Mobility Data Stories for a Better Understanding of Mobility Data

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Abstract. Numerous stakeholders are involved in mobility planning, such as citizens' initiatives, political decision-makers, and mobility consultants. Here, data and its linkage form an important building block for decision-making. However, the challenge is to process heterogeneous data sources in a problem-adequate and target group-specific manner. Therefore, this publication addresses how decision-relevant contexts can be visualized and developed into mobility data stories. First, the approaches and principles of Neifer, Freytag, and Field are presented. They show that data stories are formed from an intersection of the key components data, visualizations, and stories. After that, an example is used to show how Mobility Data Stories are developed, starting from the core question, through the selection of data, the conception of the story, to the visualization. The sample solution developed in the research process is then evaluated regarding usability and user experience with the stakeholders. Based on the evaluation results, a method for creating target-group-specific Mobility Data Stories is derived to support the stakeholders in the mobility sector with the visual and content-related preparation of the data. Further, the target-oriented mobility planning process is structured regarding the potential of mobility data stories. Finally, general guidelines for creating target-group-specific Mobility Data Stories are derived. The results show the potential of Mobility Data Stories.

Keywords: Mobility Data Story · Storytelling · Mobility data

1 Introduction

1.1 Mobility Data and Mobility Process

A solid and holistic data basis is an essential component for communication and decision-making by the stakeholders in the increasingly complex field of sustainable mobility planning. Today many new data collection methods are available to make decisions based on an expanded data basis. For example, forecasts for vehicle utilization can be developed based on real passenger numbers. A common data basis is essential for all stakeholders involved in the planning process. This includes planning in public transport and services, strategic local and regional infrastructure planning, and the integration of new and environmentally friendly forms of mobility.

At present, decision-relevant reports, analyses, and documentation are mainly compiled based on individual requests. This can result in deficits regarding the systematic and problem-oriented use of data or different degrees of processing. Data access can also exhibit different characteristics so that not all stakeholders involved in the planning process have access to the same data basis. Mobility Data Stories can provide a common basis for communication. Important correlations, results, and data are clearly visualized and communicated understandably through a story component. Mobility data can turn into stories.

1.2   Stakeholders in Mobility Planning

The mobility planning process is characterized by the participation of many stakeholders. These include mobility planners, mobility consultants, political decision-makers, transport companies, mobility service providers, and citizens' initiatives (Fig. 1). Citizens, residents, and mobility users are also increasingly involved in the mobility planning process through citizen referendums.
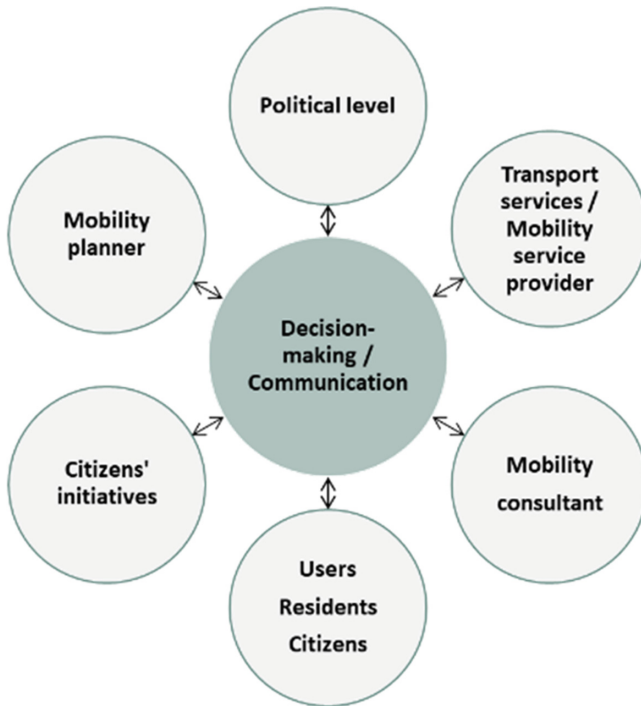

Fig. 1.   Stakeholders in the mobility planning process

Decisions of mobility planners and consultants as well as mobility service providers and transport companies are made based on extensive data and associated comprehensive analyses. Political decision-makers, users, and citizens, on the other hand, rely on a

reduced data basis. This is mainly due to the lack of accessibility of existing data sets, time restrictions, and a lack of basic understanding of the data.

2 State of the Art

2.1 Data Stories and Data Storytelling

Mobility Data Stories are fundamentally based on the principle of storytelling. Olivier Serrat defines storytelling as follows: "*Storytelling is the vivid description of ideas, beliefs, personal experiences, and life-lessons through stories or narratives that evoke powerful emotions and insights*" [1].

Thomas Neifer et al. describes data storytelling in their publication as "Process of preparing and presenting information from the results of a data analysis to motivate a decision or action in a language and visualization appropriate to the target group" [2]. Lutz Klaus summarizes data storytelling as follows: "Data storytelling is about communicating relevant developments in an understandable way with the aim of making necessary decisions" [3].

Storytelling is thus a method for directly conveying messages, knowledge, data, and insights by means of a vivid story. Using data stories, emotions and feelings can be evoked, which makes the story and thus the information more profound. In contrast to the communication of pure facts and figures, the narrative memory is addressed in this way. According to Jennifer Aaker, stories are *"22 times better captured than pure facts. A mixture of stories and facts is received about twice as well as pure facts or figures. (…)"* [4].

Data stories can take on different forms. The spectrum ranges from simple, static posters to interactive digital visualizations. The difference to classic infographics lies in the story content, although the boundaries between infographics and data stories are fluid.

2.2 Methodological Approaches

The approaches and principles of Neifer, Freytag, and Field are presented below. Based on a comprehensive literature analysis, Thomas Neifer et al. developed success factors for data storytelling and derived from them the storytelling process shown in Fig. 2.

Data must be carefully considered and selected. They form the basis for the development of a data story. Only data that relates directly or indirectly to the core topic should be included, redundant data should be avoided.

When *visualizing* the data, the focus is on the core question. In addition, the visualization is accompanied by a reduction in complexity. Extensive tables and diagrams may be difficult for a target group to grasp. Simple representations, conversely, can also be understood by people unfamiliar with the topic. It should be ensured that visualizations are as self-explanatory as possible.

Focus on the core idea refers to the fact that data and visualizations always serve to answer the question. Therefore, the development of the two elements must always be oriented to the core question.
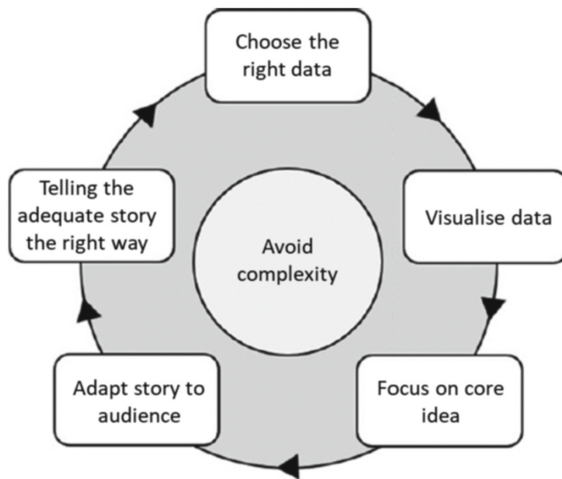
Fig. 2. Data storytelling process by Neifer et al. [2]

The story conveys the core topic and enables people to form an opinion. Neifer describes the step *Telling the adequate story the right way* as "Ability (…) to transform numbers into good stories" [2].

Adapt story to audience is also a focus. Stories may make sense in terms of the core topic but may not be suitable for the audience. Therefore, the story must be geared to the level of knowledge and understanding of the target group.

The *Avoid complexity* step applies to all data storytelling process steps. A Data Story should be easy to grasp and easy to follow. Visual aids also support this process. Unnecessarily complex visualizations and stories can have a negative impact on the attention of the target group or lead to misinterpretations [2].
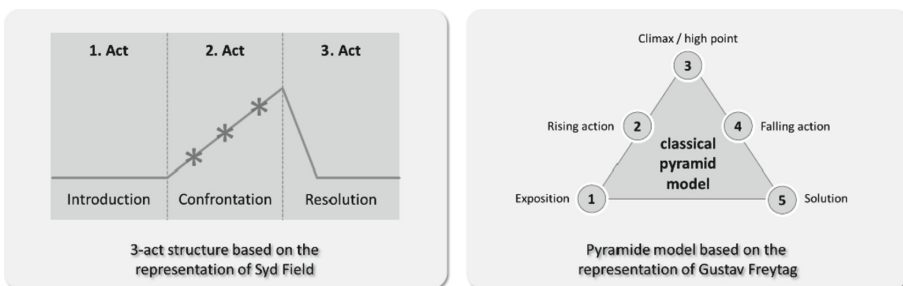

Fig. 3. 3-act structure [5] and classical pyramid model [6] in comparison

The content structure of a Data Story can be based on the principle of Syd Field's three-act system or on Gustav Freytag's classic pyramid model of drama. Figure 3 shows both principles. The basic structure of the two principles is similar. First, boundary conditions or current states are described. In this way, a comparable starting position is created regarding prior knowledge or prior information. In addition, the introduction

facilitates the entry into the topic. In the following step a confrontation, a problem or an idea is introduced. An arc of suspense is created that conveys the core topic and sensitizes the target group. In conclusion, clear results, alternatives, or solution ideas are given and consolidated with the help of explanations.

In summary, it can be determined that data stories are basically formed from an intersection of the key elements data, visualizations, and stories, as shown in Fig. 4. A balanced ratio of the three key elements is required.
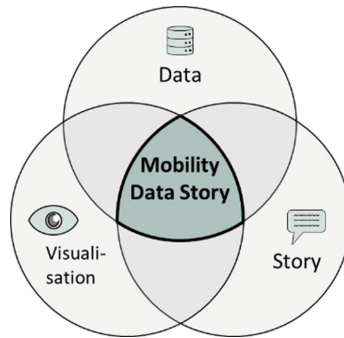

Fig. 4. Structural approach of data storytelling in accordance with [7]

3   Empirical Study

3.1   Development of Mobility Data Stories

The development of Mobility Data Stories was based on the above-mentioned principles of Field and Freytag, the data storytelling process by Neifer and the structural approach of data storytelling.

At the beginning of the development, selected core questions from the mobility sector were extracted, which can be assigned to different stages of the mobility planning process. To answer the core questions, it was possible to draw on extensive data sets on the topics of public passenger transport, individual transport, freight transport and electro mobility. The development process will be explained using the Mobility Data Story of the lack of parking spaces for trucks on German motorways as an example. The aim of the Mobility Data Story was to answer the core question: What is the current truck-parking situation along German motorways?

Within the process step *data component*, extensive data sets were analysed. The aim was to determine meaningful key figures and facts to answer the core question. This primarily concerned information on the share of freight traffic, the increase in transport volumes and legal regulations. During the analysis, care was taken to ensure that the data was transparent, unambiguous, and reliable.

Within the *visualization* component, first drafts and later digital prototypes were developed with the appropriate tools. In this way, a visualization of the core question was developed step by step. The focus was on the truck, which was highlighted by colour. In this way, the viewer's focus is directed to the core message.

The story component primarily addresses the text modules that serve to illustrate the data. During the study, a storyline has been developed using the three-act system. In this way, the stakeholders were introduced to the core question. In this example, the initial situation and the future development of transport services and traffic shares were described first. This should result in an arc of tension, which, due to the legally defined driving and rest times, leads to the conclusion that the number of trucks will also increase in the future. Finally, the current situation along the German motorways is presented and the lack of suitable parking spaces is described. The truck is the backbone of freight transport, nevertheless, one in four truck drivers cannot find a suitable parking space.
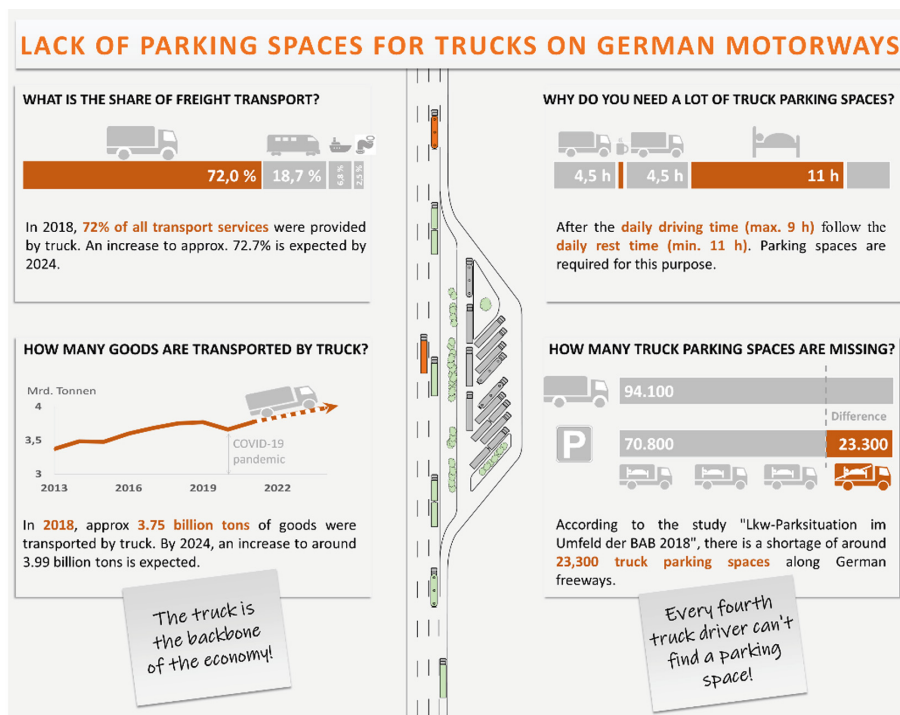

Fig. 5. Work in progress: Mobility Data Story *truck parking shortage on German motorways* based on the data [8–11]

The visualization of the data went hand in hand with the development of the story, so that a fusion between data, visualizations, and accompanying texts was created. This was to ensure consistency of content and to consolidate the connections. The Mobility Data Story was first developed as a rough framework. Afterwards, it was converted into paper prototypes and digital prototypes. The entire development process was iterative. Stakeholder feedback was constantly collected and incorporated. The sticky notes at the bottom of the image, which were intended as an aide memoire, were approved and were incorporated into the final version of the Mobility Data Story in this way, shown in Fig. 5. Finally, the Mobility Data Story was completed and converted into a format suitable for the usability and user experience tests.

3.2   Evaluation of Mobility Data Stories

The user-oriented evaluation of the Mobility Data Stories aimed to ensure the usability and user experience of the developed sample solutions in terms of completeness, comprehensibility, attractiveness, transparency, and stimulation. Ten Mobility Data Stories were tested in the topic areas of public passenger transport, motorised individual transport, freight transport, sharing transport, cycling transport, and walking transport.

Four to five test persons can identify more than 80% of the usability problems [12]. Therefore, five to seven test persons per Mobility Data Story were planned for the evaluation. Each participant evaluated four mobility data stories. The selection of the test persons was representative of the analysed stakeholders. Due to the current COVID19 restrictions, the evaluations could only be carried out via remote usability tests. For this purpose, a combination of a Webex meeting [13] and an accompanying questionnaire via the survey tool Unipark [14] was chosen. The evaluation participants received the link to the survey tool at the beginning of the evaluation and were asked to share their screen via Webex. In this way, the evaluator was able to recognise the answers of the participants and ask targeted questions.

In the process of the evaluation, it was first determined whether and to what extent the evaluation participants were in touch with data in their daily work, and whether they analyse and, if so, visualize data. All subsequent test objectives related directly or indirectly to the individual mobility data stories, and were selected to cover a broad spectrum of criteria and to receive as many comments as possible. The survey ended with the collection of demographic data. All answers were evaluated anonymously so that no conclusions can be drawn about individual evaluation participants.

Twenty participants, 10 female and 10 male, aged between 30 and 49 years, participated in the evaluation. Three participants of the evaluation participants stated that they worked in the mobility sector. Seven of the 20 respondents are partly employed in the mobility sector. These include politicians and project managers. 18 out of 20 evaluation participants stated that they always or often meet data during their activities. Only two male and two female evaluators work without having much contact to data. Figure 6 provides an overview of all the information collected.

Following the common questions about the data reference, the Mobility Data Stories were evaluated according to the criteria *selection of data*, *design of the Data Story* and *content of the Data Story* as well as the User Experience Questionnaire (UEQ) categories *attractiveness, transparency,* and *stimulation* [15]. The following is an example of the result of the evaluation of the Mobility Data Story "Lack of parking spaces for trucks on German motorways".
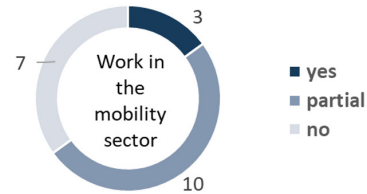
Overall, the Mobility Data Story received a consistently positive evaluation. All information and data could be easily grasped even by non-topic evaluation participants (Fig. 7). The selection of data and information scored an average of 4.3 out of a maximum of 5.0 points. The test persons also perceived the design of the Mobility Data Story positively, so that a score of 4.7 out of a possible 5.0 points was achieved here. The topic-related content was rated by the evaluation participants with an average of 4.5 out of a possible 5.0 points.
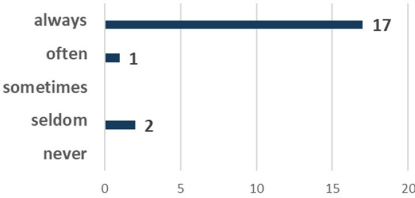
Participants of the evaluation
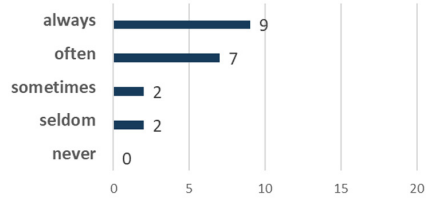
Sample: 20 participants
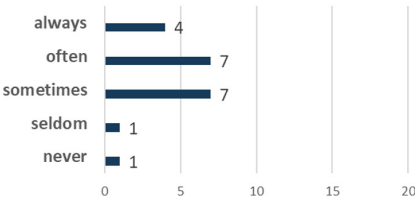
Age: 30 – 49 years

Gender: w10 | m10

Work in the mobility sector

- yes
- partial
- no

3

7

10

I come into contact with data during my work.

always	17
often	1
sometimes	
seldom	2
never	

I engage in the analysis of data.

always	9
often	7
sometimes	2
seldom	2
never	0

I engage in the visualization of data.

always	4
often	7
sometimes	7
seldom	1
never	1

I can communicate the results to others.

always	5
often	12
sometimes	2
seldom	1
never	0
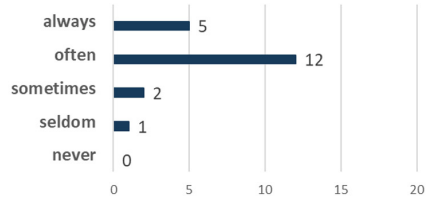
Fig. 6. Description of the acquired participants [own presentation]

Selection of data.

The data looks credible	Ø 4.4 / 5.0
The data could be collected quickly	Ø 4.0 / 5.0
The connection between the data is recognisable	Ø 4.6 / 5.0

Design of the data story.

The design of the Data Story is appealing	Ø 4.6 / 5.0
The design of the Data Story is clear	Ø 4.9 / 5.0
The data was illustrated in an appropriate form	Ø 4.7 / 5.0

Content of the data story.

No background knowledge is needed to follow the story	Ø 4.6 / 5.0
The story has a clear arc of tension	Ø 3.7 / 5.0
I was able to extract all relevant information from the Data Story	Ø 4.6 / 5.0
The core message became clear to me	Ø 5.0 / 5.0

Fig. 7. Evaluation results of the individual categories [own presentation]

Positive results were also achieved within the User Experience Questionnaire. These results are shown in Fig. 8. Attractiveness received an average score of 1.29 out of a maximum of 3.00 points. Transparency achieved an average score of 1.04 out of 3.00

points. In the category stimulation, the best result could be achieved with 1.43 out of a possible 3.00 points.
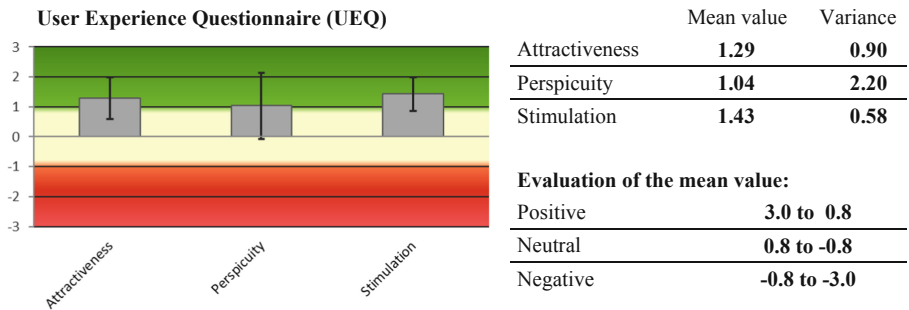

User Experience Questionnaire (UEQ)	Mean value	Variance
Attractiveness	1.29	0.90
Perspicuity	1.04	2.20
Stimulation	1.43	0.58

Evaluation of the mean value:	
Positive	3.0 to 0.8
Neutral	0.8 to -0.8
Negative	-0.8 to -3.0

Fig. 8. Results of the User Experience Questionnaire based on [15]

During the evaluations, all test persons were asked to mention their opinion and mood about the respective Mobility Data Story within the framework of the Thinking Aloud method. Both the clarity of the Mobility Data Story and the comprehensibility of the information received positive feedback. The uniformity and simplicity of the diagrams were mentioned positively several times. Finally, the visualization of the core statements
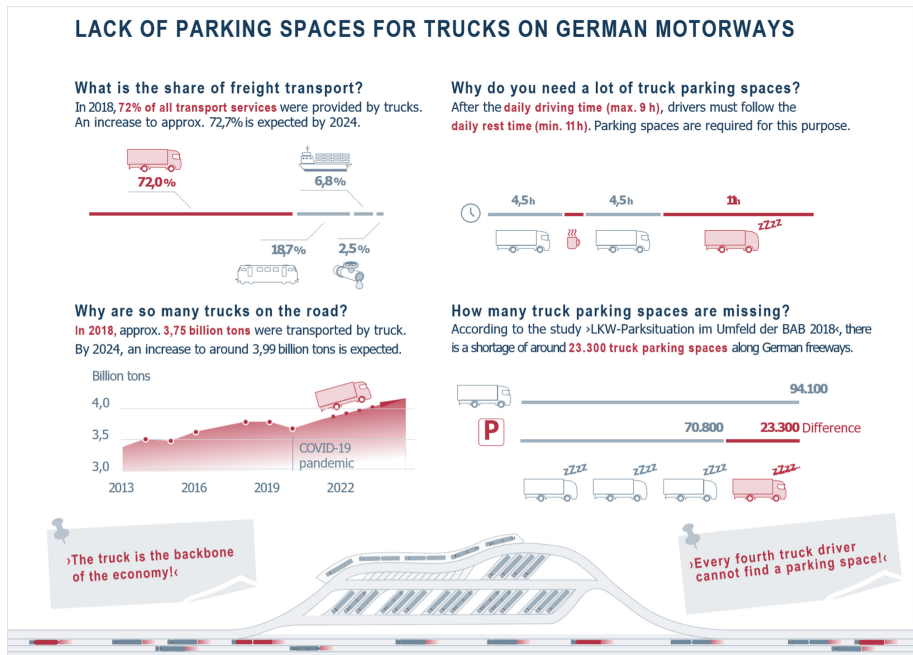

Fig. 9. Final version of the Mobility Data Story *truck parking shortage on German motorways* based on the data [8–11]

using sticky notes was mentioned positively, too. There is potential for improvement in the icon of a pipeline used in the diagram of the freight transport share. This was not recognised as a pipeline and should be replaced or revised. The Mobility Data Stories were finalised based on the evaluation results.

Figure 9 shows the final version of the Mobility Data Story *truck parking shortage on German motorways*. The Mobility Data Story was standardised using a predefined colour scheme. Due to design reasons, the separating element motorway has been moved to the lower edge of the picture.

4   Results

4.1   Mobility Data Stories in the Focused Planning Process

As a partial result of the interviews with the stakeholders, the potential of Mobility Data Stories along the goal-oriented planning process was also determined. For this purpose, the respective phases were identified in which Mobility Data Stories offer added value in terms of external project communication. External project communication refers, for example, to the communication between mobility planners, the political decision-making level and passenger associations.
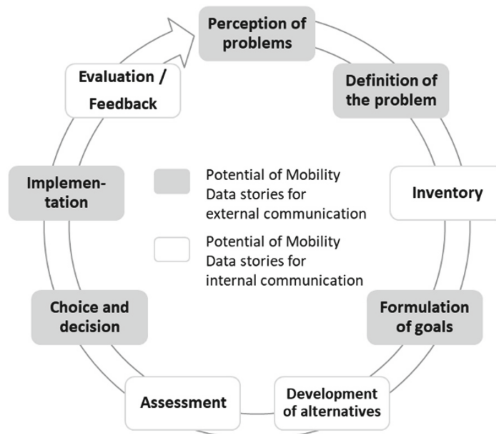

Fig. 10. Focused oriented planning process own representation based on [16]

Figure 10 shows that Mobility Data Stories can create a common basis for communication when defining problems. Furthermore, Mobility Data Stories can be used to formulate goals, i.e., to clarify the planned and theoretical target state. The interview participants also saw potential in terms of external communication in the selection and decision-making phase. In this phase, a project alternative is chosen. Stakeholders can be informed about the reasons and results of the selection process by means of the Mobility Data Story. During the implementation of infrastructure measures, for example, Mobility Data Stories can also make a positive contribution in terms of acceptance and provide information about the current implementation status.

According to the interview participants, the effects of Mobility Data Stories in external communication in the phases of inventory, alternative development, alternative assessment, and evaluation are rather low. Mobility Data Stories could support internal project communication in these phases.

4.2 Method for Mobility Data Stories

Based on the experiences from the research process and the evaluation results, a method for creating target-group-specific Mobility Data Stories was developed based on the process proposed by Neifer regarding data stories, shown in Fig. 11.
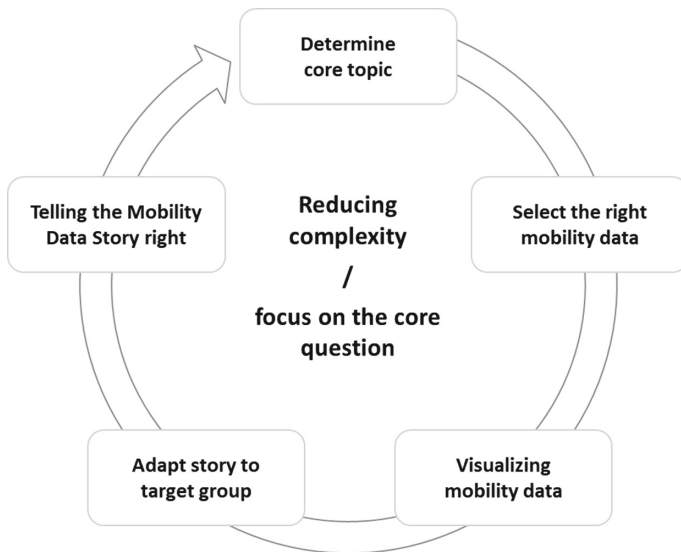

Fig. 11. Modified Mobility Data Story process own representation based on [2]

In Neifer's storytelling process, the selection of the right data was the first step. If the assumption was made, that extensive data sources are available and that facts information are available in sufficient quantity and quality, the focus on the core topic can move to the first place. In this way, the concern, the core topic, or the research question is fixed first. Then the required data are identified, selected, and analysed from an existing data pool. The rest of the process is analogous to Neifer's storytelling process: the data are visualized, the story adapted to the target group, and the story is adequately told. Neifer places the reduction of complexity in the middle of the cycle, as this affects all process steps. The empirical studies have shown that focussing on the core topic is highly relevant in all steps of the process, especially regarding the visualization and the structure of the story. It should therefore be at the centre of attention together with the reduction of complexity and thus receive continuous attention.

4.3   Guidelines for Mobility Data Stories

As part of this research work, guidelines for Mobility Data Stories have been derived based on the interview results, the experiences in the development process and based on a comprehensive literature review.

When *selecting data*, for example, one must take care to ensure that it is credible and verifiable. Insufficient, untrustworthy, and unseaworthy sources must be avoided, as these can have a negative influence on the authenticity of a Mobility Data Story. Another problem is the sometimes widely varying description and interpretation of data from different sources. For example, there are different data on how many private cars can be replaced by a Car-Sharing vehicle. Depending on the source, the range is from 4 to 20 vehicles. Data from a Mobility Data Story, which illuminate the problem area from different perspectives can, thus, lead to different conclusions in answering the core question, should be integrated in any case. Only a transparent and reliable Mobility Data Story can support democratic and balanced opinion forming. Typical examples of this are the costs, or also negative influences, of a planned infrastructure measure on the personal environment. Although in this sense it seems sensible to dispense with "unwelcome" information, this is at the expense of transparency.

Colours and colour concepts can evoke both intended and unintended associations. Although red colour formatting is often chosen as a means of drawing attention, the colour itself has a warning effect and signals danger, fire or stop.

During the evaluation, the illustrations and, thus, the core message of the Mobility Data Stories were perceived differently due to the chosen colour scheme. As an Example, see Fig. 12. The CO_2 emissions of a regular bus with approx. 80 g per passenger kilometre compared to a passenger car with 170 g per passenger kilometre appeared to be positive or ecological. This was largely due to the colour design of the corresponding illustrations.
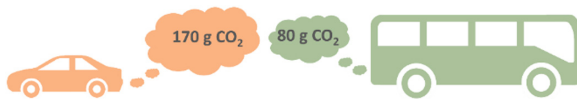

Fig. 12. Example of colour association own representation based on [17]. (Color figure online)

The design of Mobility Data Stories must pay attention to the choice of colours, the associated colour effects, and colour associations. Even when using corporate colours and colours of a corporate identity, misinterpretations can occur in the worst case.

The *wording, formulation and expression* must also be adapted to the target group of a Mobility Data Story. The different stakeholders have different vocabularies. Technical terms are no problem for mobility planners, and employees in the transport and mobility sector. Yet, the vocabularies are not necessarily understood by users or residents. Examples of this are terms such as low-floor vehicle, individual traffic, block traffic or cycle frequency.

Reducing complexity applies to all areas of a Mobility Data Story. Complex and extensive texts should be avoided, as should multidimensional representations or confusing diagrams. Here, the later target group of the Mobility Data Story must be kept in

mind. The complexity of diagrams, for example, can be reduced to a minimum without compromising the expressiveness of the presentation. Through the skilful use of colours, icons and markings, the focus can be placed on the core message. As an example, see Fig. 13. The diagram was simplified, unnecessary components removed and the focus was placed on the truck. The diagram below contains all the key statements that are important for the target group in an easy-to-grasp presentation.
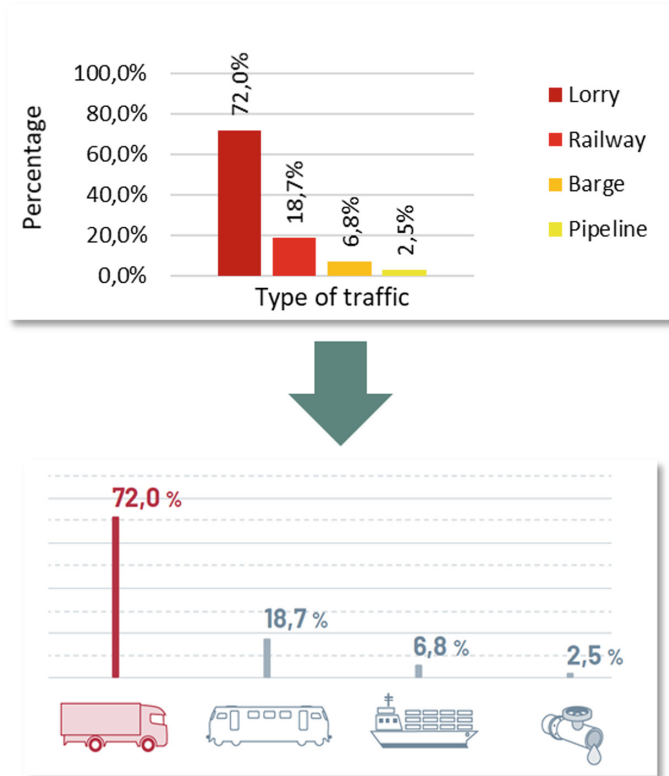

Fig. 13. Reduction of complexity own representation based on [9]

5   Discussion

Mobility Data Stories can support decisions in the mobility sector as a common basis for communication. The comprehensive existing mobility data can be used in a decision-relevant way. Depending on the scope and complexity of the core question, data analysts, designers, editors, and other experts are involved in the development of a Data Story. Smaller companies, municipalities, and planning bodies lack the resources to do this.

The main challenge is to reduce the effort required to create mobility data stories. One approach is generic Mobility Data Stories that provide sample solutions for Mobility Data

Stories for typical core questions. Typical core questions in mobility are, for example, the user-friendliness of cycle and footpath infrastructures, parking space utilisation or the citizen-focused development of rural areas. These can be further explored at any time regarding individual questions. An approach to this concept was tested for research purposes. However, further research work is needed here.

Furthermore, the interactive potential of digital Mobility Data Stories should be used. Clickable, transformable data stories or data stories that can adapted by the user are conceivable. In combination with automated analysis systems, data stories that autonomously adapt to new circumstances would be possible. In this way, permanently changing demand data or occupancy levels in public transport could still be output as a Mobility Data Story.

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