Rail-based transport systems continue to demonstrate enormous potential in terms of their innovative strength and future potential. Fascinating opportunities to tap this potential are emerging from the dynamic technological development. Following an era of potential improvements in the rail system, the time is ripe now to create visions for the mobility and logistics of tomorrow. Scenario technique is a suitable tool for blueprinting the future and developing such visions.

This paper focuses on the high growth CEP (Courier, Express and Parcel) market. This market places new challenges on production resources and production processes, for example reduction in the transport volume as well as fragmenting and internationalization of goods flows etc. Market and environment scenarios as well as alternative technical designs of the transport chain were elaborated in order to identify these requirements and acquire the necessary information for building business and technology strategies. This clearly shows which technical designs must be adopted in order to utilize the opportunities that are unfolding on the CEP market.
1 Strategic planning using scenario technique
Systematic definition of future potentials

As we create products for the markets of tomorrow, asking customers’ opinions is scarcely helpful. They are generally missing the imagination. The same applies, in principle, for sales. This conclusion is of course provocative. However, it essentially matches our experience. What product planner or developer has not in the course of his or her career had a visionary product idea and presented it to sales, only to be met with lack of understanding. Then years later a competitor brings a similar product to market.

From traditional customer orientation to visionary understanding of customer needs
[Hamel/Prahalad 1995]

The reasons for the lack of ability or readiness to take a critical look at visionary product ideas are obvious: The customer wants his or her current requirements resolved efficiently. He or she moves in the present and is not concerned with the problems and possible solutions of tomorrow. Sales is in discussion with the customer and therefore logically transforms what concerns the customer to product planning and product development.

It obviously makes little sense to ask the customer or sales whether a future solution should be like this or like that. It is more important to understand the customer problem and hence the potential benefit in the capital goods business or to recognize the customers’ needs in the consumer goods industry. Intensive contact with the customer is naturally required here. However, customer orientation should not be understood in too narrow a sense of the word as we can see from Figure 1. Customer orientation if understood in too narrow a sense delivers the articulated needs of the served customer. Furthermore, customers indicate their current needs, as already stated, and not their future needs. The articulated and current needs of the served customer only represent a small subset of the opportunities. Most opportunities are outside a narrow understanding of customer orientation.
In order to recognize these opportunities, we need to make a forecast of the markets and the technologies. The achievement of the scenario technique is to do this [GFS96]. This technique is based on two basic principles: 1) systems thinking [Ves99] and 2) multiple future.

**Systems thinking:** Companies are embedded as part of a complete system in a complex network of influence factors. The complexity of this network increases with progressive globalization, the increasing significance of ecology and the rapid pace of technological development. The interactions between the influence factors play an increasingly important role. Companies must therefore think in systems of networked influence factors. We humans have no talent for quickly analysing networked systems. Scenario technique gives the requisite support, however.

**Multiple future:** This means that several development options are taken into consideration for each influence factor. Here, the development of a logistics concept for the year of 2010 exemplifies. A key influence factor in this case is without doubt the price of petrol. It would be almost like reading tea leaves for the strategy team to estimate the price of petrol in 2010. Multiple future means to consider several conceivable developments. The following would be conceivable, for example: 1.2 €, 2.5 €, but also 10 €. 1.2 € expresses the continuation of the development of the past 30 years. This is the supposed probable development. 2.5 € does not need to be explained particularly; this is the political program of the current Government in Germany. 10 € is unlikely, but conceivable. What is certain is that a petrol price of 10 € would stimulate a completely new logistics concept, which would possibly also work if the price of petrol were ultimately only 1.2 €. Such extreme but conceivable developments obviously release creativity. The scenario technique invites us to think the unthinkable. Retrospective it is often not that the supposedly probable but the unthinkable that has become reality. The principle of the multiple future is the real strength of the scenario technique [GFS96].

The development of future scenarios and their application in strategic planning is explained by using a series of diagrams covering seven steps.
1) Identification of influence factors: First of all we establish the areas of influence surrounding the object of investigation. The object of investigation can be a product in the context of a product strategy, or a business field in the context of a business strategy. Examples of influence areas are market, technology, suppliers, politics etc. Influence factors can be identified and described for these areas of influence. Normally there are between 50 and 150 influence factors. It is necessary, therefore, to reduce this high number to the important ones. We do this in the next step.

2) Determination of key factors: The basis for this is a cross impact analysis. From the large number of influence factors, this will provide us with the factors that will primarily characterize the future of the object of investigation. This comes down ultimately to 20 factors.

3) Description of the development options (future projection): This is the well-known step of the multiple futures. It involves determining a number of conceivable development options, for each of the some 20 key factors. A future horizon must first be defined of course. The future horizon depends on the business dynamic. In the telecommunication industry we often work with a time horizon of two years. In other areas e.g. rail systems a future horizon of 20 years or more is appropriate.
4) Development of consistent future images: The basis for this is the paired assessment of the consistency of future projections. This is performed in what is called a consistency matrix containing lines and columns in which the future projects are inserted. Assuming the price of petrol were the key factor with the previously mentioned three projections and environmental protection legislation - these could be the same as today but also considerably stricter - then it is plausible that the combination petrol price\textsuperscript{10} and considerably stricter environmental protection laws will be consistent. Consistent means that these two developments could very probably appear in a scenario. The opposite would be the case with the combination of 10 € petrol price and environmental protection conditions as today. This combination is less probable, i.e. inconsistent. The automatic analysis of the consistency matrix finally leads to the scenarios. A scenario, in principle, contains the combinations of developments that fit together well.

5) Description of the scenarios in prose: The prerequisite for this is that each future projection is described in a generally comprehensible and succinct way in prose. This is necessary in order to create a common understanding for the paired assessment of the consistency of future projections. Because the consistency analysis has shown us the possible combinations of projections for scenarios, the descriptions of the projections are determine and combine. The prose text of a scenario is determined essentially by the consistency analysis and the quality of the descriptions of the individual future projections.
6) Impact analysis: Here is the main aspect the object of investigation and additionally there is the question: What impact does scenario X have on the operation parameters of a product or business strategy? The relevant responses provide us with reliable information for checking existing strategies or for developing new strategies. This is the subject matter of the last step.

7) Scenario transfer: By this the application of the scenarios in strategic planning is to understand. At this point it is to emphasize that the development of a strategy is a highly creative process. It is wrong to assume that the strategy results almost automatically and inevitably from the scenarios. However, the scenarios provide insight into future opportunities and threats and thus give the necessary impetus for developing the strategy.

2 Example of technology planning for a rail system

There are three stages in the development of strategic options for the transport of goods by rail.
Approach to developing strategic activity options for goods transport by rail

The first stage looks at the market and business environment. Environment includes areas such as society, politics, technology and competitors. The time horizon is 2010. The results are the success potentials of the market, what we call market pull.

The second stage looks at the operation field of goods transport by rail. The design factors are investigated here primarily. Design factors include, for example, technical solutions and business processes. In the scenario technique, alternative concepts of railborne transport systems are developed based on the design factors. The results are the technology potentials, what we also call technology push.

The business strategy and technology strategy are developed in the third stage. This is based on the comparison of market and environment scenarios outlined in Figure 6 on the one hand and technology scenarios on the other hand. This comparison in principle answers the question as to which technical solutions of the transport system are favorable in which market configuration.

Another important step in the scenario technique is that several future scenarios are developed. Because the future images established in the case of market and environment scenarios cannot be influenced by the individual company, the company has to accommodate this. It is possible, in theory, to adapt to every scenario. This would mean that the company would have to work out a strategy for every scenario. These would be what we call contingency strategies. However, there is generally no time for this. In addition, having to adapt or align the company to several scenarios wastes resources. One therefore typically decides in favor of one scenario. It is then the task of strategy controlling to check regularly whether the scenario on which the strategy is based becomes reality. The technology scenarios elaborated in this example are based on factors that the company can influence. It is up to the company to introduce one or other scenario, that means technology concept [GF99].
2.1 Development of market and environment scenarios

The CEP market covers all goods, which as time-critical express shipments must generally reach the recipient the next day. These are generally goods for mail order business. Because strong market growth is predicted for the CEP market for the period up to 2010, this business is very important for all transport and logistics companies.

The influence factors established represent non-tractable factors that impact the future development of the CEP market. The cross-impact-analysis came up with 19 key factors that will characterize the future of the CEP market in particular:

1. Internationalization of goods flows
2. Transport development and telematics on the roads
3. EU transport policy
4. Environmental awareness
5. Transport costs in DM/Tkm
6. Innovation culture
7. Acceptance and use of the Internet
8. Market volume for e-commerce
9. Profit opportunities on the Internet
10. Goods structure of CEP goods
11. Cooperations
12. Market volume of the CEP market
13. Sector structure
14. Coverage of the transport chain by CEP providers
15. Type of value-added services
16. IT in CEP business
17. Number and distribution of hubs and depots
18. Number of direct connections
19. Level of bundling

A number of future projections will be formulated for each key factor for the year 2010. Let us take for example the key factor Internationalization of goods flows. There are two projections here: A) Boom in international goods flows and B) Emerging of new trading blocks. Such projections form the basis for market and
**KF 1 Internationalization of goods flows**

The growth and increasing integration of the world economy (development of world trade - globalization), for example the opening up of previously regulated markets or the breaking down of trade barriers, is leading to an alignment of the goods supply and large international goods flows. A third of all goods flows are currently distributed internationally [DP99]. Furthermore, the formation of regional trading blocks is also conceivable.

**A Boom in international goods flows**

There is a boom in international goods flows on the world market. More than half of the entire goods transport goes to or comes from abroad. Large as well as increasing numbers of small to medium sized German companies from all sectors are operating internationally. The focal point is the EU domestic market. Hand in hand with this is the increasing cooperation between companies in the creation and marketing of services. This enforces the need for universal and cross-border services and requires large capacities of efficient international logistics.

**B Creation of new trading blocks**

European integration has led to the creation of a trading block. The other strong economic regions of the Triad, but also up-and-coming economic nations like China, have responded and have likewise set up trading associations. Protectionism is on the increase. The goods flows occur primarily only within the individual trading blocks.

Figure 7: Example of a key factor with two projections of the CEP market scenarios

In this case, there are four scenarios that can be visualized using the multidimensional scaling in Figure 8. The spheres symbolize so-called projection bundles, i.e. combinations of projections that fit well together, with precisely one projection for each key factor. The diameter of the spheres is a measure of the consistency of a bundle. Bundles that are similar are summarized by the cluster analysis. A cluster is a scenario.

The arrows visualize selected key factors with their projections. This clarifies the differences between the scenarios. Regarding to the horizontal arrows, it is clear that scenario 4 differs in essential areas from the other three scenarios. In addition, the three oblique arrows delimit scenarios 1 and 2 from scenarios 3 and 4. In terms of the key factor 8 Market volumes for e-commerce there is a revolution in scenarios 1 and 2 in e-commerce while in scenarios 3 and 4 the market volume remains clearly below expectations.
Visualization of the market and environment scenarios (multi-dimensional scaling) and representation of the essential future projections for key factors

The scenarios represent several futures, although obviously only one future will happen. It is therefore essential for strategy development to opt for one scenario.

2.2 Scenario-based development of technology concepts

This is based on tractable design factors. These can be influenced by a company and the relevant scenarios then developed. In this example, there are determined 17 design factors:

1. Combination of transport systems
2. IT usage for system control
3. Disturbance management
4. Planning process of transport chain
5. Combination of persons and goods transport
6. Efficiency of control and backup technology
7. Route categories
8. Network density
9. Structure of terminals
Alternative future projections are elaborated for every factor for the time horizon 2010 as with the market and environment scenarios. The projections form the basis for the scenarios, which describe conceivable technical concepts of the transport chain for railborne goods transport in 2010. The transport chain describes the transporting of the transport goods from sender to recipient. This includes different transport systems, such as heavy goods vehicles and planes and thus loading and unloading processes. Figure 9 shows the three relevant projections of the design factor type and size of train formations.

<table>
<thead>
<tr>
<th>KF 10 Type and size of train formations</th>
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<tbody>
<tr>
<td>A Autonomous transport unit</td>
</tr>
<tr>
<td>The autonomous transport unit is an individual vehicle with its own propulsion. It can control its destination independently of other transport units. The transport unit can be joined in formation with others on highly used routes to increase the volume throughput on the route.</td>
</tr>
<tr>
<td>B Module unit</td>
</tr>
<tr>
<td>The module unit is a train formation with its own propulsion. The size of the module unit varies from a number of transport units to the size of an entire train. Each module unit has its own destination. Several module units can form long formations on the way to their destinations on commonly laid subroutes.</td>
</tr>
<tr>
<td>B Classical train</td>
</tr>
<tr>
<td>The classical train comprises a propulsion unit, the locomotive, and one or more transport units. The transport units in the classical train always have the same destination. They are ranked and coupled together.</td>
</tr>
</tbody>
</table>

Figure 9: Example of a key factor with its projections alternative concepts of the transport chain

The scenarios derived finally for the transport chain are outlined in Figure 10. That there are also four is pure chance.
The arrows visualize the basic differences between the alternative concepts for transportation of goods by rail. Scenario 4 differs clearly from the remaining three scenarios. The three horizontal arrows in the upper part of the picture point to the differences in the areas of customer orientation, shipment size and service offer. The three oblique arrows in the lower right part of the picture compare scenario 4 with scenario 3.

Visualization of scenarios for the technical designs of the transport chains for goods transport by rail (multidimensional scaling) and representation of the principal future projections for key factors

2.3 Development of strategic activity options

The relevant approach is outlined in Figure 11. The alternative technical solutions are first mapped on the scenarios for the CEP market. Furtheron it is assessed which the specific requirements of the market scenarios are met by the individual technical solutions. Based on this, the appropriate directions of a strategy can be identified. These are taken from the “most probable” market and environment scenarios and the technical solutions that best fulfill the requirements in this situation. Future-robust technical solutions should be sought here, i.e. solutions that are suitable in several market and environment scenarios. This frequently does not apply to complete solutions but to part solutions, such as coupling design. The strategic future directions are then assessed whether they fit to upcoming chances and to the companies competences of tomorrow.
Comparison of technical designs and the market and environment scenarios

2.4 Future potentials of rail-based cargo transportation using the example of the scenario 1 of the transport chain

Based on a detailed description of scenario 1 of the transport chain, "Autonomous transport units even transport individual parcels on demand", the future potentials of this transport chain will be illustrated below. Figure 12 shows the automotive transport units as a basis for this design. The transport units depicted are modular in design. The passenger compartment is replaced by a cargo transportation container to enable flexible use in passenger and cargo transport.

Vision of a transport chain: Automotive transport units form a convoy and thus bridge the divide between passenger and cargo transport.
Demand-driven automotive transport units

Automotive transport units are used for transporting cargo on demand. Equipped with their own driving gear, the transport units autonomously head for their destination independent from other transport units without any intermediary stops. The transport units can join together into convoys during the journey on heavily frequented stretches to increase the throughput on the route. Individual transport units weave automatically into existing convoys, but can leave again at any time in order to reach their individual destination. The distance between the vehicles is controlled electronically within the convoys themselves. This way the divide between local and long-distance transport and between passenger and cargo transport is bridged.

High-performance route network

A high-performance route network is available to the transport units. The network density is very high both in densely populated urban areas as well as in rural areas. Heavily frequented routes are highly developed and numerous route diversions and additional overtake sections have been created. Rail access is provided via numerous access points for cargo transport, distributed throughout urban as well as rural areas. While the railway industry is focusing on economically viable routes in the densely populated urban areas, middle class companies are cultivating the routes in rural areas.

Terminal strategy

With new technologies, so-called small terminals are established very quickly at justifiable operating expenses. The performance range of these small terminals can be adapted to current requirements and is not dimensioned in principle or in a precautionary way for all conceivable applications. The terminals are connected very efficiently to the route network. The handling of cargo is carried out using mobile devices and truck-bound conveyor technology. Apart from a loading bay no major foundation work is needed for these transshipment terminals. The overall concept is committed to the fast setup and dismantling of the terminals to be able to quickly respond to local fluctuations in the goods volume. The terminals are tailored to special market segments (e.g. CEP services) as a separate network.

Control command

Control command has achieved a uniform high standard throughout Europe (European Train Control System, ETCS). It is characterized by excellent efficiency and a high level of automation. Information transfer and train diagnostics can be handled electronically. Primarily monitoring tasks are performed by human beings further on. Data for the control and backup functions is exchanged permanently either by electronic means or by radio between train and control center. The data is forwarded and evaluated online. Moving blocks allow traveling within the electronic stopping distance. This way, the throughput on main and secondary routes improves enormously.
Failure management

The production process is monitored constantly through ongoing and detailed data recording and evaluation of the relevant areas, i.e. vehicle, track, control command etc. This is based on the consistent use of modern sensors and associated telecommunication, signal and information processing. The status of the production process is thus known at all times. Technical and operational failures are detected early on. Predefined strategies are used in case of a failure to immediately identify and introduce the necessary measures.

Demand-driven planning

In addition to the track, the railway industry utilizes other transport carriers. Apart from using its own fleet of trucks, numerous cooperations exist with other transport companies. This means increasingly that a complete, all-in cargo service can be offered. The railway industry is thus involved in all stages, from pre-carriage, carriage to post-carriage. The planning process for the transport chain is handled in a demand-driven way. The railway industry plans its transport chain shortly before the order is accepted. Journeys and train programs are tailored to the respective customer at short notice. With rigid travel schedules being a thing of the past, the available routes can be used flexibly. This allows transport times and the number of dispatches at transshipment terminals to be reduced to a minimum. The flexible planning process is based on fully integrated IT systems. The various organizational divisions within the transport companies are heavily networked with each other. This ensures a fast and flexible order acceptance and preparation process, management and production. Customer orders can thus be processed and handled without delay.

Handling small shipments

In addition to containers and bundled goods, the railway industry adjusts itself to transporting parcels of a size that can be handled with simple tools, like hand-carts. A suitable production structure must be created here to deal with the activities that typically arise with such shipments as they are processed, for example collecting, sorting by target destination, bundling in carriers for long-distance transport, sorting in the receiving area by recipient.

Technology for supporting transport and business processes

The carriers are equipped with additional technologies for supporting and optimizing provider, transport and increasingly business processes. Technologies for provider and transport processes include air conditioning devices in the carriers or the preparation of load processes by providing details of the positioning of the containers in the transport units.

Value added services

The railway industry offers both transport and logistics services. In conjunction with the entire transport chain, it can manage all tasks that are relevant in the framework of the logistic service portfolio. This covers all functions that arise within the context of provider and transport services and at their interfaces. The railway industry thus offers
the entire logistics required for transportation from dispatcher to receiver. However, it can also provide services that extend beyond the transport process. Among others, these include the development of new business areas and growth opportunities, better utilization of own otherwise not realizable resources as well as insight into the business processes practiced by partners to allow company policy to be aligned more successfully to the needs of the future.

Because of the strong growth in the volume of goods as well as the booming CEP market, a flexible, intelligent transport system is needed, which can meet the needs of the market in terms of time-critical transport and can also handle heavy local and transitory fluctuations in goods volume as well as even the smallest shipment. The transport system outlined in this paper can make an essential contribution to achieve this goal.

Publications


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