenio system. However, not all BRT systems are successful. The most reported problems include resistance from the existing, informal public transportation operators or car owners, poor implementation as a result of underperforming local institutions, and overcrowding and resulting lower levels of comfort where BRT is in high demand.

Several messages for policymakers can be distilled from this review. First, local circumstances matter tremendously and need to be studied well in order to make good decisions on routes, capacity, feeders, and type of BRT system. Transport service companies as well as local companies can provide this, although with the former the sensitivity for local circumstances remains a point of attention, while for the latter, capabilities and independence have sometimes shown to be problematic.

Second, the political economy and public acceptance of BRT need to be taken into account early on: sizeable, successful BRT systems can damage incumbent transport providers. There are many ways to reduce resistance, including providing compensation for the incumbents in the form of training and re-employment of drivers of the old public transport systems for the BRT system.

Third, BRT systems are always part of a broader transport system. Good and well-managed links to other public and private transport means need to be planned. Moreover, ambassadors and advocates of BRT systems should avoid pitting BRT against other public transit systems, such as rail-based systems; they can enhance each other's effectiveness and be complementary in an overall system.

Lastly, even when the initiation of BRT systems is done successfully, the system needs maintenance, good financial management, and continued adjustment and resizing to deal with new circumstances. Proper institutional organisation lays at the basis of a BRT system that also functions in the longer run.

The role of international policy support can be around dedicated public loans from multilateral development banks, raising awareness and funding for capability development and sharing of experiences between cities. The private sector could also do more to organise itself in an international business association that advocates responsible implementation of BRT systems.

1

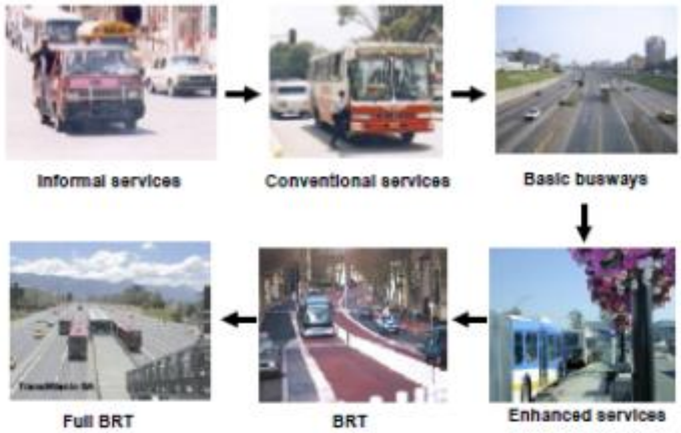
Introduction

Technology-oriented policies for low-carbon development pose questions that differ from market-based policies. Unlike market-based low-carbon policy, technology-oriented policies are not oblivious to the technological implications; they imply a choice for a technology in a sector, excluding from that point onwards other options. Given that governments are not omniscient, this holds a risk of failure or a possibility that, in hindsight, the optimal solution is not implemented. But it also has advantages as resources can be focused and uncertainty for business can be reduced.

Bus Rapid Transit systems are a public transport option that requires a public sector intervention, usually on the city level (Finn, 2012). BRT is “a rubber-tired rapid transit service that combines stations, vehicles, running ways, a flexible operating plan, and technology”. It is often associated with high quality, customer-focused service that is frequent, fast, reliable, comfortable and cost-efficient (Deng and Nelson, 2010).

It is important to note there are many forms of public bus transport (see Figure 1). In developing countries, informal bus services are still very common (e.g., matatus in Kenya, see Graeff, 2010). Such services are characterized by low prices and high frequency, but also by low safety and comfort levels, low efficiency due to duplication of routes, old vehicles and poor conditions for workers on the buses. More advanced systems include organized, conventional bus services, but these are considered slow, often polluting and noisy, and uncomfortable. Dedicated, basic bus lanes, possibly for part of the route, improve on the safety and the speed. Enhanced services can include improved bus stops and more comfortable buses. Some combination of this is often called “BRT lite”.

Figure 1: Various levels of organization in bus transit systems (ITDP, 2007)



A bus service can only be called Bus Rapid Transit when the bus drives on a dedicated bus lane that is often separated from other traffic, when the comfort level of buses is high, when the buses reach a relatively high average speed, and when there are dedicated and separately branded buses and bus terminals, with fare collection at the station rather than on the bus (this greatly enhances the speed of boarding and therefore the average speed of the bus service). A full BRT can mean that an entire city is connected by BRT, that feeder systems are in order (connections to other public transit methods, parking facilities for bicycles and cars, pedestrian access etc.), and that both express and regular services are provided on double lanes (so buses can overtake each other) (ITDP, 2007).

In general, systems that are fast, safe and comfortable have the ability to convince people to shift their transport mode in the city from personal vehicles to public transit. This is where the value lies for low-carbon development: a well-developed rapid transit system, in particular in easily-congested, rapidly growing cities, can prevent the transition to a petrol-car-based transport system. Over the past decades, road transportation has been the fastest-growing source of greenhouse emissions (Bakker and Huizinga, 2010).

This report is part of a larger project that aims to illuminate the considerations around technology options and policies, in particular on often-ignored political economy elements, to national and municipal policymakers, and to translate these to potential international technology interventions for negotiators in the UNFCCC climate talks. In this context, the aim of this report is to illustrate the technology and economic value chain around BRT and give insight in the benefits and challenges of bus rapid transit systems. The report is based on literature available in academic journals and online in policy documents and evaluations. A number of policy briefs, to be published[1] based on the sequence of case studies, go into the lessons and potential contributions of international technology policies, such as through the Technology Mechanism.

BRT systems are extensively documented in literature. Therefore, this report starts out with a review of existing BRT systems and their impacts in a number of cities in section 2. Section 3 will unpack BRT systems in their various components to figure out what are

[1] See the project website on www.climatestrategies.org.

the components, who are suppliers, and what are the challenges. Section 4 will discuss the political economy, and interests of stakeholders, if BRT systems are implemented, and section 5, based on sections 3 and 4, will distil the main messages for policymakers.

2

Development of Bus Rapid Transit systems

2.1 Existing BRT systems developments

According to BRTdata.org[2], currently 147 BRT systems are operational, transporting 25 million passengers per day and with a total length of 3851 km. The roots of BRT lay in the Americas. Before 1990, systems were operational in Brazil, mainly, in addition to several in Europe, Australia and North America. Most of these systems, however, were more like corridors and did not necessarily include the full service systems that we now call BRT. Following the huge success of such systems in Colombian cities (Bogota in particular), more cities followed. The past decade has seen an increase of BRT systems from about 35 in 2000 to the current 147. Latin American cities cover one third of all systems globally, and about 65% of all passengers transported. Over 80 cities are planning or constructing BRT systems. 2010 saw a peak of almost 20 additional cities opening BRT systems. 2011 and 2012 saw a significant slow-down.

2.2 Reasons for BRT

With the rise of BRT systems, many evaluation and review studies are conducted. Such studies reveal a large number of reasons to implement BRT systems (Rodriguez and Targa, 2004; Hensher and Gobb, 2008; ITP and IBIS, 2009; Kogdenko, 2011; Deng and Nelson, 2012):

- Congestion reduction: The main reason for most BRT systems is the reduction of congestion and therefore the reduction of travel time for residents. For example, in Lagos, Nigeria (ITP and IBIS, 2009), this was quoted as one of the prime arguments for implementing the BRT system.

[2] A database of BRT systems maintained by a.o. WRI's EMBARQ, the IEA Across Latitudes and Cultures - Bus Rapid Transit Centre of Excellence (ALC-BRT CoE). More information on www.brtdata.org.

- Increased road safety: In developed countries, public transport is less accident-prone than private transport by car. In developing countries, the existing transport system through public mini-buses is often notorious for its lack of safety.
- Travel convenience: Compared to minibuses or informal means of transportation, BRT systems are convenient. Compared to private car travel, BRT buses are considered less comfortable.
- Revenues/costs ratio: In almost all cases, a public authority or public bank invests in the BRT system. Compared to other rapid mass transit systems, the investment costs are relatively low while the revenues can be comparable. An economic effect could be that land development has been found to increase as a consequence of BRT.
- Lower cost overruns: Because of shorter implementation times compared to rail-based mass transit systems, BRT systems have lower cost overruns.
- Equity: Depending on the fare levels, BRT systems can provide a cheaper alternative to informal public transport or private vehicles. In Lagos, for instance, almost 60% of users reported that BRT was cheaper than their previous mode of transport, which for some 93% of the users was other public transport. Almost 20% indicated that the lower price was the main reason to use BRT (ITP and IBIS, 2009). Evaluation studies indicate that affordability is important for the success of the BRT system.
- Creation of new job market: BRT systems can lead to higher-quality and more stable jobs than the informal public transport it replaces in developing countries. There is, however, no comparison of number of jobs between informal systems and BRT.
- Reduction of local pollution (NOx, PM, CO, SO_2): Transport is a major cause of air pollution, in particular in urban areas. Annual deaths presumably caused by air pollution globally ran into the hundreds of thousands in 2004 (Cohen et al., 2005). By reducing the use of private cars and using higher-quality buses than conventional buses, air pollution can be reduced. The Bogota TransMilenio system is reported to reduce pollution levels by 40% (Levinson et al, 2003).
- Reduction of noise level in urban areas: Similar to reduction of local air pollution.
- Contribution to CO_2 reduction: If the BRT system replaces car or minibus travel, it can reduce emissions. However, when BRT replaces travel by foot or bicycle, the reduction in CO_2 emissions may be limited. An overall assessment of reduction of CO_2 emissions by BRT could not be found.

The proportion of the population using BRT systems is negatively correlated with GDP per capita, as countries with lower per capita incomes generally (but not always) have lower car ownership and higher demand for public transit (Hensher and Li, 2012). From this, one can conclude that BRT may contribute to preventing that car ownership and use rises quickly in low-income countries as individual incomes start rising. In addition, it is established that well-implemented BRT systems in densely populated megacities can result in people using BRT rather than their cars (Deng and Nelson, 2010).

2.3 Comparison of BRT to other options

BRT seems to be an appropriate solution for problems related to increasing air pollution and excessive travel times in urban areas, in particular in rapidly developing cities. Its impact on congestion is not always unambiguous, however, as the running ways of BRT systems generally take lanes away from car traffic, leading to more congestion in the remaining lanes, while at the same time reducing congestion by offering car, bus and minibus users an alternative. It needs to have sufficient critical mass and capacity to make a difference for congestion.

BRT also has potential to reduce greenhouse gas emissions. Investment costs and lead times are lower than for other rapid transit systems, in particular compared to metro. Metro might still be the preferred option if the city is particularly densely built up, and the street width does not allow for the inclusion of a dedicated bus lane. Elevated light rail systems are generally still faster and more comfortable, but also less flexible and more expensive.

Table 1 clearly shows the dilemma for decision-makers between different mass transit options: whether to implement the capital-intensive and expensive option of a metro, that can reach high capacities and speeds, and has low impacts aboveground, or whether to implement an option like BRT that has lower capacities and speeds, and costs considerable space aboveground, but has much shorter lead times, lower costs and more flexibility. It will depend on the context of the city what is feasible. Historic city centres often have narrow roads, making a BRT much more costly and less acceptable, as historic buildings would need to be torn down. For such a situation, a metro might be the only way. In cities with high car ownership and relatively low congestion problems, BRT might not be economically feasible. But in cities with much sprawl and wider roads, high population densities and large groups who cannot afford a car, BRT might be the more affordable option.

Table 1: Comparison of mass transit options (table taken from Deng and Nelson, 2011). (Minimum headway means how much time has to be allowed between vehicles.)

Transport mode	Bus rapid transit	Light rail transit	Metro
Right-of-way requirements	Mainly shared right-of-way (at-grade) or exclusive right-of-way or arterial lanes	Exclusive right-of-way (elevated) or shared right-of-way (at-grade)	Exclusive right-of-way
Support	Roadway	Steel track	Steel track
Vehicle propulsion	Internal combustion Engine	Electric	Electric
Vehicle control	Mainly visual	Sign control	Sign control
Construction time	<18 months	2–3 years	4–10 years
Space requirement	2–4 lanes taken from existing road	2–3 lanes taken from existing road	Little impact on existing road
Flexibility	Flexible in both implementation AND Operation	Limited flexibility, somewhat risky in financial terms	Inflexible and financially risky
Direct impact on traffic flow	Depends on design/ available space in roadway corridor	Depends on design/ available space in roadway corridor	Does not take space away from roadway
maximum capacity (passenger/unit)	160	170–280	240
Minimum headway (seconds)	12–30	75–150	120–150
Maximum frequency (Transit units per hour)	120–300	24–48	24–30
Line capacity (passenger/h)	Medium 9 000–30 000	Medium 12 200–26 900	High 67 200–72 000
Maximum speed (km/h)	60–70	60–80	70–100
Commercial speed (km/h)	15–25 (higher for some commuter systems)	15–25	30–40
Average capital cost (2000 US$/mile) (millions)	13.46	34.70	168.51
Average operation cost (2000 US$ per vehicle revenue mile)	4.73	12.22	8.54

Note:
(1) Cost adjusted to fiscal year $2000; calculated by CPI avg
(2) These findings were obtained from American case studies. It assumes that capital costs of BRT are substantially higher than those in developing countries
Sources: Vuchic (2005); Zhang (2009); IEA (2002).

2.4 Effectiveness of BRT

Studies have evaluated BRT systems for effectiveness in various places. Studying the ultimate aim of BRT – to entice people who would have otherwise used a car to use public transit – means conducting extensive surveys and evaluating the counterfactual.
Hensher and Li (2012) applied regression to 46 urban BRT systems all over the world to establish variations in ridership across different systems. From this, they derived the statistically significant factors that contributed to the ridership change drivers. Their results indicate clearly that what seem like details in the implementation of BRT systems can make a difference in the effectiveness of the system. Factors such as capacity and length of the BRT network, frequency during rush hour, pre-board fare collection and verification and average distance between stations (less is better) matter

significantly. Institutional factors are also important: the presence of “quality control oversight from an independent entity/agency” would increase ridership compared to systems where such control is not present or not implemented well. Systems that have been in operation for longer, in particularly those in Latin America, have higher numbers of ridership. Connections also matter: within the BRT system but also with other public and private transport modes. Hensher and Li (2012) also find that the fare matters and that there is a considerable price elasticity.

Kogdenko (2011) evaluated the Beijing, Jakarta and Delhi BRT systems on their contribution to sustainable development. This contribution was evaluated on criteria around environment, economy and social factors. She found that although all three systems improved the transport situations in the three cities in terms of bus transfer times and road safety, they are not necessarily functioning in an optimal way. Beijing performed best. The main cause was insufficient capacity leading to overcrowding, lower comfort and slower travel times. Deng and Nelson (2012) also evaluated the Beijing BRT positively.

Various recommendations have been made by these and other evaluation studies. Main recommendations included that future BRTs should use the latest transport planning details; when this is not done, they are not likely to meet the capacity demand. Political support is also essential (ITB and IBIS, 2009; Kogdenko, 2011), in addition to a (public) body that can act as the BRT system’s owner (see next chapter). Some studies mentioned a stakeholder engagement programme to make sure that transport organisations were in agreement and customer needs were met (Graeff, 2010; ITB and IBIS, 2009). The integration of the BRT system with feeder systems was also regarded as a critical success factor (Kogdenko, 2011; Hensher and Li, 2012).

2.5 The potential of BRT

Although BRT is implemented in an increasing number of cities, its potential is by no means depleted. However, it is not easy to establish the greenhouse gas emissions it might potentially reduce, as the internally consistent energy systems models commonly used to project what happens to global energy systems and CO_2 emissions are more based on technologies, which can be modelled against a technological cost, and less on systemic and behavioural change.

However, some estimates can be made. More than 80% of the people in the world do not own a car (IEA, 2012) and more than 50% of the global population is now living in cities (UN, 2012). The IEA projects that “BRT can contribute substantially to global CO_2 savings, potentially up to 0.5 $GtCO_2$ cumulative in the 2010 to 2050 time frame” (IEA, 2012). For this, BRT would have to be widely implemented, although the documentation does not reveal how many cities would implement BRT for such reduction numbers (IEA models run on regional, not urban, level).

Although the recent fast rise of BRT systems seems to have slumped considerably in 2011 and 2012, the potential for growth is still large. No information could be found, on

BRTdata.org or elsewhere, to explain the slump. Knowing that could however provide interesting information on how the BRT system concept could be applied in other places. Examples in Europe and Canada demonstrate that BRT can also be useful for larger, less densely populated, areas as an alternative to trains, although in such cases the function as a feeder to other transport modes, such as trains or metro, could become more important (Rambaud et al., 2008).

3

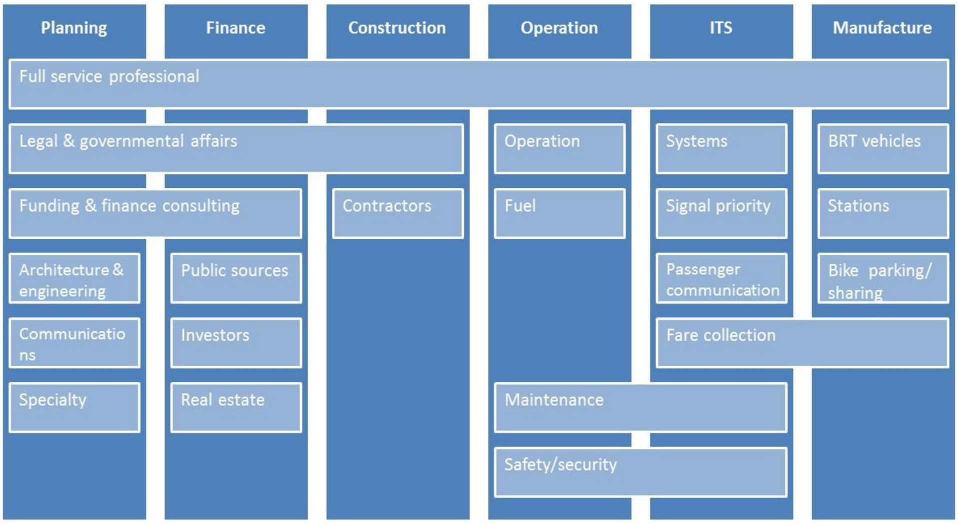
Systematic discussion of Bus Rapid Transit systems

BRT systems seem simple, but have a number of components that clarify that a considerable organization and economy can emerge around them. This section first explains the technological components of BRT systems, then the organisation of BRT systems and subsequently lists the private-sector suppliers of technology, knowledge and services.

3.1 Value chain analysis

For US-based BRT systems, Duke University has conducted a thorough analysis of the value chain and is keeping an online database of companies and public sector organisations supplying parts of that value chain. From their work, it can be concluded that in the United States, BRT systems are initiated and often (co-)financed through public-sector sources, but largely or fully implemented by the private sector. The value associated with BRT systems along the chain varies greatly with the circumstances and the size of the system, but generally, in the United States, amounts to up to a hundred million US dollar in capital investment (Lowe and La, 2012). The business model of BRT systems is that these investments are recuperated through ticket sales and smaller services, such as advertising in buses and on stations. Figure 2 schematically represents the value chain of BRT systems in the United States.

Figure 2: Value chain of BRT systems in the United States. The authors identify public sector involvement fully in financing through public sources, and partly in investors, communications, maintenance, safety/security and operations. Further explanation of the terms used in this figure can be found in the next sections (source: Duke, 2013).

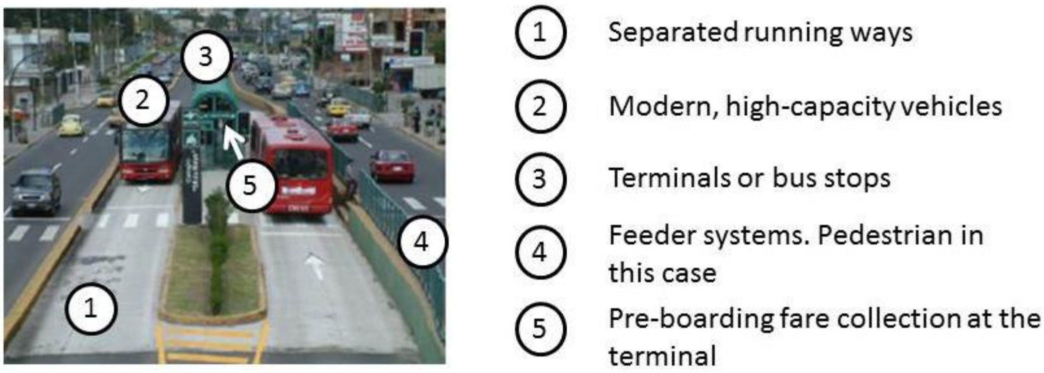


3.2 Technology components

The technological and knowledge components of a BRT system are well-documented in the literature (Deng and Nelson, 2011; Finn, 2012). Hardware components are (see also figure 2):

1. Running ways (corridors): In many cities, 2 to 4 dedicated lanes in a street have to be cleared and refurbished for a BRT corridor or system.
2. Vehicles and fuel: Generally, the buses used are high-capacity buses of 150 or more passengers, running on diesel, sometimes articulated (split in two or even three independently moving parts). In the case of buses running on cleaner gas, the fuel supply might also be done by a specialised company (Lowe and La, 2012).
3. Stations: the bus terminals or stations vary greatly, from simple stops with a roof and one wall to dedicated buildings with fare collection systems and even small shops.
4. Feeder systems (connections to other transport modes): a BRT system depends heavily on how it is connected to other transport modes, as the travel from a bus terminal to another is generally only part of the journey. Depending on the context, pedestrian access, bicycle parking, connection to train, parking facilities etc. are critical.
5. Fare collection: The most successful BRT systems feature pre-journey fare collection systems. This distinguishes BRT from regular bus services, which usually collect fares at the driver, delaying the departure of the bus until all passengers have made their payments.

Figure 3: Visualisation of hardware components of a BRT system, in this case of the Quito Ecovía line (Photo by Lloyd Wright; source of photo: Wright and Hook, 2007).



In general, the hardware does not pose the greatest problems to BRT systems, as the separate technologies are well known. The “soft” part of technology is at least as important and usually more challenging to coordinate, although by now there are various private-sector actors that can provide a package of services. The supporting services and consultancy around BRT consist of:

- Route structure and capacity planning: The intellectual labour of obtaining data on transportation demand, traffic streams, and based on that planning a route structure for a city.
- Services and operations: all aspects related to Information services for customers, cleaning and maintenance of the stations, drivers and conductors, etc.
- Intelligent Transportation Systems (ITS): ITS have been reported to improve operational efficiency of BRT systems considerably, such as in Beijing, for instance by reducing delay at intersections and increasing passenger boarding speed through electronic ticketing (Deng and Nelson, 2012).

Marketing and branding: many BRT systems have a distinct name and brand (e.g., the TransMilenio in Bogota, TransJakarta in Jakarta etc). It is essential for customer trust that the brand name is seen favourably.

3.3 Organisation of BRT

It has been noted before that the organization of BRT systems is probably one of its greater challenges in developing countries. Some authors have recommended better exchange of experiences (Graeff, 2010), something that seems to have contributed to the diffusion of BRT in Latin America (see the activities of the ALC-BRT-CoE – www.brt.cl).

Finn (2012) gives a detailed account and summary of how BRT systems are organized. He notes that in all cases, BRT systems require new collaborations between public and private partners. The relations between them need to be established, and this takes time. There are different ways to distribute tasks in a BRT system, but he distinguishes three clear operational roles:

1) the BRT system owner, which is always a public entity. Often it is the transport authority in the city or region, or a specifically formed subsidiary of a transport authority. The system owner is generally owned by the municipality. It makes policy and strategic decisions about the reach and size, nature, tariff structure and economic conditions of the system, and selects the operator of the other functions. It can also pose additional demands and boundary conditions for private operators, such as the re-employment of former informal public transport providers.

2) the BRT system manager manages the bus operations, terminals, running ways, services and marketing, and quality control. These functions can be contracted to separate companies again, but in general the management works best if it is in one place. The BRT system manager can be part of the transportation authority, an existing transport systems operator or a special-purpose entity under the transportation authority. Finn (2012) notes that the system management can be an organization of its own with potentially up to 500 employees, excluding bus drivers and conductors.

3) the BRT assets manager: conducts the daily service and maintains the assets, such as running ways, stations, fee-collection etc. This is most likely to be a private company but it can also be done by a public company or a public-private partnership. Multiple asset managers can operate on a single BRT system; for instance, the acclaimed Bogota TransMilenio system is currently operated by seven companies (Veolia website, 2013).

Although companies offer the full package of the services listed in the previous paragraph (basically everything except the buses themselves), and can act as BRT system manager as well as assets manager, it is necessary that a public transit authority (the system owner) maintains a significant level of knowledge about the system. A private company may have an interest in higher prices in order to increase profit margins, even when it is not necessary, or purchasing lower-quality buses. The public authority should represent the public interest in a credible way but should also make sure it has independent information to rely on for decisions. Therefore, there is an argument for separating the contract for system manager and the asset manager.

In terms of policy or incentives, successful BRT systems can be implemented without subsidies as costs can be recuperated through fares. Many do make use of public investment funds, such as a national public bank or a multilateral bank. The early phases of TransMilenio, for instance, were financed through a World Bank loan but run without subsidies otherwise (ITBP, 2007). Some authors argue that the involvement of international financiers is also beneficial for knowledge transfer, in knowing how to organise and contract out operation of a BRT, and should therefore be an essential element of financing when a city embarks on a BRT system for the first time (Kogdenko, 2011).

3.4 Private sector suppliers

There are various suppliers of both hard and soft technology for a BRT system. The corridors are most likely constructed through local companies in the road construction sector, although BRT is generally relatively straightforward in this respect, as existing roads are usually upgraded, separated and marked. It would lead to temporary local employment. The buses are provided by bus companies that have specialised in BRT buses. Examples are Marcopolo, a Colombian-Brazilian company which provides buses for example in Bogota and Johannesburg, Mercedes, Volvo and Scania. As a single sizeable BRT system can operate hundreds of buses, providing buses for a BRT system can be an attractive order.

System and asset managers can be various companies, such as Veolia Transportation, URS corporation and other transport providers. Some of them provide services along the entire value chain, while others specialise in specific services. It goes too far to discuss all companies that provide services; in the United States alone there are hundreds that benefit from the BRT value chain (Lowe and La, 2012).

3.5 Innovation aspects of BRT

Expansion of an operational BRT system to new corridors, more stations or more intensive use by buses means that the concept is known with customers (and presumably well-used), the institutions are in place and have gained experience and the hardware has been tested in the local context. In that sense, this would qualify as diffusion of the technology and not find great challenges, if the existing system has been functioning well.

From an innovation perspective, however, every city that implements its first BRT system is demonstrating a technology in a new environment. Every city is different in terms of size, density and built environment, and every city’s inhabitants have different habits and preferences, are in different economic circumstances, and have different travel needs. Some studies have given the appropriateness of BRT for different urban environments, in terms of population density, existing transport system and level of development.

Blanco et al. (2012: Figure 1) highlight different roles of different actors in the technological innovation system for different phases of technological diffusion. Treating BRT systems as a group of technologies and practices that is in the demonstration phase, the following roles can be identified around a new BRT system:

- Government can raise awareness among customers, fund data collection and interpretation and provide loans for the investment around BRT systems. Politicians (rather than policymakers) play an important role to raise awareness, interest and support for BRT in their constituencies. In addition, policymakers can enable BRT through urban and spatial planning, linking BRT with other means of transport (feeding) and discourage car ownership and use.
- The financial sector can provide loans in addition to purely public loans. In particular development banks have played an important catalysing role for BRT systems in developing countries.
- The private sector’s role around BRT is to supply most elements in the value chain of BRT, as well as innovate towards improved and more cost-effective solutions.

However, the private sector is generally not well-organised around services of BRT systems (Lowe and La, 2012) and companies that also have rail transit services in their portfolio may prefer selling those as they are generally more capital-intensive and could allow for a higher value-added.

- Users of BRT systems are the ultimate test for the new BRT system in practice. A barrier can be that those not benefiting from BRT (the car-users whose roads are narrowed by the implementation of BRT) are in some cases more influential and better organised than the users of the system (as has been noted around the BRT system in Delhi, see Padmanabhan, 2012). Users can also use their vote to reward the politician who championed the system.

The cases of successful BRT systems have often seen a fruitful collaboration between (multilateral) development banks and a visionary public sector ambassador (often a mayor).

4

Political economy of Bus Rapid Transit systems

The political economy of BRT systems is not extensively studied as such, but has come up on several occasions. Here, two cases of documented examples can be given of how the interests of different stakeholders lead to conflict around BRT systems: the BRT corridor in Delhi and BRT initiatives in African cities.

In Delhi, India, the BRT corridor has led to vehement protests by car owners as the system removes part of the road available to cars, the vehicle of choice for inhabitants of Delhi who can afford it. There is some reason for criticism of the BRT implementation in Delhi: because of low institutional capability, outdated data and low involvement of international experience, the system did not perform as well as it could have (Kogdenko, 2011). However, there is more at stake than just factual assessment of the system performance.

An article by Anil Padmanabhan[3] discusses recent developments as follows: “The [BRT] experiment highlighted the political economy of transport. That is, how do you divvy up road space among all users: should it be [sic] on the equity principle that will logically maximize public good or should it favour private vehicle owners?” He goes on and concludes that a court decision in favour of BRT made the right decision, as by far most of the funds for infrastructure are spent on facilitating car travel anyhow, while proportionally fewer people make use of them. He rejects the economic argument that the time of car owners is worth more than those of public-transit users on equity reasons. Nevertheless, among many well-to-do in Delhi, the BRT systems are pitched as a nuisance and a waste of public money. Negative media attention is said to have contributed greatly to this negative image (Kogdenko, 2011). In the Delhi case, the political economy around BRT systems has contributed to a poorer performance.

In various African cities, BRT systems are considered or in operation. Implementation in Johannesburg (South Africa) and Lagos (Nigeria) has so far been conducted relatively

[3] Information based on opinion article by Anil Padmanabhan: http://www.livemint.com/Opinion/bmP5xMHAdlTr8ZYblx2GJM/Delhi-HC-bats-for-public-good.html?facet=print.

successfully, although the introduction of mass transit in general (also rail services in Johannesburg) has led to visible and extensive protests by taxi drivers. Nairobi is an example of a city where in particular the informal matatu service industry would be hurt by the entry of a BRT system. Matatu is the local word for minibuses that seat 14 people and drive on routes that are not planned but emerge according to customer demand. Graeff (2010) describes matatu form of public transit as "dangerous, profit-driven, environmentally unfriendly but also necessary to be mobile and maintain a daily routine of going to work, to school or to market. Simply stated, [the matatu industry] provides a necessary service to millions of people who will continue to use it as needed to be mobile." So the functionality of the incumbent transit system should not be underestimated, but there is a lot of room for improvement.

Graeff describes the matatu industry as "organised chaos", in the sense that it self-organises quite successfully in many respects but does not fulfil public needs sufficiently. The list of problems mentioned by interviewees around the public transit situation in Nairobi is long: lack of political will and a political champion, poor driving behaviour of matatu-drivers, safety for customers as matatus are increasingly stuck in traffic jams, job security for matatu crews and support staff, police bribes, poor data and information about transport demand, traffic flows and the matatu industry. Graeff indicates that BRT, in the context of the remainder of the transit system, can provide solutions to many of these problems, but warns against top-down implementation without raising support with users, politicians and matatu operators. She recommends including the existing transit providers in the decision-making process around BRT in order to bring their knowledge, experiences and wishes to the table.

These examples, as well as the value-chain discussion in chapter 3, lead to an overview of the possible interests of different actors around the BRT system:

- Public transit commuters: In general, public transit commuters are content with BRT systems as they provide more comfort and are faster than informal or normal bus public transit systems.
- Car users: Initially, resistance may arise as roads get narrower to make space for BRT corridors, stations and feeder systems, including in some cases pedestrian and bicycle lanes. In the longer run, if BRT functions so well that car use is reduced, the effect may be beneficial as other traffic pressure is reduced, although that in turn may lead to higher car use again as the attractiveness is increased.
- When the BRT system is successful, all inhabitants of a city benefit from higher quality of life, a healthier environment and better public transit services. For people living along routes, BRT systems are documented to lead to more economic activity and in some cases increased value of property. Moreover, businesses along the route and near stations seem to benefit, although it is unclear whether the effect is as large for BRT as for metro or light rail.
- For workers in the public transit sector, a switch to a BRT system can mean the loss of employment. However for those that manage to switch jobs to the BRT company, the quality of work and pay of employment generally increases. Several BRT projects in cities have deliberately started programmes for re-educating and employing drivers and other personnel of the incumbent transit system in the new BRT system.
- Company operating the system, supplying buses and other services: Obviously, private-sector suppliers to BRT systems benefit from greater turnover. However,

some that provide full-value chain services also supply services around competing technologies and systems, such as light rail or metro systems. Given higher investment costs around these systems, such companies might advocate other transit solutions over the more cost-effective BRT.

- Politicians: the politician who is the champion of a successful BRT system gains political influence; the mayor of Bogota became a bit of a global celebrity because of the system he championed in his city. However, in many places, interests of the incumbent, formal or informal public-transit systems are aligned with interests of politicians, who sometimes co-own private bus companies. In such cases of conflicting interests, the politicians stand to lose influence and income because of BRT systems and may resist. The politician also has to firmly believe that taking away road space from cars will deliver the projected benefits.

5

Messages for policymakers

Depending on the city environment, BRT systems can make a significant contribution to improved urban living, shorter travel times and greenhouse gas emission reductions. In addition, it has significant turnover; a single BRT system can lead to tens of millions of USD in investments and higher-quality employment, although it can also lead to lower employment in any informal public transport systems it may replace.

BRT is a mature technology but its application and fit with local circumstances depend heavily on context, which makes it less mature in areas where it is not yet implemented. In particular, organisational issues and resistance from the incumbent transport system can be show-stoppers when BRT is initiated. Overcrowding (resulting from poor planning but great use) as well as faulty financial management or maintenance can be challenges later on.

Deciding on a BRT system as opposed to maintaining the status quo or introducing another mass transit system, as well as agreeing on how the system is implemented, requires a number of aspects to be taken into account by national and local policymakers and politicians:

- BRT can be a threat to existing public or private transportation systems, which in developing countries are often informal and privately-owned but comprising a significant work force. Policymakers however can also make use of the dissatisfaction and large social disadvantages of the existing system (worker job security, quality of work, commuter safety and comfort, road safety, aside from air quality and other environmental reasons). Resistance can be taken away by offering employment to drivers and off-board personnel in the new BRT system. Moreover, BRT can be associated with a positive image and pride around the city.
- BRT should always be seen as part of a transit system. It is not a 100% solution and should be used appropriately in its context. In cities with low-density housing and high car ownership, like in the US, it needs to connect well with car-based feeding and provide for safe and affordable parking space. In other places, bicycle connections, connections with informal public transit, railways or with pedestrian-based neighbourhoods can be more important.
- The private sector has a significant role in BRT systems. What can be done to facilitate them to play a more constructive role? Suggestions have been made to

form business constituencies to lobby for more BRT systems. However, a consideration could be that private sector interests may lie in systems that are less cost-effective for the public purse but provide higher value-added to business stakeholders.

- The TransMilenio experience shows that BRT systems, especially in densely-populated larger cities with low car ownership, need to be scaled to handle large crowds. TransMilenio is so well-used that it is losing popular support because of overcrowding.
- In general, BRT supporters should avoid pitting (public) transit means against each other, acknowledging that in many contexts, every transport mode has a role to play. In practice, however, some companies might prefer higher-value transit modes over BRT.

What international interventions could be helpful around BRT systems, taking into account the national context and private sector role?

- The local public sector generally initiates a BRT system. Cities can learn from other cities. The experiences in Bogota's TransMilenio project were shared widely; many other urban planners visited Bogota to learn. Cities considering BRT are recommended to conduct site visits and find other ways of learning from other cities with a similar context to see how they set up their BRT systems, planned capacity and dealt with resistance. This could be facilitated by international funders.
- Several papers indicated that financing by multilateral development banks (MDBs) was a helpful start for BRT. Such MDBs could make cities more aware of the possibilities of BRT and could develop specialised loan services for BRT systems.
- International business organisations could organise private sector suppliers on an international level to implement more and more extensive BRT systems.

In conclusion, it seems that the TransMilenio project has been tremendously important for the deployment of the almost 150 BRT systems currently in place, as it showed that BRT systems can deliver high-capacity and high-efficiency public transit while at the same time greatly improving quality of life in a city where transportation problems were mounting. The question to international policymakers is what combination of strategies, consisting of a combination of capability, technology and organisational elements, can make BRT an even more wide-spread transit mode that serves the rising middle class in practically every appropriate provincial town in fast-industrialising areas of the world.

References

Bakker, S., and C. Huizenga (2010): Making climate instruments work for sustainable transport in developing countries. *Natural Resource Forum* 34 (4), pp 314-326.

Blanco, G., L. Wuertenberger and H. de Coninck (2012): The Technology Mechanism under the UNFCCC: Ways Forward. Climate Strategies Policy Brief in the Climate Technology & Development project. Available on http://www.climatestrategies.org/ (consulted December 2012).

Cohen, Aaron, H. Ross Anderson, Bart Ostra, Kiran Dev Pandey, Michal Krzyzanowski, Nino Künzli, Kersten Gutschmidt, Arden Pope, Isabelle Romieu, Jonathan M. Samet, Kirk Smith (2005): The global burden of disease due to outdoor air pollution. Journal of Toxicology and Environmental Health, Part A, 68:1–7.

Deng, Taotao and John D. Nelson (2012): Bus Rapid Transit implementation in Beijing: An evaluation of performance and impacts. Research in Transportation Economics xxx (2012) 1-6 (*In press)*.

Deng, Taotao and John D. Nelson (2011): Recent Developments in Bus Rapid Transit: A Review of the Literature, Transport Reviews: A Transnational Transdisciplinary Journal, 31:1, 69-96

Duke University (2013): Bus Rapid Transit - 10 high-quality BRT features and the firms that provide them, available at http://www.cggc.duke.edu/environment/cleanenergy/brt/index.php (consulted January 2013)

Finn, Brendan (2012): Organisational structures and functions in Bus Rapid Transit, and opportunities for private sector participation. Research in Transportation Economics, in press.

Graeff, Jennifer (2010): The Organization and Future of the Matatu Industry in Nairobi, Kenya

Hensher, David and Zheng Li (2012): Ridership drivers of bus rapid transit systems. Transportation 39 (6), pp 1223-1224.

Hensher, David and Thomas Gobb (2008): Bus rapid transit systems: a comparative assessment. Transportation (2008) 35:501–518.

IEA (2012): Energy Technology Perspectives 2012. IEA: Paris, France.

IEA (2002): Bus systems for the future: achieving sustainable transport worldwide. IEA: Paris, France.

ITDP (2007): Bus Rapid Transit Planning Guide. Edited by Lloyd Wright and Water Hook. Available on http://www.itdp.org/microsites/bus-rapid-transit-planning-guide (consulted January 2013).

ITP and IBIS (2009): Lagos BRT-Lite Summary Evaluation Report. Written by Integrated Transport Planning Ltd and IBIS Transport Consultants Ltd.. Available on: http://www.uitp-bhls.eu/IMG/pdf/BRT_Lite_Summary_Report_FINAL_V2.pdf (consulted January 2013)

Kogdenko, Nadja (2011): Successfulness of Bus Rapid Transit systems in Asia: Ex-post evaluation. ECN-O--11-013: ECN, Petten, Netherlands.

Levinson, Herbert S., Samuel Zimmermann, Jennifer Clinger (2003): Bus Rapid Transit, a synthesis of case studies. Transportation Research Board 2003 Annual Meeting, Washington D.C..

Lowe, Marcy and Monica La, 2012. U.S. Bus Rapid Transit: 10 high-quality features and the value chain of firms that provide them. Available on http://www.cggc.duke.edu/pdfs/DukeCGGCBRTslidedeck_FINAL_9-05-2012.pdf (consulted January 2013).

Rambaud, Francois, Sébastien Rabuel, Thierry Du Crest, Pascal Deprez (2008): The French BRT approach: The Key messages. Presented in Dublin at COST TU 603. Available on http://www.uitp-bhls.eu/IMG/pdf/French_BHLS_Abstract_presentation__Dublin_2008.pdf (consulted January 2013)

Rodriguez, Daniel and Felipe Targa (2004): Value of Accessibility to Bogota's Bus Rapid Transit System. Transport Reviews, Vol. 24, No. 5, 587–610.

Veolia website, 2013: http://www.veoliatransportation.com/transit/bus-rapid-transit/key-contracts/bogota.

Vuchic, V. (2005): Urban transit: systems and technology. John Wiley: Hoboken, NJ, United States.

UN (2012): World Urbanization Prospects: The 2011 Revision. Department of Economic and Social Affairs. Available on http://esa.un.org/unpd/wup/CD-ROM/Urban-Rural-Population.htm (consulted January 2013).

Zhang, M. (2009): Bus versus rail meta-analysis of cost characteristics, carrying capacities, and land-use impacts. Transportation Research Record 2110, 87-95.

ECN

Climate Strategies

University of Sussex
SPRU –
Science & Technology Policy Research

Radboud University Nijmegen

UNICEN
Universidad Nacional del Centro de la Provincia de Buenos Aires

IIT DELHI

THE FLETCHER SCHOOL
TUFTS UNIVERSITY

Author contact:
Heleen de Coninck
Radboud University Nijmegen
T +31 24 365 3254
h.deconinck@science.ru.nl
www.ru.nl

Project contact:
Lachlan Cameron
ECN
T +31 88 515 4227
cameron@ecn.nl
www.ecn.nl