# 6 Electronic fare determination

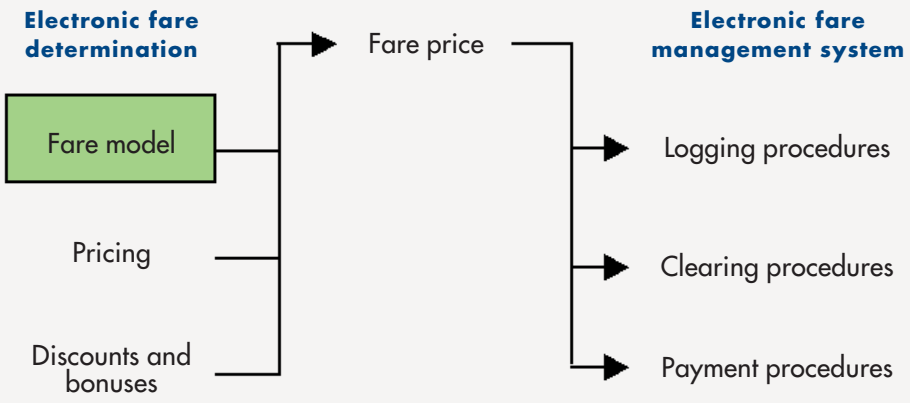
## 6.1 Introduction

### 6.1.1 The role of the fare model in the system of fare price and fare management

Fare models fundamentally belong in the context of electronic fare determination and electronic fare management. This classification is outlined in the following description (according to Gründel, Fraunhofer IVI, 2002).

**The role of the fare model in the system of fare price and fare management**

FIG. 6.1.1




### 6.1.2 Significance of electronic fare management systems with automatic fare calculation

The German Public Transport Act *(Personenbeförderungsgesetz, PbefG)* imposes three fundamental requirements of equal priority on price systems for public transportation. The first two are directly related to passengers' interests; the third basic requirement reflects the public interest in economically efficient transportation companies, which is only possible with a well-developed palette of products:

- Feasible and transparent fares
- Equitable fares
- Profitable fares

A critical point in fulfilling these three fundamental requirements lies in the organization of the fare region.

Two basic forms have emerged for this purpose:
- area-based fares (flat fare, zone fare, ring-shaped or matrix of cells)
- route-based

Of the three basic requirements, area-based fares emphasize feasibility and transparency. Their systematic approach simplifies the understanding of the fare and thus the passenger's purchasing of the ticket. This is especially important in highly networked transportation flows, as can be found especially in cities and densely populated urban areas. It also allows self-service by the passenger, as is necessary especially for city and suburban rail. Moreover, the area-based zones in many cases serve to define municipal territories. These advantages have led to the fact that area-based fares now predominate in Germany for instance, to the same degree in both cities and densely populated urban areas.

In contrast, route-based fares are geared towards the basic requirements of equitability and profitability. Today they are considered less suitable for complex integrated transportation networkswith high transfer rates and self-service, due to the extensive fine differentiation necessary and the resulting greater need for information. This approach is currently being used primarily for route-oriented, less pronounced traffic flows in a region.

Another important characteristic of fare modeling is the division of the fare region. It is considered the most important of all elements of fare design because it is essentially irreversible, and the most political, because it is closely related to municipal policy.

Other classic elements of fare structuring include:
- frequency of use (travel once or multiple times, week, month, year)
- time (peak or off-peak time of day, length of trip)
- persons and items (adults, children, workers, young apprentices and trainees; baggage, animals)
- means of transportation (passenger rail/1st or 2nd class, urban rail, express bus)

Compared to the classic fare structures outlined above, electronic fare structuring offers new scope for design through
- methodical approaches not yet realizable with current technology
- a more subtle and differentiated use of classic elements of fare design

For instance, a two-component fare structure becomes possible, as practiced in the communication and public utilities industries with great success.
In dividing the fare region, a route-based element can now also be implemented in cities and urban areas, since the passenger must no longer be familiar with fares. Thus, the aspect of transparency that has dominated up to now becomes less important.

The paper ticket in the product assortment is replaced by an electronic customer medium. Multifunctionality allows use not only among different transportation companies and networks, but also in a wide range of other service domains.

Of fundamental importance, however, is that with the new versatile instrument of the electronic user medium, a reorganization of sales and distribution channels typically becomes possible, leading to reductions in costs.

### 6.2 New fare systems in the VDV core application

New fare systems must comply with all legal regulations and statutes. Moreover, it is crucial that they also follow the rules of the VDV core application. This ensures that all ticketing and fare management systems following these rules are able to function interoperably in the future.

The following remarks on modern fare structuring are in accordance with the rules of the VDV core application.

### 6.3 New price systems as an opportunity to simplify fare rules

Local transit fares should take into consideration the interests of the residents of a city and its surroundings, a region, or an urban area. They should also take into equal account the economic requirements of transportation companies active there. Because they necessarily vary from city to city, region to region, and urban area to urban area, they also differ in their prices and fare rules. This is appropriate in principle.

However, individualization can and may no longer extend to such fare rules that for reasons of transparency and clarity should be uniformly valid throughout the country and be able to be coordinated without technical difficulties. Examples include age limits for children, free travel for children accompanying adult ticket holders, the begin and end of prohibited travel periods, and the transportation of dogs and bicycles.

With the introduction of an electronic fare, such fundamental fare rules must be standardized. Apart from the fact that such a measure would be positively greeted by the public, innovations must principally remain unencumbered from shortcomings and omissions of the past.

### 6.4 Market requirements

#### 6.4.1 Customer expectations

Surveys conducted in the course of pilot tests of chip cards in recent years have consistently indicated that:

- Passengers are open to new technology in conjunction with a new fare system
- The advantages of electronic tickets are recognized
- Especially a fairer and more transparent fare system is expected
- There is the perception that transportation are obliged to use the new technical possibilities as soon as possible, for the benefit of their passengers as well

This means that great expectations exist in addition to the sense of openness. These expectations especially necessitate intensive assistance to passengers before and after introducing the new electronic fare system, particularly during a relatively long introductory phase, along with a comprehensive ongoing information campaign within the framework of a new marketing concept.

If the expectations of the described customer perspective can be successfully met, experts are certain there will be no acceptance problems whatsoever.

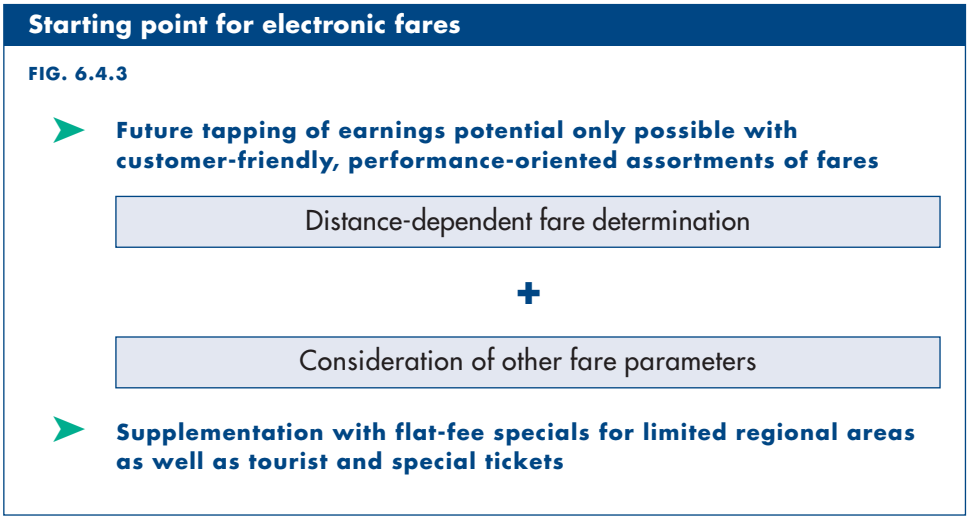
### 6.4.2 Appeal to target groups

With an electronic fare system, the concentration should initially remain on the local and regional business fields up to now, with their local and regional target groups (public transportation-oriented customers, crossover customers, and those oriented towards private transportation).

Due to the new methodical approaches and a more flexible manipulation of fare elements, in conjunction with more modern sales and distribution channels, barriers to access are disappearing. This will enable much stronger and more effective market penetration. For instance, anyone possessing a multifunctional chip card and hence requiring practically no familiarity with fares will, as a matter of course, increasingly use trains and buses (whether a public transportation-oriented customer, crossover customer, or those oriented toward private transportation). A prerequisite, however, is that the other basic conditions are acceptable, including frequency of transportation, punctuality, cleanliness, and service.

### 6.4.3 Future earnings potentials

The future strategy for integrated transportation networks and transportation companies can best be summarized in the following diagram:



## 6.5 Methodical approaches to fare and price structuring

### 6.5.1 Fare approach: two-component fare

For every public transportation trip, the price is composed of two components; the first component represents a prepayment element.

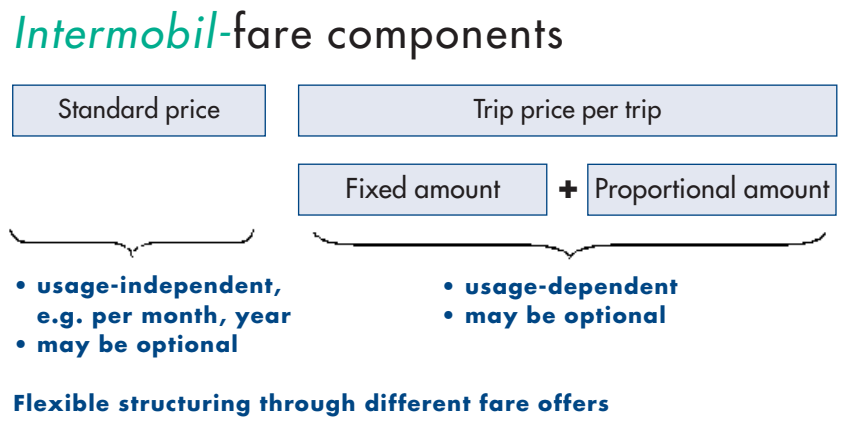
- First component = base price. This base price is paid in advance for a predefined period of time (month/year).
- Second component = trip price. It is subdivided into
  - ➔ a trip-dependent, fixed component = standard price. This is a fixed price component for every trip, due upon boarding in the first means of transportation used.
  - ➔ a distance-dependent flexible component = proportional service price. This is a price component incurred for each trip, the amount of which results from the addition of the applicable fare elements (see Section IV).

Various fare alternatives can be formed from combinations of these two price components.

Using the example of intermobil, the following diagram demonstrates the relationships described here (Gründel, Fraunhofer IVI, 2002).

Fare approach: **two-component fare**

**FIG. 6.5.1**




### 6.5.2 Pricing approach: competition-oriented price form

In this approach, it is assumed that public transportation is in competition with private motorized transportation. If public transportation offers better and, in particular, faster transport services for certain connections, this service is then offered at a higher price. This is typically the case especially in urban areas and commuter zones. If, on the other hand, private motorized transportation dominates, then public transportation must be less expensive.

As a supply-oriented design element for both higher and lower fare prices, essentially the following come into consideration – Alternative 1:

- time (times of peak or off-peak traffic)
- direction of load (mornings into the city, evenings outwards)
- location (city, state, region)
- type of transportation.

Alternative 2 might be a time-limited fixed standard price in conjunction with relatively inexpensive proportional pricing (load direction, location, type of transportation) as elements for differentiation.

### 6.5.3 Pricing approach: quota of travel rights/kilometers

In this approach, a certain mobility quota is purchased in advanced in the form of travel rights or kilometers. As soon as they have been used up through travel, they can be re-loaded. This is a clearing procedure and not a pricing alternative. Fare discounts are integrated through price factors. In this way, discount rates apply for instance after using up a certain quota. The passenger is electronically logged upon boarding and exiting; the fare is calculated using the fare pricing factors and deducted.

## 6.6 Selection of fare elements

**Overview, selection of fare elements**

FIG. 6.6.1

| | |
|---|---|
| **Factor: Region** | Route section<br>• kilometers<br>• partial section / stations<br>subdivided into price levels (A-X)<br>b) Zone:<br>• circular<br>• square<br>• matrix of cells<br>defined: price levels ( A – B – C ) |
| **Factor: Time** | a) Peak traffic time<br>b) Off-peak time<br>c) Length of travel<br>d) Weekday |
| **Factor: Persons/ Items** | a) Adults<br>b) Children<br>c) Workers<br>d) Non-workers<br>e) Apprentices/trainees<br>f) Items: baggage/animals |
| **Factor: Frequency of usage** | a) Once<br>b) Multiple<br>c) Week<br>d) Month<br>e) Year |
| **Factor: Means of transportation** | Speed – comfort<br>a) Passenger train (1st/2nd class)<br>b) City rail / subway (1st/2nd class)<br>c) Express bus |
| **Factor: Load direction** | Into town<br>Out of town |
| **Factor: Quality** | Punctuality |
| **Factor: Discounts** | Discounts on fares according to marketing aspects |

### 6.6.2 Structuring of the fare elements

#### 6.6.2.1 Factor of region

The introduction to this chapter already touched on the importance of the factor of region. It also explains why the broader division of the fare region into site-specific units such as zones and matrices of cells is largely the norm today. In electronic fare determination, the individual route can be made the basis for the fare. Transparency and simplicity lose their significance as advantages of region division. Passengers no longer have to concern themselves with start and destination stations for fare reasons.

The prerequisite for a route-based fare is a survey of the fare region. Sections and stations must be recorded in a matrix and stored in the background system.

The following questions must be answered for a route-based fare:
- Basis for calculation: actual distances or "as the crow flies"?
- How will parallel sections and connections be assessed?
- What kind of rounding will be used?

The need for such regulations has fundamentally always existed in kilometer- and partial section fares.

The advantages of a route-based fare are summarized in the following.

**From the customer viewpoint**
- Unambiguous, transparent specification of route
- Fair, route-based price calculation
- Finely differentiable price steps, instead of relatively large price jumps as is the case for short trips that cross over into another fare zone

**From the business viewpoint**
- Company-specific, flexible pricing
- Possibility of selective, demand-oriented traffic control through profit-relevant pricing
- Fractional revenue allocation among cooperating transportation companies
- High degree of autonomy in designing product assortment
- Efficient data on sales and transportation structures

#### 6.6.2.2 Factor of time

By logging the passengers upon boarding and exiting, the electronics ensures exact price differentiation between peak and off-peak traffic times. The same applies for observing the "window of time" each fare allows a passenger on a route or in a network, which can hardly be checked today, practically speaking.

#### 6.6.2.3 Factor of persons/items

The fare element of "persons" can be structured by subdividing it into adults, children, and apprentices/trainees. This element requires identification of the person elements from the electronic customer media. A similar differentiation of "items" is necessary in the fare rules.

#### 6.6.2.4 Factor of usage frequency

In addition to "region," the factor of "frequency of usage" forms the second important element of the proportional service price. New: the "block classification" of the old ticket assortment can be replaced in the new methodical approaches with a self-limiting curve of usage frequency. Price differentiations related to the time factor lead to corresponding, overlapping curves of usage frequency. The fare module enables the electronics to log and evaluate the correct usage curve for each trip.

#### 6.6.2.5 Factor of means of transportation

Express buses, trams, city rail and subways, as well as additional comfort components such as first class vehicles can likewise be expressed monetarily through special proportional service price elements.

#### 6.6.2.6 Factor of load direction

The load direction can be used as a fare element, depending on the main flows of traffic at certain times of day.

#### 6.6.2.7 Factor of quality assurance

It would also be technologically possible to give passengers an ad hoc price discount, for instance if delays exceed a certain length of time, vehicles are overcrowded, or certain scheduled trips are cancelled.

#### 6.6.2.8 Factor of discounts

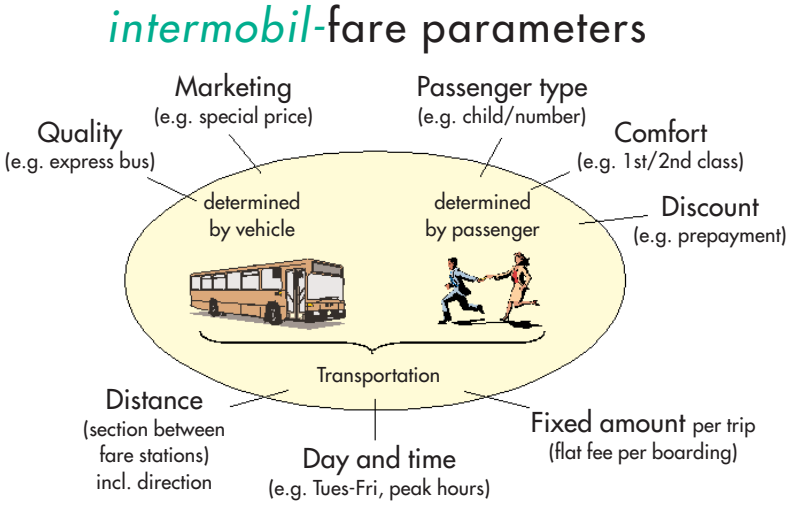
Discounts are not formal fare structuring elements. They facilitate pricing from a marketing perspective. But because of their direct relation to the fare elements, discounts are often represented together with fare elements.

### 6.6.3 Interaction of the fare elements

The intermobil example demonstrates the used of different parameters in a fare model (Gründel, Fraunhofer IVI, 2002).

**Interaction of fare elements**

**FIG. 6.6.3**



## 6.7 Significance and function of sales & distribution

### 6.7.1 Sales & distribution structures

Transportation companies offer services
- transportation by bus and rail
- according to a fixed schedule
- with a specified schedule period

To accept such a service offer, the customer requires a ticket as authorization and receipt for the paid fare, which can be acquired through a variety of distribution channels.

Such channels today essentially consist of
- sales through drivers
- the company's own points of sale and private points of sale
- stationary and mobile ticket machines

Sales & distribution act as a bridge function. The easier it is for the potential passenger to access the assortment of tickets and the easier tickets can be purchased, the greater are public transportation's chances in the market. Sales are additionally the "bottleneck" factor that determines the variety or the limited nature of the ticket assortment. Depending on the number and structure of the distribution channels, sales represent an increasingly significant portion of costs (statistical average: 8-15% of net turnover).

### 6.7.2 Reorganization of sales & distribution

When using electronic ticketing and an adequate electronic fare management system, a logical event chain leads to reorganization of sales.
Through the development of new technologies and their implementation in new customer media, companies have access to tremendous opportunities. The details of this are described in Chapter 3.
New customer media logically offer a range of opportunities for realizing sales and fare ideas. However, the sales department must not merely be familiar with the new media for this purpose; it must also master them. These possibilities can then be used for the benefit of all participants, both the customer and the transportation company. This necessitates modification of the business processes and the structures in which they are realized. A new business profile will develop as a result. These changes have also been illustrated in detail in Chapter 2. Sales & distribution have a new assignment: selling mobility products. Contactless chip technology may do away with the bottleneck character of sales to a degree inconceivable up to now. It is essential to take advantage of associated opportunities for greater proximity to the customer, a more differentiated palette of fares, and more streamlined (and hence less expensive) sales and distribution structures – in connection with the introduction of an electronic fare. Only an electronic fare together with new sales structures will result in higher revenues and lower costs. In this way, the introduction and long-term operation of an electronic fare and an electronic fare management system are justified, both from the customer's point of view and in terms of business management.

The improvement of the overall situation for the passenger is illustrated in the following diagram.

**Perspective of electronic fare models**

FIG. 6.7.2

**"Board and ride"**

Simple operation by the passenger

+

**"Pay as you ride"**

Automatic fare determination

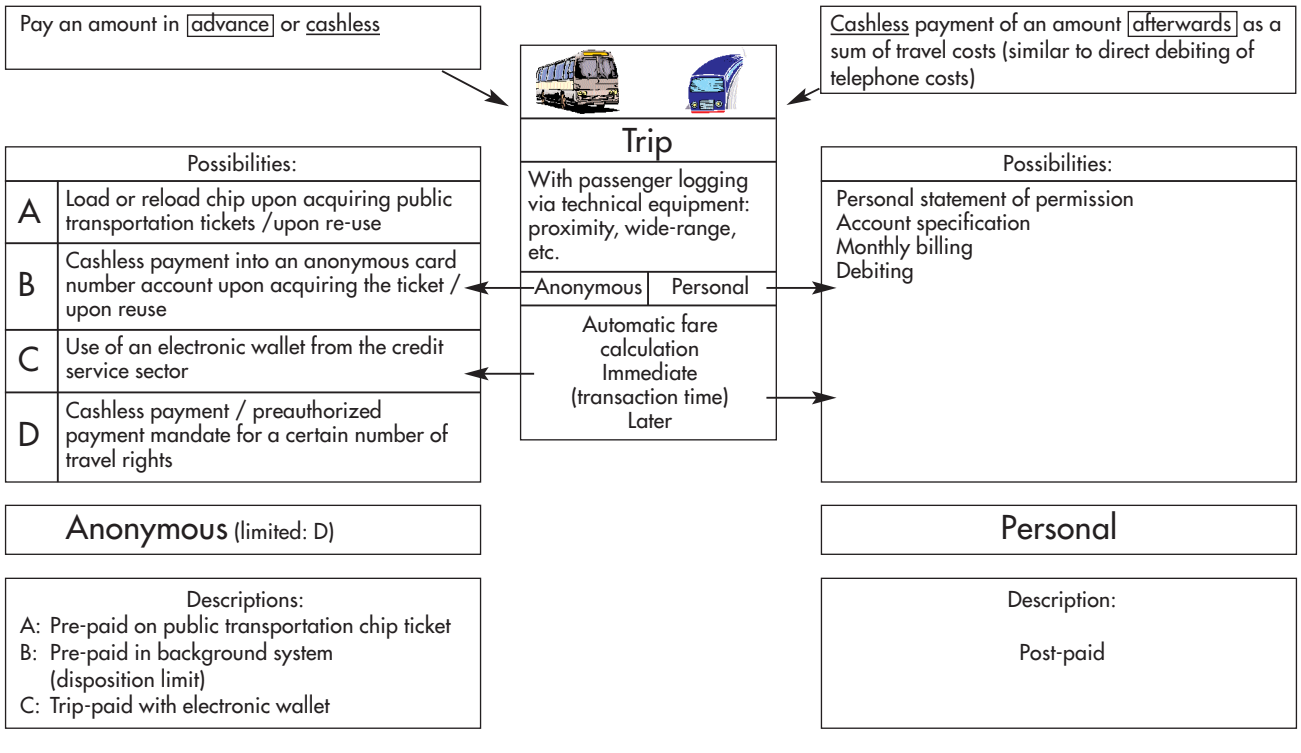
- **Decoupling of fare structure and operation by the passenger: more flexible fares possible**
- **Profitability, proportionality, feasibility can be newly optimized**
- **Familiarity with fares no longer mandatory**

## 6.8 Clearing procedures

A variety of procedures are available for clearing ticket acquisition transactions with the passenger; they can be used individually or in combination. The following diagram, the essence of which is taken from the "ChipTarif" report of the German Federal Ministry of Transport, Building, and Housing, gives an overview of the details. The clearing method is distinct from the payment method.

**Clearing procedures**

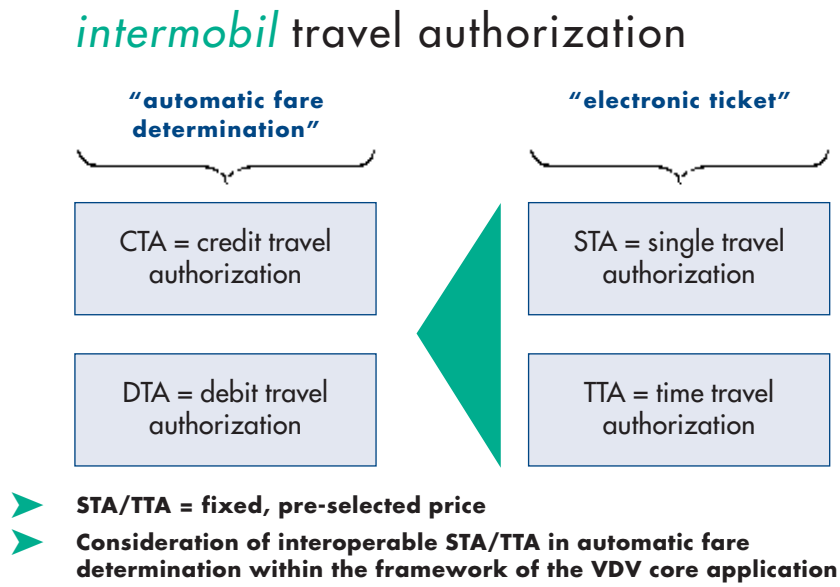
FIG. 6.8.1



The connection between travel authorization and payment procedure is illustrated in the following diagram (Gründel, Fraunhofer IVI, 2002).

**Travel authorization and payment procedures**

**FIG. 6.8.2**




- **STA/TTA = fixed, pre-selected price**
- **Consideration of interoperable STA/TTA in automatic fare determination within the framework of the VDV core application**

## 6.9 Future communication with the passenger

### 6.9.1 Information today

An expanded and electronically based fare assortment together with a novel bridge function for sales and distribution necessitates a new manner of communicating with the passenger.

The German Public Transport Act *(PBefG)* stipulates how, when, and where transportation companies are required to inform customers about fare prices and rules.

Article 39, Paragraph 7 for instance specifies that transportation companies must locally publicize transportation fees and the special conditions of carriage before their introduction; the notification is to be displayed in locations that passengers typically frequent.

In practice, this means that at every stop and/or at every ticket machine, a price panel with an abridged list of stops is posted. The special conditions of carriage (= fare rules) are only posted or available in leaflet form at points of sale or large transfer points. Regular customers with season tickets are personally advised at the points of sale, at least upon initial purchase; subscribers are notified of changes in writing.

For the general public, impersonal information continues to be considered inadequate (keyword: "fare jungle"), especially when a complex fare system must be conveyed – and all this on a display panel of limited size.

### 6.9.2 Communication of tomorrow

The more an electronic fare moves away from classic fares in the structuring of its fare elements and simultaneously orients itself towards the individual passenger on a personal basis, the more difficult it naturally becomes to publicly portray innovations in a conventional manner, in the form of (complete) fares fixed in advance. What makes it even more difficult: in the course of innovation, it is also expected that the current information system, perceived by the public as insufficient, will be improved. And increased proximity to the market, as offered by an electronic fare, absolutely necessitates better communication.

By no means does the wheel need to be reinvented; there are comparable service providers, for instance in the public utilities sector or even more so in the telecommunications industry. Like public transportation, these industries must build up and maintain an infrastructure, as well as comply with a government-stipulated obligation to provide information. And they offer the individual use of their infrastructure for a fee, even under conditions of competition. Like public transportation, they also use region (local, long-distance calls), time (M-F, weekends), and usage intensity (minute-, second-billing) as pricing elements; base and service proportional price differentiations play a prominent role

Based on such service providers and particularly taking into consideration current and future information technologies in public transportation (including electronic timetable queries, info-terminals, the internet, and mobile telephones, to name the most important) in the case of e.g. an electronic fare with the fare elements

- route-based region classification
- fixed standard and service proportional price system

the following chain of communication would be possible:

**Fare panel**
Statement of the fixed base price component, e.g. € 1. Statement of the different route-based service proportional components. Illustration of representative total price examples. Posting of such a fare panel at locations where only brief information is available today. This completely fulfills the requirements of Art. 39 Par. 7 Public Transport Act. Incidentally, it is important to recall that without objection, tickets are already being sold today for which the overall trip price does not result until individual use, e.g. a strip card; only the price of a single strip is fixed.

**Marketing measures**
Within the framework of marketing, the electronic fare is to be advertised more broadly and extensively, in conjunction with ongoing and seasonal price advantages.

**Modern information technology**
Through modern information technologies currently in development or expansion, it will be possible to communicate and query the route-based region classification and the total price for each individual connection. It is essential to communicate with customers about key issues in this domain. Technical advances in fares and sales would thus perfectly keep pace with the further technical development of schedule information.

## 6.10 Aspects related to revenue allocation among cooperating transportation companies

### 6.10.1 Current procedures

As soon as several transportation companies offer their customers a common palette of fares in the form of a joint or transition fare, the question of internal revenue allocation arises. After all, the sale of the ticket is no longer equivalent to its complete use on the seller's buses and railways.

In practice, three systematic approaches for revenue allocation procedures have emerged:

- Procedures oriented towards previous revenues (allocation according to revenues before the establishment of the cooperation)
- Procedures oriented towards supply (allocation according to infrastructure and operating performance)
- Procedures oriented toward demand (allocation according to ticket usage among the participating companies)

Because they are linked to the palette of fares, demand-oriented procedures are the most appropriate. However, a good data basis is essential here; with today's complex logging procedures and their considerable processing time, this is currently only possible to a limited extent.

### 6.10.2 Opportunities and possibilities for tomorrow

Electronic detection of passengers' boarding and exiting for purposes of fare calculation and the processing of this data in the background system offer the possibility of making demand-oriented revenue allocation procedures considerably more exact (and thus fairer), quicker to process, and overall more efficient. Compared to such a procedure, those cited in Section 6.10.1 appear completely inadequate. The electronics additionally allows the step-by-step changeover from one of the mentioned procedures to demand-oriented revenue allocation – and thus without immediate interruptions.

Experience shows that after just a few years, allocations oriented towards previous revenues or the supply side have little to do anymore with the reality of passenger flows; they have become outdated, fundamentally unfair regulations (nevertheless stipulated by contract) that make further expansion of public transportation difficult, if not impossible.

With suitable structuring of an electronic ticket, e.g. with the elements of fixed standard and service proportional price, revenue allocation can even be systematically further refined through these two elements; for instance, the fixed base price can reflect the relatively different costs of city rail/bus implementation, or the important but often short-distance feeder function of the bus to the rail system can be better assessed financially through fixed base price allocation. Such fine differentiation is lacking today – a weakness of many revenue allocation procedures currently in use.

Electronic fare determination provides all the data necessary to achieve revenue allocation according to actually realized transportation services, i.e. those services actually used.

Such data includes
- Transported persons (according to routes, company or transportation network)
- Fare type or authorization type for each transported person
- Actual ticket usage according to routes, with boarding and exiting stations, transfers, and transitions in chains of paths
- Transportation companies to whom the authorization was paid (pre-paid) or who are to be paid (post-paid)
- Usage frequency per fare type
- Overall extent of travel realized
- Extent of travel realized with the respective transportation company

On the basis of such data, it is possible to determine the proportion of income per transportation company. The mathematical models necessary for this already exist; they can be used to classify revenues according to the criterion of earnings capacity as well as according to the respective proportional usage, including all partial paths.

Another decisive advantage exists. All demand-oriented models used to calculate revenues allocation today are typically determined from transportation data collections, comprised of traffic counts and surveys. Critical points in this process are the correct planning of the statistically necessary sample size (here in the homograde case), the projection of the sampling results to the reference unit, typically over the course of a year, and the updating of the data in the case of dynamic or event-related changes in demand, since a yearly data collection is omitted for reasons of costs. In the described case of using electronic fare determination, no updates are necessary since current usage data is always at hand.

### 6.11 Success of public transportation

Public transportation will only be successful if it follows the following formula at all levels (Gründel, Fraunhofer IVI, 2002).

**Criteria for the success of electronic fare models**

FIG. 6.11

➤ **Profit stabilization and enhancement**
- Customer-oriented palette of fares
- New possibilities of price structuring

➤ **Reduction of barriers to access**
- Minimization of necessary familiarity with fares
- Proportional relation to services performed
- Fare transparency

➤ **Customer retention**
- Advantage and comfort offers
- Discount and bonus models