Work towards Optimum Quality of ITS – An introduction

EU EIP 4.1: Determining Quality of European ITS Services

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1. Context

The level of quality of traffic information services is a significant parameter that affects how users perceive the information service and how they use it in real life. The quality of information affects how often drivers use the information service, and how much the information affects driver's decision making. If a driver experiences bad quality, the information does not have any effect on decision-making, thus no benefits for the society are achieved. Furthermore, low quality information leads to wrong decisions, leading to costs for society in the form of decreasing traffic safety and flow. In the U.S. Shah and Wunderlich (2005) have concluded based on a simulation study, that an error in the measured quantity can be at maximum 9-21 % to allow net benefits for the society from the use of information. The same study concluded that once the error has been decreased to the level of 5 %, no significant benefits can be reached for further quality improvements. As there usually are some costs involved in the improvement activities of quality, it can be concluded based on the mentioned research results, that an optimum quality level is likely to be found for traffic information services.

The Grant Agreement of EU EIP-project sets the initial scope for this Task 4. "Work towards Optimum Quality for ITS":

"The optimum quality is determined on the basis of what is the most cost-efficient in terms of socio-economic benefit/cost ratio in different operating environments. This is important in order to prevent member states from over- or under-investing in service coverage and quality. It requires a sufficient number of quality assessments accompanied with benefit and cost information from national studies or corridor projects so that widely deployed services such as different types of real-time information services represent likely candidates of study. The optimum may change in time due to introduction of new technology solution, and this needs to be addressed specifically."

2. Goal of the Optimum Quality Task

The goal of the task is to analyse the mechanisms for acquiring societal benefits from selected ITS services and to build a link between data and service quality and the societal benefits. This analysis will be further used to assess different investment and process development options in the improvement of the quality, in order to give guidance to the Member States on which quality level should be targeted for selected services from cost-efficiency's perspective.

3. Theoretical framework of Optimum Quality

Based on the pre-study of this Task, optimum quality of traffic information services is a topic that has not previously seen much thorough research. However, many organisations have some sort of inherent optimum quality approach in the planning of their ITS investment programmes, even though the optimum quality level is not usually quantitatively set. Even though not much ITS specific literature on optimum quality could be found, optimum quality is a topic that has been widely researched under other domains, such as production industry (for different consumer goods). Juran presented his famous and classic theory on optimum quality already in 1951, after extensive research in production industry. Juran's classic model for optimum quality costs addresses the following common phenomena:

- increasing conformance (of quality targets) reduces economic losses due to defective products
- the cost of quality improvement and control increases geometrically as perfection is approached
- due to the above mentioned common laws, the optimum quality is always short of perfection, i.e. the optimum level is < 100 % quality.

These phenomena are illustrated below.

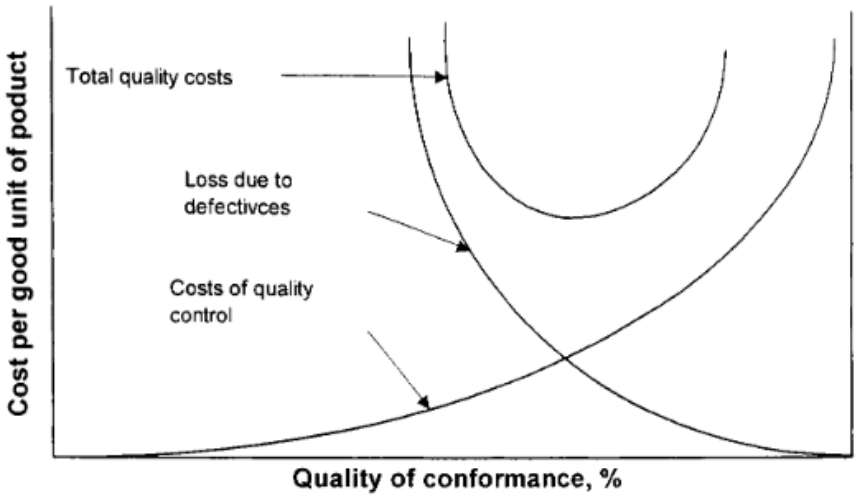


Figure 1. *Model for optimum quality costs (Juran 1951).*

Analysing Juran's theory from the perspective of ITS information services, it can be argued that at least the phenomena regarding increasing costs for quality improvement usually applies. However, technological changes and new concepts may significantly alter the form of the cost curve and thus change the location of the optimum quality point.

Analysing the cost of defectives -curve, one must think about the right way to apply the theory in the field of ITS. Instead of economic losses due to decreased sales or increased amount of reclamations, one must consider lost socio-economical benefits due to incomplete information quality. Lost socio-economical benefits may realise when consumers make travel or driving decisions based on false information, and loose time or increase accident risks or congestion because of that. The smaller the errors in information quality, the smaller the possibilities for such adverse effects are.

With these small adjustments to the original theory it can be argued that Juran's classic theorem gives a reasonably good ground for further inspection in the field of ITS.

In the following illustration Juran's theory is applied to the world of ITS and further, to the EUEIP Quality Framework. Instead of using the function of socio-economic losses (due to incomplete quality), we apply so called Capital Budgeting Theory and estimate the function of socio-economic benefits acquired with different quality levels. According to Capital Budgeting Theory, there is an economic inflection point, beyond which available quality improvement action no longer yields socio-economical benefits to the same extent that investments costs arise. This point in the quality scale is the Optimum Quality level in the EUEIP Quality Framework. The application of Capital Budgeting Theory in the scope of EUEIP's information quality activities is illustrated in figure 2.

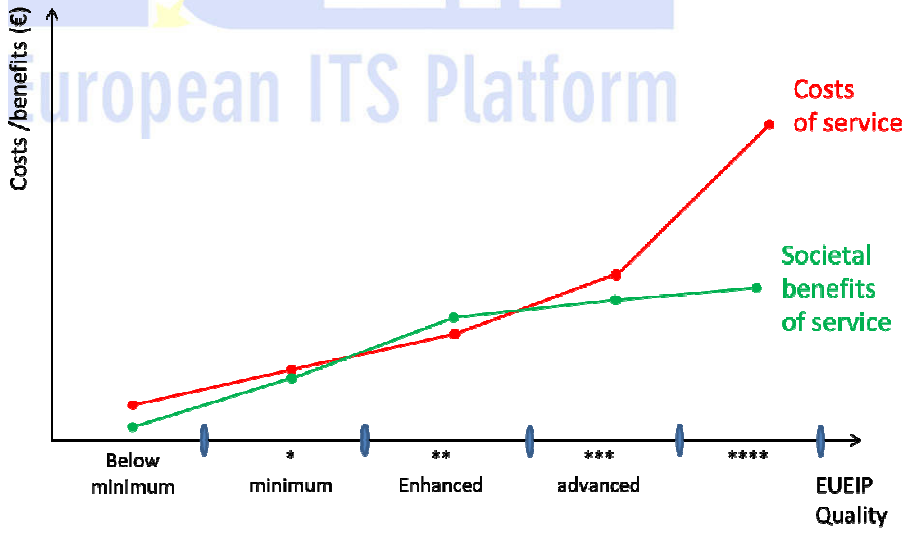


Figure 2. *Illustration of the development of service improvement costs and societal benefits in the EUEIP Quality framework.*

The above explained approach forms the theoretical background in this Optimum Quality Task. In order to quantitatively analyse ITS services, one would need quantified data on costs of service production as well as estimates on societal benefits on different EUEIP quality levels. It should however be noted already at this point that it is acknowledged that it is very difficult to study real services in quantitative manner following this theory. In the following chapters it is explained what kind of approach can be used from the practical perspective.

The term “societal benefits” deserves further explanation. In this task we are studying the economical and environmental impacts that realise when users use the information services in trip planning and execution (e.g. driving behaviour). These changes in users alter the outcome of travel in the traffic system (traffic flow, safety etc.). The changes in the traffic system in turn present the societal impacts i.e. impacts on households and companies as well as consequences of traffic system impacts on environment, health and overall satisfaction.

The societal impacts derived from information services industry, as well as impacts derived from the use of information in operative traffic management, are excluded from this study.

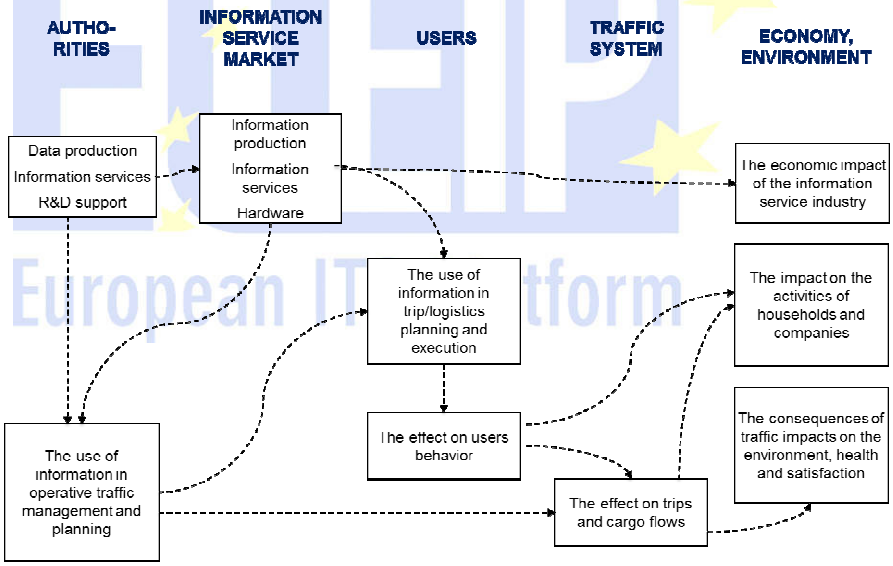


Figure 3. *Illustration of the chain of impacts for traffic information services (Laine, Metsäranta, Saarinen (2013) Value of Information, pre-study. Liikenneviraston tutkimuksia ja selvityksiä 48/2013.)*

4. Literature study and stakeholder consultation on the availability of empirical data

The ambitious goal of defining optimum quality meant that there was a need for quantified data. It would be necessary to understand what are the quantifiable investment and operating costs as well as socio-economic benefits of the different services at different quality levels. During late spring and summer of 2018, a literature study and stakeholder consultation was done in order to get an overview of the empirical data available that could be used for defining the optimum quality. The objective of this initial step towards defining optimum quality was to identify:

- for which services there are quantifiable impact evaluations available,
- how specific or comprehensive are they in terms of service types (e.g. overall systems or, service categories or individual services), impact (e.g. just safety or safety, economic and environment), and quality parameters (e.g. quality of an overall service or for instance just latency or location accuracy)
- if there are comparable studies (e.g. same service, quality parameters and impact aspects) available from different countries, and
- if there are quantitative methods in use for defining and/or measuring optimum quality.

An excel template was prepared to collect the input from the partners in a structured and more easily comparable way. The template allowed for providing input on selected services and for each different quality parameter, including aspects such as service area and coverage, methodology for defining optimum quality, available data, service quality level, costs and benefits. In addition to filling the excel template, any supplementary evaluations, practices and insights perceived as useful were also asked for.

The round of collecting inputs indicated how limited the amount of quantitative quality information is and how difficult it is to compare the results of different evaluation studies. While there are quality and impact evaluations as well as cost/benefit analyses, they tend to either focus on very specific aspects (e.g. specific quality parameter such as latency) or consider impacts of a service on, for example, safety without addressing the relevance of the different quality parameters. Similarly, the cost/benefit aspect is hard to pinpoint on even specific services, let alone quality aspects, as they often relate to comprehensive traffic management systems. Road operators' investments typically improve their traffic management as a whole, not specifically RTTI/SRTI services.

Another great challenge for comparability is that impacts may often be very specific to the context, meaning replicating them elsewhere can very well yield different costs and

benefits. Time also affects both cost and benefits. Advances in technology and better data availability, for example, can result in better solutions with lesser costs than before, thus shifting what might have been considered an optimum quality before.

In conclusion, quantitative analysis and definition of optimal quality is extremely difficult and a more practical approach is needed. At the moment, the link between costs and benefits (e.g. impacts on safety or traffic flow), individual services and the specific quality parameters is unclear. Therefore, the impact mechanisms need to be better understood, identifying the key elements to focus on, and how the quality can be improved towards a cost-optimal point. And, in fact, rather than an optimum quality point, the dynamic and context-related nature of the costs and potential benefits, an optimum quality range with key factors and assumptions (e.g. further defining the use case) is more appropriate.

5. Research objectives

Based on the findings from the initial study phase summarized in chapter 4 it was decided to fine-tune the research objectives written in the original work plan of EU EIP project. The focus was set on more realistic and practical results that should benefit the Member States in their ITS related investment and quality improvement activities. The main research objectives identified for the Optimum Quality task are:

- to identify different use cases and significant impact mechanisms in achieving societal benefits of selected information services
- to identify the importance of different quality criteria for the realisation of the significant impact mechanisms
- to recommend a “target quality level” or an ”optimum quality range” for the critical quality criteria using the Validated Quality Package framework
- to recommend road operators’ actions by which to improve the critical quality elements efficiently, taking into account ongoing technical development
- to recommend road operators’ role and actions in the service value chain for different service types in order to maximise societal benefits

The planned methodology includes, among others, the identification of impact mechanisms, linking of these mechanisms with quality aspects, assessing an optimum quality range for selected ITS services, and recommendations for methods how to improve quality.

The methodology was tested in a stakeholder workshop in October 2018 and it proved to be feasible for the task (see Annex 1).

Annex 1: Optimum Quality and defining the workplan – Workshop summary

EU EIP Context and Workshop Goals

Within the EU EIP Sub-Activity 4.1, the work for *Task 4 "Work Towards Optimum quality of ITS"* was initiated early 2018. The goal of the task is to analyse the mechanisms for acquiring societal benefits from selected ITS services, and to build a link between data and service quality and the benefits. This analysis will be further used to assess different investment and process development options in the improvement of the quality, in order to give guidance to the Member States on which quality level should be targeted for selected services from cost-efficiency's perspective. The first sub-task in Task 4, namely *Task 4.1. "Identifying evaluation studies incorporating quality aspects and perform meta-analysis for feasible ITS services",* was completed in August 2018. Based on the findings, in *Task 4.2 "Test plan for Optimum quality of ITS",* a draft for such a test plan was produced by the Task Leaders (FI) and other Active Beneficiaries of the Sub-activity.

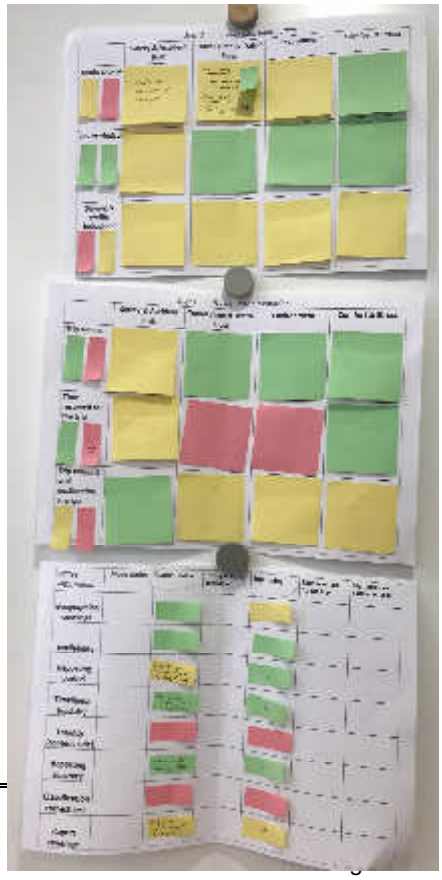
In the EU EIP Grant Agreement a following Milestone was set for the Sub-activity 4.1. and its Optimum Quality Task: to organize a workshop and agree on the test plan for Optimum Quality of ITS. To reach this Milestone, a workshop was organized on 8th October 2018 in Cologne, Germany. Workshop invitation were sent to all participants of the EU EIP Sub-Activity 4 as well as selected German road operators representing external stakeholders. The workshop and its goals was divided in two parts:

1) External workshop; to test the feasibility of the analytical approach towards Optimum Quality presented in the draft Test Plan

2) Internal workshop; to discuss the outcome of the external workshop, develop the test plan based on the findings, and agree on the goals and structure of the final Test Plan.

Workshop Process

The workshop consisted of an introduction of the objectives and the planned approach (identifying or defining impact mechanisms > critical quality criteria > proposed quality range), followed by group work. The group work aimed to test whether the planned approach would be feasible by having the participants discuss and try working on three phases.



Phase 1: Identifying most relevant impact mechanisms for selected SRTI/RTTI services

In the first phase of the group work, the participants used post-it notes to indicate the links between changes in user behaviour (e.g. route choice or driving behaviour) that result from a selected information service (Wrong Way Driver, Incident Information or Travel Time Information) and desired

societal impacts (e.g. improved safety or traffic flow). The participants had different coloured post-it notes they could use to indicate the significance.

Phase 2: Identifying the importance of different quality elements to achieving the effect for the service

In the second phase, the participants used a similar coloured post-it note approach to indicate how significant the different quality elements of the service are in creating the outcomes (i.e. affecting what choices travellers make). The participants were asked to focus especially on the aspects found most relevant in the first phase. On the notes they could write down further elaborations on how or under which circumstances the mechanism works (e.g. pre-trip vs. on-trip).

Phase 3: Assessing where the optimum quality ranges for the selected service would be

In the final phase of the group work, the participants looked at the Validated Quality Requirements[1] for the service in question. The previous phase served to highlight which quality aspects were considered the most relevant and therefore the group should particularly focus on. The groups would then discuss and consider whether the basic quality levels would be suitable or if recommendations should be for aiming higher. The participants also tried to define which quality levels are might be unreasonable to aim for (i.e. unnecessarily high quality or too low cost/benefit ratio).

Workshop Findings and Outlook

The workshop and the discussions that followed with the activity partners showed that the approach seems practical in terms of identifying most and least relevant elements and helping tie the quality factors to the aspired impacts. At the same time, it also highlighted the large number of variables and point of views involved. The importance and requirements of quality attributes vary based on a specific use scenario. The factors include time of day (amount of traffic) or year (weather), climate (snow and preparedness), type of event or information (e.g. level of incident), user group and service channels (pre-trip or on-trip), to name a few. Another relevant factor in defining the optimum or cost-efficient level of quality is that the targeted quality level is also dependent on policy goals. A zero casualty objective, for instance, is more concrete than better traffic flow. That is, the valuation of the benefits can vary based on the perspective. Another point of view is, that the analysis of the optimum quality levels should affect setting of the policy goals.

Overall, the revised research plan for optimum quality was considered appropriate, the primary study objectives being refined as follows:

- **Identify** different use cases and significant impact mechanisms in achieving societal benefits of selected information services (selection amongst SRTI and RTTI services)
- **Identify** the importance of quality elements for the realisation of the impact mechanisms
- **Recommend** a “target quality level” or an ”optimum quality range” for the critical quality criteria using the Validated Quality Package framework
- **Recommend** road operators’ actions by which to improve the critical quality elements efficiently, taking into account ongoing technical development
- **Recommend** road operators’ role and actions in the service value chain for different service types in order to maximise societal benefits

The participation of external parties was – and is – valuable not just for getting input to define and refine details but to ensure the real needs of practitioners are kept in mind to produce practical and useful results and recommendations.

[1] Validated Quality Requirements are based on revised definitions for SRTI/RTTI Quality by EU EIP Sub-activity 4.1; they are a result from a recent validation action and will be published soon on the EU EIP website.