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Contactless ticketing: state-of-the-art and user impact

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Abstract

Contactless fare collection is believed to substantially change the transport's industry approach to fare collection and to improve the level of service for public transport. The purpose of the paper is to describe the application of the contactless smartcard technology for transport ticketing purposes. The analysis focuses on the characteristics of a group of existing applications and of the proposed Swiss EasyRide concept. A case-study analysis is developed on the latter to assess the magnitude and the type of the changes that this new technology will imply for the users, taking into account the demand segmentation by ticket type that exists before the introduction of a contactless ticketing system.

1 Introduction

Except for passes, paper tickets have been for decades the only transport title, and the evolution concerned mainly the ticket sale and validation, with the introduction of automatic machines. The introduction of magnetic strips on tickets offered new capabilities, such as recording data on the ticket during validation, but did not essentially modify the behaviour of the passengers. An authentic transformation of the approach to fare collection is now rapidly taking place, because of the development of the contactless smartcards.

A "smartcard" or IC (integrated circuit) chip card is a plastic card with embedded memory and microprocessor chips, or just with a memory chip. Memory cards allow only data storage. Microprocessor cards are also capable of on-card data processing. The chip on the card is read by either surface contact (contact interface) or induction coils (also embedded within the plastic) that receive radio

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signals fed into the chip (contactless interface). The contactless data transmission does not require the users to insert the cards in slots, giving substantial gains in terms of maintenance costs and of speed of transaction. According to the feasible distance of data transmission, the contactless systems are distinguished in proximity (up to 15-30 cm) and remote (hands-free) systems (up to several meters).

Combining the data processing capability and the lack of physical contact between card and validation device, contactless microprocessor smart cards appear to be a promising fare-collecting instrument. To date many transport companies have tested or already implemented contactless fare collection systems, mostly using proximity cards. One of the largest projects is "EasyRide", a smartcard-based ticketing concept under development by the Swiss Federal Railways (SBB/CFF), the Swiss Post (operator of a large bus network), and the Public Transport Association (UTP) to substitute all the existing transport tickets by 2005. This project bears several interesting aspects: its geographic and operational scale (nation-wide system with a large number of operators involved), the proposed validation technique ("walk-in / walk-out", without need to present the card past the reader), and the combination with a vehicle location system to allow distance-related fares. Another significant aspect is the particular structure of transport demand in Switzerland, where many passengers already hold a nation-wide intermodal and multi-operator annual pass.

2 State-of-the-art of contactless ticketing

As already stated, contactless fare collection will substantially improve the level of service for public transport. For the passengers, it enables easier and faster entrance in the system, as well as increased freedom in the management of their trip. For the companies, it makes it possible to reduce the equipment acquisition and maintenance costs, to set up more complex fare collection strategies (such as intermodal and multi-operator tickets); in addition, easier and more detailed collection of transport demand data becomes possible.

Although studies or trials have been carried out for a lot of contactless ticketing schemes, the number of real-world applications is still relatively small. Eight cases have been selected for a broad analysis to understand the present diffusion of the technology and to observe the impacts on the users (Guglielminetti [1]). Their main characteristics are presented in tables 1 and 2.

Other transport networks with operational schemes of contactless ticketing are, for instance, the Jura region in France, Oulu and Turku in Finland, Marburg in Germany, the Nottinghamshire county in UK, Ajax, Burlington and the Outaouais region in Canada, Washington in U.S.A., and Pusan in Korea. Several big European cities, such as Paris, Madrid, Berlin, Warsaw, London and Rome, are planning to introduce smartcard-based systems in the next years and are carrying out pilot tests and field trials.

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Table 1 – Main system characteristics of the selected applications

Town and inhabitants	*First introduction*	*Previous ticketing system*	*Type of card*	*Type of ticket replaced by smartcards*	*Modes of transport concerned*	*Transport operators involved*
Amiens(F) 160'000	August 1999	paper tickets	hybrid smartcard	season tickets multiple-journeys t.	urban buses	1
Nice (F) 360'000	Jan. 1999	paper tickets	hybrid smartcard	season tickets multiple-journeys t.	urban buses	1
Valence (F) 300'000 (area)	March 1996	re-loadable MC and single-unit paper tickets	CLC	by June 2000 all tickets except tickets for occasional users	urban buses	1
Valenciennes (F) 340'000	Dec. 1997	paper tickets	hybrid smartcard	season-tickets (also chargeable with units for trips not covered by the season-ticket)	buses regional trains	2
Tampere (SF) 190'000	Sept. 1995	paper tickets mechanically cancelled	CLC	all	public and private buses	1 public + some private
Gothenburg (S) 450'000	1993 (trial) 1995 (wide deployment)	MC	CLC	season tickets	buses, trains, ferries	>1
Hong Kong (China) 6 millions	Sept. 1997	MC and cash paid tickets on buses	CLC	all except tickets for occasional users	metro, buses, light-railway ferries	5
Seoul (Korea) 11 millions	March 1996	token and paper tickets	CLC	all, in conjunction with existing token/ticket systems	buses	65

CLC = contactless microprocessor card MC = magnetic-strip stored-value card
Hybrid = microprocessor card with two chips allowing both contact and contactless interface

Table 2 – Contactless ticketing system dimension and other applications

Town	*System size (vehicles and stations equipped)*	*Transactions per day*	*Number of cards in use*	*Other functions implemented or foreseen*
Valenciennes (F)	270 buses 12 train stations	80'000 (buses only)	72'000 (9/1999)	parking (CV, mid 2000); public libraries, swimming-pools, school restaurants (foreseen)
Valence (F)	95 buses	15'000 (28'000 by end 2000)	15-20'000 (3/2000; 30'000 by end 2000)	trains (foreseen by 2002-2003)
Nice (F)	250 buses	75'000	85'000 (03/2000)	parking (CV, mid 2000);
Amiens (F)	120 buses	53'000	35'000 (03/2000)	trains (SNCF), parking et city services (foreseen)
Tampere (SF)	160 public buses private buses	100'000	130'000 (03/2000)	swimming-pools (since 3/1999) other applications foreseen (parking, recreation, etc.)
Gothenburg (S)	350 validation units	not available	not available	no other applications reported
Hong Kong (China)	5'000 processing devices	4 millions	7.5 millions (02/2000)	additional applications envisaged but still not realised
Seoul (Korea)	8'700 buses	2.6 millions	4.5 millions (12/1997)	Seoul underground

Reliability and security of the smartcard appear as the most important characteristics from a user's point of view. Even if some cases of card malfunctioning are reported (Tampere), the system is much more reliable than magnetic-strip cards. Beside these advantages, ensured also by contact smartcards, contactless systems also allow high throughput, a key element for transport fare collection systems. The elimination of cash handling is another benefit, but also other stored-value cards allow it.

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Contactless technology provides potential for fast and simple transactions. Since the passengers are required to perform a validation in a way different from the traditional one, an information campaign is necessary, especially during the first months of the operation of the new system. Personnel must be present in stations and on the vehicles, to show the users how to validate their cards (in Valenciennes this was the only way to overtake the initial users "resistance").

An important element to take into account is the ticketing system that was in place before the contactless technology: where stored-value cards were already in use (such as in Valence, Gothenburg, and Hong-Kong), people were already accustomed to this kind of fare collection. For them, the only innovation was the lack of contact during validation and the loss of the ability to see the validity of the ticket and/or the remaining value on the card. Lack of contact creates the risk that passengers do not feel in control of the transaction, but the nature of the transaction may be communicated to the cardholder on the validator's display (and eventually through audible tones), or by other means (dedicated consultation terminals, card jackets with a display screen, etc.).

Although no special fares are in force for intermodal trips in any of the cities, intermodal travellers are not required to purchase several tickets for the trip. Multi-applications are still at the beginning phase: swimming pools in Tampere, parking in Valenciennes and Nice.

The possibility to get improved statistics about passenger journeys allows transport services to be tailored according to actual customers' needs, especially if in / out validation takes place allowing data collection on origin-destination basis. Even if the improved information about passenger journeys seems to be scarcely used up to now, with the exception of Tampere, it must be expected that it will be taken into account in the near future for network planning. Availability of detailed data about passenger movements can also have (or be perceived as) a negative issue, due to the potentiality to track individual movements. Thus, privacy protection must be ensured.

Due to the cost of the contactless microprocessor smartcard, the question of occasional users is an important one. Most operators (Amiens, Nice, Valence, Gothenburg, Hong-Kong) still prefer to keep a non-contactless system for occasional users. However, totally contactless ticketing is a conceivable option, by introducing, for instance, contactless memory smartcards, less expensive than those with microprocessor, or a "tourist card" as now studied for Hong-Kong. In this case, the remaining value is refunded at the departure and the card can be reloaded. Another solution is single-trip reloadable contactless tickets collected at the exit gates (for closed systems).

The fare collection systems described in the tables 1 and 2 concern public transport networks operating in urban or metropolitan areas. The implementation of contactless ticketing is also foreseen for interurban transport, even if full-scale applications in this area are still at an early stage. The French interurban bus company Cars Philibert, for instance, recently equipped 33 buses with contactless validators and replaced the 600 passes with contactless smartcards. On the new cards it is possible to charge additional money for occasional trips on lines not covered by the pass. A contactless fare collection system has been re-

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cently introduced also by the regional bus company SüdbadenBus of Freiburg, in Germany.

With regard to the rail networks, aside from extending urban fare collection system to regional trains (for instance, the national French rail company is involved in the Valenciennes and Paris projects), railway companies are nowadays interested in developing contactless ticketing systems for national networks also.

Deutsche Bundesbahn (DB) expressed interest for a nation-wide contactless fare-collection system and is following very close the Swiss project described in the next chapter. Nederlans Spoorwegen (NS) conducted back in 1992 a feasibility study on the replacement of the existing paper tickets by smartcards. The project is now evolving towards a national card for all public transport, but the first implementation will take place for urban networks; the extension to the rail system is foreseen in a second phase. In France, the national rail operator (SNCF) seems to be more oriented towards regional transport contactless passes, by agreement with local transport companies. The Helsinki contactless TravelCard (distributed to the public from October 2000) will be used also on the regional trains of the Finnish Railways (VR). VR will decide on further extension to the whole Finland on the basis of the experiences of the Helsinki area scheme. In the UK, Stagecoach intends to offer a fully integrated smart card ticketing system across the whole of its bus network and wishes to extend the system into the rail lines operated by itself (South West Trains) and also by other companies. Danish railways (DSB) are planning the introduction of a national rail smartcard. The East Japan Railway Company have ran several field trials for a contactless ticketing system that proved to be faster than and as stable as the existing one, which is based on magnetic-strip tickets.

Network-wide rail application of contactless ticketing clearly implies an in / out validation, in order to allow distance-based fares. That can be achieved in totally or partially closed systems ("check-in / check-out": the passengers should show the card past the reader device while both entering or leaving the system) or in open system using remote contactless interfaces ("walk-in / walk-out": the card is automatically validated when the passenger boards or get off the vehicle). With in/out validation, passengers can change route and destination during the trip. This evolution is a substantial change with respect to the present practice of railway travellers. The other human impacts will be similar to those mentioned for urban transport.

3 The EasyRide project

3.1 Description of the project

In Switzerland, a partnership between the federal railway company (SBB), the Swiss post, who operates many regional bus lines, and the association of public transport companies (VÖV) has been set up to study a nation-wide smartcard-based ticketing system called EasyRide (EasyRide Working Group [2]). In/out validation is required for most operators, but the Swiss contactless system is

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based on the "walk in / walk out" (WIWO) project instead of the more common "check-in / check-out". That means no need to present the card past the reader, because it is automatically validated, wherever it is, when the card holder boards or alights the vehicle (hands-free validation).

Vehicles will be equipped with an onboard computer, a device for self-location (GPS or other positioning system) and a GSM module to communicate with the central system. Control personnel on vehicles remain necessary, due to the conservation of an open system and to the presence of occasional users. Owners of a so-called EasyRide contactless pass will receive periodically the invoice of their trips. To reduce as much as possible the risk of unpaid invoices, the card will be delivered only after a control on the user's income or when the applicant presents a valid debit or credit card (in that case, the invoices are directly charged on that card). A stored-value contactless card (E-ticket) will be available for users not willing to have an EasyRide pass (occasional users, tourists, etc.).

EasyRide is design to potentially allow the utilisation of the vehicles of any Swiss public transport company (including urban networks, railways, etc.). Revenue allocation among the companies for multi-company journeys will be easier and more precise than the present system based on periodic surveys on vehicles. The system will allow complete integration among modes and operators, and extensive fare flexibility, such as off-peak hours discounts and negotiated rates (for instance for the personnel of a company having an agreement with the transport operator). Multi-applications with non-transport functions are also considered.

Full system operation is scheduled for 2005. The investment to replace the existing system and install the necessary equipment on 11'000 vehicles is roughly € 380 Millions; a huge amount of the existing ticket machines will have to be replaced in any case within 2005. Savings are expected as a result of the reduction of the sales personnel, and of the elimination of the users' surveys. More revenues are foreseen due to the expected increase of public transport patronage (alike individual transport, no spending decision will be necessary before travelling).

3.2 Advantages of EasyRide with respect to other contactless system

The EasyRide concept, distinguishes itself from most other contactless fare collection systems, by providing WIWO validation and post-payment, in order to let EasyRide to better fit to the need of nation-wide ticketing, as:

- WIWO validation allows transport companies to avoid degrading the present boarding conditions of the numerous Swiss public transport passengers who at present use annual passes (cf. next section);
- hands-free validation appears also particularly suitable for elderly, disabled persons, and people travelling with luggage or pushchairs;
- post-payment is more suitable to nation-wide ticket (long distance transport), as pre-payment would require to store on card high amounts of money.

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4 EasyRide: impacts for the users

The EasyRide system is so extensive and complex that its permanent impacts may not become apparent for several years. Nevertheless an analysis of the present behaviour of rail passengers (type of tickets used and trip's purposes) allows a preliminary assessment of the foreseeable impacts. The level of satisfaction for the existing fare collection system affects significantly the user reactions to a new one. The analysis focuses on the SBB passengers, for which several ticket types are currently available (table 3 gives a simplified overview).

Table 3. Main ticket types currently available for SBB passengers

Type of ticket	*Validation before the trip*	*Remarks*
Full-fare ticket	No	-
Collective ticket	No	Tickets for groups of 10 or more people; 20% reduced fare
Multiple-journey ticket	Yes	12 trips on the same route paid as 10 (15% reduced fare)
Universal annual pass	No	Free travelling on SBB and most Swiss transport companies
Route pass	No	Pass for a specified route; various discount practices (e.g. for 1 year, 8 months are paid)
Half-fare card + ticket	No	Half-fare card is valid 1 or 2 years and allows buying tickets at half price. Usable in conjunction with simple journey, daily or multiple-journeys tickets.
Half-fare card + daily ticket	Yes	
Half-fare card + multiple-journey ticket	Yes	
Regional pass	No	In many areas (Zurich, Basle, etc.) regional passes allow to use all the local transports, including SBB lines
Soldiers	No	Enrolled persons dressed in uniform travel free of charge, no ticket or paper is needed

User-friendliness and attractiveness of a ticketing scheme depend on quality criteria that may include:

- **Accessibility** to public transport; buying a ticket before each journey is not mandatory any more
- Overall **ease of use** of the system
- **Comfort**; no need to carry cash anymore
- **Quickness**, leading to reduced boarding time
- Easiness of **validation**
- Fare **transparency**, that is knowledge of the fare before travelling
- **Flexibility**, possibility to shift destination without buying a new ticket
- **Intermodality**, allowing to travel over several modes/operators with a single common ticket
- **Privacy** protection, to avoid retracing individual journeys

A comparison of the existing tickets is shown in table 4 (without ease-of-use criterion, mainly relevant to new systems). Some special ticket types (transport companies' staff tickets, InterRail, etc.) are not shown; they represent 7% of the total trips. Purchase of tickets without cash is already possible for credit card or debit cards holders both at ticket desks and with automatic selling machines.

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Table 4. Quality assessment of the existing ticket types

	Ticket type									
	Full-fare ticket	Collective ticket	Soldiers	Multiple-journey ticket	Annual pass	Route pass	Half-fare card + ticket	Half-fare card + daily ticket	Half-fare card + multiple-journey ticket	Regional pass
Trips (in 1'000s)	14 738	1 171	132	5 693	62 611	40 643	50 522	1 654	11 987	46 468
% trips	5.8%	0.5%	0.1%	2.2%	24.7%	16.0%	19.9%	0.7%	4.7%	18.3%
Main trip motives (with > 10% of the trips)	(11%) (23%) (18%) (13%) (18%)	(29%) (13%) (38%) (10%)	(100%)	(28%) (42%) (12%)	(50%) (18%)	(74%) (19%)	(16%) (22%) (10%) (19%) (16%)	(26%) (28%) (28%)	(53%) (14%) (15%)	(68%) (19%)
Accessibility	No	No	Yes	Partial	Yes	Yes	No	Partial	Partial	Yes
Comfort	No	No	Yes	No	Yes	No	No	No	No	No
Quickness	0	0	0	Vt	0	0	0	Vt	Vt	0
Validation	No	No	No	Yes	No	No	No	Yes	Yes	No
Transparency	Yes	Yes	-	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Flexibility	No	No	No	No	Yes	No	No	Yes	No	Partial
Intermodality	Yes*	Yes*	Yes*	Yes*	Yes*	Yes*	Yes*	Yes*	Yes*	Yes*
Privacy	No	No	No	No	No	No	No	No	No	No

"Yes" means that type of ticket satisfies the quality criterion.
VT = time for an electromechanical validation by the device on the platform
* = intermodal trips with a single ticket are already possible within several modes and operators (the so-called "direct fare" network)

commuter to work
"utility" trips (shopping, visits)
other purposes (recreational, holidays) – young people
other purposes (recreational, holidays) – adults
commuter to school / university
soldiers' trips
other purposes (recreational, holidays)– families
other purposes (recreational, holidays) – seniors

The introduction of EasyRide will induce changes for the users. Needless to say, the type and the magnitude of these changes depend not only on the features of the new system, but also on the characteristics of the existing one.

Within EasyRide, special fare conditions that are currently in use will be taken in charge by the "authorisation" system; the users will communicate to the system when and how they benefit of special conditions, such as:

- temporary fare discounts (group trips, combined offers including transport and entrance to cultural or sport events, etc.)
- trips paid by a third party (such as the employer or a travel agency, etc.) and in consequence to be charged on another than the user's account.

The EasyRide card holder will be also able to temporary disable the card. The table 5 shows an important feature of the system: if needed, EasyRide allows a company to keep the existing fare structure. Thus, companies may decide to maintain ticket types that presently satisfy the users (a final decision on the EasyRide fare structure has not been taken yet).

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Table 5. Feasibility of the existing fares after implementing EasyRide

Current ticket type	***Feasibility with EasyRide***	
		Procedure
Full-fare ticket	Yes	The trip is recorded and listed on the periodical invoice
Collective ticket	Yes	Temporary activation of the special condition (group trip)
Soldiers (free travelling)	Yes	Temporary deactivation of the EasyRide card (if carried by the holder)
Multiple-journey (MJ) ticket	Yes	The system applies the reduction on the basis of the number of trips on the same route
Universal annual pass	Yes	Various possibilities, such as pre-payment of an annual fixed charge without periodical invoices (the trips are recorded only for statistical purposes) or periodical invoices to paid until reaching a pre-fixed annual amount (afterwards the user travels free of charge)
Route pass	Yes	Pre-payment of a route pass; periodical invoices only for the other trips
Half-fare card + Ticket	Yes	Pre-payment of an annual amount to get half-price fare; trips charged at half-price on the periodical invoice
Half-fare card + Daily ticket	Yes	Users who pre-pay an annual amount to get half-price fare, may also pre-pay for one-day free travelling (an "authorisation" is given and communicated to the system)
Half-fare card + MJ ticket	Yes	Combination of the procedure for MJ ticket and half-fare card (see above)
Regional pass	Yes	Pre-payment of a fixed amount for travelling free of charge within one region; only the trips outside that region are included in the periodical invoice

An analysis of the impacts for the users segmented by ticket type is shown in table 6. To isolate the effect of the switch from the existing ticketing system to the new technology, the fare structure is admittedly unchanged, though some changes are likely, in order to benefit from the flexibility induced by EasyRide.

Impact analysis shows that major user benefits are: no need to carry cash, improved flexibility, and enhanced intermodality. Downsides are less common but need to be taken into account: transparency may degrade for about a third of the users, while fears for privacy loss concern all the users. Both transparency and privacy issues have therefore been instrumental in EasyRide design. Consultation terminals, card jackets with a display screen, a WEB site, etc. will provide information (recorded trips, charged fares, etc.). A lack of transparency could perhaps be still perceived, associated to the lack of pre-trip information on fares. A strategy has been outlined to cope with privacy issues: personal data and trips data will be separately recorded, except on invoices; users will be granted access to all their individual data; any use for marketing purposes will require user's authorisation; operators will have access only to trip data.

Majority of SBB passengers are either commuters travelling to work (47% of the total trips), or commuters to school or university (15% of the total trips). They largely use passes and multiple-journey tickets (table 4). Implementation of EasyRide has to take into account that those two groups experience already a high-quality ticketing system: discounted fares, possibility of intermodal travelling, no need to purchase a ticket before the trip. That is especially true for annual pass holders, while route pass holders and multiple-journey tickets users will benefit of improved accessibility and comfort while travelling on routes different from the usual one.

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Table 6. Impacts of EasyRide for the SBB users

Quality criterion	Current ticket type used										% of trips		
	Full-fare ticket	Collective ticket	Multiple-journey (MJ) ticket	Universal annual pass	Route pass	Half-fare card + ticket	Half-fare card + daily ticket	Half-fare card + MJ ticket	Regional pass	Soldiers	⇧ (big improve-ment)	⇗ (slight improve-ment)	⇩ (risk of worsen-ing)
Accessibility	⇧	⇨*	⇗	⇨	⇨	⇧	⇗	⇗	⇨	⇨*	25.7%	7.6%	0.0%
Ease to use**	⇗	⇨	⇗	⇨	⇨	⇗	⇗	⇗	⇨	⇨	0.0 %	33.4 %	0.0 %
Comfort	⇗	⇗	⇗	⇨	⇗	⇗	⇗	⇗	⇨	⇨	0.0%	49.8%	0.0%
Quickness	⇨	⇨	⇧	⇨	⇨	⇨	⇧	⇧	⇨	⇨	7.6%	0.0%	0.0%
Validation	⇨	⇨	⇧	⇨	⇨	⇨	⇧	⇧	⇨	⇨	7.6%	0.0%	0.0%
Transparency	⇩	?	⇩	⇨	⇨	⇩	⇩	⇩	⇨	⇨	0.0%	0.0%	33.4%
Flexibility	⇧	⇧	⇧	⇨	⇧	⇧	⇨	⇧	⇗	⇨	45.1%	18.3%	0.0%
Intermodality	⇗	⇗	⇗	⇨	⇗	⇗	⇗	⇗	⇗	⇨	0.0%	68.2%	0-0%
Privacy	⇩	⇩	⇩	⇩	⇩	⇩	⇩	⇩	⇩	⇩	0.0%	0.0%	92.9%

* A preliminary operation is still required (authorisation).

** The system is designed to be easy to learn and without need to perform an active validation; therefore it is likely to be very simple to use, but this issue will be further verified during the field trials.

N.B. only 92.9% of the total trips are taken into account for this table (trips with special tickets are excluded)

5 Conclusions

Contactless smartcard are a promising technology, able to improve over existing fare collection systems, for both transport companies and passengers. Accurate system design, on the basis of the analysis of the existing ticketing system and present users' behaviour, however, is essential to ensure users' acceptance.

The Swiss EasyRide system, currently under development, claims to be designed with these factors in mind. Some of its attributes, such as the walk-in / walk-out validation and the post-trip payment, address specific needs, those to replace the universal annual travel pass for Switzerland. For the users, the main improvement will be a better accessibility to public transport and a higher comfort. Fare flexibility, intermodality, and better tailoring of transport services on real demand are also substantial benefits. At the same time, public transport companies will gain cost efficiency, better knowledge of demand, and more precise revenue sharing. Transparency and privacy issues are likely to be the main source of users' distrust or rejection of the system. Appropriate strategies have been planned to cope with this concern.

To date, the operational applications of contactless ticketing are at urban or regional scale; the EasyRide project bets on the concept feasibility for long-distance public transport too.

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