Anastasiya Chyrkina, BSc

Usability study of a large-scale warehouse management system

MASTER'S THESIS

to achive the university degree of

Master of Science

Master's degree programme: Computer Science

submitted to

Graz University of Technology

Supervisor

Univ.-Prof. Dipl.-Ing. Dr. techn. Wolfgang SLANY

Institute for Software Technology

Graz, March 2017

AFFIDAVIT

I declare that I have authored this thesis independently, that I have not used other than the declared sources/resources, and that I have explicitly indicated all material which has been quoted either literally or by content from the sources used. The text document uploaded to TUGRAZonline is identical to the present master's thesis.

....

Date Signature

Abstract

In the modern world thousands of new inventions are released every day and already existing products are continuously upgraded. Expectations of potential users tend to grow due to great variety and high quality of provided services and products. That is why it is extremely important to take into account user experience not only developing new concepts but also redesigning and extending stable long lasting systems. Therefore, thinking about high user acceptance rate, usability aspects are the most affecting impact factors to be worked out and incarnated.

As a global market leader in the automation technology industry SSI Schaefer ensures high quality decisions allowing to support corporate growth for the customers in the long run. Delivering supply chain solutions for warehouse intralogistics worldwide to multinational companies, logistic software WAMAS is used to control and optimize various processes in manuell and highly automated warehouses. The WAMAS product always offers new functionalities in regular releases covering core processes within warehouse such as storage, picking, stock management, and more. In order to make the usage of such system possible, WAMAS user interface provides hundreds of dialogs to view, maintain, and process data. Therefore, it is a crucial task to keep desktop, tablet, and other and mobile user interfaces efficient and user-friendly at the same time.

The main purpose of this thesis is to investigate how to keep desktop graphical user interface (GUI) solutions simple, powerful, and useful. Firstly a brief introduction of motivation factors and goals to be achieved (Chapter 1) is summed up. Afterwards, theoretical basis, tools and practices to be applied are considered and evaluated in Chapter 2. The overview of software product to be examined is provided in Chapter 3 of the work. Heuristic evaluation is carried out as the first part of current research on existing user interface solution in order to recognize existing deviations from certain usability criteria (Chapter 4).

The second part of the thesis describes applied investigation activities carried out to identify potential usability problems or drawbacks. For these purposes a usability questionnaire was elaborated in Chapter 5. Analysis of collected user feedbacks is carried out and documented (Chapter 6).

The third part of the work addresses further investigations which result in guidelines definition. These doctrines cover as well the best practices which are obliged or preferred as well as some aspects to be avoided. Such fundamentals are suggested to be used by GUI developers as checklists when implementing new system functionality. Those outcomes can be found in Chapter 7.

A brief summarization of achievements, related research activities, and possible future works are outlined in Chapter 8.

Abstrakt

Heutzutage werden viele Tausende Erfindungen veröffentlicht und bestehende Produkte kontinuierlich verbessert. Die Erwartungshaltung der Benutzer steigt aufgrund der großen Auswahl und hohen Qualität der angebotenen Produkte. Daher ist es außerordentlich wichtig, Usability von neuen und auch bestehenden Systeme zu beachten. Die Benutzererfahrungen und Benutzerakzeptanz sind daher die wichtigsten Punkte, die beachtet werden müssen.

Als globaler Vorreiter in Automatisierungstechnologie unterstützt der Konzern SSI Schaefer ihre Kunden richtige Entscheidungen zu treffen, um ein anhaltendes Wachstum zu gewährleisten. SSI Schaefer bietet mit WAMAS eine Lagerverwaltungssoftware für internationale und multinationale Unternehmen an. WAMAS ist hochgradig flexibel und konfigurierbar, um die Ein- und Auslagerung bestmöglich zu kontrollieren und zu optimieren. In jeder Version werden neue Funktionalitäten eingeführt, welche verschiedene Funktionen wie Lagerung, Kommissionierung, Bestandsverwaltung kontinuierlich verbessern und adaptieren. Dafür ist es besonders wichtig, die grafischen Benutzeroberflächen für diverse Plattformen wie zum Beispiel Standrechner, Tablets oder andere mobile Geräte möglichst benutzerfreundlich anzubieten.

Das Ziel dieser Masterarbeit ist die Untersuchung von grafischen Benutzeroberflächen um diese einfach aber trotzdem hochgradigparametrierbar und einfach nurzbar zu machen. Nach einer kurzen Einführung in die Vorteile von hochwertiger Usability in Kapitel 1 werden in Kapitel 2 die theoretische Basis, verschiedene Hilfsmittel und umfangreiche Methoden untersucht und evaluiert. Eine Übersicht des WAMAS Softwareproduktes wird in Kapitel 3 beschrieben. Im Kapitel 4 werden heuristische Auswertungen durchgeführt, um die bestehenden Lösungen von grafischen Benutzeroberflächen in Bezug auf Abweichungen von bestimmten Usability Kriterien zu erkennen.

Der zweite Teil der Masterarbeit beleuchtet weitere potentiellen Einschränkungen und Nachteile. Zu diesem Zweck wird eine Befragung für die bestehenden Benutzer des Systems ausgearbeitet und durchgeführt. Die Analyse der erhobenen Informationen wird in Kapitel 6 durchgeführt und dokumentiert.

Im dritten Teil der Arbeit werden weitere Untersuchungen durchgeführt, um Richtlinien zu erstellen. Es wird auf bestehende ideale Praktiken eingegangen, die implementiert werden sollten, eingegangen. Auch Richtlinien und Implementierungslösungen, welche vermieden werden sollten, werden veranschaulicht. Die daraus entstehenden Checklisten helfen für GUI Entwicklern das Produkt benutzerfreundlich und einfach bedienbar zu machen. Diese Ausarbeitungen werden in Kapitel 7 präsentiert.

Eine kurze Zusammenfassung der Arbeitsergebnisse und weitere zukünftige Analysemöglichkeiten werden in Kapitel 8 beschrieben.

Acknowledgements

I would like to express my gratitude to Professor Wolfgang Slany who supervised and consulted me during the entire process.

This thesis would not have been possible without support from the head of SSI Schäfer Product Development department, Uwe Rohloff, the most enthusiastic and the most experienced person I have ever known.

My special thanks are extended to Matthias Wirthmann as the best sparring partner in the context of usability and to survey participants for their inputs.

I am also very grateful for Robert Bartl for supporting and encouraging me in all ways.

The last but not the least, I would like to thank all my friends, relatives, colleagues for support and criticism.

Contents

List of Abbreviations

CC – control center
CSIA – customizable stock identifier attribute
ERP – enterprise resource planning
FOG – flow of goods
GUI – graphical user interface
IBD – inbound delivery
IBO – inbound order
ISO – International Organization for Standardization
LU – loading unit
LU-ID – loading unit identifier
NN/g – Nielsel Norman Group
OBD – outbound delivery
OBO – outbound order
SSL – secure socket layer
TPO – transport order
UCD – user-centered design
UX – user experience

List of Figures

List of Tables

Chapter 1

Introduction

Usability is like an oxygen – you do not notice it until it is missing.

– Unknown

Having a goal to be the best but not just among the best, there's a plenty of challenges to be met. SSI Schaefer logistic group has clear understanding and own strategy how to reach this goal. Total customer satisfaction is always treated with the highest priority. The growth of customer businesses is ensured by making routine as well as specific business processes easy to control and maintain. In order to make it possible, SSI Schaefer benefits from innovative technologies constructing software and mechanical components that are integrated together. From the other hand, the company also initiates continuos improvements for already existing solutions that make provided products and services the most attractive on the logistics market.

To ensure long-term business success it is not only critical to make use of logistic know-how which can be adapted to various customer needs and requirements. It is also very important to understand branches of business which customers attend. This knowledge supports all business processes be correctly defined and executed. These two main strategical goals initiate the motivation to figure out global solutions which can be easily applied also locally. Such complete offering could be efficiently adopted taking into account sizes and specifics of the customer's business, lingual and cultural impacts, and so on. That's exactly what WAMAS (WArehouse MAnagement System) product solution is devoted to.

The logistic software with standardized processes provides not only modularly structured components for both manual and automated warehouse

processes. It also conducts control and monitoring functionality which can be extended according to particular user needs. Another powerful mechanism is related to the opportunity to collaborate with different external ERP systems via the standard interfaces. In other words, WAMAS supports all possible intralogistics processes optimizing workflows and resources.

However, it is not possible to go forward without changes. Tending to perfection and reacting promptly to market evolution require improvements in every area including graphical user interface (GUI) components. Those are important for all user categories including potential future customers. Simplicity and efficiency of system dialogs, transparency of system processes and their dependencies are the most valuable attractiveness criteria appreciated by system users. To fulfill these requirements is not less important than to understand strategical goals of the customers and implement business processes accordantly. In order to reach a high degree of user trust existing GUI solutions will be firstly evaluated on different levels, so that the problematic areas can be determined and the improving suggestions can be formulated.

Chapter 2

Theoretical background

2.1 Usability Concept

There're several different ways in which usability definition can be formulated. Considering usability as a quality attribute to assess the implemented user interfaces of the certain system (Nielsen, 2012) the following five most significant components have to be mentioned:

1. Learnability
   Capability of the system to support users when learning how to make use of it

2. Efficiency
   Ability to serve in order to provide quick and easy achievement of desired results

3. Memorability
   Easiness to restore knowledge how to operate the system after it was already learned once and didn't use for a while

4. Satisfaction
   User attitude to the system when accomplishing any activities with it

5. Errors
   Number of errors made by system users, ways to deal with errors and possibilities to recover after error occurred

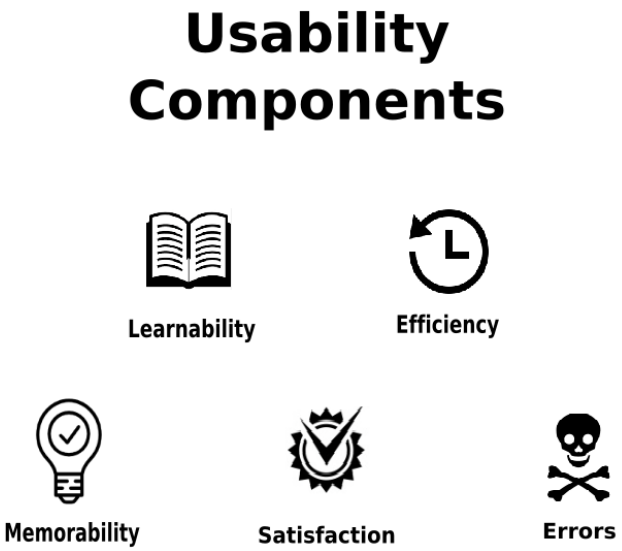


Figure 2.1: *Usability Components*

Some of usability research experts also add *effectiveness* as a sixth usability component when talking about Web site usability facets. This component determines users' ability to accomplish their goals.

It is especially crucial to improve and tend to high usability degree of online services and Web sites. However, it's also very important paragraph when developing an interactive system. Together with other factors as price or technology, user satisfaction leads not only to better results and efficient system use but also positively influences staff attitude in general. This benefits in low turnover, positive employee feedback, etc. In the context of current usability research it is not considered the case that the system would not be used further because of poor usability – however, it can be also a reason for losing the user audience.

The assumptions discussed above can be also derived from the following usability definition: Usability is a degree in which an interactive system can serve a certain user to reach defined goals *effectively*, *efficiently*, and *satisfactory* in a certain usage context[1]. This definition is formulated slightly in another way but generally, corresponds to the same hypotheses.

[1]https://www.iso.org, last call 05.08.2016

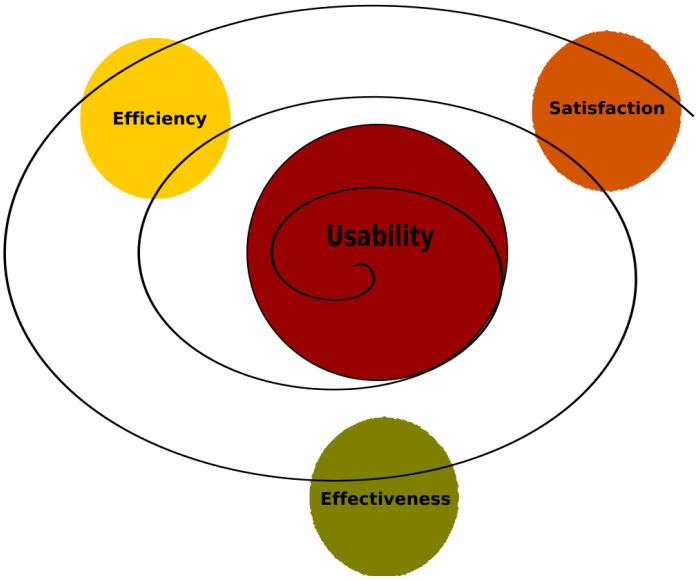


Figure 2.2: *Usability Attributes*

There are three main components on the figure 2.2 which are depicted to define three measurable usability attributes. Effectiveness characterizes here integrity and accuracy of achievements, it's a usability attribute which indicates an ability to complete tasks. Efficiency is another measurable attribute which stands for all the resources required to accomplish the task. Those are production costs, human resources, and other material, financial, time efforts. And last but not the least usability attribute is satisfaction achieved using the system. This can be defined as a subjective grade of comfort and acceptance while performing the tasks.

2.1.1 Usability vs User Experience

When researching usability area and topics, it is also important to mention *user experience* term and, with regards to that, specify the relation between these two concepts. According to agreed definition [1, 50], a synergy of perception and reactions of a certain user is understood under user experience (UX). Those are derived from expected and observed when performing tasks with the help of the interactive system. Generally seeing, user experience covers also everything related to usage of the system, i.e. "anticipated use", "actual use", and "digested use", while the usability itself refers to the "actual"

only. Therefore, usability can be treated as UX part at the same time as its criteria can be applied in order to evaluate the UX aspects [6, 43].

2.1.2 Usability As a Part Of Development Process

Understanding the importance to pay attention to usability terms and best practices is a significant step on the way to usability principles fulfillment. Not less important is the knowledge when and how can the usability investigations and application procedures can be applied [24, 26]. The practices which help to conduct usability are treated in the next section in more details. All of them can be applied at defined development stage. According to this criteria usability methods can be classified categories represented in the listing 2.1 (examples for each of categories are also provided):

Category	Method
Planning and Feasibility	Stakeholder Meeting, Competitor Analysis
Requirements	*User Survey*, Brainstorming
Design	Paper Prototyping, *Heuristic Evaluation*
Implementation	Style Guides, Rapid Prototyping
Testing and Management	Diagnostic Evaluation, *Heuristic Evaluation*
Post Release	*User Survey*, Remote Evaluation

Table 2.1: *Usability Methods*

Some of them (as those which are denoted with *italic* font above) can be applied at several stages of the development process – those usually require no involvement of certain team members and experts and, therefore, are easier to conducts. Others are very specific and, in contrast, require certain resources to be devoted. There are over 30 different recognized usability methods in total [48].

It is always a challenge to make a decision when to apply which of the methods. Considering such conditions as **available time and resources**, **possible access to users**, or **available skills and expertise**, it is possible to restrict result set of methods to be chosen. For instance, it is obviously not an option to provide interviews, focus group research, or user surveys under conditions of no direct user access. From the other hand, limitation of resources causes certain obstacles when conducting heuristic evaluation or performance testing. That is why it is a proper analysis of all influencing factors has to be done before deciding for one or another technique to be applied. Making use of a suitable one will not only lead to proper results and

expected achievements, but also have a positive impact on resources required as well as on satisfaction level of users and usability researches involved.

2.1.3 Benefits of Usability Improvements

In order to originate the motivation and intentions to invest into usability aspects, it is important to see and understand particular advantages that can be achieved. There can be some issues slightly different for bigger companies and for private entrepreneurs, but in general, all positive effects about addressing usability are the following [48]:

- **Sale benefits**
  Increased competitive edge, a higher level of customer satisfaction, higher usability ratings in the trade press.
  Who can benefit: vendors, sales managers.

- **Development benefits**
  Reduced development time, more accurate designs, less late changes required / requested, reduced later redesign costs, reduced documentation costs and amounts, simplified planning activities, smoother user acceptance testing, improved risk management.
  Who can benefit: GUI designers, developers, documentation writers, project managers, risk managers.

- **Support benefits**
  Reduced costs of training materials, reduced training time, lower efforts for help line support.
  Who can benefit: support engineers, end users.

- **Use benefits**
  Improved user performance, increased productivity, less training time, reduced amount of user errors, a lower lever of staff turnover.
  Who can benefit: end users.

To summarize, appropriate application of usability techniques and user-centric approach can significantly improve any kind of business. Important issue to pay attention to is the difference between the costs invested in usability activities and the potential savings during the four main business-related processes mention above – sale, development, support, and use. Another challenging question that has to be taken into account is how completely usability of the concrete system can be achieved. Obviously the benefits have to be essentially greater than the resources devoted additionally.

2.2 User-Centered Design Approach

Independently from inspection-based usability evaluation techniques there is also an intention of this thesis to apply other methodologies in order to estimate the quality of interactive system. For this purpose one of the most simple and, therefore, widely used user-centered procedure is chosen within the scope of the current work – namely, a *usability survey*. Together with usability tests it is a very popular and commonly applied method to receive a user feedback making use of *usability questionnaires*. If properly elaborated and suitably applied, questionnaires are powerful tools for eliciting, recording, and gathering of information regards user experiences with an interactive system. This statement is actually a recognized definition of the questionnaire itself, which also describes its main applications. Before getting in details in which way it is efficiently to ask, so that the users not only speak out the trivial experiences but also start to think deeper, some theoretical basis about related processes and procedures is required.

User-centered design (UCD) definition describes this approach as the one extending the development process with user-oriented activities. The main intention behind is to develop the interactive systems easy in use influencing the quality and accuracy of system requirements. According to this methodology, a user is put in the center with the highest priority to define rules and restrictions, initiate changes and get the desirable system functionality of acceptable quality [32, 51].

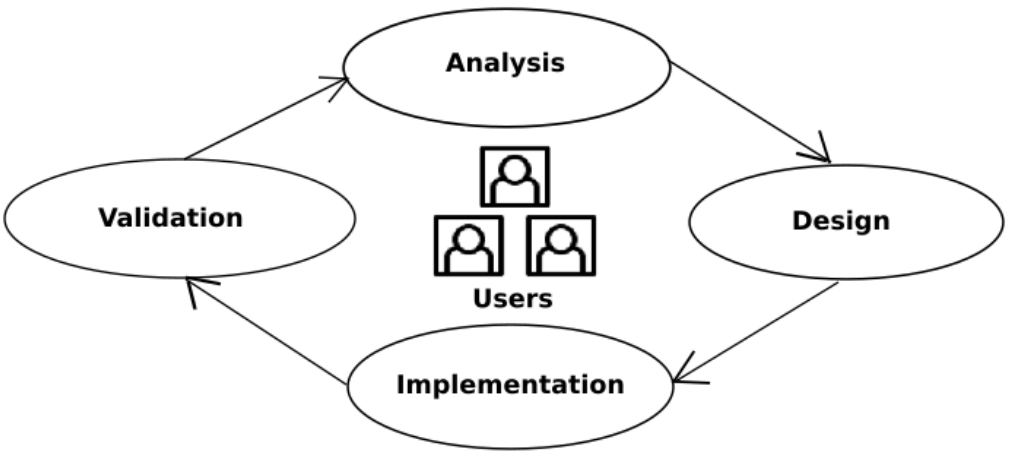


Figure 2.3: *User-Centered Design Process*

2.3 Usability Evaluation

Under *usability evaluation* the process of collecting information to describe usability of some interactive system is understood; achieved knowledge tends to be used either in order to improve the system qualitatively or to estimate the actual quality of the interactive system. The term usability evaluation covers both inspection-based as well as user-centered usability evaluation procedures [19, 25].

There are two recognized types of usability evaluation – formative and summative [48]. If the main idea behind the formative evaluation is to improve system interface design as it is still under construction, the summative evaluation is usually executed to make conclusions about the quality of interactive systems in terms of usability. This type of evaluation takes place after the system development is mostly or completely finished. In the scope of current work, some different summative usability evaluations are carried out in order to find out if the designs of the existing system are acceptable from a user perspective.

2.4 Usability Inspection Methods

A term *usability inspection* is used to describe a set of methods and techniques which are devoted to finding usability problems in the system design having evaluators inspect system GUI. Those can be dedicated as well as to find out certain "local" usability problems with the aim to define their severity and classification but also to investigate usability level of the entire system. Represented in 1990 for the first time [25], usability inspection techniques became the most widely used within a couple of years. There are several essential benefits which make them attractive to apply. Firstly, because many inspection methods are based on analysis of user interface specification, this can result in a substantial advantage. Namely, inspection can be conducted in the early development process phase, so that the implementation progress has no impact on inspection activities.

Another advantage of usability inspection methods is their simplicity. Because almost all of the methods are easy to apply there is no need to involve specifically educated authorities to perform usability inspection, although the experts may achieve better and more efficient results.

A table 2.2 represents a listing of all known inspection methods with brief descriptions of main features and concepts behind each of the technique [26].

1	**Heuristic Evaluation**	Existing system interfaces are analyzed against recognized usability principles. As an outcome, a list of potential usability issues is formulated. Can be carried out by a single person.
2	**Heuristic Estimation**	Relative usability of two or more system interface designs are estimated quantitatively.
3	**Cognitive Walkthrough**	Interactive system is evaluated in a task-specific manner. The questions are asked either directly during the test or after.
4	**Pluralistic Walkthrough**	System interfaces are analyzed by developers and stakeholders in details in a discussing manner.
5	**Feature Inspection**	Sequences of the features required to accomplish certain tasks using the system are investigated.
6	**Consistent Inspection**	Comparative evaluations of the system interfaces to find out if the system designs can be used in the way it is implemented in other systems. Provided by experts who already have multiple experiences in the discussed area.
7	**Standards Inspection**	System interfaces are inspected by an expert to be compliant to recognized standards.
8	**Expert Review**	Interactive system is explored by experts in order to generate a detailed report about main usability issues and deviations from recognized principles found. Usually, more than one expert is involved.
9	**Formal Usability Inspection**	Rule-based combination of both individual and group inspections with defined roles. Includes elements of heuristic evaluation and cognitive walkthroughs.

Table 2.2: *Usability Inspection Methods*

Heuristic evaluation, heuristic estimation, cognitive walkthrough, feature inspection, and standards inspection are those inspection methods for which it is sufficient to have one inspector. However, these methods may also use multiple inspector evaluations in order to formulate final outcome. For example,

heuristic evaluation results can be represented as a combination of several inspection reports and the heuristic estimation output can be calculated as a mean value of single estimates.

Such inspection methods as the pluralistic walkthrough and consistency inspection are defined as group inspection methods and require more than one inspector to be involved [48].

2.4.1 Heuristic Evaluation

Term *heuristic* in a context of usability stands for certain accepted rule and principle which helps to reach the usability itself. Heuristics serve mostly to guarantee the usability but do not define how to accomplish it. In other words, heuristics are concrete and simple; they are said to be applied to support an implementation of dialog principles.

Heuristic evaluation definition was formulated in the early 90s by Nielsen and Molich as a usability engineering method for finding the usability problems in a user interface design so that they can be attended to as part of an iterative design process [22]. According to the statement, it is hypothetically true that there exists no interactive system which usability degree is high enough so that there is no potential for improvements.

The next ten basic principles which are usually used for evaluations were iteratively revised and applied for multiple investigations of interactive systems [29]. These are proved to be efficient and simple at the same time, that makes them be a good solution for any kind of usability evaluation.

1. **Visibility of system status**
   The system should always give users appropriate feedback within a reasonable time in order to keep them informed about what is going on.

2. **Match between system and the real world**
   The system should speak the users' language, with words, phrases, concepts and conventions familiar to the user, rather than system-oriented terms, making information appear in a natural and logical order.

3. **User control and freedom**
   Users often choose system functions by mistake, therefore it should be possible to make use of clearly marked "emergency exit" to leave the unwanted state easily. Support undo, redo, exit points.

4. **Consistency and standards**
   Users should not have to wonder whether different words, situations, or actions mean the same thing. Follow platform conventions.

5. **Error prevention**
   Eliminate error-prone conditions or check for them and present users with a confirmation option before they commit to the action. It is better to prevent a problem from occurring than to provide appropriate error messages.

6. **Recognition rather than recall**
   Minimize the user's memory load and facilitate decisions by making objects, actions, and options visible. Instructions for use of the system should be visible or easily retrievable whenever appropriate.

7. **Flexibility and efficiency of use**
   Make the system efficient for different experience levels using accelerators, shortcuts, advanced tools. Allow users to tailor frequent actions.

8. **Aesthetic and minimalist design**
   Dialogues should not contain information which is irrelevant or rarely needed because every extra unit of information diminishes the relative visibility of others.

9. **Help users recognize, diagnose, and recover from errors**
   Express error messages in plain language, precisely indicate the problem, and constructively suggest a solution.

10. **Help and documentation**
    Provide help and documentation which is easy to search and focused on the user's task. Keep the content concise and laconic.

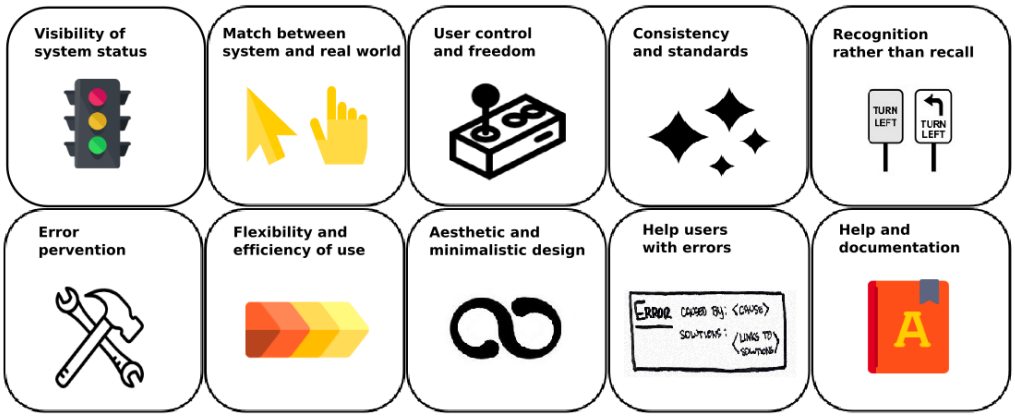


Figure 2.4: *Usability Heuristics by Jacob Nielsen*

Although the heuristic evaluation is defined as a single inspection method, it is quite challenging for one individual (even for a usability expert) to figure out all usability issues judging the interactive system to be compliant recognized principles – heuristics. Another important point with it is that different people do see the system from different points of vision. Consequently, involving more inspectors leads to achieving more complete results and more trustworthy system interface evaluations. Having more experienced – and also motivated – people leads to much more efficient outcomes. In other words, there is always a need for heuristic evaluation. It is also important to mention that some specific usability problems could be often found by people having a certain lever of experience in usability evaluation or a particular way of thinking, education, or beliefs.

Generally speaking, the heuristic evaluation can take place at every stage of system development [36]. Of course, it is better to get reliable feedback and improvement recommendation earlier so that system interfaces and design can be easier modified or replaced with more suitable. But it is always a good practice to review the solutions which are already in use, especially if the system is continuously developed and extended being used by experienced auditory as well as by users with no background knowledge of the system.

Taking into account main characteristics and benefits of the heuristic evaluation, it was decided to apply this methodology at the first stage of the current usability research as the best fitting for existing study case.

2.5 User-Centered Usability Evaluation

User-centered usability evaluation (also often known under *usability test*) is a type of usability evaluation during which representative users carry out certain tasks with the help of interactive system in order to recognize and record existing usability problems or to measure efficiency, effectiveness, and satisfaction achieved using a system [46]. In a common case, a usability test consists of three main phases and has the following structure:

1. Test planning and preparation activities
   Writing usability test plans and test scripts, recruiting appropriate usability test participants

2. Test execution
   Carrying out all testing procedures according to selected methodology

3. Communication of usability test results
   After test activities were finished and published, writing of usability test report follows.

Each of test participants who takes part at one usability test session can possess one of the next roles: moderator, secretary, observer, or usability test participant. Of course, in certain cases, some of listed roles can be let out.

A typical (face-to-face) usability test usually runs under such circumstances that a moderator and a test participant are located in the same room. However, there are also other possible ways to conduct testing activities. If role representatives have different locations while performing usability test, it is still possible to provide communication by means of video conference or phone call or via the Internet. In such case, it is said to be a remote usability test. Moreover, there is another kind of usability test, so-called uncontrolled usability test, which refers to non-real time investigations. In this case, all usability test tasks are firstly carried out and recorded and afterward analyzed.

2.5.1 User Survey

Evaluation during which a user provides subjective statements or reactions in the form of questionnaire responses based on the experiences from operating with an interactive system is called a *user survey*. Usually, it is one of two common goals to be achieved when carrying out a user survey:

- evaluate estimation of using an interactive system
- collect information about the context of use, in other words, for which purposes and in which way an interactive system is used

A method applied to accomplish both of possible goals of usability evaluation is discussed below in details.

2.5.2 User Questionnaire

There is a comprehensive definition of a questionnaire proposed and published by usability engineer and researcher Jurek Kirakowski in the early 2000s: it is a method for elicitation, recording, and collecting information. This is a simple but at the same time substantial depiction of the tool and its fundamental applications. According to this definition, a questionnaire practically gets a respondent concentrated on a specific issue or topic as a target and a certain way to reach this target.

There is obviously a number of issues and tasks to clarify when taking a decision to make use of a questionnaire for usability investigations. Among ordinary questions concerning a type of the questionnaire to be used, its sizes, content, structure and others, there has to be firstly decided and clearly understood what are the expected achievements, the outcomes of user survey. Having this knowledge it is possible to make a proper choice of a questionnaire to elaborate an appropriate own one or, if applicable, a way to adjust or extend some of existing for particular needs of usability evaluation. Consequently, correct targets can be defined and the proper means to achieve expected results can be proposed.

Other important aspects which have to be taken into consideration when preparing a questionnaire are its reliability and validity. In terms of usability, these characteristics technically show to which degree a chosen questionnaire fulfills the expectations according to its application. It is a crucial task to prove all three usability components – effectiveness, efficiency, and satisfaction. The presence of every of these three elements has to be checked separately; unfortunately, it happens frequently, that one of fundamental usability components either insufficiently represented or not introduced at all. Therefore, there are three specific types of analysis procedures to be carried out in order to prove presence and degree of each of usability components of an interactive system. These are effectiveness analysis, performance (or efficiency) analysis, and evaluation of user satisfaction degree correspondently,

which have to be considered for every consistent questionnaire[2].

[2]http://www.ucc.ie/hfrg/resources/qfaq1.html, last call 21.12.2016

Chapter 3

State of The Art

3.1 Area of Discussion

Logistics principles are known since the time of ancient Greece and were widely applied in the military as powerful means in procurements and resource management. However, history and development of logistics as a scientific discipline has no stable behavior through the years. There is still a plenty of logistics theories which are treated to have both advantages and disadvantages depending on different estimation criteria. Better or worse, each of the theoretical approaches motivated by multiple economic, political, social factors contributes into logistics science as it is known nowadays. Integrating resources, warehousing, transportation, inventory, and others, logistics tends to optimize material and correspondent financial and informational processes. The main logistics goal can be formulated as having the right product of certain quality in the right quantity at the right time at the right place with the right costs. At the same time the following rules have to be hold [7]:

- High product quality
- Maximal customer satisfaction
- Minimal costs

When considering such definition of logistics and its main goal and rules, these identify nowadays so called *business logistics*. The term was firstly introduced in the s1960s and stands for all processes in industry sector dealing with challenges of the supply chains. These are tasks of warehousing, transportation, inventory, etc. as well as all related planning and management

activities, which can be both internal and external depending on which of resource coordinating flows are included.

Beginning and technically the most significant milestone in history of business logistics was introductions of automatic mechanisms in the middle of XX century. Together with incrementation of automation degree the theoretical fundamentals and knowledge basis of logistics as a science were rapidly extended and reinforced. Necessity to provide knowledge organization was clear; tending to introduce certain classification in logistics area it was inter alia decided to distinguish between logistics material flows inside a warehouse and external shipping processes of resources. This decision resulted in emergence of a new discipline – intralogistics [2]. The most important definitions and application of this discipline are considered in the subsection below.

3.1.1 Intralogistics and Its Applications

As already discussed above, *intralogistics* as a new direction in logistics science appeared to define a discipline of organizing, managing, executing, and optimizing in-house material flows. Involvement and improvement of automatic high rack conveyor and goods distribution systems in warehousing yielded in considerably higher speed and better compatibility of all elements in intralogistics. As the first step in application of computational intelligence in this business area, warehouse management processes were elaborated, so that that could be executed with the help of computers. The routine incoming and outgoing goods processes within warehouse were foremost overtaken by simplest IT warehouse management systems.

Technical progress and continuously introduced and innovations in both hardware and software branches significantly influenced further directions of intralogistics development [39]. Warehouse management and control systems have been significantly extended with new functionality. Barcode mechanisms, mobile peripheral devices, considerable improvements in database technologies and network stability and reliability resulted in dramatical growth of intralogistics systems. There was obviously always a tendency to provide possibly high degree of automation for developed systems – as in every business application area influenced by technical progress in the second part of XX century. Evolution in intralogistics field, however, has an extensive history and covers a lot of discoveries and engineering achievements in manual warehousing as well. A software system chosen for investigations within the scope of current work is one of such warehouse management systems, which combines functionality with support of a variety of logistics processes within

a warehouse executed manually. A subsection below contains descriptions of WAMAS 5 specific features and characteristics – a software solution for manual warehousing.

3.1.2 Warehouse Management System Software

Nowadays there is demand for intralogistics systems on the very diversified market – from small manual warehouses to large-scaled and automated warehouses. Depending on different criteria such as customer business requirements and available resources (warehousing spaces, devices, etc.) logistic processes to be supported vary significantly as well. SSI Schaefer as a branch leading company group takes on to cover the entire market. With a powerful logistics software solution – warehouse management system WAMAS 5 – particular customer needs and expectations can be qualitatively fulfilled.

Following intralogistics business processes are supported by WAMAS 5:

- **Incoming goods** including such activities as goods registration on different types of storage locations of warehouse areas
- **Transport** orders to move stock within warehouse, so that items and loading aids get booked to the corrected storage location for further activities
- **Replenishment** activities to support stock reinforcements in time and on the correct storage location
- **Inventory** to assure correct reliable stock data within a warehouse and to be flexible to introduce any kind of stock data adjustments
- **Picking** activities of collecting goods to get them prepared for further processing in required quantity and composed together according to orders
- **Packing** to support proper reliable arrangement of goods and provide management of loading units content
- **Loading** activities which organize goods between transport vehicles to get ready to leave a warehouse
- **Outgoing goods** as a final stage of intralogistics processes to make goods leave a warehouse

To support various intralogistics processes executed manually within a warehouse using WAMAS 5 as the main software system, there are diverse peripherals involved. Mobile, voice, and tablet terminals, pick by light and pick to light devices, for instance, are very helpful for warehouse employees when picking, packing, and making stock ready for further outgoing goods operations. Printers which produce barcodes in formats requested by a customer in accordance to specific needs can be used for creation and replacement of all sorts of labels and delivery/order notes. There are also different conveyor stackers and vehicle units engaged in the warehouse processes – those have a number of sensors for parameters logging, such as temperature or humidity.

All of the mentioned auxiliary devices and peripherals require additional software configurations, an involvement of specific technologies and frameworks. It results in a variety of different GUI solutions and implementations which have to be originally investigated separately for local advantages and disadvantages. It is essential, in the first place, to know and understand existing workflows, graphical elements as well as usability issues and deviations from recognized norms of each of proposed user solutions. Having this knowledge is important to define a general concept and a way in which all of the supported system clients have to work together basing on edges of each of facilities. Thereby it is possible to contribute to a consistent powerful solution for warehouse management activities. Current WAMAS 5 usability research is devoted to the existing GUI solutions of the desktop client. Detailed descriptions and explanations of existing desktop dialogs, their interactions, and other GUI elements are represented in the next subsection.

3.2 WAMAS Desktop

In current work, the desktop client of WAMAS 5 product software is investigated only. This decision to restrict the research area was influenced by several factors. The complexity of the system and variety of GUI elements to be analyzed for all existing system clients (desktop, mobile, etc.) do not allow to provide the examination of the quality of the whole system. The amount of data to be treated is to big for both processing the data and documenting the results within one document. It would be impossible to focus on every detail to be analyzed and to assure that it is nothing lost or forgotten. From the other hand, it would be also very difficult to find an audience among system users with knowledge and work experiences of the whole functionality scope. Taking into account the arguments above, specific desktop dialogs which are used most often in order to maintain and process

the core system functionality were examined.

3.2.1 Desktop Dialogs Classification

In order to make data analysis and documentation of results easier, some kind of dialog classification is provided within the document. All WAMAS 5 desktop dialogs are grouped into subsets according to specific characteristics and properties the dialogs possess. These classification criteria are independent from each other, so there is no way to define any rules or relationships between the dialog subsets. The following dialog characteristics were taking into account when classifying the research data:

- accessibility of the dialog
  There are some certain dialogs which can be neither triggered directly from the dialog search string nor from the menu bar listings. Such dialogs are defined as **secondary** and are accessible only on further steps of configuration process after some data was already prefilled in **primary** predecessor dialogs.

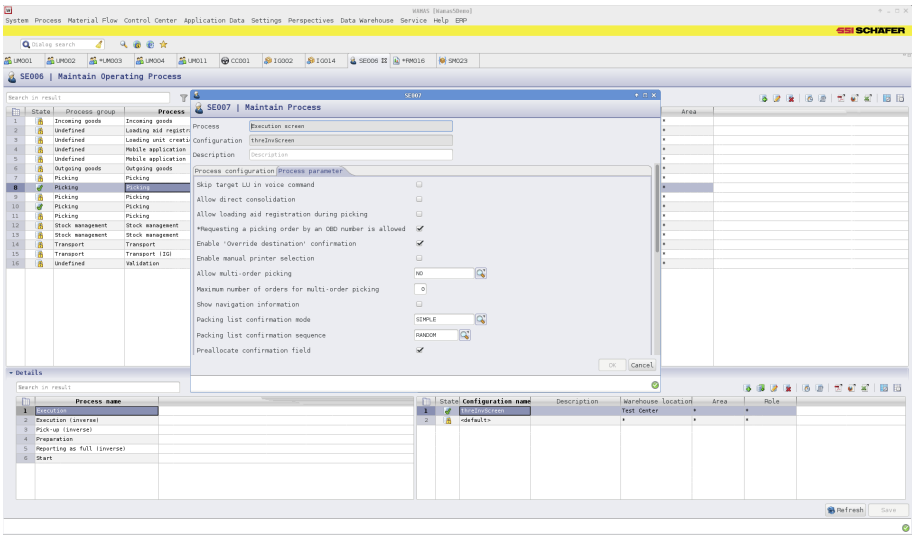


Figure 3.1: *SE007 | Maintain Process*

For instance, service dialog **SE007 | Maintain Process** (figure 3.1) could not be displayed if no process was selected for editing in previously opened **SE006 | Maintain Operating Process**.

- application purpose of the dialog
  Warehouse management system database contains lots of different data. To make some kind of database records available for a user the **overview** dialogs are provided. Each of them has the same structure and similar functionality. As an example **SM023 | Loading Units Overview** dialog represented on the figure 3.2 can be considered: search, extended search, search result and details sections are the typical parts of overview dialogs.

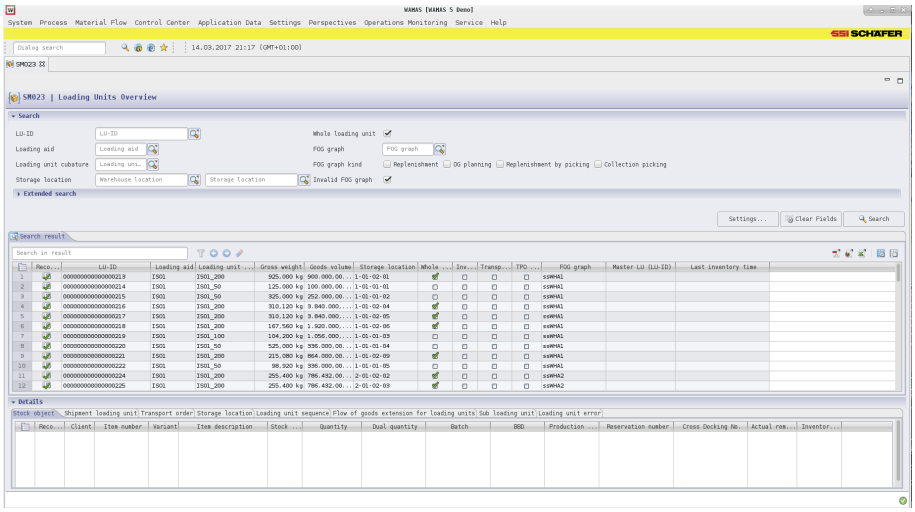


Figure 3.2: *SM023 | Loading Units Overview*

Another kind of dialogs serves to edit and maintain the data. **Form-based** and **table-based editing and maintenance** types are distinguished among this dialog application purpose group. Both dialog types are described in later chapters of the document where certain examples are also provided. And finally, there are **assignment** dialogs which main purpose is to configure some certain set of rules when a particular assignment has to be applied in the system. In such a way it is possible to defined which print functions are applied for different print channels with the help of **RM016 | Maintain Print Function Assignment** dialog.

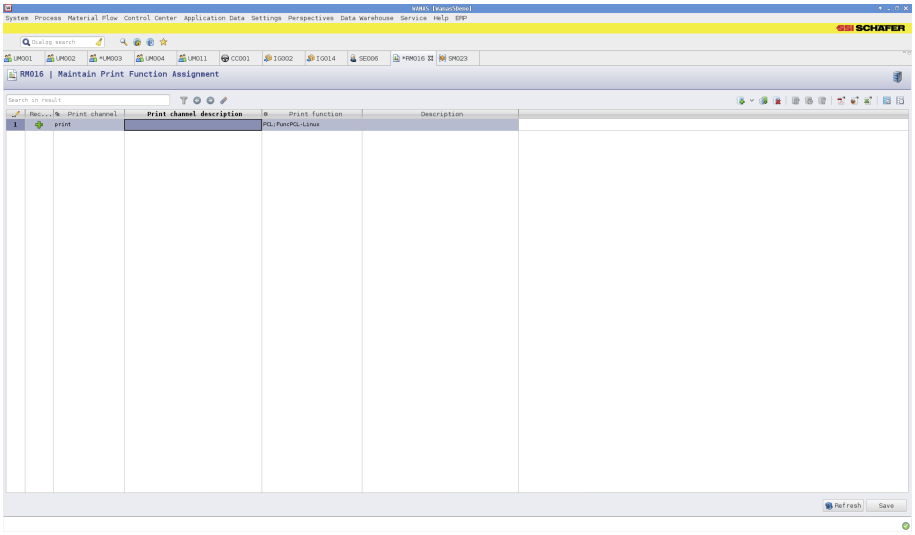


Figure 3.3: *RM016 | Maintain Print Function Assignment*

- format dialogs are represented in
  In some cases, it is not necessary to navigate a user to another dialog. If the work with previously opened dialog has to be continued after a single action took place it does not make sense to display an independent dialog for the whole desktop working area. Instead of that some specific dialogs as **modal, message list, and confirmation** dialogs are implemented. Confirmation dialogs, as well as message list dialogs, do not have any dialog title as can be seen in the example below on the figure 3.4:

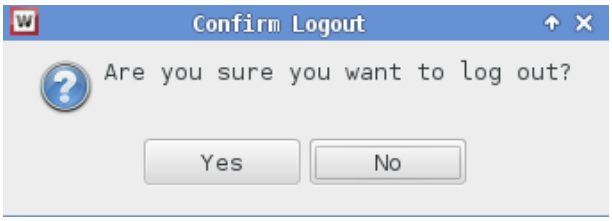


Figure 3.4: *Confirm Logout*

It is also to be mentioned that some dialogs can be used both as maintenance or modal depending on the process they are involved in. In this case, the modal dialog version has the same dialog title. Some

examples of such dialogs used in both ways are **WH004 | Storage Locations Overview** or **MD001 | Items Overview**.

3.2.2 Desktop Working Area

To get an overview and a better understanding of WAMAS 5 desktop application, in general, the working area is described according to sections it is divided into. Detailed descriptions of them are represented below.

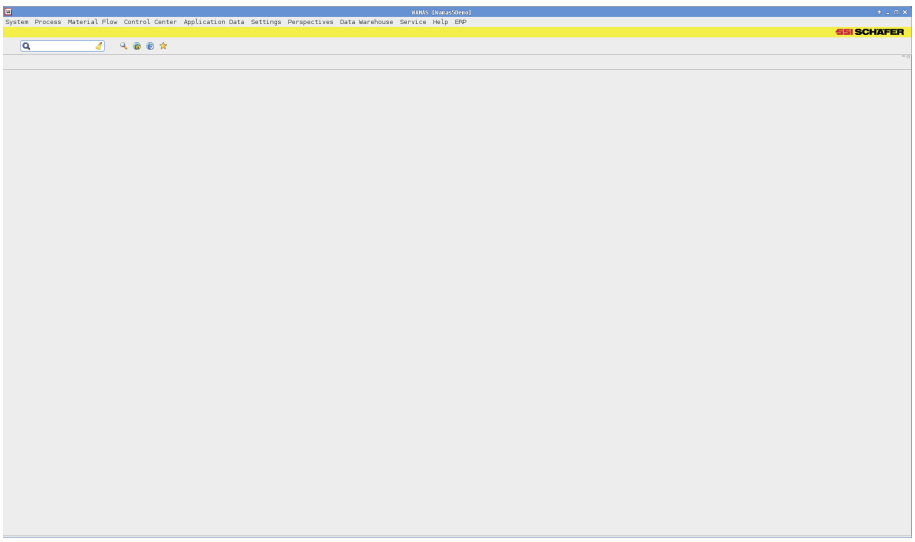


Figure 3.5: *WAMAS 5 Desktop Sectioning*

1. Menu modules

   The basic WAMAS 5 desktop dialogs can be open by the user from the listings in the menu bar. Some of the are organized into sub-modules according to the purpose of use.

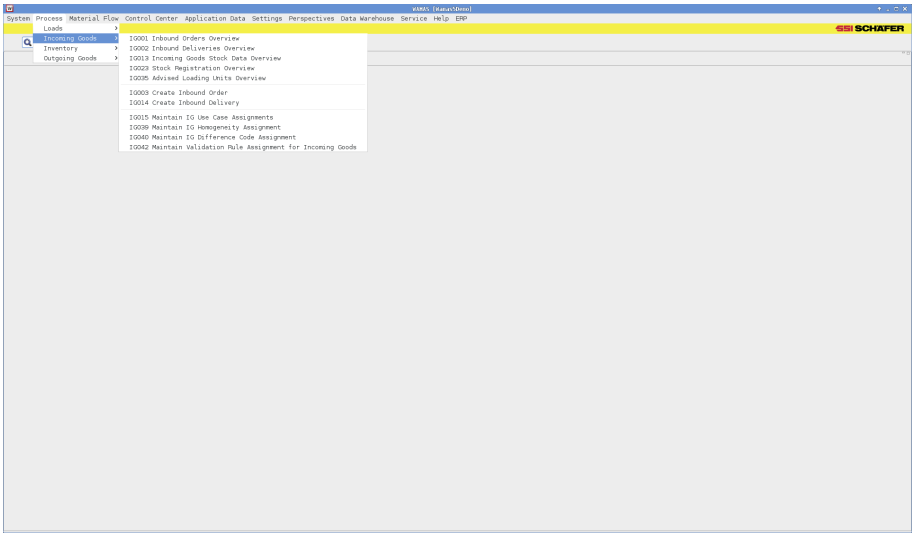


Figure 3.6: *Menu Modules*

However, there are also some dialogs which are not present in menu bar listings. Those are designed as secondary in configuration sequence and make no sense if the data was not pre-filled within other dialogs on the sequence steps before. Examples of such dialogs are represented in the next chapters of the document. Both primary and secondary dialogs naming format has a simple structure. Each dialog possesses unique title and number, where title described the main purpose of the dialog and the number consists of two capital letters according to the section the dialog belongs to (IG for incoming goods, MD for master data and so on) and exactly three digits. The only exception is ERP dialogs software module - those dialog names starts with three literals "ERP" with regards to dialog application purpose.

- **System** which includes the basic operations available in desktop version of the software, namely - start mobile client and voice simulator, change password (as described on the figure 3.7), logout, and exit application

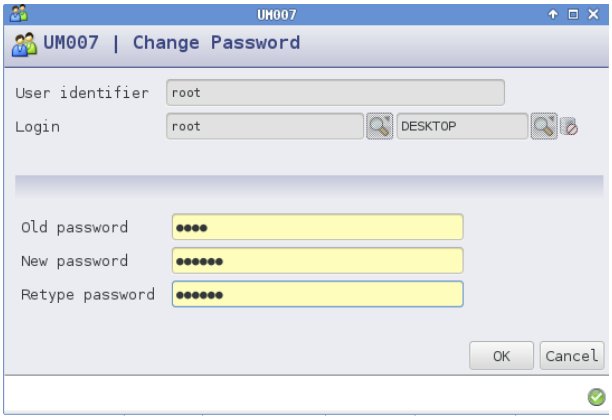


Figure 3.7: *UM007 | Change Password*

- **Process** that contains all process dialogs categorized into submodules according to functionality they provide - incoming goods, inventory, outgoing goods, and loads
- **Material Flow** where the dialogs for automatic systems configurations can be found. Those are also classified into following submodules: device controller, material flow area manager, SOC (System Operation Control) communication service, transport order generator, external device controller, pallet conveyor system, WCS (Warehouse Control System) device controller, storage-retrieval machine, material flow manager, clearing station, bin conveyor system, and mobile rack device controller
- **Control Center** which covers system messages configuration dialogs, reports and dashboards, as well as the dialogs, used to control the processes in automated warehouse
- **Application Data** that is a collection of all application data dialogs and consists of load information service, data interface, stock, warehouse, master data, movement data and global system parameters maintenance dialogs
- **Settings** – this dialog module is formed by report management, internationalization, routing, and user management dialogs. They are of such a kind, that every configuration change affects the whole warehouse (i.e. time zone)
- **Perspectives** provides possibilities to switch between three existing system perspectives - dialogs overview itself (for example, to configure data and processes), warehouse modeling (to work with

warehouse areas, routing inside it, etc.), and warehouse checker (e.g. to find the route between particular storage locations and to calculate costs for it)

- **Data Warehouse** that includes data warehouse configuration and monitoring dialogs
- **Service** dialogs provides functionality to import / export data, configure and monitor system and its processes
- **Help** includes information about software version and option to check if there're some new updates available
- **ERP** combines the dialogs which are used to maintain the communication with other external software products. Those are provided for testing and development purposes and are usually available for members of development team only.

2. Dialog search

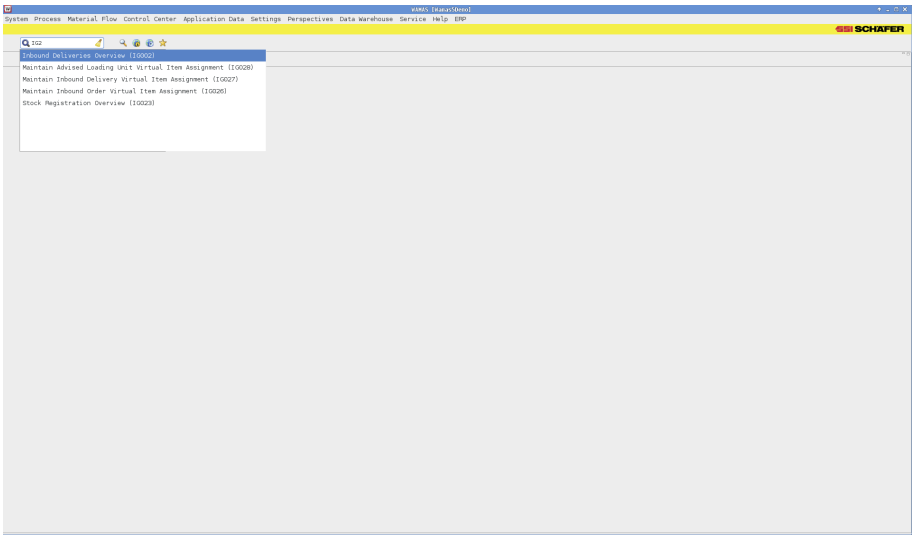


Figure 3.8: *Dialog Search*

The dialog search field provides an alternative way for the user to open some particular dialog instead of searching for it in the menu bar. In order to find the desired dialog, it is possible to search for both dialog title and dialog number. Moreover, it is also possible to search for single words or digits contained in the dialog name. In this case, the

result set is provided in a drop-down listing, so it is possible to select the desired dialog from suggestion list instead of providing its exact name.

3. User Preferences

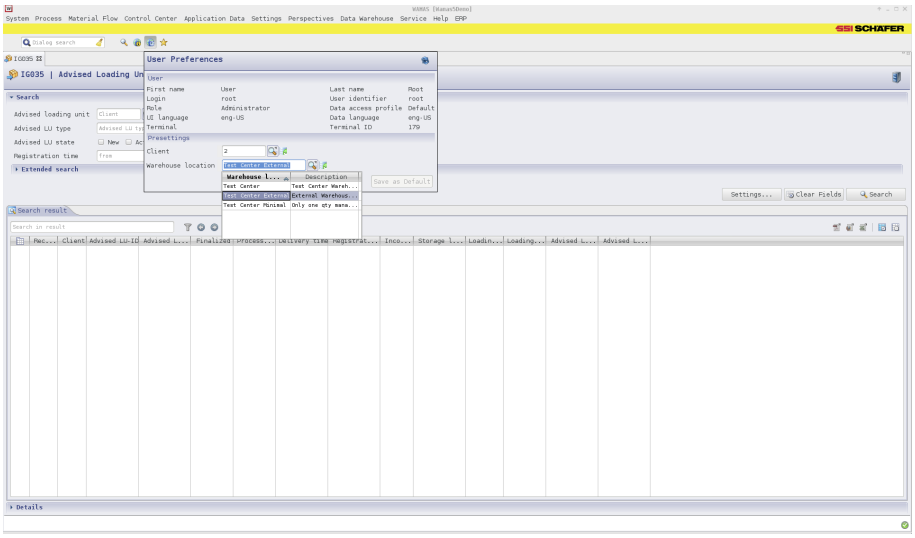


Figure 3.9: *User Preferences*

To have a possibility to personalize desktop client for a particular person or a group of persons user preferences can be configured in the system (figure 3.9). Those contain information about the current user, his / her role and the language used. Having this data pre-configured, a user is able to pre-fill some certain dialog fields when working with WAMAS 5, and namely warehouse location and client attributes will be overruled even if already filled with contradicting values.

4. Bookmarks

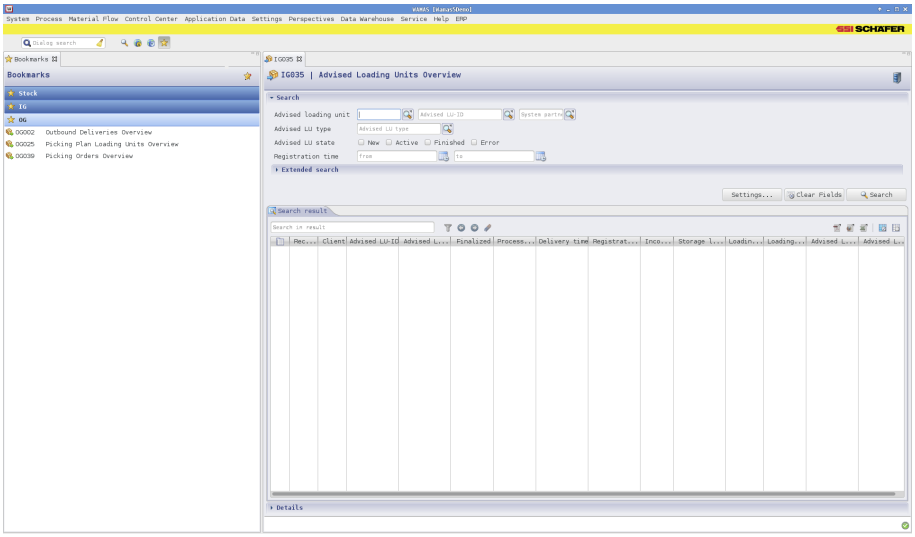


Figure 3.10: *Bookmarks Overview*

Taking into account complexity of the system, it is usually not a case that a user requires more than a certain set of system dialogs when fulfilling some goal using WAMAS 5. In order not to force a user every time to search for dialogs of interest using search field of the menu bar, the software supports bookmarking functionality. It allows to create a list of dialogs and even categorize them. This list can be always extended as well as reduced according to user needs. It is also possible to hide and to show the listing of configured dialogs which disappears/appears on the left part of working area correspondently.

5. Dialog area

   An essential part of the desktop working area is devoted to the dialogs themselves which include dialog titles and contents. Each opened dialog is represented in a separate tab which is signed with dialog number. It's possible to close any of displayed dialogs, to change the sequence in which they are displayed on the desktop screen, or even to divide the screen into several sections (see figure 3.11 below). Every dialog may be opened only once at the same time, the only exception is modal dialogs.

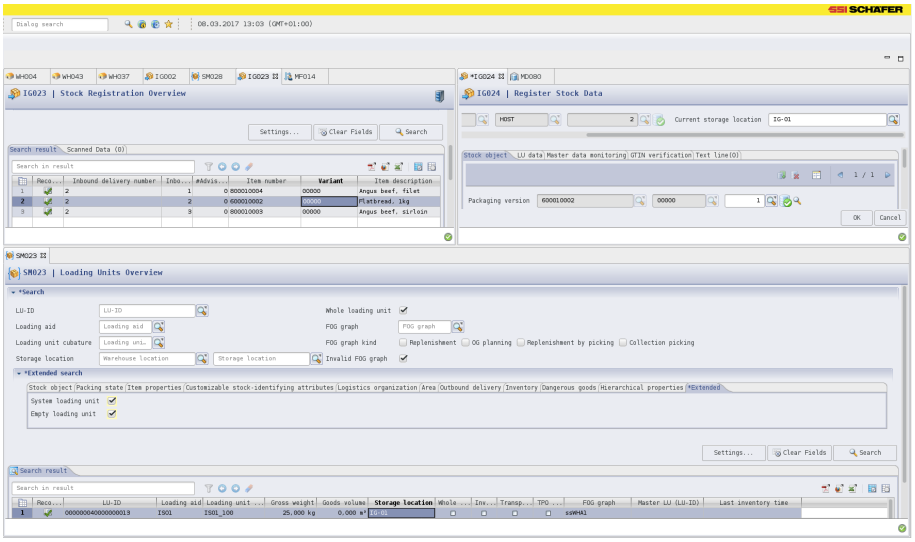


Figure 3.11: *Dialog Divided View*

Numbers of dialogs which contain some unsaved changes are marked with an asterisk in the beginning. The dialog tabs are also displayed in a different manner depending on which dialog is currently active. i.e. all dialog tabs are not highlighted in opposite to one it is currently worked with.

3.2.3 Controls

In order to make it easier to work with a great variety of system data executing different tasks and processes, the following controls were defined:

- icons
- action keys (shortcuts)
- buttons
- data entering fields of different types

Having various data in place it is essential to support different input options depending on the type of the data. For instance, **text input fields** are applied for external references and artifact descriptions, **number fields** are useful for diverse quantity input fields, **number fields with value range** are usually provided to search for the values belonging to specified interval,

date input fields are applied for all possible date entries in the system and are also extended with time input slots in cases when it is necessary. There are also **checkboxes** implemented to be able to indicate if an attribute has to be considered, ignored, or not applicable.

3.3 System End-Users

There are a couple of important points to be mentioned regarding the WAMAS 5 end-users. Taking into account business specifics and complexity of functionality supported by the warehouse management system, there is a certain level of intralogistics knowledge required in order to be able to operate the system. In other words, the interactive system is designed to be used by the experts acquainted with the logistics processes. Application managers, control center operators, system administrators are supposed to hold some particular responsibilities for process executions and be able to make business-specific decisions. Particular user training activities usually take place before the system is used in production.

Chapter 4

Software Heuristic Evaluation

As already mentioned in previous chapters, for the present thesis it was decided to apply an usability inspection method in order to estimate WAMAS GUI solutions of the desktop client. Taking into account such impactive factors as available time and resources, skills, possible user access, an evaluation method comparing the existing interface elements to established human factors principles was chosen - the earlier discussed heuristic evaluation. An application of existing ten heuristics recognized by Nielsen Norman Group[1] were considered for a wide variety of WAMAS desktop interface elements.

4.1 Visibility of System Status

There is a known best practice to make the status of all running processes available for users so that the users get notified and can respond under conditions of any changes. It is also important that the statuses are easy to see and interpret and that the status information is always up-to-date and accurate.

There are plenty of logistics processes that can be performed with the help of WAMAS software. Obviously, it is of great importance to continuously inform the user about the progress and especially in the case of something working not as expected or no progress being possible anymore. Along with generated activity protocols and system messages (functionality supported by WAMAS) which can be reviewed additionaly, there is a visual reflection of system status changes and dynamics. Some of the examples which demonstrate status mechanism implementations slightly differing from the variety of WAMAS desktop dialogs are represented below:

[1] https://www.nngroup.com, last visited 10.11.2016

- It is always clear which stage possesses one or another order or delivery. In the figure 4.1 an overview of deliveries is represented containing inbound deliveries (IBD) with status *Draft* or *New* (0% Progress), *Active* (20% Progress for released deliveries without stock registration begun and 20 up to 99% Progress for released deliveries with some registered stock), and *Finished* (100% Progress – completely registered stock or manually finalized).
  Additionally, there are a number of helpful flags that will be set if some delivery was already released or if some delivery was finalized manually. The value of *Progress* attribute specifies the degree stock registration completeness – starting with value 20% as a delivery gets released, it is proportionally increased up to 100% after some stock is got registered.

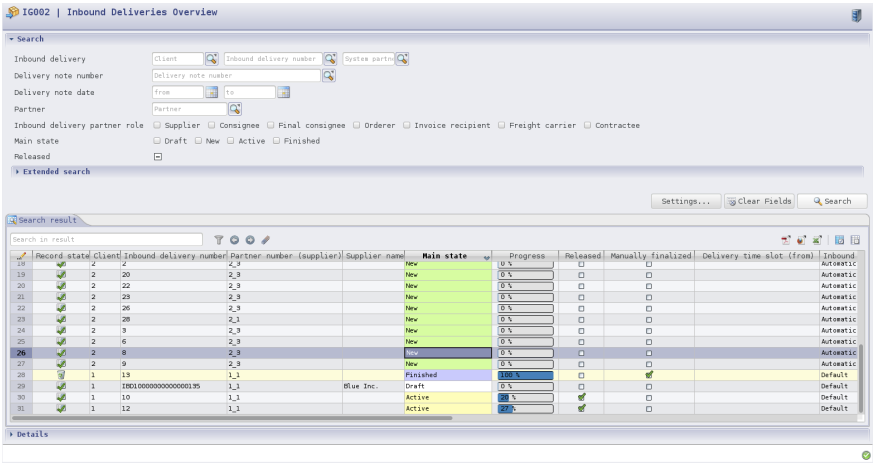


Figure 4.1: *Inbound Deliveries Overview – Status Visualization*

The same logic is also true and implemented for outbound deliveries (OBD). As it is represented in the figure 4.2, there are deliveries in different states depending on the planning and process execution progress.

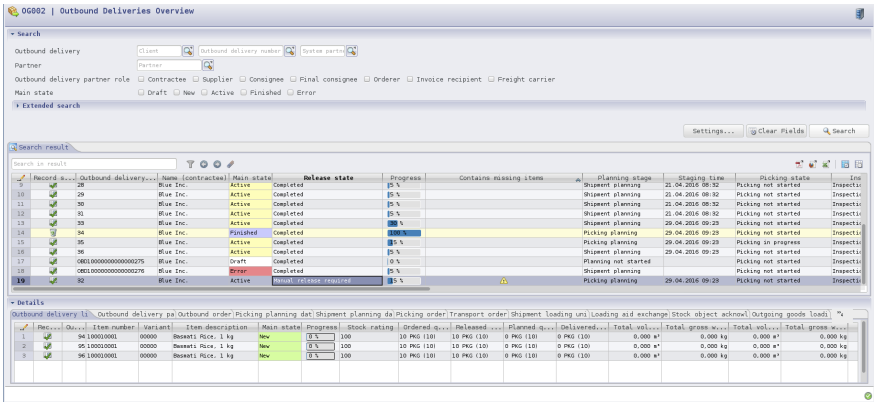


Figure 4.2: *Outbound Deliveries Overview – Status Visualization*

Logistic processes dedicated to picking, packing, or loading goods to get them ready to be moved away from the warehouse are generally more complicated. Therefore, there are multiple possible constellations of an entire outbound delivery state as a combination of main state, progress, and planning stage. Together with such states as *New*, *Active*, or *Finished* which describe smooth process execution, it can also happen earlier or later that some of the deliveries gets an *Error* state. It is one of the the plausibly expected scenarios and it is required to have a possibility to carry it out – so a user gets a notification about the necessity to introduce some changes to the process execution.
There are also some other kinds of user notifications that some of the orders or deliveries may require attention and some additional actions. For instance, a flag *Contains missing items* can be set and release state *Manual release required* as soon as the delivery was planned for picking and it was identified that there is not enough available stock to proceed with picking.

- As mentioned in the previous chapter of the current work, WAMAS supports functionality to edit multiple records at once. Hereby it is important to get a user informed about the progress because such execution may take longer as a processing of single records. A figure below 4.3 demonstrates in which way the system makes such information visible for users when creating more than one transport order (TPO) with a single action:

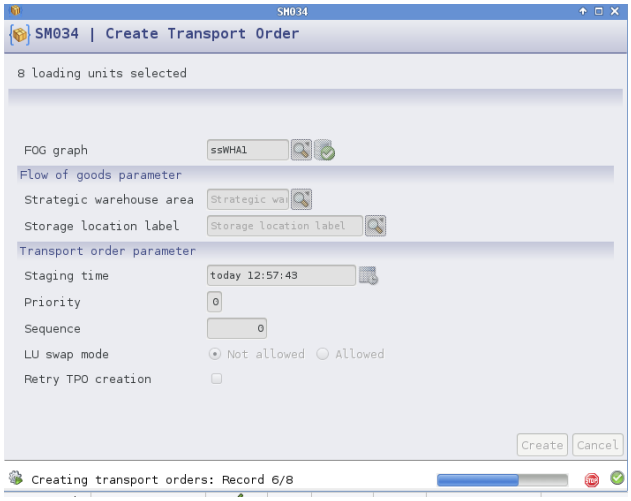


Figure 4.3: *Create Multiple TPOs – Progress Visualization*

- There are also much more mechanisms which inform users about running tasks and their progress through the system: progress bars 4.4, progress fields with percent measurement units, process statuses with color-coding, etc.

Figure 4.4: *Progress Bar*

Conclusion 1: In general, status mechanisms are widely supported by WAMAS desktop client.

4.2 Match Between The System and The Real World

It is possible to benefit a lot in usability degree taking into account user skills and previous experiences. Implementing system features to be used in the way things are used in everyday routine results in positive user satisfaction and simple learn processes to get used to the system. Another good point is to make the whole system functionality visually as obvious as possible.

The users should ideally spend no time trying to understand or make a guess what a GUI element is for or which results some actions can have. Applying metaphors in form of specific images, icons, sounds, etc. much more efficiency of use of the interacting system may be reached with the same capabilities.

There is a big number of icons which are used through the WAMAS dialogs. The most of them are elaborated in the same way as it is commonly used for different types of software products. For instance, a loupe is used to indicate search functionality, a floppy disk stands for saving option, a plus symbol is used for adding a new record, and a red cross – for deleting a record that is currently reviewed. Some of the typical WAMAS solutions are described in more details below:

- Simply and usable are the icons represented in the figure 4.5 below. As known from a variety of other systems and products, pressing on the icon with a green plus a new record is created, on the icon with double patterns a record is got duplicated, on an icon with a pencil a record can be modified, and icon with red cross a record is deleted.

Figure 4.5: *Basic Data Maintenance Functionality*

- Having great amounts of data processed by WAMAS which can be reviewed in maintenance dialogs, there is a functionality implemented that allows a user exporting certain result set to be saved in a file. Supported file formats are Adobe PDF Acrobat, HTML, and Microsoft XLS – and correspondent recognized logos are used for icons indicating possible actions. It has to be noted, for HTML document the logo of Mozilla Firefox browser was chosen; it is not completely correct as far as the HTML is supported by all and not only by this particular browser, but it understandable for users who associatively build a connection between the browser and the language.

Figure 4.6: *Supported Data Export Types*

- It is commonly used to place a loupe icon to indicate search functionality available – within a search query input string, at the button to be pressed for generating result set, etc. In current WAMAS implementation, the dialog search string is expanded with broom icon in order to be able to completely erase an input. It is also to be mentioned that the searching process begins as soon as any characters (both digits or literals) are entered, so there is no necessity to press any button or to trigger result set generation in some other way. There is a fuzzy logic behind which allows searching for both dialog titles and numbers.

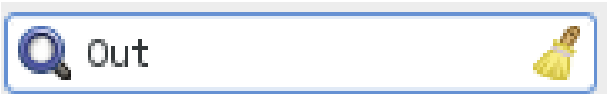


Figure 4.7: *Auxiliary Search Icons*

- If it has to be possible to configure an attribute selecting one value from the small set of known values, there is a simple and powerful solution. In case the number of possible values is not greater than 10 (otherwise, the screen is overloaded with elements to configure) and there is enough space to display all attribute values simultaneously, radio button mechanism suit very well. Such functionality is also supported by WAMAS. Should there be only one access mode selected for items in the warehouse and the possible values are pre-defined as recognized and used in intralogistics context, the radio buttons are in place in item maintenance dialog. The same solution (figure 4.8) is implemented for customizable stock identifier attributes on the item level.

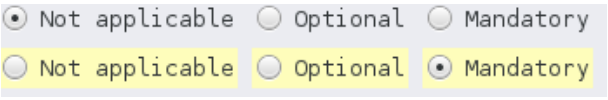


Figure 4.8: *Radio Buttons – Item Parametrization*

- On the other hand, there are some icons in place in WAMAS which are not so much intuitive how it can be expected. Review history or review changed history actions are already a little bit unclear itself – and the icons which are provided to make this functionality visible are also misleading.

Figure 4.9: *Toolbar Icons of Maintenance Dialog*

Conclusion 2: There exists potential to provide some improvements supporting users when operating WAMAS. Connections and similarities between functionality offered by the system and user expectations based on experiences from the real world can be made even stronger. Icons and buttons can be redesigned to be self-explanatory and intuitive.

4.3 User Control and Freedom

Any type of interactive system should provide a user an ability to make decisions. Even if there is a probability that a user can choose not the most appropriate way to execute the process or to organize processing data, it should still be possible to go forward with such decision.
If examining WAMAS desktop client functionality on the subject of user control, there is a number of features which make users feel free and flexible when operating the system. Ability to edit data inputs pre-filled with the data from the previous process execution step. However, it is not always possible to go back to the earlier stages – such system behavior is required with regards to logistics conditions and restrictions. For example, it is can not be allowed to plan an order or delivery anew after some goods were registered or initially ordered quantity was picked. In other situations, if it is allowed to support *Undo* and *Redo* operations, a user has a possibility to enter input values (manually or selecting from drop-down listing where applicable) even it can result in data inconsistencies.

- When proceeding with stock registration based on some particular already released IBD, *IG024 – Register Stock Data* dialog is automatically pre-filled with IBD stock-specific data, such as an item to be registered, a quantity, stock-identifying attributes, and so on (can be looked up in the figure 4.10).

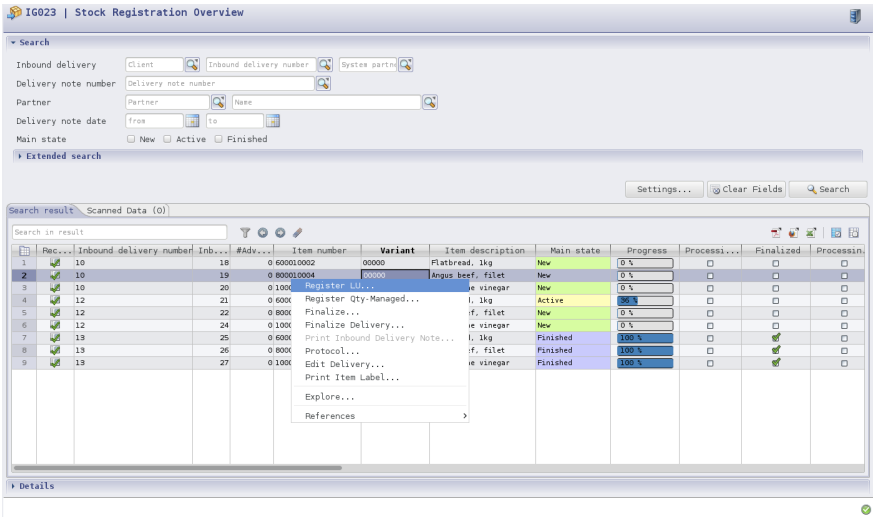


Figure 4.10: *IG023 – Stock Registration Overview*

After a dialog to confirm stock registration represented in the figure 4.11 is opened, it is still possible to apply some corrections.

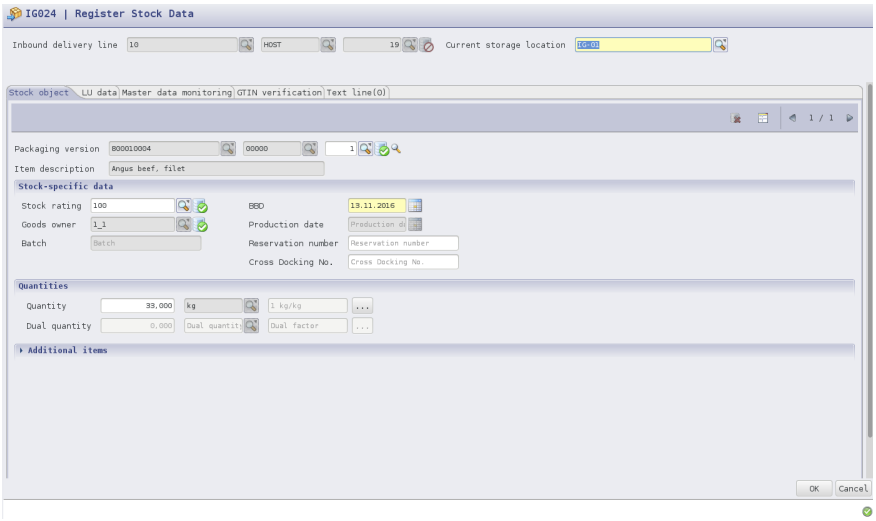


Figure 4.11: *IG024 – Register Stock Data*

- At the same time it is always possible to stop working with a dialog or discard the input values pressing on *Cancel* button 4.12 in creation dialogs. *Reset* button 4.13 in maintenance dialogs, or *Refresh* button 4.14 in assignment dialogs. Cancelation and resetting features are

available as long as the changes in a dialog are not saved – and refreshing functionality, in contrast, makes it possible to review the changes were already applied in the system but still not displayed in the particular dialog because of some reasons. This allows a user getting actual status of the process being currently executed.

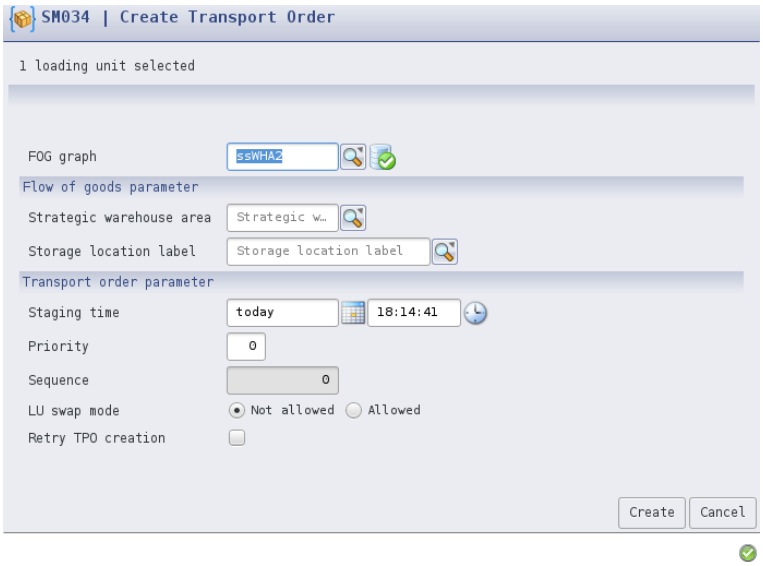


Figure 4.12: *Cancel Button of Creation Dialog*

Figure 4.13: *Reset Button of Maintenance Dialog*

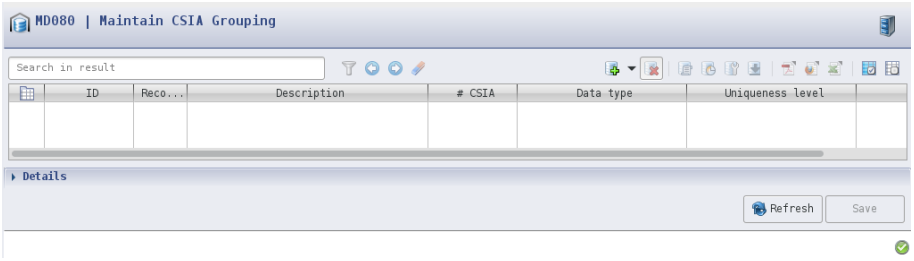


Figure 4.14: *Refresh Button of Assignment Dialog*

- One more quite small but very useful issue to be mentioned in this context – an appearance of pop-up dialogs to confirm and continue or to interrupt the process when canceling some changes. As an example provided with figure 4.15, there is always a pop-up message displayed if the system should discard all the recent changes to a user attempt to close a dialog before saving.

Figure 4.15: *Unsaved Changes Notification Pop-Up*

Conclusion 3: This heuristic is appropriately fulfilled by WAMAS. If some improvements can be applied to make users feel more confident and free when operating with the system, those are classified as enhancements or additions to already existing proper solutions.

4.4 Consistency and Standard

In order not to confuse system users it is a common practice to keep consistency through the whole system. This should cover not only to having the same GUI elements standing for the same functionality, but also to keep those placed correspondently in all dialogs where applicable. Another important issue to keep in mind is that a single style of language only has

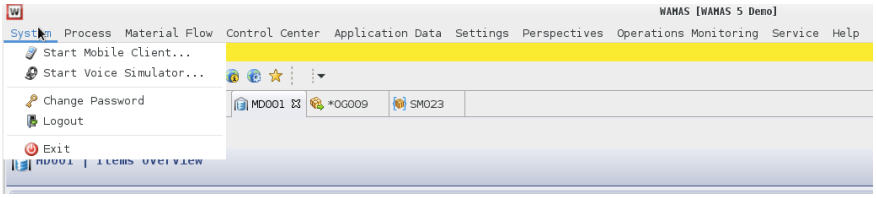


Figure 4.17: *Logout Option Under Menu Toolbar*

to be in place. This is related and applicable both natural and computer programming language made used of.

- Dialog naming convention used through WAMAS allows distinguishing between system modules the dialogs belong to. As described in the previous chapter of the work, the literals contained in dialog title in the very beginning stand for a certain module, such as IG for incoming goods and OG for outgoing goods. Implementation of icons which are in place to denote one or another module is also consistent – as shown in the figure 4.16 there is a variety of symbols used for incoming goods, master data, stock management dialogs, etc.

Figure 4.16: *Dialog Titles*

  When considering the second component, a digital part, of dialog titles, there are unfortunately no requirements or constraints elaborated. That means there is no scheme which can be used to decide how some certain dialog has to be named. If a dialog title is known, there is no way to find out which type of dialog it can be. Therefore, there is still a concept to work out – to formulate some general rules and constraints completely that not only a literal but also digital dialog title component would be defined in a rule-based manner.

- Basing on past experience with interactive systems and software products, users would expect to find log in / sign in option at the top right of the screen. WAMAS desktop solution, in contrast, proposed this functionality on the left as shown in the figure 4.17.

Conclusion 4: Some slight adaptations of existing WAMAS platform-related solutions are desired.

4.5 Error Prevention

For any kind of interactive system, it is said to be a tend to elaborate GUI designs and solutions as good as possible. Understandable, adequate error messages and notifications that something went wrong when operating with the system are important and not to be disregarded. But it is much more efficient and user-friendly way to prevent a problem from occurring. For instance, it is definitely better not to allow a user proceeding without some mandatory inputs than to inform a user afterward what the failure cause is related to.

- In WAMAS there is a strong validation mechanism in place. On the figure 4.18 below one of the typical pop-up dialogs in represented which is implemented for error prevention purposes. It informs about confirming inconsistent data or some operations which may result in process interruptions. As a consequence, it is most likely that the user would like to make double check and some adjustments to input data rather than to directly go forward. Taking this fact into account the most probable user action choosing between two dialog suggestions available – *"Yes"* or *"No"* to proceed – the second one is taken in focus. This prevents a user from posting the doubtable data pressing *Enter* button by accident.

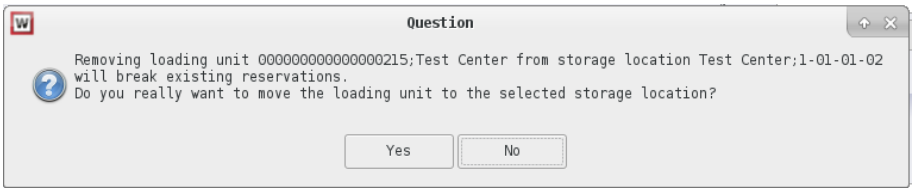


Figure 4.18: *Modal Dialog For Action Confirmation*

- As a secondary error preventing activity in the process described above there is one more confirmation pop-up to consider (figure 4.19). Should an option to discard data modifications be chosen, there is a chance that the user did not tend to loose the data or did the choice in a mistaken way. That is why there is still an opportunity to get back to the earlier process step and reconsider all previous decisions.

Figure 4.19: *Modal Dialog For Action Confirmation – 2*

- However, multiple data consistency checks and additional calls through the system may have a significant effect on a performance level. When considering an interactive system of such complexity and dimensions as WAMAS has, sometimes there is reasonable to skip some intermediate control points in the process and inform a user on later steps about possible inconsistencies. This is possibly not the most efficient solution from the user point of view because it could result in the necessity to repeat already passed process steps, re-input more than incorrect data, and in such way confuse a user. Therefore, it can be decided for this implementation if such use case scenarios do happen rarely in a large-scale system. Otherwise, system architecture will significantly contradict to effectiveness as one of core usability components.
  As mentioned above, WAMAS is developed to be a very complex system, so that thousands of different intralogistics processes can be properly configured and maintained. There is always a challenging task to keep a balance between system processing efficiency and degree of user supporting activities nearby.

Conclusion 5: Further investigations to find out if there are some more optimal solutions to provide a higher level of error prevention would be desired. Changes in system architecture and reworking software implementation may benefit in performance level – hence, there would be possible to integrate additional intermediate checks and support users more.

4.6 Recognition Rather Than Recall

Not to force users to remember all system-related data, but to provide them with the required information for every process step is very important, especially in the case of the large-scale interactive system. This will not only result in higher efficiency, reduce time users require to finalize task with the help of the system, but also prevent some possible errors and failures which are caused by inaccurate user inputs.

- It is better to provide a user with an opportunity to select from a listing of valid values than to let a user make an input typing a value or copying and pasting it. This cannot completely exclude the probability of inappropriate input by mistake instead of an expected but will guarantee a proper input format and type.

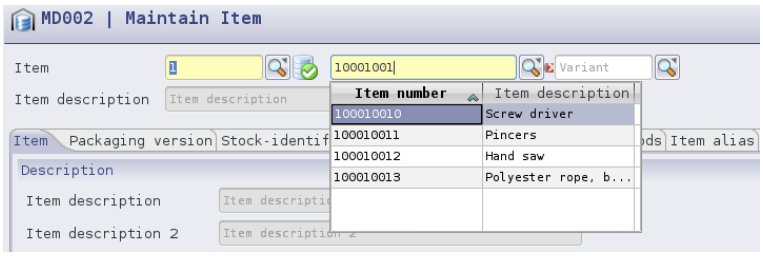


Figure 4.20: *Item Drop-Down Listing*

The same intention has a mechanism that allows pre-filling artifact-related and depending data. For instance, if a picking order was created for some OBD is defined to be executed by list, there is a correspondent WAMAS desktop dialog *OG100 - Enter Picking List Data* (figure 4.21).

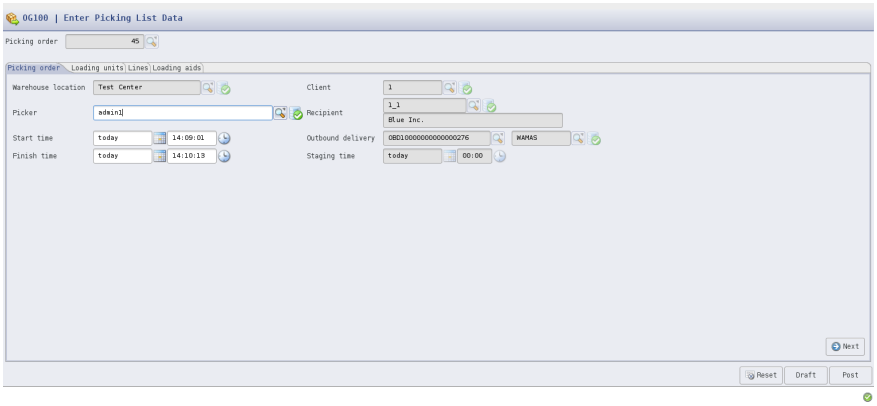


Figure 4.21: *OG100 – Enter Picking List Data*

Should a user enter a picking order identifier to the first dialog input field on the top, other dialog fields get also filled with order-related data such as items and quantities to be picked, storage location where the stock has to be picked, loading units and loading aids involved, etc. Having such a mechanism in place it is not only ensured that a user

does not accidentally enter wrong picking order data, but it is also less time spent to place a picking order.

- Another good example of the fulfillment of this heuristic is the existing solution for menu toolbar represented on the figure 4.22 and described in more details in the previous section. Dialog listings grouped according to module a particular dialog belongs to allows user choosing a required dialog without exact knowledge of dialog title. Hence, it is not important to keep a lot of information in mind.

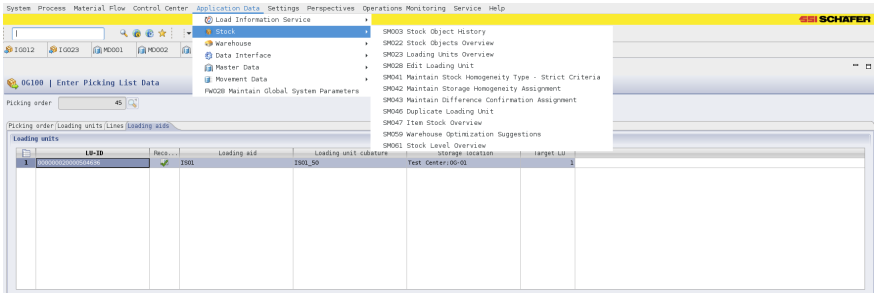


Figure 4.22: *Dialog Suggestions*

Another advantage is a minimization of an error probability because of mistyping or mixing up dialog titles.

- At the same time, there are some architectural solutions which could be reviewed for WAMAS desktop client. Unfortunately, there are some cases when a user is not provided with already existing attribute values when creating new artifacts in the system. As represented in the figure 4.23 below, it is not possible to get suggestions for system partner in the drop-down listing when creating a new advised loading unit (LU).

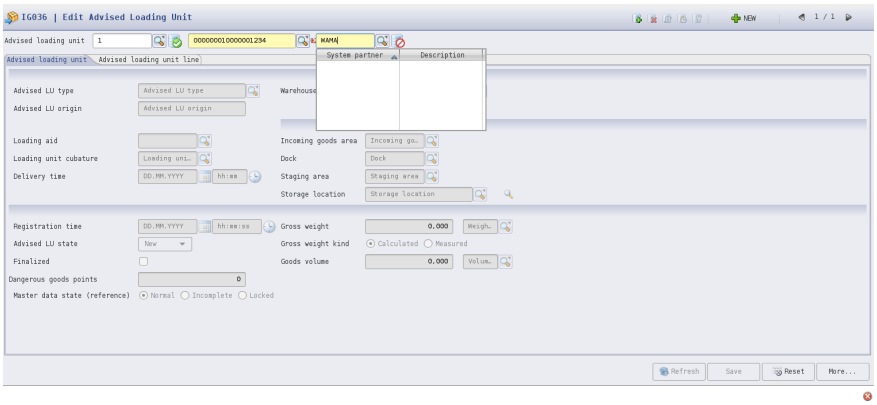


Figure 4.23: *IG036 – Edit Advised Loading Unit – 1*

As soon as the advised LU is saved in the system, there is also a connection between created loading unit identifier (LU-ID) and the system partner. Consequently, WAMAS provides input suggestions to a user when reviewing already existing data in *IG036*:

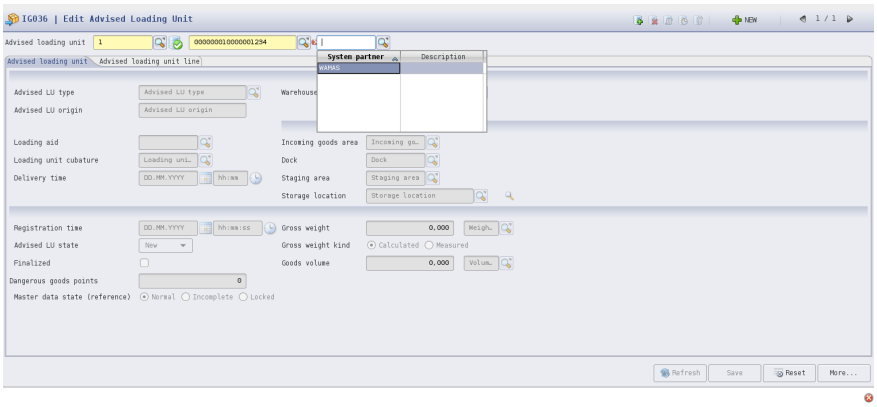


Figure 4.24: *IG036 – Edit Advised Loading Unit– 2*

Conclusion 6: In order not to challenge users to keep in mind big amounts of system-related data some changes in software architecture solutions would be required. This will also reduce the number of use cases when system users have to take decisions about data to input – therefore, reduce risks for invalid or inappropriate user inputs.

4.7 Flexibility and Efficiency of Use

Within the scope of the current work and in the context of the considered system the seventh recognized usability heuristic has not that much impact as the other nine. As far as WAMAS software can be used in one specific area only and operated by the users with certain experiences and intralogistics knowledge, it is not an aim to make the system so understandable and usable for an inexperienced audience without sufficient background as for advanced users. However, there is an intention to apply general usability principles and practices to WAMAS desktop client dialogs. Some features and functional solutions to improve performing efficiency and give rise to better user experiences are described below.

- Almost all overview dialogs, for which records editing is applicable, there is a multiple edit option available (figure 4.26). The number of attributes which can be edit via such option at once is limited as represented on the figure 4.26 if comparing to a single edit dialog.

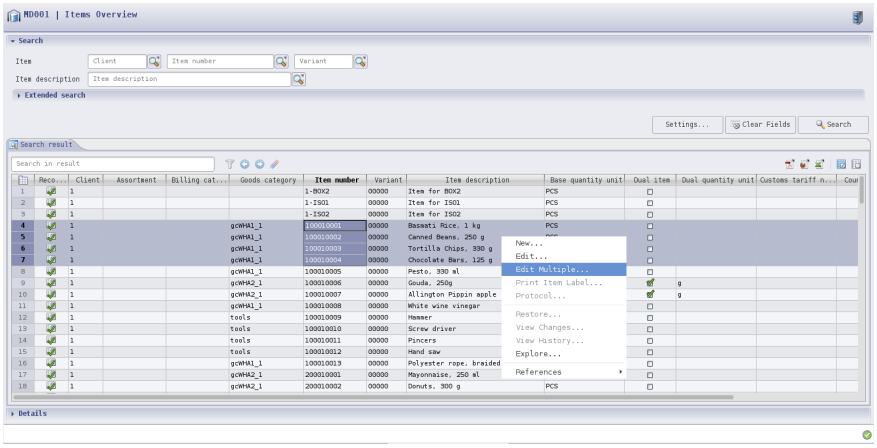


Figure 4.25: *MD002 – Edit Multiple Items*

Such implementation is explained due to some data dependencies constraints – for instance, some of the data artifact characteristics has to remain unique per record and may be changed only separately. Those attributes that are allowed for changes via multi-edit dialogs can be replaced after correspondent check-boxes were enabled (see figure 4.25 below). This mechanism prevents from undesirable multiple record updates by mistake.

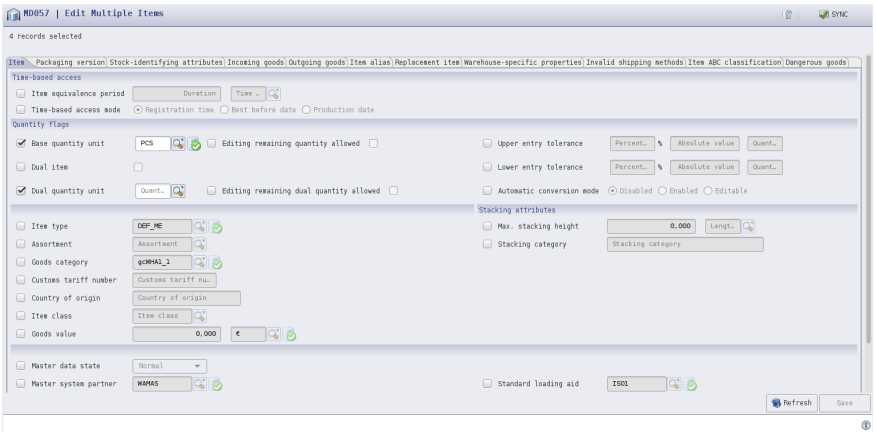


Figure 4.26: *MD057 – Items Overview with Multi-Edit Option*

The only issue with functionality of multiple editing is related to the performance level. Obviously replacing several records in a database and visualize new values in GUI requires more resources and takes more time than the same operations performed with a single record. The decision if and how to make use of multi-edit dialogs remains by a user.

- There is some other very specific functionality which supports users when performing repeated operations with WAMAS – customizable tab sequence mechanism. This allows to configure fields and the order they get navigated within desktop dialogs a user is supposed to fill in. Such sequences can be created with the help of a dialog *UM019 – Maintain Tab Sequence* (figure 4.27) where a user is able to define dialogs and dialog fields the sequences have to be applied to.

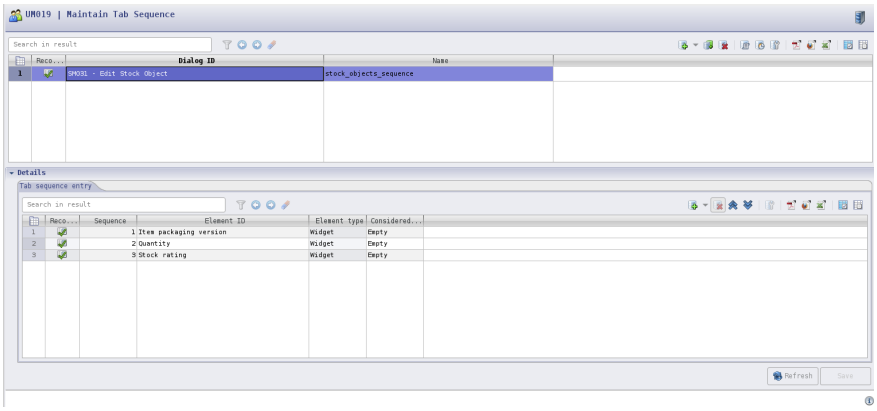


Figure 4.27: *UM019 – Maintain Tab Sequence*

In addition, a dialog *UM020 – Maintain Tab Sequence Assignments* (figure 4.28) is provided which allows configuring the values to be filled within the sequences for certain desktop dialogs.

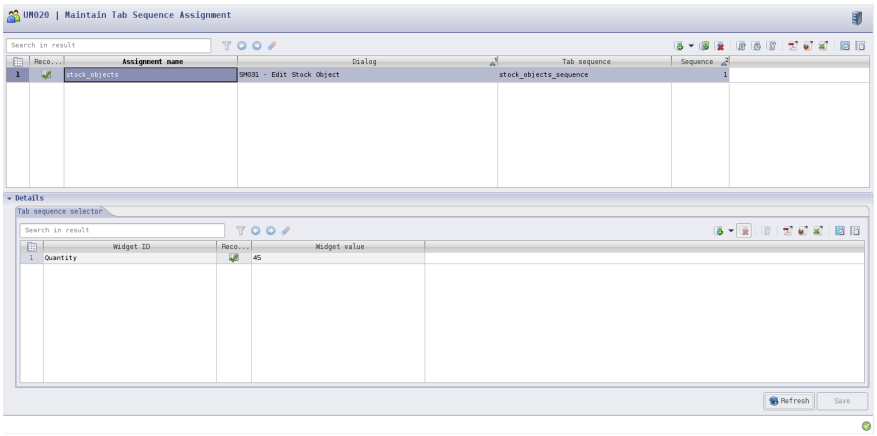


Figure 4.28: *UM019 – Maintain Tab Sequence*

Both of these WAMAS desktop dialogs and functionality they provide may be a powerful tool to support users executing routine processes. However, it is not only necessary to be aware that such dialogs exist, but also to have knowledge which configurations can be useful and applicable – to decide about dialog fields, possible input values, etc.

- As an interactive system containing a large amount of data used within multiple complex processes, WAMAS desktop dialogs support advanced

filtering and searching. The more complicated overview dialogs include *Extended search* section – various text, drop-down listing, radio button input fields can be either hidden by default when opening a dialog or shown according to user decision (figure 4.29):

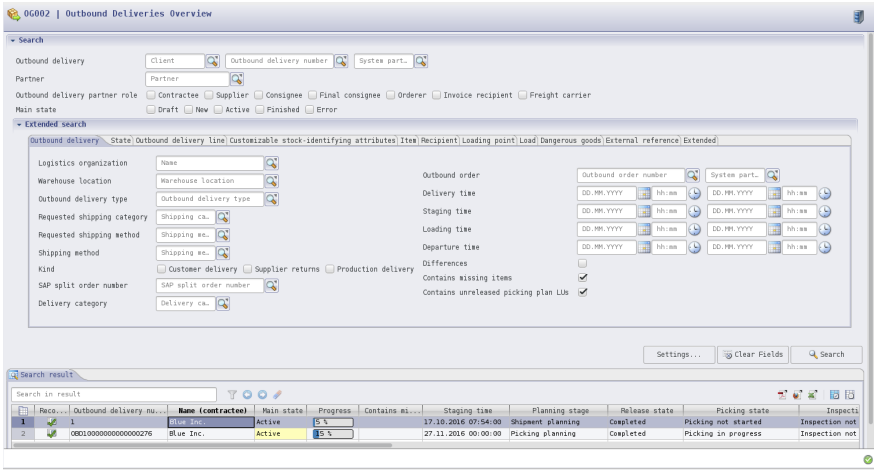


Figure 4.29: *OG002 – Extended Search Section*

When using extended filter functionality there is an issue to be taken into account – even if a user hides a section after some filters were enabled, applied filtering constraints remain. However, there is a simple and useful "Clear Fields" button which deactivates all of the filters at once if any were in place.

- Another remarkable mechanism which serves for additional efficiency when operating with WAMAS is *shortcut* implementation. There is a variety of keyboard combinations triggering which it becomes easier to fill input fields, proceed with a process, etc. For example, pressing control button and right arrow button simultaneously when an input field of the type "Date and Time" is in focus results in entering the current date and time of user interface. Most of the shortcut combinations involve control button and can be useful for system users which have some experiences with WAMAS desktop dialogs. The simplest shortcuts as navigate to the next or to the previous dialog field can be easily learned and applied by novice users – on the other hand, some of the specific keyboard combinations are not easy to find and require some time to get used to.

Conclusion 7: WAMAS provides various mechanisms which make experienced users operate the system more efficient. Once learned, those become useful and easy to apply. At the same time, such a functionality can be unclear and confusing for those users who do not have enough knowledge about specific system functionality.

4.8 Aesthetic and Minimalist Design

Gravitating towards simplicity and minimalism is not a trivial goal in a context of the large-scale system executing complex processes. There is a big amount of data sets in place which are used to describe various logistics artifacts, user-related entities, the system controlling and monitoring functionalities. On the other hand, there is a variety of features, settings, configurations which have to be available, so that a user has full rights and feel free manipulating WAMAS. Eliminating some part of functionality or restricting accessible data may not only confuse or mislead system operators but even result in mistakable system configurations and distorted processes.

Icons, supporting graphics, buttons, and input fields used for WAMAS desktop dialogs are designed in a standard comprehensive manner. As circumstantially described within the second heuristic of the current chapter, these GUI elements are thought to be self-explanatory – what they mostly are.

- Especially overloaded appear the maintenance dialogs, such as item maintenance dialog *MD002 – Maintain Item* on the figure 4.30. There is no better solution than to divide specific item attributes and configurations into separated tabs within the dialog to make data more readable.

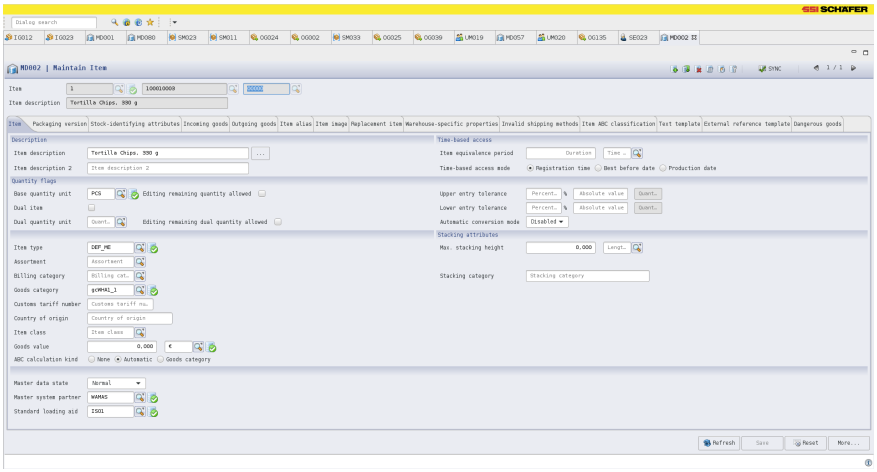


Figure 4.30: *MD002 - Maintain Item Dialog Complexity*

This implementation has such disadvantages as validation mechanism that is provided throughout the entire dialog. In the case of validation conflicts, users have no other option than to navigate between tabs searching for field with contradictory, invalid, or missing input.

- For the overview dialogs, there is it is possible to customize content re-arranging the data that is displayed. In common case, dialog records are represented in a table form, where each of the strings stands for a particular record and the columns indicate different artifact attributes. Depending on the process or operation to be carried out, there are some attributes which have no practical impact and, therefore, can be hidden. in order to make it possible to restrict the displayed set, users are able to set desirable column preferences (as represented on the figure 4.31).

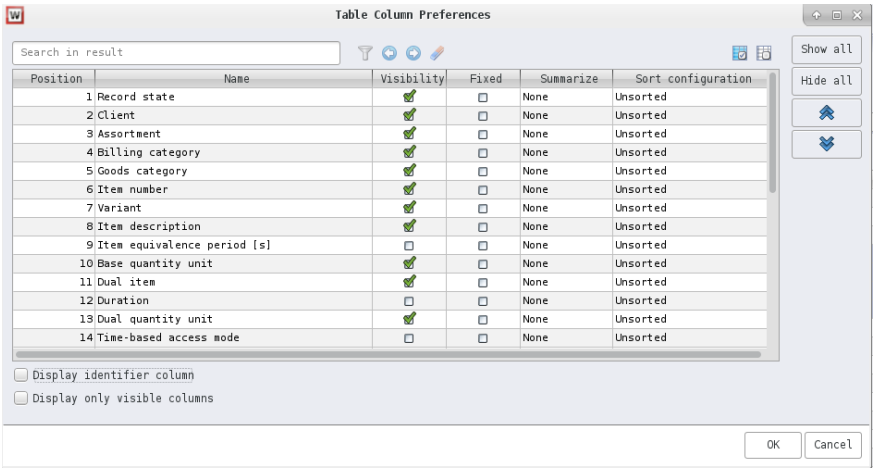


Figure 4.31: *Table Column Preferences*

Those can be applied not only to define whether a particular column attribute has to be hidden but also to specify the order in which the required columns are displayed – fixed sequence or sorted according to the pre-defined criterion. Consequently, it is also possible to save such user configurations as default for certain dialog or global all WAMAS desktop dialogs. Each time a user opens a dialog, there are standard column settings in place, but those can be easily replaced with previously saved user-indicated configurations.

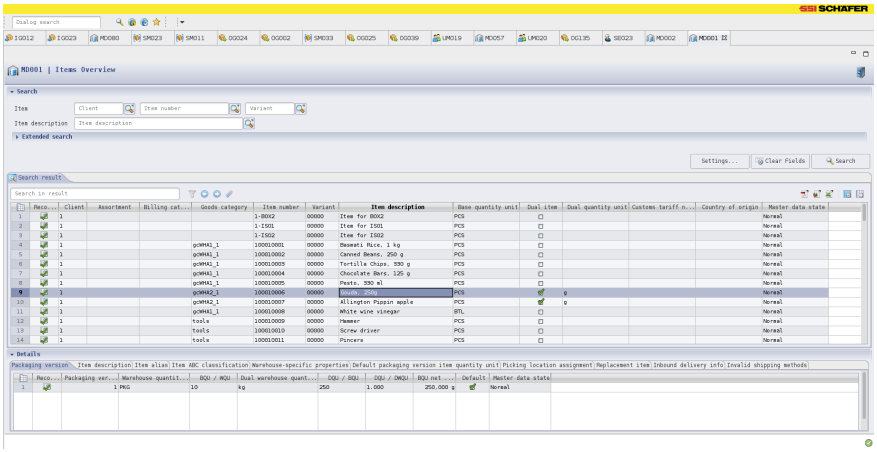


Figure 4.32: *MD001 – Items Overview I*

Additionally, it is possible to enable or hide toolbar and status bar

for all desktop overview dialogs. To compare there are two different views of the same WAMAS desktop dialog *MD001 – Items Overview* wth standard settings before application of specific table column preferences (figure 4.32) and after column display settings were adjusted (figure 4.33).

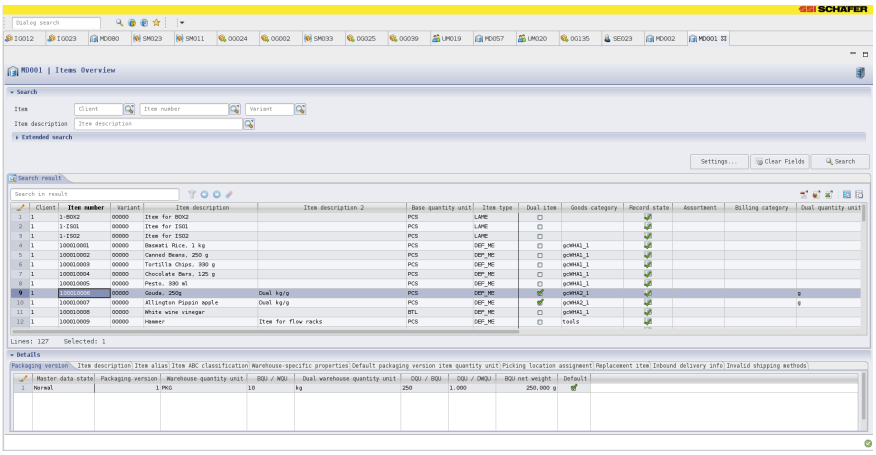


Figure 4.33: *MD001 – Items Overview II*

Conclusion 8: Generally, whether to provide minimalist design is up to users according to their particular needs and depending on the processes or operations to be executed. On one hand, such implementation solutions leave some freedom and flexibility; on the other hand, it can become a challenge for unexperienced users without knowledge that the system supports such kind of customization. After all, the level of possible design adaptations is low.

4.9 Help Users With Errors

There is no perfect software product – same, there is interactive system always operating faultless and strictly according to users' expectations. If it is not realistic to provide all use scenarios to be smooth and successful, it is required to support users when resolving uncertain system states and trustworthy conditions. Recognize, analyze, and recover from errors occurred are three fundamental principles to hold when facilitating users dealing with instabilities. Independent from the nature of the problem – user misconfigurations, incorrect usage of the system, software-related issues – each of them has to be determined by the system and possible solutions to resolve a case

have to be suggested. Error messages have to be understandable for all users and laconic, but meaningful.

- WAMAS validation mechanisms are covering all possible data and process configurations available through the system. Keeping in mind system sizes, it is a big number of various algorithms; some of them are universally elaborated within the system, others are defined for each desktop dialog separately. The challenge to confront is to formulate each single notification in such way that it provides useful suggestions how to resolve appeared conflicts. That is why it is not possible to apply some common solution for message generation, instead, for each particular use case there has to be a correspondent validator algorithm in place.

  Currently, WAMAS can guarantee that no incorrect or corrupting configurations could be established by users. This is very important and positive aspect about the interactive system. At the same time, there are some notifications appeared to avoid misconfigurations, but unfortunately not helpful enough to resolve the problem. As shown in the figure 4.34, there is indeed a validator triggered because of missing item packaging version, but it is not specified exactly where and how to correct data configurations. There are a lot of item-related data divided into separate tabs with an intention to make it easier to work with data, but without any precise definition of appeared data conflict, such data architecture is still confusing in some cases.

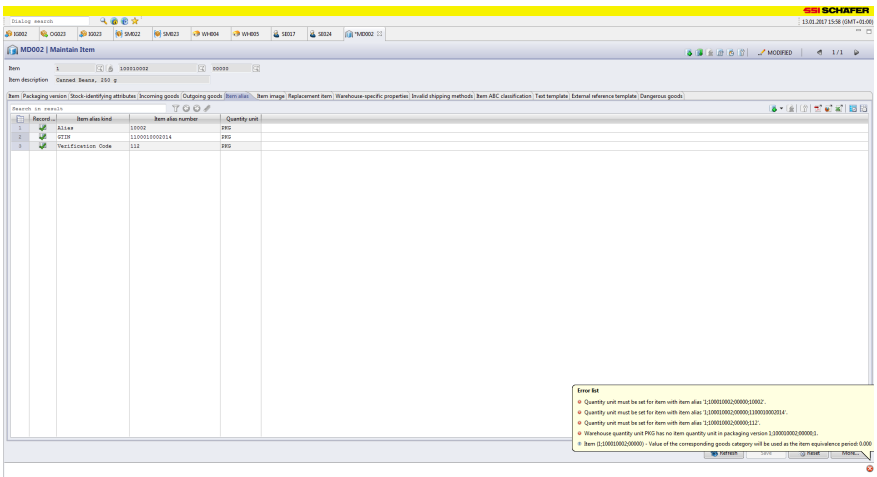


Figure 4.34: *MD002 – Item Validation Within Maintenance Dialog*

- There is also another way to inform users about process execution, to record process history and to provide some explanations about system activities. WAMAS creates corresponding activity protocol while processes are carried out. Selecting an option "Protocol..." from the context menu in overview dialogs, *FW027 - Activity Protocol* support dialog gets open (represented on the figure 4.35). It contains messages of all activities occurred in the past related to particular process or artifact, correspondent user decisions, and business logic. Significant informative attributes to describe an activity are message itself (accompanied with message type), time of occurrence, and a user identifier which stand both for either a user operating WAMAS or some background process that triggered the activity.

  As for standard overview dialogs, it is possible to search through the activity protocol messages. There is no special functionality behind the dialog besides, but it is helpful as provides information what internal activities took place and whether some processes were interrupted. There are, however, no exact

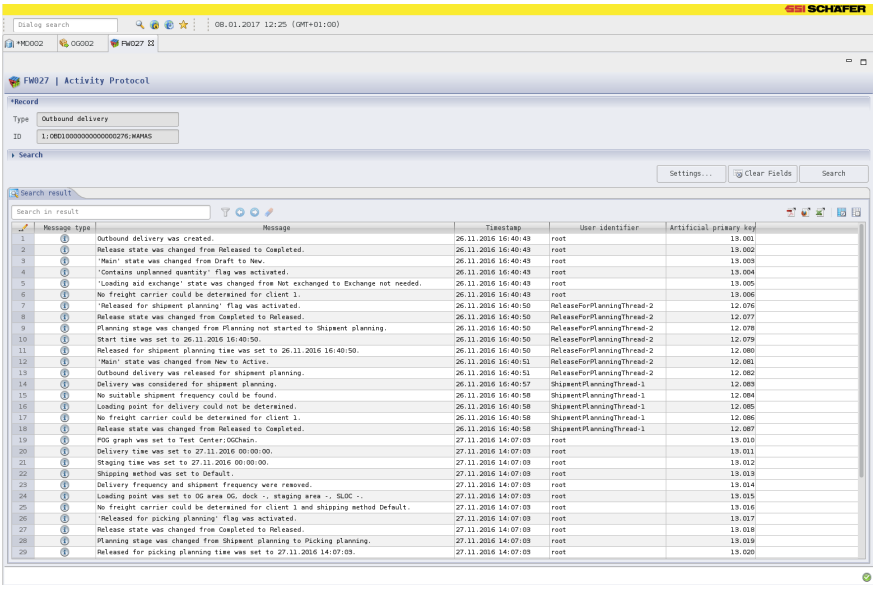


Figure 4.35: *FW027 – Activity Protocol*

- Another user supporting mechanism integrated into WAMAS is system message management. Those messages are either used for tracking non-standard system events such as errors and warning, but not for

routine process execution. There are several dialogs contained in Control Center (CC) system module to configure and work with system messages which can be reviewed in the dialog *CC001 – System Messages Overview* (figure 4.36). In contrast to activity protocol, it is possible not only to get information about errors or warnings occurred but also a possible solution to resolve the situation. System messages are linked to those WAMAS desktop dialogs that suggest solutions, so it is convenient for users to get quickly navigated to desirable system functionality. To accomplish it, a user can select "Solutions" option from the context menu and subsequently the dialog with the suggested solution.

It is also possible to maintain comments for particular system messages (the option also available from the context menu leading to the dialog *CC008 – Change System Message Comment*) so that the simplest issue tracking management is practicable. There are also different system message types defined according to the system they were generated: WAMAS system messages, sub-system messages, and hardware system messages.

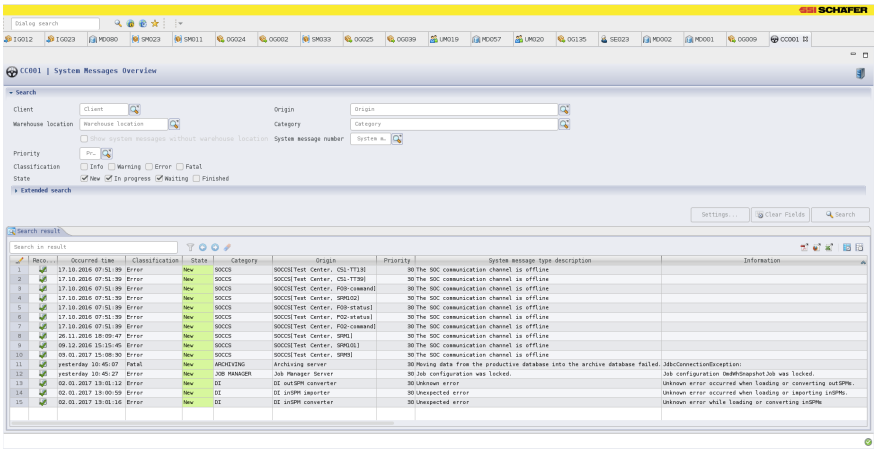


Figure 4.36: *CC001 – System Messages Overview*

Conclusion 9: There is a variety of user supporting mechanisms integrated into WAMAS which can be helpful to analyze and recover errors while operating interactive system. Most of them are quite simple and have potential to be extended and become powerful instruments in the context of error management. If the complexity of algorithms and workflows increase, the system becomes less intuitive, as a disadvantage, there is also need to instruct users.

4.10 Help and Documentations

It is a recognized common statement that user documentation and help functionality are required only in that case if GUI design solutions are not good enough. In other words, if system users often tend to request help, there are some obvious problems with interfaces or workflows. However, this is not always true. As for any complex and large-scale interactive system, there is specific WAMAS system documentation provided. This is definitely a requirement to have such – as well as to get it updated and extended it together with the growth of system functionality. Depending on user needs, intentions, the way the system is supposed to be operated there is a variety of documents of different structure and content available.

For instance, the administrator manual contains necessary information describing possible WAMAS system set up according to warehousing needs. This document is useful for those that are responsible for administrative tasks such as warehouse modeling, configuring logistical processes, etc. Although some parts of the system as overview dialogs are not described in the document because it is seen to be self-explanatory, it is still a lot of information and a large document. Further examples are WAMAS user manual which provides an overview of the user interfaces, WAMAS process manual with descriptions of logistical processes and features supported by the interactive system, WAMAS receipts manual which describes all standard receipts, their basic properties, and possible configurations.

One significant issue with WAMAS-related specifications is that their content is only available in the form of text documents. This means, there is no support of online help accessible from the system directly. Moreover, as the scope of system functionality gets expanded the documentation is updated as well. Consequently, the users require up-to-date information to request renewed document versions.

Conclusion 10: In general, it is not possible to send a help request when operating with the system. There is no functionality provided to support user responding questions or resolving conflicts or obscurities if required.

Chapter 5

User Survey

Doesn't matter whether you test websites, intranets, PC applications, or mobile apps. With 5 users, you almost always get close to user testing's maximum benefit-cost ratio.

– *Jacob Nielsen*

As it was decided for investigations carried out in the previous chapter of the current work, the main principles and theories of Nielsen Norman Group were taken as outlines for the usability evaluation. On the basis of ten fundamental heuristics formulated by recognized usability experts, analysis of the interactive system was conducted and the main usability issues were discussed and summed up. In order to prove those achieved results, it came to the decision to carry out another one – user-based – usability study. There are different techniques and ways to collaborate with system users; dependent of chosen methodology results of varied quantity and quality can be received. That is why it is almost impossible to make a proper decision respectively without sufficient knowledge of the product to be evaluated, the audience to work with, resources available for researching activities. Even having enough knowledge about dedicated team and facilities there are still some open questions and point to be discussed. In the past years, Jacob Nielsen communicated multiple usability test sessions with a various number of test participants and published several scientific papers on the topic announcing impressing findings. According to results of such investigations, the optimal number of participants to run a successful user test is equal to 5. Instead of investing big budget and much time into complex usability tests engaging a lot of users, an effective solution is to provide as many small tests with fixed number of participants as possible.

According to former research conducted by Nielsen and Landauer in early 1990s [28], there is a defined dependency between the number of usability problems existed and the number of users which take part in testing. The following tendency is true, on the word of usability experts, that *involving more and more participants, an amount of learned information does not increase significantly* after the third user attendance. The explanation of this theory is simple – the same issues will be seen by different people. The statement was exploratory proved for diverse interactive systems (PC applications, mobile applications, etc.) examined by test participants belonging to various target audience categories. As usually expected, while analyzing research outcomes there were found some typical exceptions where a bigger number of test participants is required to get effective results, but those are specific cases and not related to the given work.

To provide more a accurate definition of found dependency, it was formulated as a mathematical exponential expression of the following form:

$$p = N(1 - (1 - L)^n) \tag{5.1}$$

where n is a number of users participated in usability testing,
p is a number of found usability problems in the system design with n users,
N is a total number of usability problems existing in the design,
L is a proportion of usability problems recognized by a single user[3].

There is a known fact based on multiple research activities of NN/g (Nielsen Norman Group) that those of frequent occurrence values of L tend to 31%. Putting in use this mean value and providing simple calculations, the following can be easily concluded:

- carrying out users testing with *a single participant* involved allows finding out about *a third of all issues* with usability design solutions;
- after *the second user* impact is added, it is a little bit over *a half of all issues* recovered;
- if testing with *five users* the number of potentially found usability issues tends to *90% of existing* – starting from this point it becomes unnecessarily complex to involve further participants, moreover, it will rather lead to time wasting when filtering the same user results as test outcomes without bringing any new, not yet considered before perceptions.

[3]https://www.nngroup.com/articles/why-you-only-need-to-test-with-5-users/, last call 22.01.2017

5.1 Focus Group for User Tests

Basing on derivations discussed below, a specific focus group of 5 users – employees of the same logistics company – was chosen to participate in planned user test. The invited participants are experienced in intralogistics and warehousing and have been working in the area of discussion for years. Further selection criteria were basic knowledge in usability aspects and previous experiences in user evaluation. People with such practical knowledge can often better focus on essential system features and recognize more usability issues. One more important individuality which is inherent to all focus group members is a certain duration of working with WAMAS. Till the moment of time when user testing activities took place, the company has already integrated WAMAS software to execute all main business processes and just finished acceptance tests on the customer side. That means, logistics experts who are supposed to work with the interactive system to achieve business goals of the company are already got acquainted with WAMAS GUI enough but do still a clear perception of critical issues and possible intransparencies in the usability of the system.

5.2 Testing Method

Taking into account previous investigations and influence factors, it was decided to carry out user testing procedures in a specific way. For this purpose, a certain survey was elaborated so that participants do not spend much time and efforts to provide a feedback. The individual questionnaire, from one side, makes testing activities easy and understandable for participants. Users can decide for each of questions whether it is sufficient to choose one of proposed rating values only or to provide an open answer additionally. From the other side, it allows to ask not only about commonly known usability aspects (as it would be possible with standard usability questionnaires) but also about system specific features. Moreover, the solution to elaborate a new survey supports estimation procedures which are applied to the participants' responses.

It was decided to make the questionnaire available as a Web application. This makes it simple to fulfill the questionnaire and to send responses back. Obviously, in order to protect user responses, there is secure socket layer (SSL) encryption applied.

The main characteristics and the way in which user testing activities were constructed are described in details below.

1. Survey derived for system end-users

   As was already discussed above, the considered interactive system is of great complexity. That is why it is not efficient to let system usability be estimated by people who are not familiar with intralogistics and who do not have enough knowledge and experiences with WAMAS desktop client. That is why system users from customer side were chosen who do not only have sufficiently acquainted with intralogistics but also are using WAMAS software in-house.

2. Specially designed questionnaire with 19 elements

   - System-related terminology
   - Three different types of questions according: *factual-, attitude-, opinion-type* used depending on knowledge expected to be received in each particular case
   - *Closed, open-end, opinion questions* – all of the possible answer options are available for participants within the questionnaire
   - Among others, questions with *mandatory input* (figure 5.1) to ensure that each response is useful and brings some data to be analyzed

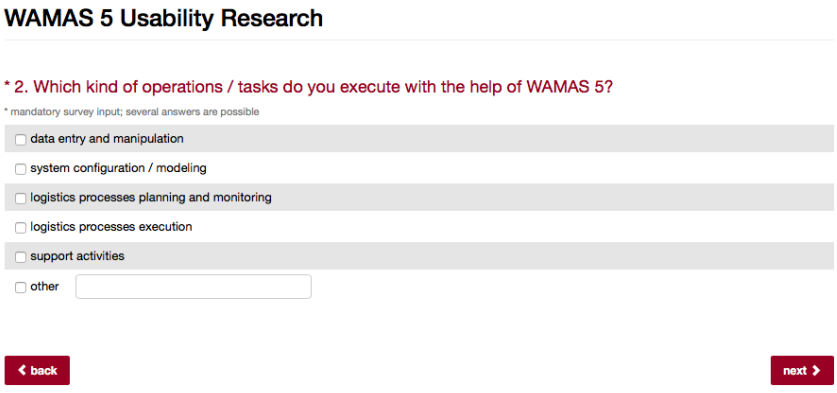


Figure 5.1: *Sample mandatory question*

3. Specific structure of questions (both represented on the figure 5.2)

   - *Ratings* with pre-defined values are proposed to evaluate proposed statements according to the degree of fulfillment and importance.

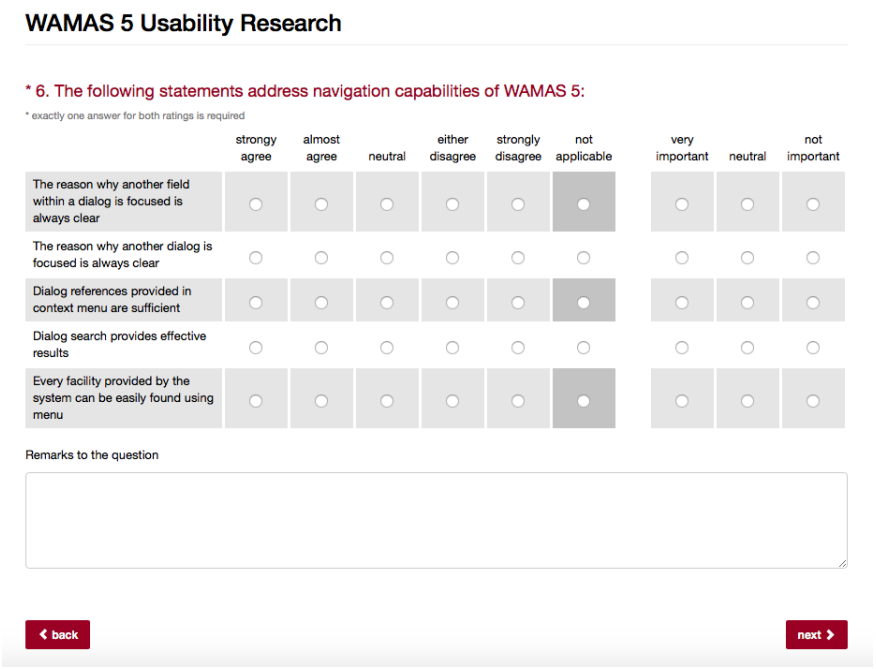


Figure 5.2: *Sample question with two ratings and text input field*

- As an extension to rating scales and in order to support open format answers and comments there are additional *text input fields* provided for each question block of statements; also applicable in the form of feedback forms to improve and estimate the quality of proposed questions.

4. Thematically grouped questionnaire structure

   All the nineteen questions are categorized into particular sections of the questionnaire. Every category is accompanied with a brief description and clarifications what the related questions are about and which impact is expected.

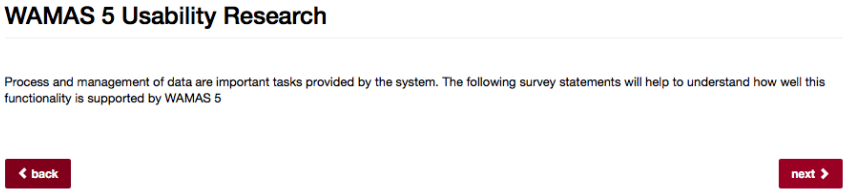


Figure 5.3: *Intermediate section introductions*

5. User-friendly design and simple navigation within the questionnaire

   - *"Back"* and *"Next"* options are provided to make users feel comfortable and confident when working with the questionnaire. Additionally, there is a progress bar in place which indicates the degree of survey completeness. This is not only useful in case of restricted time available but also to avoid any possible concerns while filling the questionnaire Both of the features are represented in the figure 5.1.

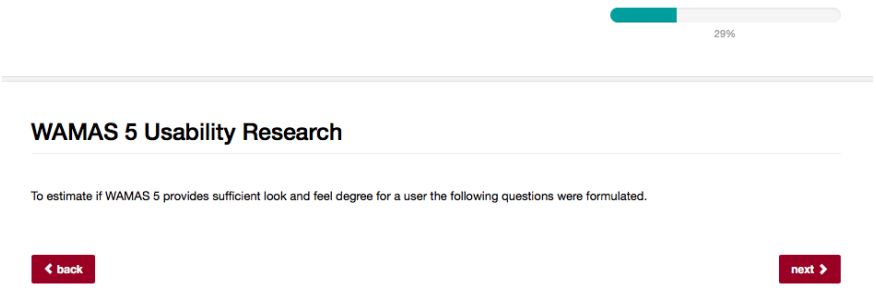


Figure 5.4: *User supporting elements*

   - Proper input validation and simple understandable notifications in case some of the mandatory inputs were overseen are in place as well.

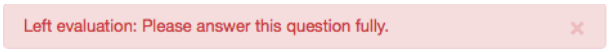


Figure 5.5: *Notification message in case of incomplete answer*

   - Specific highlighting and color-coding are used in order to make it more comfortable to fulfill the questionnaire. For instance, radio buttons of possible answer options of different types are displayed with different background color. The color also changes if an input field is taken in focus hovering a mouse over.
   - Another feature that makes it convenient to works with the questionnaire is its scalability. Depending on the sizes of the browser window, content displayed on the page gets adjusted, so that the questions can neither get cut off nor be incompletely displayed.

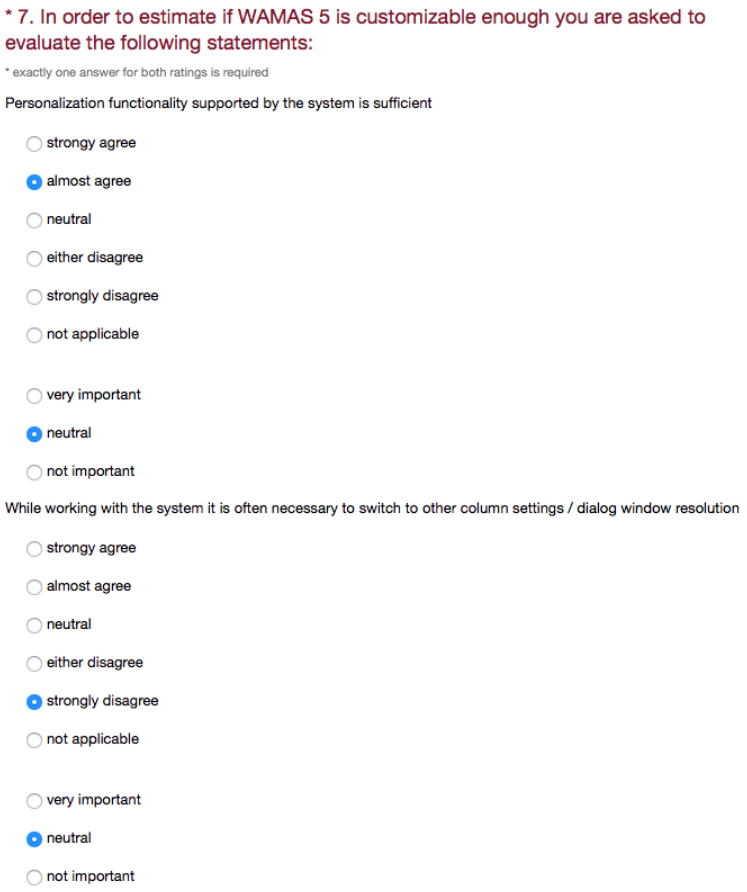


Figure 5.6: *Question – re-sized view*

Chapter 6

Analysis

As was described in the previous chapter of the present work, there is a questionnaire elaborated in order to accomplish user tests in a form of a survey. Five system end-users were involved and have provided their feedback responding to statements about different characteristics of the evaluated interactive system. The proposed questionnaire consists of 19 units which are devoted to user background, data and process management, user experiences with the system, and general look-and-feel WAMAS characteristics. Most of the questions are constructed as statements to be evaluated using prepared rating entries and are mandatory inputs. These decisions about format and structure make the survey easy to complete and intuitive in use, but also guarantee sufficient data inputs and responses which are readable and interpretable at the same time.

Average participation time is 21 minutes; the longest duration of the user session is equal to 33 minutes and the shortest user session took 17 minutes to accomplish the survey. All of the participants provided responses on a desktop.

The following two ratings (figure 6.1) were provided for each group of statements proposed for evaluation – according to the degree of fulfillment and importance of particular WAMAS GUI capability.

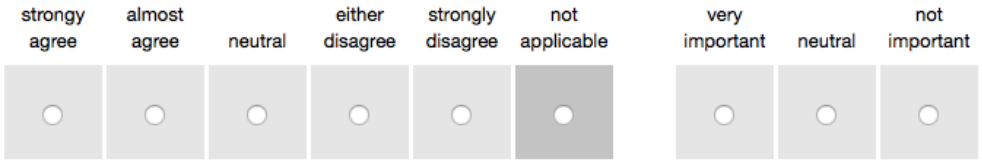


Figure 6.1: *Two ratings proposed for evaluation*

The first rating is technically a typical Likert scale with an odd number of selectors so that a participant always has an option to provide a neutral assessment. The second one is a three-scaled-rating of the same format. Combining these two types of data it is possible to analyze and find out which parts of the system and functional solutions have to be improved in order to make them closer to users' expectations and needs. Another benefit of this structure is an opportunity to get knowledge if a questionnaire itself was properly elaborated if the content is sensible and the statements and are efficiently for usability evaluation. More statements are responded with *"not applicable"* considering the first rating, less information can be extracted from the feedback. In this case, it would be critical to re-think and adjust content, the way in which the questions are formulated, or both. Similarly, if there a lot of statements responded with *"not important"* considering the second rating, there might be improper functionality covered with the questionnaire, too many statements proposed for evaluation, or not precisely enough formulated questions again.

One more remarkable value regarding the participants' inputs is a percentage of *"neutral"* responses of the both ratings. If for the second rating the degree of importance can be defined by one of three proposed values, there are twice more selections available for the first rating. If a rate of "neutral" responses is high – tends to 50% or is even higher – there is potentially a need to decide about focus group to involve to fulfill the questionnaire. There can be either a majority of participants with insufficient experiences in usability evaluation, so the focus group should be extended and strengthened with more motivated, skilled in this area users.

According to results the participants provided to proposed statements, there are 368 unbiased responses in total among the mandatory 3600 inputs. This value – less than 10% of overall results – covers those responses from both proposed ratings and is definitely in acceptance range. In other words, it is possible to conclude that the choice of the focus group is rational to achieve defined goals.

In addition to pre-defined answer selections in case the answer set is strictly limited there are open questions in place. These can be always used if it is reasonable to let users express their point of view in free form. Unfortunately, open questions designed as optional questionnaire inputs are often not attractive for participants. Within current survey, there were only 3 open format entries provided against 55 input possibilities. If there are no unclarities to inquire for, such a low degree of explicit responses is not an issue at

all. Otherwise, there is a possible solution, in this case, is to additionally conduct personal interviews with survey participants.

6.1 Navigation

According to results of the user survey, there is a potential to introduce improvements to this part of system functionality. The issues to be considered and correct are clear and the costs to apply the changes are not high. It is important to reconsider implementation of navigation functionality because the changes will significantly improve user experiences and impressions about the interactive system. Findings to the topic are described below.

- As was described in Chapter 3, there is dialog search functionality in place which supports users when looking for required dialog. Entering dialog title in dialog search string there are technically one of two possible ways to open a dialog – matching either a dialog number of a dialog title. It is a fuzzy logic search mechanism implemented to get the appropriate set of matches. This means, for example, entering *"te"* a user expects to get a resulting set of dialogs which titles contain both *"test"* and *"item"*. Analogically, entering *"23"* into dialog search string such dialogs as *"SM023 – Loading Units Overview"*, *"IG023 – Stock Registration Overview"* and *"OG023 – Picking Location Assignments Overview"* are expected to appear in a listing.

  There were detected some inconsistencies and deviations from expected search results. As an attempt to simulate user behavior who is searching for *MD022 – Maintain Terminal* dialog entering dialog title, the following input was tried out – three beginning letters *"ter"* of the word *"terminal"*. Instead of having the appropriate dialog at the first position in search results listing, however, there is completely different suggestion found as shown in the figure 6.2.

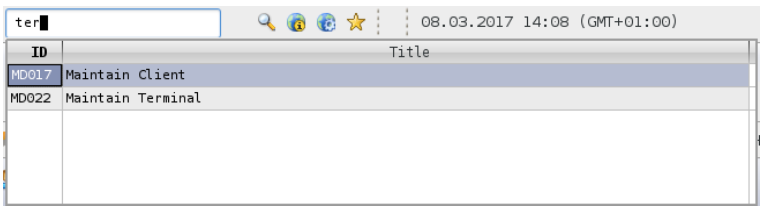


Figure 6.2: *Dialog Search Resulting Set*

There are also other similar examples observing unexpected system outputs when searching with both dialog numbers and dialog titles, which were mentioned by users and are confusing.

Possible solutions: Fuzzy logic search algorithm has to be reconsidered, reworked, and extended in order to give acceptable results as matching suggestions when executing dialog search.

- As an alternative to dialog search, there are multiple menu bar modules contained dialog references available. Those are organized into dialog listings depending on dialog purpose of use. The idea is to provide users with an ability to always find desirable dialogs even without exact knowledge of their title. It is a requirement to be able to find and open any of WAMAS 5 desktop dialogs with the help of menu. Each of dialogs has to be referenced in the menu when it was implemented.

  According to provided investigations and received user reports, there is a number of dialogs which are not referenced in menu modules. This becomes frustrating for users trying to find particular dialogs and leads to inconfidence when operating the system.

  Possible solutions: It is required to check all the dialogs entries which are currently available in the menu bar and references for missing desktop dialogs.

6.2 Customization

Every user who executes any operations using WAMAS desktop client has an own system instance for own purposes. This is important that each of system users can apply certain settings which are the most attractive and easy to use from personal experiences and point of view. As was already mentioned in Chapter 3, there is a possibility to configure particular user preference setting which can be used further for all desktop dialogs. For instance, it is always possible to provide all activities for a specific client and at the specific warehouse location. This can be particularly helpful for system operators responsible for the stock management and planning activities.

At the same time, there is still place for improvements and extensions of further support of customization functionality in WAMAS. According to usability survey results, system users do still recurrently have to spend some

time to personalize GUI before it can be used efficiently. Depending on the processes and tasks a certain user carries out there are different desktop dialogs with are used more often. Specific dialogs may be never opened or even not known for users who are not responsible for non-routine operations. There are system users who do not work with reporting functionality and are not required to configure correspondent assignments – or there is a group of users who will never manage the messages and telegrams sent between WAMAS and partner systems. It is possible to restrict system functionality for particular users via user management configurations and limit the number of accessible dialogs in order to reduce complexity of the interactive system for the users. However, it is also important to provide users with easy access to necessary modules according to operating activities.

Moreover, there are also different dialog configurations that are most suitable according to user preferences and data which should be available and displayed. Column settings, main and details section tabs, various filters can be configured differently to default settings which are in place opening a dialog for the first time. Spending time to prepare system functionality for use, to set personal user setting for all required dialogs daily is quite time-consuming and a bothersome routine. Consequences of these inconveniences are not only inefficient resource allocation but also negative impressions of system users.

Possible solutions: Saving personal settings when running system down and restoring them if a desktop client is running for the next time and the same user is logged in will result in significantly different user experience with the interactive system. The possible technical implementations and efforts need to be considered and afterward, it can be decided for an optimal one.

6.3 Data Input Functionality And Support

Some certain inconveniences and misleading solutions were found by survey participants with regards to implementation of data input functionality.

- There are several issues with editing input fields and checkboxes which require better implementation mechanism and have to be reworked. The first problem is related to three-state input fields – a "neutral", not applicable input can be mistakenly identified as an empty input. Another problem is related to associated input fields which technically have a hierarchical type of dependency. An example of such field bundle is represented on the figure 6.3 – input fields *packaging version* and

variant are related to *item number* and do not make sense without a "parent" input. However, if a user removes an item number field in the dialog, "child" input fields are not automatically reset and remains filled.

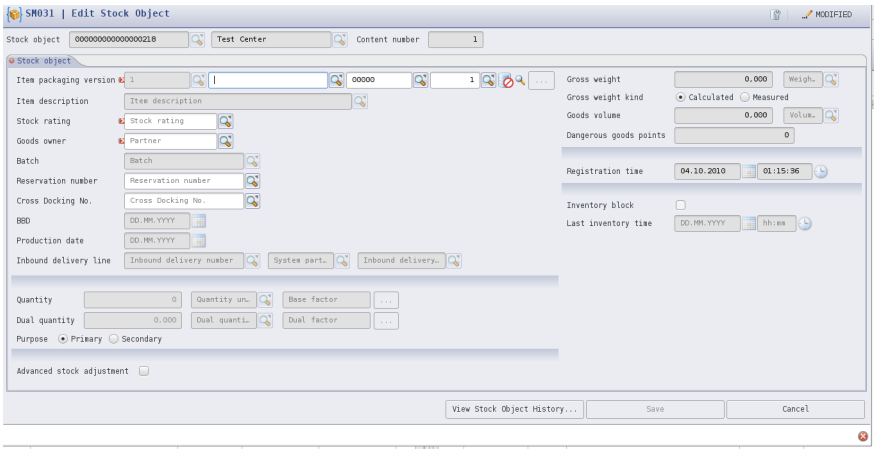


Figure 6.3: *SM031 – Edit Stock Object; Modal View*

From the other side, indirectly dependent input fields *Stock Rating* and *Goods Owner* (certain dependency from the item number is defined via picking location assignment) disappear after item number input was removed. Such behavior is both inefficient and inconsistent from the user point of view.

Possible solutions: In the case of any hierarchical dependencies between dialog input fields additional validation mechanisms have to be introduced. Namely, if a value of a "parent" record was removed, values of all of dependable "children" records have to be deleted as well. Considering the example above, it is not desired to have values of *Packaging Version* and *Variant* in place after *item Number* was removed. Similarly, a value of *Variant* should be removed in case there is no *Packaging Version* any longer.

- Based on the example described in the previous subsection, there can be defined similar cases when hierarchical dependencies between data input fields cause misleading validation through WAMAS 5 desktop dialogs in general. There are some known incidents when input activities are almost blocked or completely interrupted so that it is only possible to revert uncompleted unfinished data configurations and start from

scratch. Such system behavior is present mostly in assignment dialogs where hierarchically dependent attributes are available to be set within a particular configuration.

One of important and often used application data dialogs *WH009 – Maintain Storage Search Assignments* gives an opportunity to create configurations of different complexity. Two mandatory assignment inputs, in this case, are *Warehouse Location* and *FOG Graph* which are marked in red if a new assignment record was created. It is possible to make an assignment more specific and restrict storage search rule for a particular item. Should a user fill the *Item Number* and *Variant* – either entering input values manually or selecting from a drop down suggestion listing – a validation error *Item – No data found* is displayed. The reason of such system behavior is missing item-related data, namely, an input of the *Client* attribute (see figure 6.4). However, there is no hint to inform users about the cause of misconfiguration. The only way to proceed with dialog assignment configurations is to delete an incomplete assignment record.

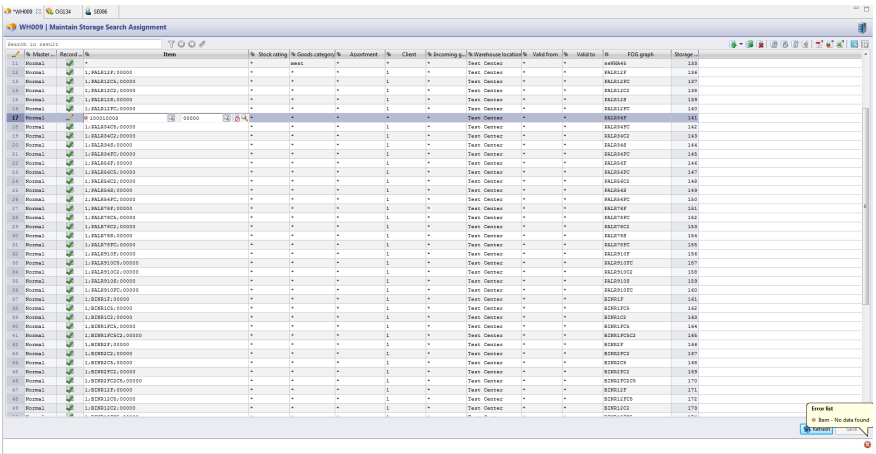


Figure 6.4: *WH009 – Maintain Storage Search Assignments*

The same, not intuitive implementation is found in the most of the assignment dialogs which contain dependable attributes as configuration options. Analogically to *Item Number*, *Variant*, and *Client*, there is a certain hierarchical dependency between other attributes in the software system. It not possible to configure a*Strategic Area* without a *Warehouse* input or *CSIA* if *Client* input is missing.

Possible solutions: There are technically several issues to be reworked in order to make managing of dependable attributes convenient and practical in use. Firstly, it is required to provide users with meaningful validation notifications in case of incomplete configuration. And second, there is a need for support users to recover and to correct assignment configurations. As far as it is only missing input value that results in invalid dialog entry, there should a be a way to proceed and to provide required input without deleting of entry record.

- As it follows from questionnaire results, in some cases it is not easy to distinguish between mandatory and optional input fields. According to current implementation, not all of the data inputs are validated on the fly and a user gets notifications that some of the inputs are missing or incorrect only after an attempt to complete a process. It is not an intention or a missed issue, but a way to reduce workload and simplify background processes when dialog input fields get filled. That causes certain inconsistencies how validation checks are applied among the system desktop dialogs. Once a user is used to validation done on the fly, it may be confusing to get notifications about some missing inputs in hindsight.

  Possible solutions: Additional investigations of technical solutions to improve system performance, in general, are essential. However, there are other possibilities to inform users whether an input for a particular field is mandatory. A simple solution is to indicate mandatory and optional input fields differently in GUI. For example, there is commonly known practice to mark the fields to be obligatory filled with an asterisk (*) or with another recognized symbol.
  It is also important to remember that is is not enough to make use of different colors – such implementation increases the number of usability issues for color-blind users.

6.4 Validation And Error Handling Support

A significant and very important in terms of user support part of system functionality is devoted to validation and error handling mechanisms. Implemented properly, algorithms to validate inputs, to check process configurations and parametrization not only result in reliable data but also facilitate users when operating the interactive system and benefit in higher work efficiency.

- Preventing users from entering invalid inputs on the fly is an obvious way to reduce the time required to configure a process. WAMAS basically supports validation of input formats through the desktop dialogs. There is a mechanism in place to distinguish between *alphanumeric* and *numeric* data formats; there are also different input field formats provided for *date* and *date and time* attribute formats.

  From the other hand, there is no general content check mechanism to inform users directly if provided inputs are not valid in the given context. Trying to register a stock object on some LU-managed storage locations, a user gets a notification that a chosen storage location is not quantity-managed and it is hence not possible to proceed with stock registration only after a confirmation button was pressed. This means the validation can only be triggered by a user action and not provided by the system automatically. A reason for such technical implementation is an attempt to low a level of system performance. Validating all possible data inputs on the fly will result in significant data processing activities in the background and, consequently, in long-time system responses.

  Possible solutions: It has to be decided if to tend to better performance and higher system response level or to fully support users with validation. In the best case measurements of system performance values in both cases with no immediate input validation and with implemented background processes has to take place for affected dialogs. Investigations of possible appropriate technical implementation solutions are also required. Having correspondent knowledge, right decision can be made in which cases one of possible implementation solutions makes more sense.

- Another issue is related to notification messages provided in case of invalid input data. Validation notifications have to be re-designed and become more understandable and meaningful. For example, if there is a dialog of a complex structure including multiple tabs and sections, it is not always obvious which input field contains some inappropriate value. If applicable, a suggestion in which way it is possible to correct a faulty input has to be provided as well.

  Possible solutions: A direct reference to incorrect input entry is necessary. If applicable, a suggestion in which way it is possible to correct a faulty input has to be provided as well.

- According to user experiences with the system, WAMAS 5 doesn't generally forbid to proceed with parametrization, which can result in invalid configurations afterward. Such desirable system behavior cannot be supported fully, however. Logistics processes are non-trivial and almost always require user intervention, so that decision making how to proceed is left to the user. There are a lot of corner cases and specific situations to be handled; the variety of possibilities to achieve expected results and legal usable ways to deviate from the standard workflows. For example, it is possible to proceed with shipment planning of an outbound delivery disregarding dimension violations – conflicts will be resolved later during repacking process.

  Possible solutions: It is more efficient and reasonable to let system users takes decisions than to deepen and extend existing algorithms applied to validate parameterizations. WAMAS 5 is supposed to be used by people with good logistics knowledge who are aware how to manage warehouse processes properly.

- As was also mentioned by system users, there is not enough support in order to revert faulty actions. Considering this system behavior to find probably ways to improve usability it is important to take into account consequences as results of logistics processes. It cannot be allowed to go back to the previous process stage, for instance, if some stock manipulations have already taken place. It is also crucial to distinguish between activities, incorrect from the users' perspective but still valid in sense of allowed configurations, and those activities which result in corrupted data. In the second case, there are usually available option to apply corrections. If some of the required further inputs were forgotten, a user is able to provide missing data and proceed with processing. Analogically, if it was not possible to continue some process because of improper input data, it is possible to make changes and correct process inconsistencies.

  Otherwise, it is user responsibility to pay attention during process execution and ensure that all actions and input data are appropriate and won't cause any conflicts or data violations in future.

  Possible solutions: According to the state of the art, there is always a way to apply changes accept of data or process state doesn't exist in the same form any longer. Because of application field specifics, it is not always allowed to revert business processes. Currently there is no potential for concrete changes of this part of system functionality.

6.5 System Reaction

In general, there are no specific issues found depended on the way and functionality how system responds to user actions and inputs. There is nothing to document except those usability problems discussed in other sections which can be referenced and classified as related to system reaction. For example, as was already mentioned there are improvements required for validation mechanisms. Namely, notifications and text of validation messages have to be made clearer, understandable, and non-ambiguous. Moreover, in particular cases validation logic has to be extended in such a way that a user is not only informed about occurred conflicts but also gets suggestions how the conflicts can be resolved.

6.6 User Support

First and last, almost no significant deviations from user expectations in the context of user support were not expressed during the survey. Taking into account very specific area of discussion and complexity of the evaluated software, it seems to be an obvious fact for users also – these are rather unprofitable efforts to provide any kind of integrated user support. In common case there is no stable connection can be guaranteed in warehouse and WAMAS is used offline. Although some users would wish to have online help in place, there is unfortunately currently no basis or concept to elaborate such solution.

6.7 System Performance

One of explicit user requests concerning system improvements and extensions of its functionality is support of batch operations. If registering stock on multiple loading units or storage locations, creating transport orders for already registered loading units, editing specific characteristics or attributes of artifacts belonging to the same group, it is obviously very helpful to be able to execute such operations at once. There are different possibilities in WAMAS to trigger multiple analogous events so that a user is not forced to repeat the same action for each of related artifacts. Some of the batch operations are carried out in the same way as a single operation, others are executed via particular dialogs. Moreover, there are also certain differences between implementation solutions of such specific dialogs. For instance, it

is possible to create multiple loading units (LUs) when registering incoming

goods via IG024 within the same workflow which is used for a single LU registration. This mechanism (figure 6.5) is simple and clear; it is both possible to set a number of loading units to be created (correspondently a number of LU-IDs to be generated) or to add LUs one by one manually.

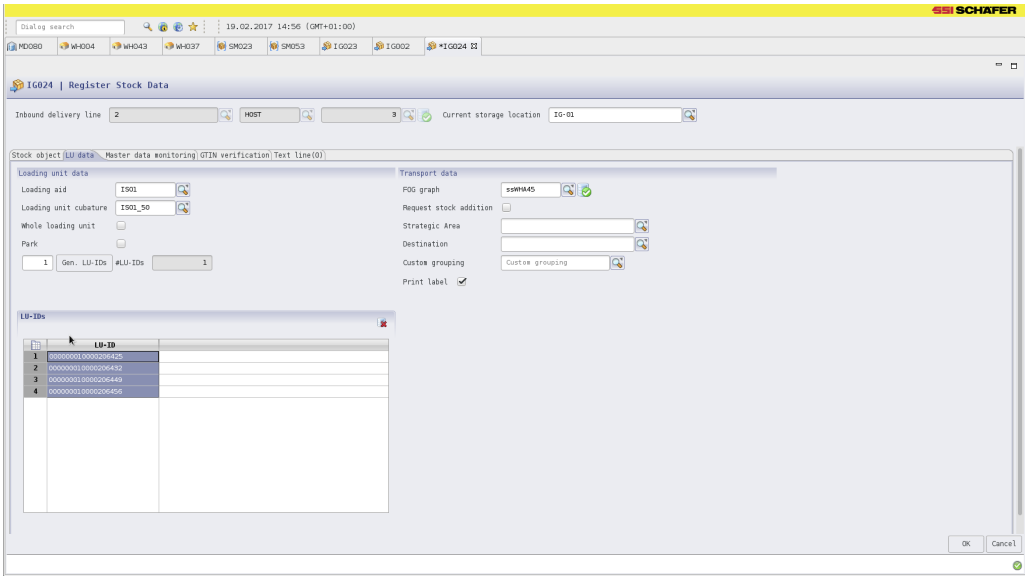


Figure 6.5: *IG024 – Register Stock Data; multiple LUs registered*

Another, completely different, example of data multi-processing in WAMAS is provided with the dialog *WH043 – Maintain Multiple Storage Compartments*. This desktop dialog is available from the context menu of the correspondent overview dialog *WH004 – Storage Compartments Overview* only if two or more records are selected. The multi-edit dialog looks exactly like a simple maintenance dialog *WH017 – Maintain Storage Compartment* with the only difference that each input fields – attributes of a storage location – has to be separately enabled via additional checkbox as shown on the figure 6.6.

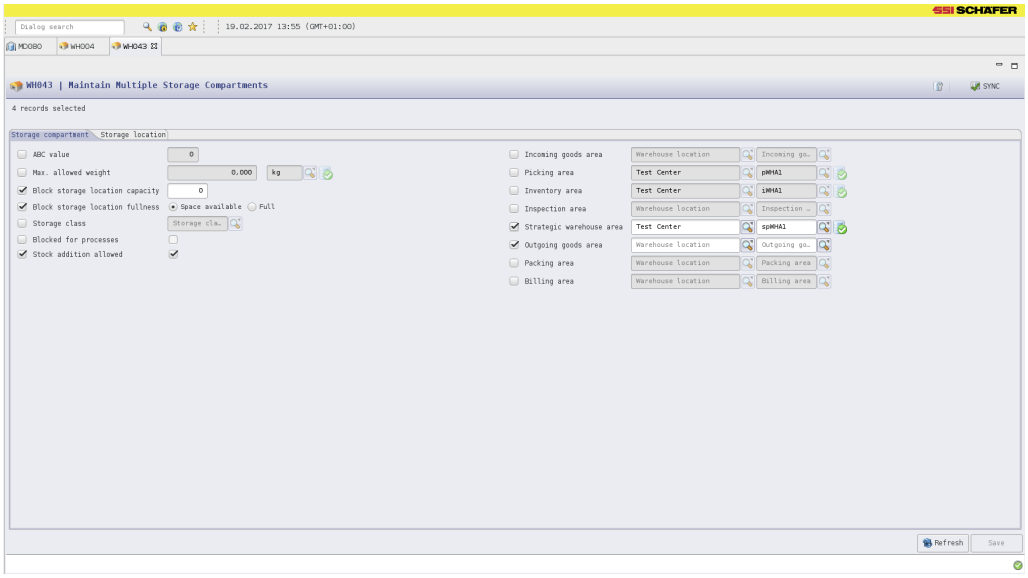


Figure 6.6: *WH043 – Maintain Multiple Storage Locations*

There are also other examples of WAMAS multi-edit dialogs. These are designed in other way and are different from simple maintenance dialogs. In case if system artifacts are complex and characterized by a variety of attributes of different structure, there is no use case scenario for which batch edit functionality has to be provided. For instance, loading units can include a diversity of stock objects – from items of different quantity unit system up to additionally registered loading aids. Having totally different loading units in record listing, there is no sense to allow applying some changes to some group of them at once. However, WAMAS supports sub-editing for multiple LUs, so that users are able to provide adjustments of basic primary attributes in a simple manner. Technically the search criteria of the overview dialog *SM023 – Loading Units Overview* are originally taken as a set of attributes which can be edited for multiple records at the same time. Such loading aid characteristics as a storage location, flow of goods (FOG) graph assignment, etc. can be changed for several loading units without any necessity to check for possible data inconsistencies or misconfigurations.

There is also another issue to be mentioned when considering multi-edit dialogs implemented in WAMAS. In the case of multiple records selected for edit, there are no initial values of the attributes displayed in maintenance dialogs. To achieve a higher level of transparency there are additional validation identifiers per input field or a set of fields to inform a user about different values supposed to be replaced. There is no other business logic or

functionality behind such identifiers except of comparing the input values. It is up to the user if to proceed with changing of different values at once.

Not only data manipulations but also process management is supported in WAMAS desktop dialogs for multiple records in parallel. Various orders and deliveries can be released, finalized, canceled, etc. within one single transaction. There are no additional GUI extensions except visualization of the status bar and appropriate text notification, so that user can keep progress on track. As shown in the figure 6.7, it is specified the number of orders which were selected for processing and approximate current status. There is no estimation of process duration or a certain percentage of process completion in place, however.

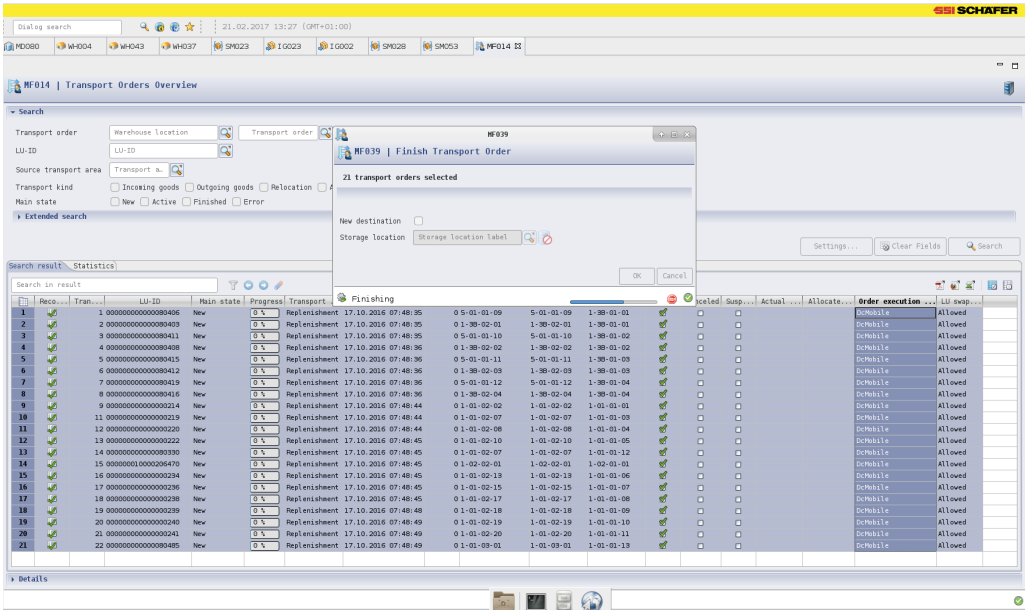


Figure 6.7: *MF039 – Finish Transport Order*

As described above, there are different ways to support users with batch operations in different contexts. Additionally designed and implemented GUI elements up to entire desktop dialogs are provided to facilitate data manipulations and process execution for multiple records at once. Nevertheless, there is another issue related to system load and performance characteristics. More records haves to be updated in parallel, longer takes the process. There is no further specific research or measurements provided in this area yet. This is definitely a good point to investigate and decide about possible

improvements and extensions to increase usability degree.

Possible solutions: In order to propose any refinements and define software architecture improvements it is important to recognize exact problems with system performance firstly. Further user test sessions not only allow to measure a duration of certain processes and transactions but also to find out user expectations and acceptable ranges. From the other side, investigation of possible improvements of architectural solutions, potential code refactoring procedures, and other technical issues is required. These are commonly needed activities to be carried out for large-scale interactive systems, which support usability degree of the system in general.

6.8 Common Feeling

Usability as a research area and related investigations mainly consider users and their experiences. Therefore, it is significant to ask and discuss not only about certain features and elements of examined interactive system but also about users' impressions in general. In some cases, global questions are even more efficient and supporting for a user to realize possible usability issues.

According to feedback from WAMAS end-users, the interactive system does not provide enough level of confidence, unfortunately. With regards to survey results, some of the user do not feel free and do have certain concerns when operating WAMAS. In order to learn more and detect the use scenarios which cause uncertainties, it is recommended to execute face-to-face user tests.

Possible solutions: Watching users as they are fulfilling prepared tasks allows to find out those usability issues which remains inconspicuous for users themselves.

Another remarkable issue is that all of the participants were strongly convinced: it is necessary to learn how to operate the interactive system before it can be used efficiently. It is not a negative characteristic if taking into consideration system complexity, but a reason to elaborate a proper training for target auditorium. Instructing and training users before WAMAS is introduced as the main system to work with is certainly an important step and time-consuming process not to be left out.

Possible solutions: User-oriented training and workshops are required. Additionally, presentation of newly implemented, extended, improved, changed functionality should take place on the regular basis.

6.9 Terminology

Some survey participants have mentioned the presence of some ambiguities between terms used through the desktop dialogs of the interactive system. However, no concrete examples of such mismatches could be found when investigating terminology and translations. The only explanatory assumption is that confusions are related to the very specific area of business and discussions. There is no universal dictionary of logistic terms recognized internationally. For instance, a term *loading unit* (LU) used in one organization stands for the same artifact as a term *transport unit* (TU) from another logistic dictionary. Similar to this, there is an open discussion if a term *amount* hast to be replaced with a term *quantity* in every context. This has also an effect on all composite terms as for *quantity panel*, *quantity unit*, *quantity reduction*, and others.

Although this is rather an organizational problem which cannot be influenced by providers of warehouse software, it is even more crucial to support consistency within particular interactive systems. WAMAS design and development team guarantees qualitative terminology and translations in place. There are pre-defined processes and workflows of collaboration for requirements engineers, software developers, technical writers.

Possible solutions: Keeping and following mentioned best practices results in the consistent and correct language used as well for WAMAS dialogs and also for user supporting manuals and documentation. However, there is still space for investigations and improvements as long as system users refer to possible ambiguities. The most efficient way to proceed is to conduct further user interviews and discuss terminology and related issues. Each of supported languages has to be considered separately. Thereby it will be possible to find out whether there are any global inconsistencies between logistic terms or there exist some ambiguities in particular languages. Having this knowledge required corrections can be introduced.

Chapter 7

Checklists

In order to support GUI specialists working on the system development in future, it was decided to briefly summarize findings of the current research in two listings. The best practices and restrictions are supposed to be taken into consideration when designing new WAMAS 5 desktop dialogs. These rules are kept simple and short, so it can be always easily referred to. It was no intention to provide detailed guidelines, but only to accent the most important principles to follow.

7.1 List of Dos

1. Reference new dialogs in the menu toolbar.
2. Ensure that new dialogs do not break already existing workflows (except it is an intention).
3. Check whether both order and grouping of input fields within new dialogs are consistent with regards to the already existing dialogs; check the alignments.
4. Check whether a format of new input fields is reasonable and not contradicting to already existing input fields among all system dialogs.
5. Check all text entries within new dialogs including dialog title; if a decision for validator messages and other formulations is required, contact technical writers.
6. Implement a practical validator mechanism for new dialogs – think about meaningful validator messages covering all possible cases of misconfiguration.

7. Assure that all standardized WAMAS 5 shortcuts are enabled for new dialogs if applicable.
8. Distinguish between editable and non-editable fields; distinguish between optional and mandatory input fields.
9. Indicate whether there are unsaved changes within a dialog.
10. Rather provide a user with input value suggestions than allowing to enter an input manually.
11. Stay minimalistic.

7.2 List of Don'ts

1. Do not implement new GUI elements if not checked whether there already exist any similar standardized for WAMAS 5.
2. Avoid validation messages with no reference to the input field where an error occurred.
3. Do not use colors as only characteristic to distinguish between input field types or process/action states.
4. Ensure that data input is efficient – reduce the number of additional buttons or mouse clicks if possible.
5. Hide auxiliary data input in default dialog settings.

Chapter 8

Conclusions and Future Work

Within the scope of the current thesis, the usability of the large-scale warehouse management system WAMAS 5 was investigated and evaluated. Significant benefits in business-related processes is a general motivating factor to invest in usability improvements.

Because of the system complexity and dimensions, it was decided to take only the desktop client functionality into consideration. In order to get appropriate information about the existing GUI solutions and find possible disadvantages, several methods were applied to analyze the system desktop dialogs. As one of the simplest but still powerful inspection methods, the heuristic evaluation was conducted to learn about potential usability problems. Each of the ten heuristic principles was considered separately and particular examples of either fulfillment or deviations from standards were defined. Conclusions with regards to the feasibility of every usability heuristic within the system were formulated.

With the intention of finding out further issues with the desktop GUI implementation, evaluation of the system dialogs by means of the user survey was carried out. For this purpose, a special system-oriented usability questionnaire was elaborated. Keeping testing procedures simple and dedicated resources moderate, there were five test participants involved. Being not a head to toe examination, but having a goal to improve design solutions, the main goal is to find the major usability problems with the first test study. Obtained user responses were properly documented and analyzed. The results of user tests comply altogether with the outcomes of the heuristic evaluation. Most of the discovered usability issues were related to error prevention and validation system mechanisms. There is always a challenge to find a balance between the acceptable performance level and the level of user support. Another topic which requires further investigations and has potential

to be reworked is data input and validation solutions implemented among the system desktop dialogs. Regarding the mentioned drawbacks, concrete suggestions for changes to the functionality were formulated. However, there are still open questions related to the technical implementation of proposed solution because of performance issues as well.

Finally, two referential "dos" and "dont's" checklists for GUI developers were formulated. These were kept brief and are proposed to be used when implementing new system functionality.

After the initial usability investigation of the system desktop dialogs procedures took place and the correspondent results were documented, it is possible to start with the first changes to GUI design. In parallel, it would be helpful to conduct further user test sessions to find out more about already mentioned usability issues. It would be reasonable to benefit from more intensive communication with the end-users and to apply other testing methods such as direct user interviews and observations. Moreover, as soon as the desktop elements and workflows are updated with the agreed changes, it will be also required to conduct user tests again. Getting more knowledge and distinct understanding of optimal solutions, it would be necessary to properly document those and provide certain GUI guidelines to be followed in future among all the dialogs.

As further steps of the usability evaluation and improvements, the other WAMAS 5 system components could be considered. Apart of the desktop dialogs evaluated within the current work, there is a desktop warehouse modeling tool which has to be investigated in the context of usability. There is also a big variety of tablet and mobile devices which are involved in the execution of different processes in the warehouse. Investigation of the existing workflows will require essential efforts – it has to be decided about the scope, methodology, focus group, etc. Nevertheless, it is an important part of continuous improvement process to keep the entire WAMAS 5 functionality qualitative, usable, and attractive for the various customers.

Bibliography

[1] William Albert and Thomas Tullis. *Measuring The User Experience: Collecting, Analyzing, Presenting Usability Metrics*. 2nd ed. Newnes, 2013.

[2] Dieter Arnold. *Intralogistics*. Springer, Berlin, 2006.

[3] Carol Barnum. *Usability Testing Essentials: Ready, Set... Test!* Morgan Kaufmann, 2011.

[4] John Brooke. "SUS - A quick and dirty usability scale". In: *Usability evaluation in industry* (1996), pp. 4–7.

[5] Alan Cooper et al. *About Face: The Essentials of Interaction Design*. 4th ed. Wiley, 2014.

[6] Jesse Garrett. *The Elements of User Experience*. 2nd ed. New Riders, 2011.

[7] Wiendahi Hans-Peter. *Fundamentals of Production Logistics*. Springer, Berlin, 2009.

[8] Jonathan Hicken and Stef Miller. *How To Write Great Questions For Your Next User Test*. User Testing Blog. URL: `https://www.usertesting.com/blog/2014/11/17/how-to-write-great-questions-for-your-next-user-test/` (visited on 10/27/2016).

[9] Inkscape. *Inkscape*. June 30, 2012. URL: `http://inkscape.org/` (visited on 12/11/2016).

[10] Jeff Johnson. *Designing with the Mind in Mind: Simple Guide to Understanding User Interface Design Guidelines*. 2nd ed. Morgan Kaufmann, 2014.

[11] Jurek Kirakowski. *Questionnaires in Usability Engineering*. URL: `http://www.ucc.ie/hfrg/resources/qfaq1.html` (visited on 11/29/2016).

[12] Jurek Kirakowski and Nigel Bevan. "What Is Usability". In: *Human Aspects in Computing: Design And Use of Interactive Systems And Work With Terminals*. 1991.

[13] Helmut Kopka and Patrick Daly. *Guide to LaTeX 2ε*. 4th ed. 2015.

[14] Steve Krug. *Don't make me think!* 3rd ed. mitp, 2014.

[15] Philipp Lehman. *Biber: A BibTeX replacement for users of BibLaTeX*. Oct. 18, 2013. URL: `http://biblatex-biber.sourceforge.net/` (visited on 02/10/2014).

[16] Jaime Levy. *UX Strategy: How to Devise Innovative Digital Products That People Want*. O'Reilly, 2014.

[17] Joanne Locascio et al. "Utilizing Employees As Usability Participants: Exploring When And When Not to Leverage Your Coworkers". In: *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*. 2016.

[18] Harald Milchrahm, Wolfgang Slany, and Andreas Holzinger. "Process Patterns for Agile Usability". In: *Advances in Computer Human Interaction*. 2010.

[19] Rolf Molich et al. "Comparative usability evaluation". In: *Behavior & Information Technology*. 2004.

[20] Jacob Nielsen. *10 Usability Heuristics for User Interface Design*. Nielsen Norman Group. 2015. URL: `https://www.nngroup.com/articles/why-you-only-need-to-test-with-5-users/` (visited on 09/15/2016).

[21] Jacob Nielsen. "Enhancing the explanatory power of usability heuristics". In: *Proceedings of SIGCHI conference on Human factors in computing systems*. 1994.

[22] Jacob Nielsen. "Finding usability problems through heuristic evaluation". In: *Proceedings of SIGCHI conference on Human factors in computing systems*. 1992.

[23] Jacob Nielsen. *How to Conduct a Heuristic Evaluation*. Nielsen Norman Group. 2015. URL: `https://www.nngroup.com/articles/how-to-conduct-a-heuristic-evaluation/` (visited on 12/23/2016).

[24] Jacob Nielsen. "The usability engineering life cycle". In: *Computer* 25 (1992), pp. 12–22.

[25] Jacob Nielsen. *Usability Engineering*. Elsevier, 1994.

[26] Jacob Nielsen. "Usability inspection methods". In: *Conference companion on Human factors in computing systems*. 1994.

[27] Jacob Nielsen. *Why You Only Need to Test with 5 Users*. Nielsen Norman Group. 2015. URL: `https://www.nngroup.com/articles/ten-usability-heuristics/` (visited on 10/29/2016).

[28] Jacob Nielsen and Thomas Landauer. "A mathematical model of the finding of usability problems". In: *Proceedings of ACM INTERCHI'93 Conference*. 1993.

[29] Jacob Nielsen and Rolf Molich. "Heuristic evaluation of user interfaces". In: *Proceedings of SIGCHI conference on Human factors in computing systems*. 1990.

[30] Jacob Nielsen, Donald Norman, and Bruce Tognazzini. *NN/g*. Nielsen Norman Group. URL: `http://www.nngroup.com/` (visited on 01/17/2017).

[31] Don Norman. *Design of Everyday Things*. Basic Books, 2013.

[32] Don Norman and Stephen Draper. *User Centered System Design*. Hillsdale, 1986.

[33] John Pane, Brad Myers, and Patrick Daly. *Usability Issues in The Design of Novice Programming Systems*. 1996.

[34] *Questionnaires in Usability Engineering*. The user experience professionals association. URL: `http://www.usabilityprofessionals.org/` (visited on 12/03/2016).

[35] Christian Rohrer. *When to Use Which User-Experience Research Methods*. Nielsen Norman Group. 2015. URL: `https://www.nngroup.com/articles/which-ux-research-methods/` (visited on 08/02/2016).

[36] Jeffrey Rubin, Diana Chisnell, and Jared Spool. *Handbook of Usability Testing: How to Plan, Design, And Conduct Effective Tests*. 2nd ed. John Wiley &Sons, 2008.

[37] Christian Schindler et al. "Enhancing Wrapper Usability through Ontology Sharing and Large Scale Cooperation". In: *Workshop on Representation and Analysis of Web Space (RAWS-05)*. 2005.

[38] Martin Schmettow, Cedric Bach, and Dominique Scapin. "Optimizing Usability Studies By Complementary Evaluation Methods". In: *Proceedings of the 28th International BCS Human Computer Interaction Conference*. 2014.

[39] Stefan Segerlund and Dominik Halbeisen. *Intralogistics: A Guide to Warehouse Planning*. Studentliteratur, 2016.

[40] Jeff Suaro and Joe Dumas. "Comparison of Three One-Question, Post-Task Usability Questionnaires". In: *Proceedings of SIGCHI conference on Human factors in computing systems*. 2009.

[41] Jeff Suaro and Erika Kindlund. "A Method To Standardize Usability Metrics Into A Single Score". In: *Proceedings of SIGCHI conference on Human factors in computing systems*. 2005.

[42] Jeff Suaro and James Lewis. "Correlations Among Prototypical Usability Metrics: Evidence for The Construct of Usability". In: *Proceedings of SIGCHI conference on Human factors in computing systems*. 2009.

[43] Jeff Suaro and James Lewis. *Quantifying The User Experience: Practical Statistics For User Research*. Elsevier, 2012.

[44] Ivana Taylor. *3 Things You Didn't Know About Survey Measurement Scales*. QuestionPro. URL: `http://www.questionpro.com/blog/3-things-you-didnt-know-about-survey-measurement-scales/` (visited on 10/30/2016).

[45] Ivana Taylor. *4 Measurement Scales Every Researcher Should Remember*. QuestionPro. URL: `https://www.questionpro.com/blog/4-measurement-scales-every-researcher-should-remember/` (visited on 10/30/2016).

[46] Jerry Taylor. *User Testing, Explained*. TNW. URL: `https://thenextweb.com/creativity/2015/04/27/user-testing-explained` (visited on 10/05/2016).

[47] TUG. *TeX Users Group Home Page*. TeX Users Group. 2012. URL: `http://tug.org/` (visited on 02/27/2017).

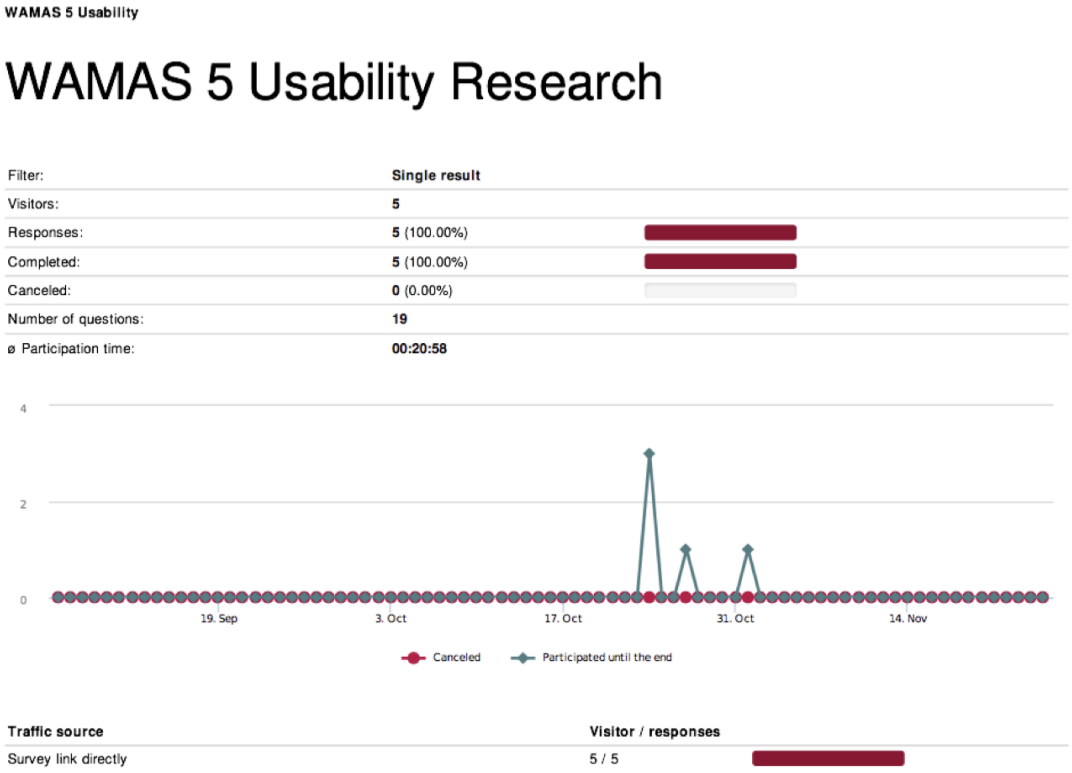
[48] UsabilityNet. *UsabilityNet: usability resources for practitioners and managers*. 2003. URL: `http://www.usabilitynet.org/` (visited on 08/17/2016).

[49] Chauncey Wilson. "Triangulation: the explicit use of multiple methods, measures, and approaches for determining core issues in product development". In: *Interaction* 6 (2006), pp. 46–48.

[50] Chauncey Wilson. *User Experience Re-Mastered: Your Guide to Getting The Right Design*. Morgan Kaufmann, 2009.

[51] Chauncey Wilson. *User Interface Methods: A User-Centered Design Method*. Morgan Kaufmann, 2014.

Appendix A



WAMAS 5 Usability

WAMAS 5 Usability Research

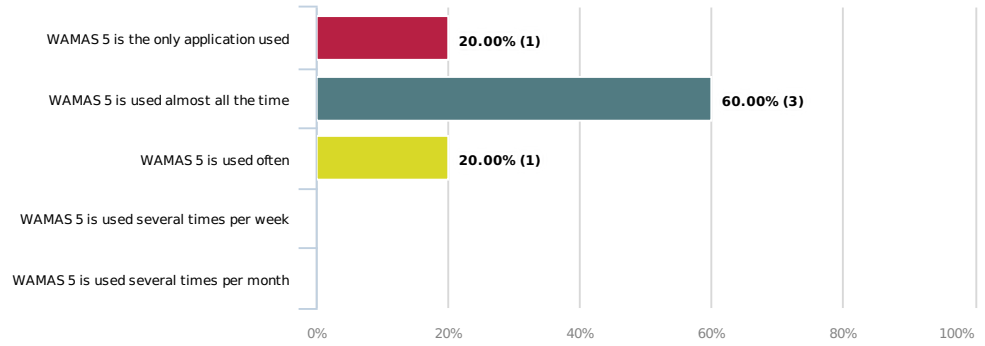
Filter:	Single result
Visitors:	5
Responses:	5 (100.00%)
Completed:	5 (100.00%)
Canceled:	0 (0.00%)
Number of questions:	19
ø Participation time:	00:20:58

Traffic source	Visitor / responses
Survey link directly	5 / 5

2. Question page: User Background
1. Question 5

How often do you use WAMAS 5 to carry out some operation (logistics processes, data configuration, etc.)?

* mandatory survey input

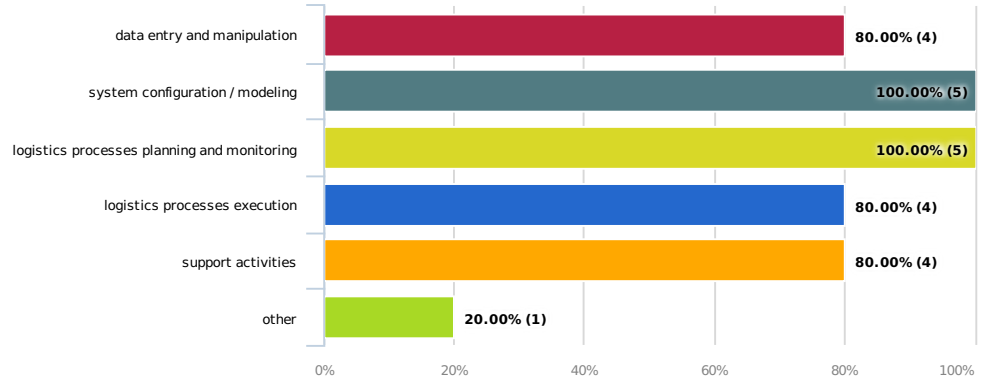


WAMAS 5 is the only application used	20.00%	*1*
WAMAS 5 is used almost all the time	60.00%	*3*
WAMAS 5 is used often	20.00%	*1*
WAMAS 5 is used several times per week	0.00%	*0*
WAMAS 5 is used several times per month	0.00%	*0*
		5

3. Question page: User Background
2. Question 5

Which kind of operations / tasks do you execute with the help of WAMAS 5?

* mandatory survey input; several answers are possible



data entry and manipulation	80.00%	4
system configuration / modeling	100.00%	5
logistics processes planning and monitoring	100.00%	5
logistics processes execution	80.00%	4
support activities	80.00%	4
other _____	20.00%	1

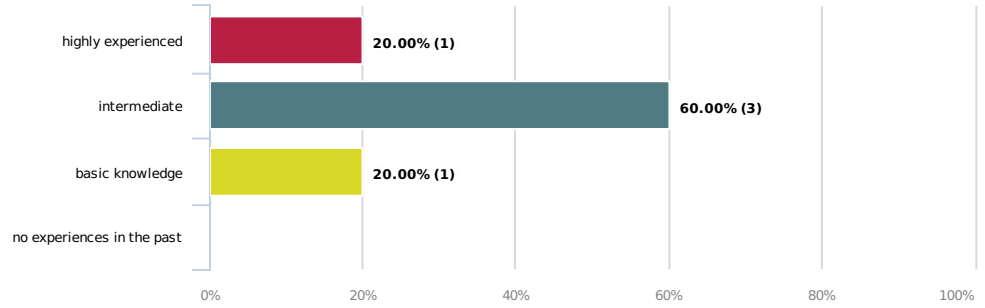
testing of requests / new functions / implementing new clients / roll out of W5

23

4. Question page: User Background
3. Question 5

How do you estimate your skills and experiences in warehouse logistics?

* mandatory survey input



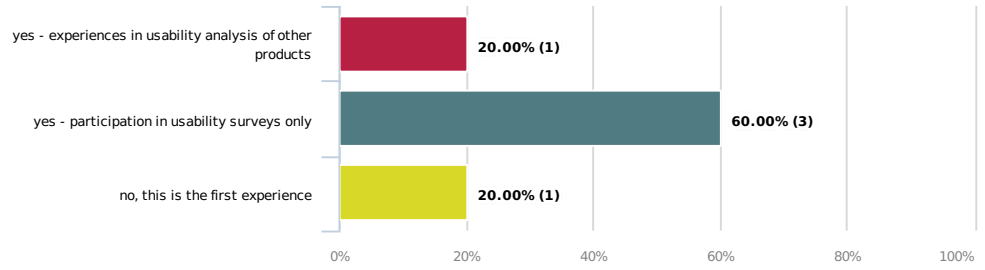
highly experienced	20.00% *1*	
intermediate	60.00% *3*	
basic knowledge	20.00% *1*	
no experiences in the past	0.00% *0*	

5

6. Question page: User Background
5. Question 5

Do you have any experiences in usability evaluation?

* optional question

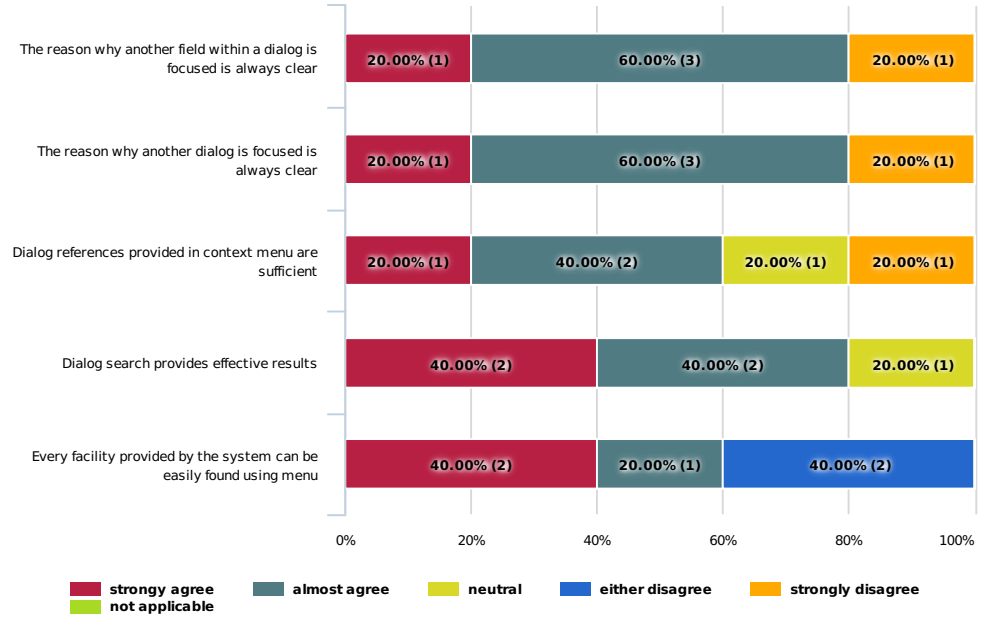


yes - experiences in usability analysis of other products	20.00%	1
yes - participation in usability surveys only	60.00%	3
no, this is the first experience	20.00%	1
		5

8. Question page: Look & Feel – Navigation
6. Question 1 5

The following statements address navigation capabilities of WAMAS 5:

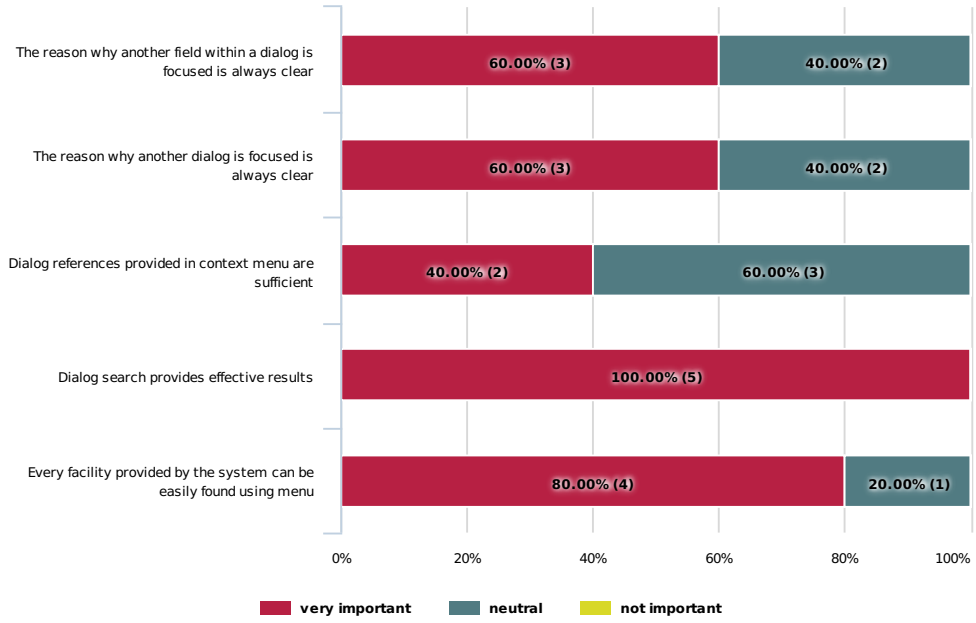
* exactly one answer for both ratings is required



	strongy agree	almost agree	neutral	either disagree	strongly disagree	not applicable	ø	
The reason why another field within a dialog is focused is always clear	20.00% 1	60.00% 3	0.00% 0	0.00% 0	20.00% 1	0.00% 0	**2.40**	5
The reason why another dialog is focused is always clear	20.00% 1	60.00% 3	0.00% 0	0.00% 0	20.00% 1	0.00% 0	**2.40**	5
Dialog references provided in context menu are sufficient	20.00% 1	40.00% 2	20.00% 1	0.00% 0	20.00% 1	0.00% 0	**2.60**	5
Dialog search provides effective results	40.00% 2	40.00% 2	20.00% 1	0.00% 0	0.00% 0	0.00% 0	**1.80**	5
Every facility provided by the system can be easily found using menu	40.00% 2	20.00% 1	0.00% 0	40.00% 2	0.00% 0	0.00% 0	**2.40**	5
							2.32	

The following statements address navigation capabilities of WAMAS 5:

Second ratings:



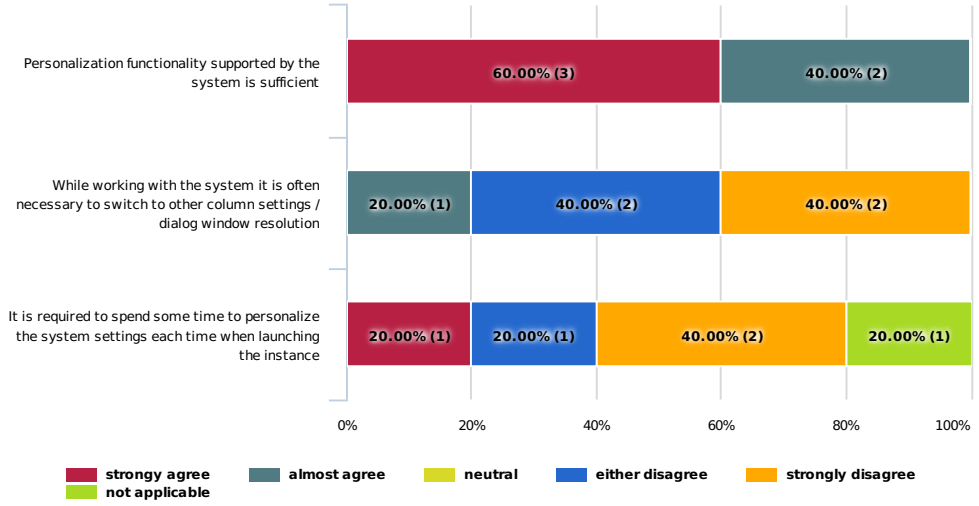
	very important		neutral		not important		ø	
The reason why another field within a dialog is focused is always clear	60.00%	*3*	40.00%	*2*	0.00%	*0*	**1.40**	*5*
The reason why another dialog is focused is always clear	60.00%	*3*	40.00%	*2*	0.00%	*0*	**1.40**	*5*
Dialog references provided in context menu are sufficient	40.00%	*2*	60.00%	*3*	0.00%	*0*	**1.60**	*5*
Dialog search provides effective results	100.00%	*5*	0.00%	*0*	0.00%	*0*	**1.00**	*5*
Every facility provided by the system can be easily found using menu	80.00%	*4*	20.00%	*1*	0.00%	*0*	**1.20**	*5*
							1.32	

Remarks to the question	*1*
no	

9. Question page: Look & Feel – Customization
7. Question 5

In order to estimate if WAMAS 5 is customizable enough you are asked to evaluate the following statements:

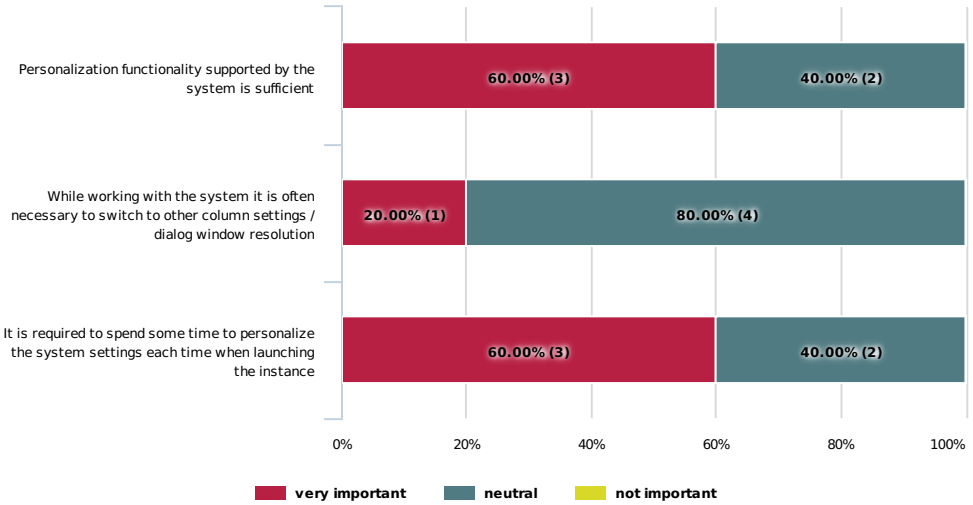
* exactly one answer for both ratings is required



	strongy agree	almost agree	neutral	either disagree	strongly disagree	not applicable	ø	
Personalization functionality supported by the system is sufficient	60.00% 3	40.00% 2	0.00% 0	0.00% 0	0.00% 0	0.00% 0	**1.40**	5
While working with the system it is often necessary to switch to other column settings / dialog window resolution	0.00% 0	20.00% 1	0.00% 0	40.00% 2	40.00% 2	0.00% 0	**4.00**	5
It is required to spend some time to personalize the system settings each time when launching the instance	20.00% 1	0.00% 0	0.00% 0	20.00% 1	40.00% 2	20.00% 1	**3.75**	5
							3.00	

In order to estimate if WAMAS 5 is customizable enough you are asked to evaluate the following statements:

Second ratings:



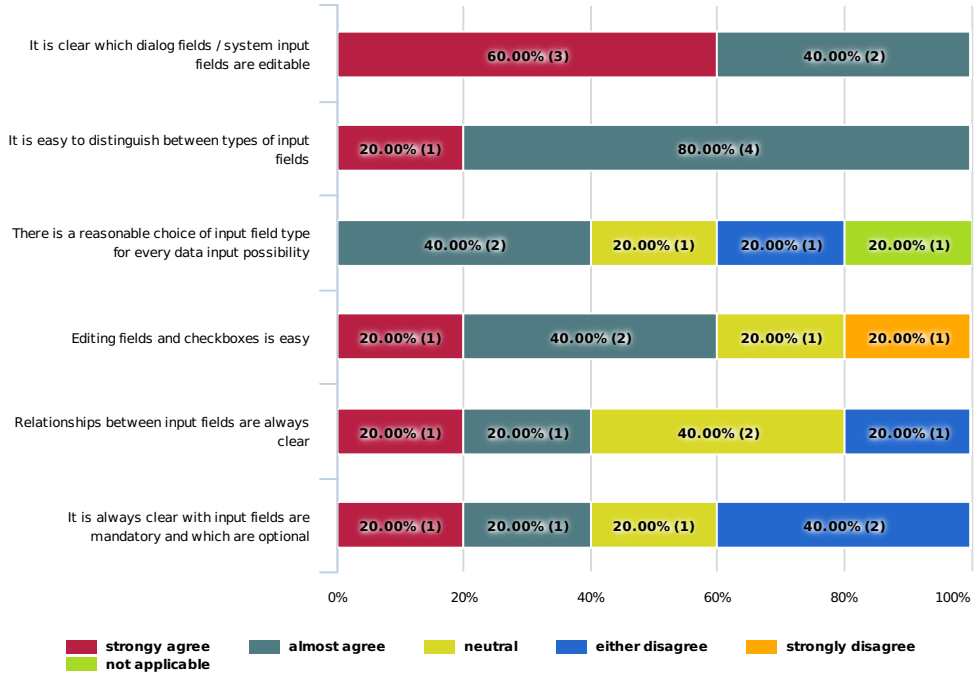
	very important		neutral		not important		ø	
Personalization functionality supported by the system is sufficient	60.00%	*3*	40.00%	*2*	0.00%	*0*	**1.40**	*5*
While working with the system it is often necessary to switch to other column settings / dialog window resolution	20.00%	*1*	80.00%	*4*	0.00%	*0*	**1.80**	*5*
It is required to spend some time to personalize the system settings each time when launching the instance	60.00%	*3*	40.00%	*2*	0.00%	*0*	**1.40**	*5*
							1.53	

Remarks to the question	*0*
There are no text answers yet.	

11. Question page: Data and Process Management – Data Input
8. Question 1 5

Please give your feedback according to data input forms provided by WAMAS 5:

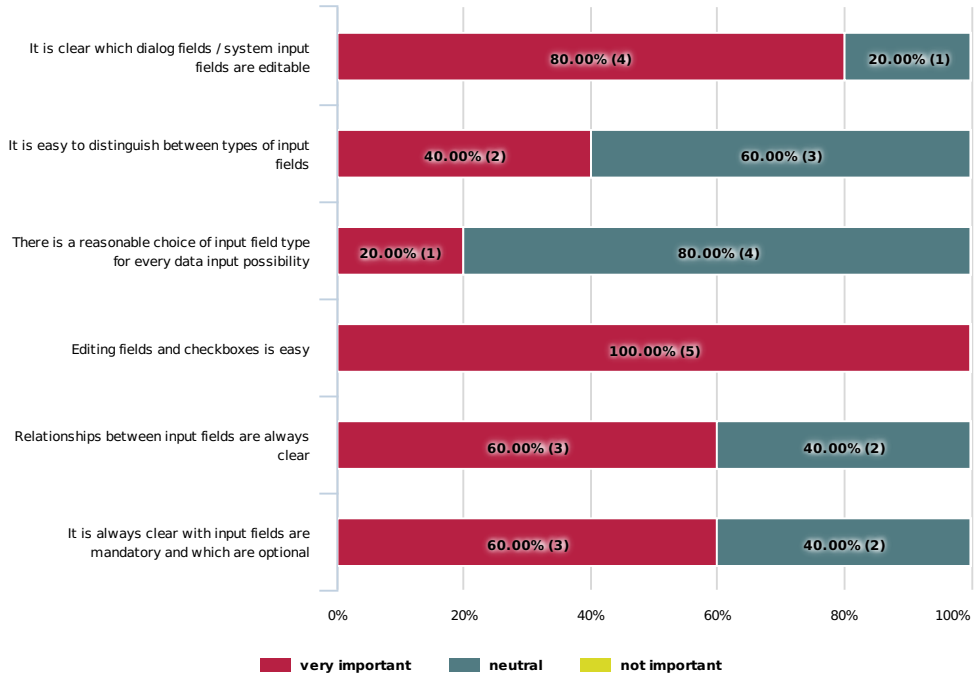
* exactly one answer for both ratings is required



	strongy agree	almost agree	neutral	either disagree	strongly disagree	not applicable	ø	
It is clear which dialog fields / system input fields are editable	60.00% 3	40.00% 2	0.00% 0	0.00% 0	0.00% 0	0.00% 0	**1.40**	5
It is easy to distinguish between types of input fields	20.00% 1	80.00% 4	0.00% 0	0.00% 0	0.00% 0	0.00% 0	**1.80**	5
There is a reasonable choice of input field type for every data input possibility	0.00% 0	40.00% 2	20.00% 1	20.00% 1	0.00% 0	20.00% 1	**2.75**	5
Editing fields and checkboxes is easy	20.00% 1	40.00% 2	20.00% 1	0.00% 0	20.00% 1	0.00% 0	**2.60**	5
Relationships between input fields are always clear	20.00% 1	20.00% 1	40.00% 2	20.00% 1	0.00% 0	0.00% 0	**2.60**	5
It is always clear with input fields are mandatory and which are optional	20.00% 1	20.00% 1	20.00% 1	40.00% 2	0.00% 0	0.00% 0	**2.80**	5
							2.31	

Please give your feedback according to data input forms provided by WAMAS 5:

Second ratings:



	very important		neutral		not important		ø	
It is clear which dialog fields / system input fields are editable	80.00%	*4*	20.00%	*1*	0.00%	*0*	**1.20**	*5*
It is easy to distinguish between types of input fields	40.00%	*2*	60.00%	*3*	0.00%	*0*	**1.60**	*5*
There is a reasonable choice of input field type for every data input possibility	20.00%	*1*	80.00%	*4*	0.00%	*0*	**1.80**	*5*
Editing fields and checkboxes is easy	100.00%	*5*	0.00%	*0*	0.00%	*0*	**1.00**	*5*
Relationships between input fields are always clear	60.00%	*3*	40.00%	*2*	0.00%	*0*	**1.40**	*5*
It is always clear with input fields are mandatory and which are optional	60.00%	*3*	40.00%	*2*	0.00%	*0*	**1.40**	*5*
							1.40	

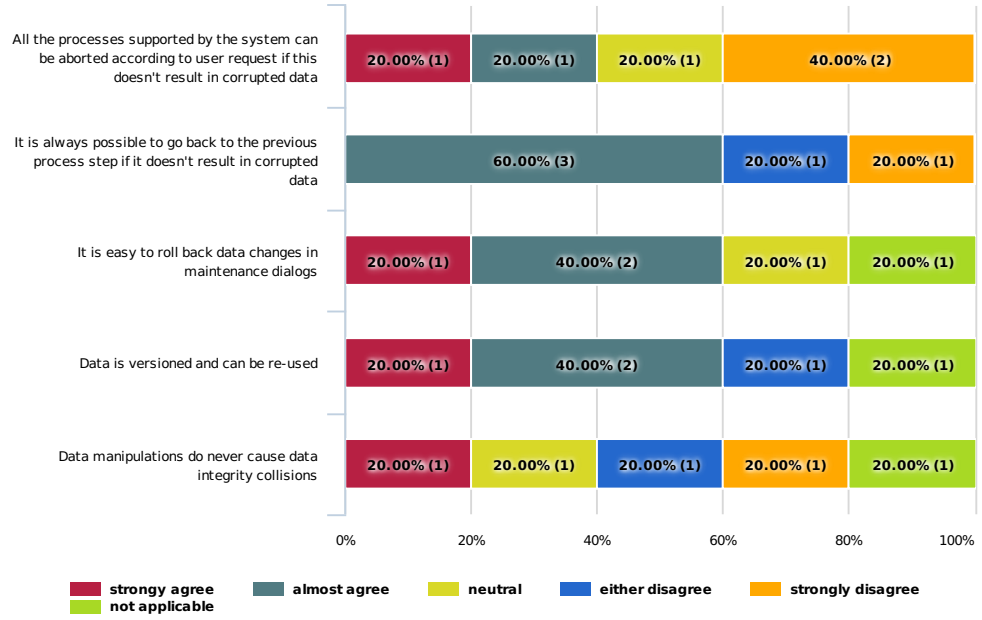
Remarks to the question *0*

There are no text answers yet.

12. Question page: Data and Process Management – Cancellation and Archiving
9. Question 5

Please evaluate the cancellation and archiving functionality of WAMAS 5:

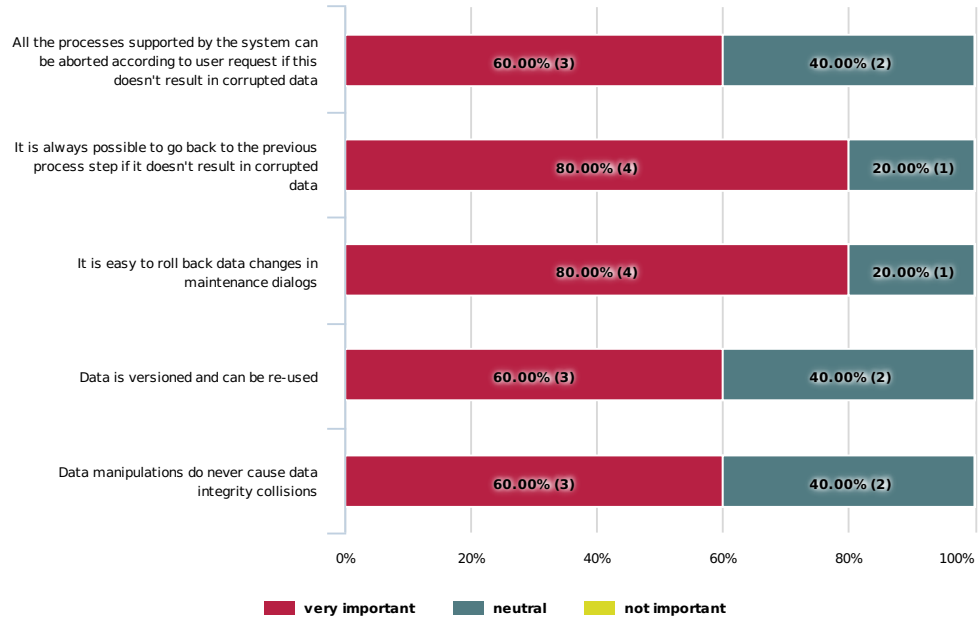
* exactly one answer for both ratings is required



	strongy agree	almost agree	neutral	either disagree	strongly disagree	not applicable	ø	
All the processes supported by the system can be aborted according to user request if this doesn\'t result in corrupted data	20.00% *1*	20.00% *1*	20.00% *1*	0.00% *0*	40.00% *2*	0.00% *0*	**3.20**	*5*
It is always possible to go back to the previous process step if it doesn\'t result in corrupted data	0.00% *0*	60.00% *3*	0.00% *0*	20.00% *1*	20.00% *1*	0.00% *0*	**3.00**	*5*
It is easy to roll back data changes in maintenance dialogs	20.00% *1*	40.00% *2*	20.00% *1*	0.00% *0*	0.00% *0*	20.00% *1*	**2.00**	*5*
Data is versioned and can be re-used	20.00% *1*	40.00% *2*	0.00% *0*	20.00% *1*	0.00% *0*	20.00% *1*	**2.25**	*5*
Data manipulations do never cause data integrity collisions	20.00% *1*	0.00% *0*	20.00% *1*	20.00% *1*	20.00% *1*	20.00% *1*	**3.25**	*5*
							2.77	

Please evaluate the cancellation and archiving functionality of WAMAS 5:

Second ratings:



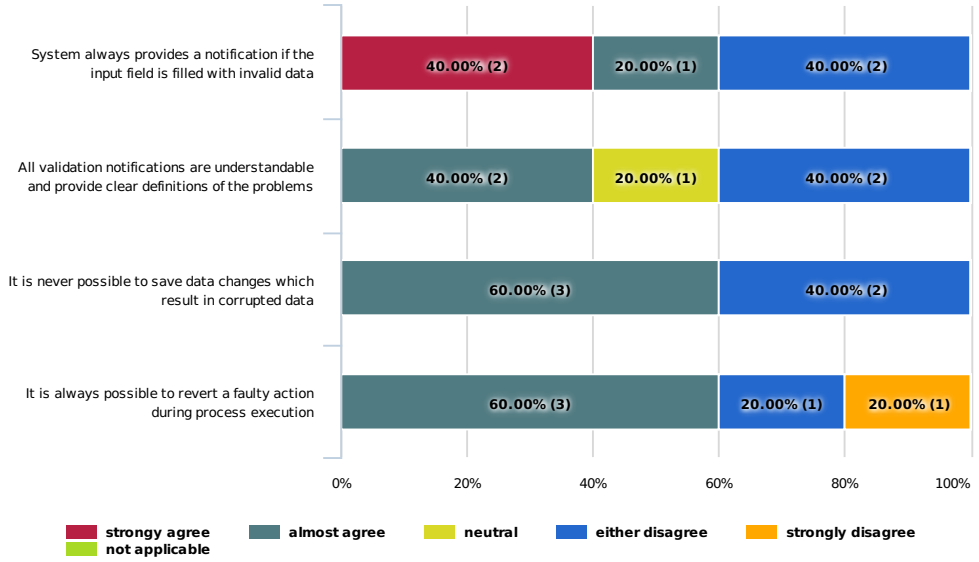
	very important		neutral		not important		ø	
All the processes supported by the system can be aborted according to user request if this doesn\'t result in corrupted data	60.00%	*3*	40.00%	*2*	0.00%	*0*	**1.40**	*5*
It is always possible to go back to the previous process step if it doesn\'t result in corrupted data	80.00%	*4*	20.00%	*1*	0.00%	*0*	**1.20**	*5*
It is easy to roll back data changes in maintenance dialogs	80.00%	*4*	20.00%	*1*	0.00%	*0*	**1.20**	*5*
Data is versioned and can be re-used	60.00%	*3*	40.00%	*2*	0.00%	*0*	**1.40**	*5*
Data manipulations do never cause data integrity collisions	60.00%	*3*	40.00%	*2*	0.00%	*0*	**1.40**	*5*
							1.32	

Remarks to the question	*1*
fog example searching with archive in DI004 (question 1)	

13. Question page: Data and Process Management – Validation / Error handling
10. Question 5

The next statements address validation and error handling supported by WAMAS 5:

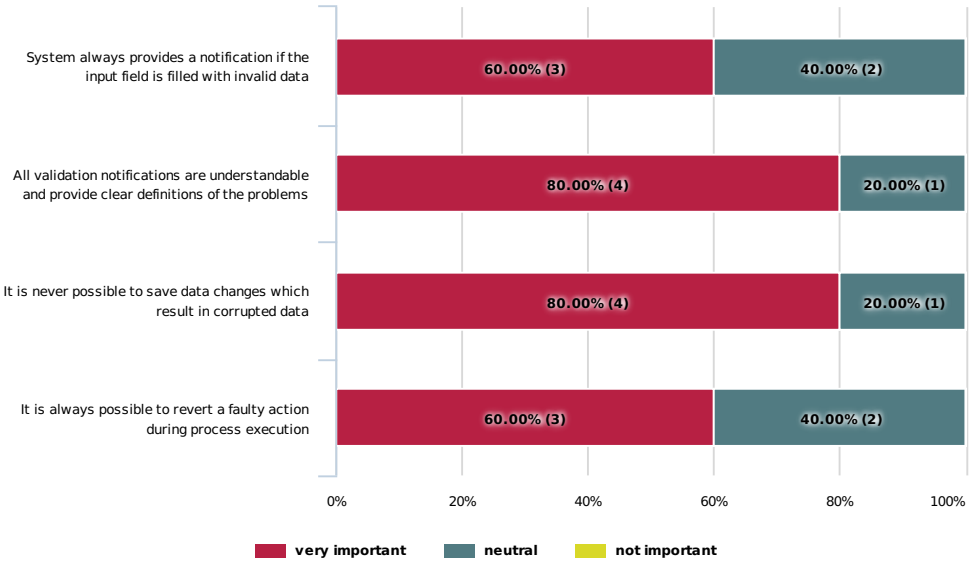
* exactly one answer for both ratings is required



	strongy agree	almost agree	neutral	either disagree	strongly disagree	not applicable	ø	
System always provides a notification if the input field is filled with invalid data	40.00% 2	20.00% 1	0.00% 0	40.00% 2	0.00% 0	0.00% 0	**2.40**	5
All validation notifications are understandable and provide clear definitions of the problems	0.00% 0	40.00% 2	20.00% 1	40.00% 2	0.00% 0	0.00% 0	**3.00**	5
It is never possible to save data changes which result in corrupted data	0.00% 0	60.00% 3	0.00% 0	40.00% 2	0.00% 0	0.00% 0	**2.80**	5
It is always possible to revert a faulty action during process execution	0.00% 0	60.00% 3	0.00% 0	20.00% 1	20.00% 1	0.00% 0	**3.00**	5
							2.80	

The next statements address validation and error handling supported by WAMAS 5:

Second ratings:



	very important		neutral		not important		ø	
System always provides a notification if the input field is filled with invalid data	60.00%	*3*	40.00%	*2*	0.00%	*0*	**1.40**	*5*
All validation notifications are understandable and provide clear definitions of the problems	80.00%	*4*	20.00%	*1*	0.00%	*0*	**1.20**	*5*
It is never possible to save data changes which result in corrupted data	80.00%	*4*	20.00%	*1*	0.00%	*0*	**1.20**	*5*
It is always possible to revert a faulty action during process execution	60.00%	*3*	40.00%	*2*	0.00%	*0*	**1.40**	*5*
							1.30	

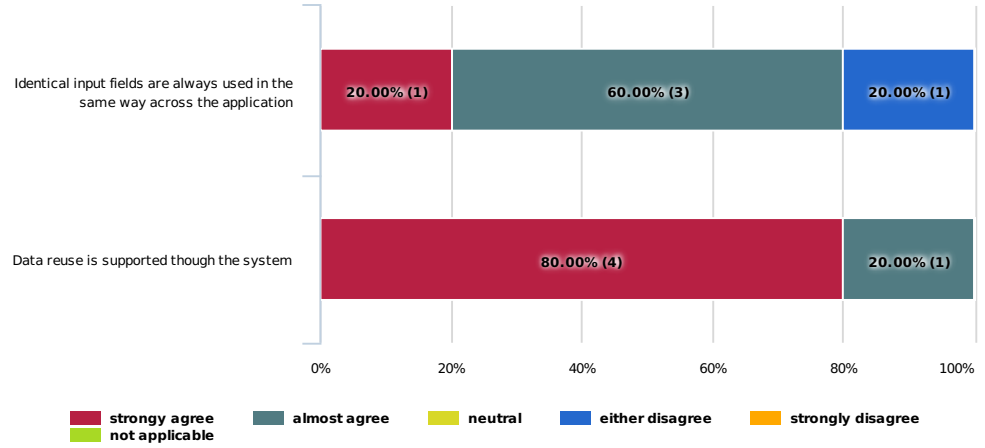
Remarks to the question *0*

There are no text answers yet.

14. Question page: Data and Process Management – Other Issues
11. Question 5

Here some more important questions concerning data management are proposed for evaluation:

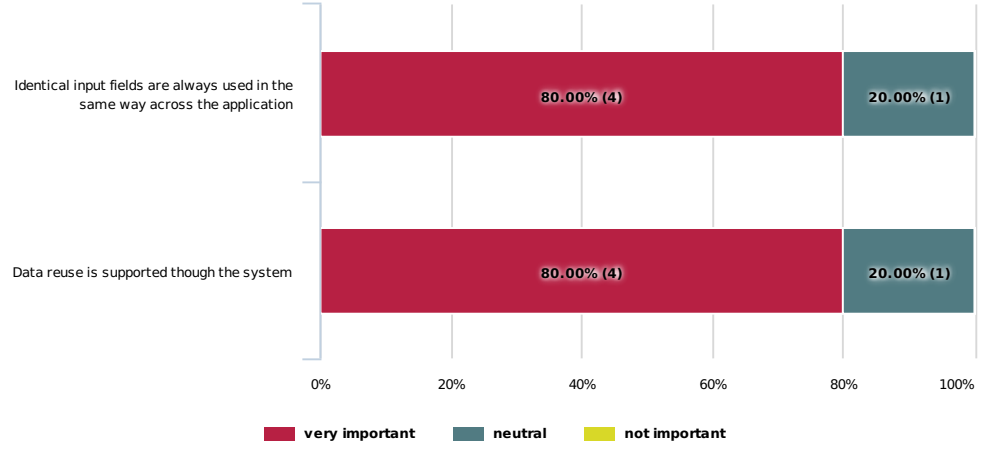
* exactly one answer for both ratings is required



	strongy agree	almost agree	neutral	either disagree	strongly disagree	not applicable	ø	
Identical input fields are always used in the same way across the application	20.00% 1	60.00% 3	0.00% 0	20.00% 1	0.00% 0	0.00% 0	**2.20**	5
Data reuse is supported though the system	80.00% 4	20.00% 1	0.00% 0	0.00% 0	0.00% 0	0.00% 0	**1.20**	5
							1.70	

Here some more important questions concerning data management are proposed for evaluation:

Second ratings:



	very important	neutral	not important	ø	
				1.20	

	very important		neutral		not important		ø	
Identical input fields are always used in the same way across the application	80.00%	*4*	20.00%	*1*	0.00%	*0*	**1.20**	*5*
Data reuse is supported though the system	80.00%	*4*	20.00%	*1*	0.00%	*0*	**1.20**	*5*
							1.20	

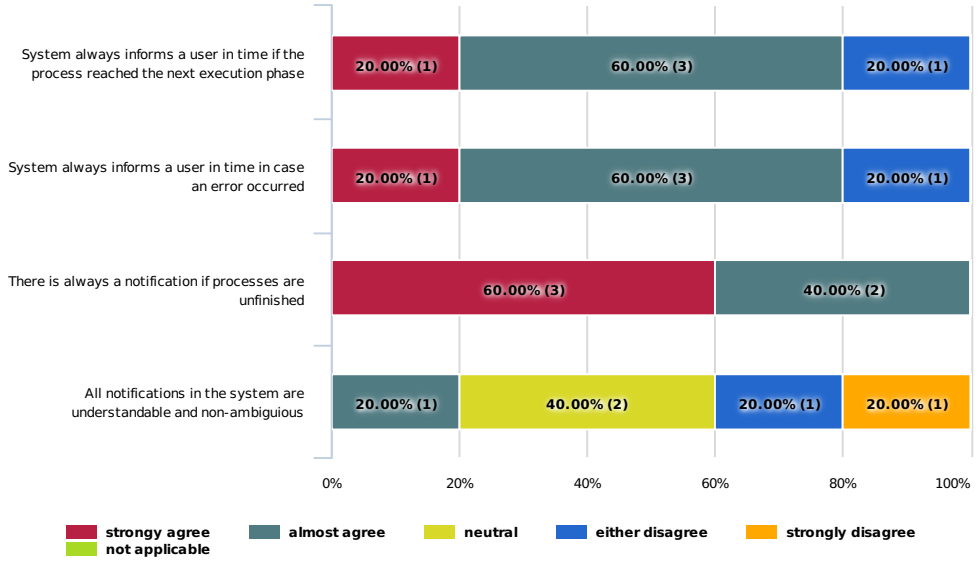
Remarks to the question *0*

There are no text answers yet.

16. Question page: User Experience – System Response
12. Question 5

To understand if the system reacts as expected there are the following statements to estimate:

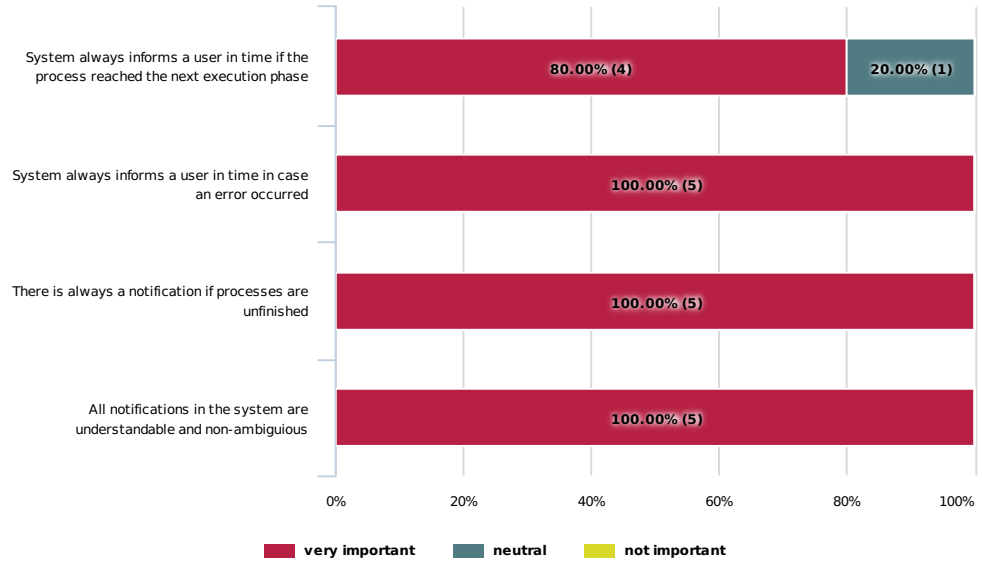
* exactly one answer for both ratings is required



	strongy agree	almost agree	neutral	either disagree	strongly disagree	not applicable	ø	
System always informs a user in time if the process reached the next execution phase	20.00% 1	60.00% 3	0.00% 0	20.00% 1	0.00% 0	0.00% 0	**2.20**	5
System always informs a user in time in case an error occurred	20.00% 1	60.00% 3	0.00% 0	20.00% 1	0.00% 0	0.00% 0	**2.20**	5
There is always a notification if processes are unfinished	60.00% 3	40.00% 2	0.00% 0	0.00% 0	0.00% 0	0.00% 0	**1.40**	5
All notifications in the system are understandable and non-ambiguious	0.00% 0	20.00% 1	40.00% 2	20.00% 1	20.00% 1	0.00% 0	**3.40**	5
							2.30	

To understand if the system reacts as expected there are the following statements to estimate:

Second ratings:



	very important		neutral		not important		ø	
System always informs a user in time if the process reached the next execution phase	80.00%	*4*	20.00%	*1*	0.00%	*0*	**1.20**	*5*
System always informs a user in time in case an error occurred	100.00%	*5*	0.00%	*0*	0.00%	*0*	**1.00**	*5*
There is always a notification if processes are unfinished	100.00%	*5*	0.00%	*0*	0.00%	*0*	**1.00**	*5*
All notifications in the system are understandable and non-ambiguious	100.00%	*5*	0.00%	*0*	0.00%	*0*	**1.00**	*5*
							1.05	

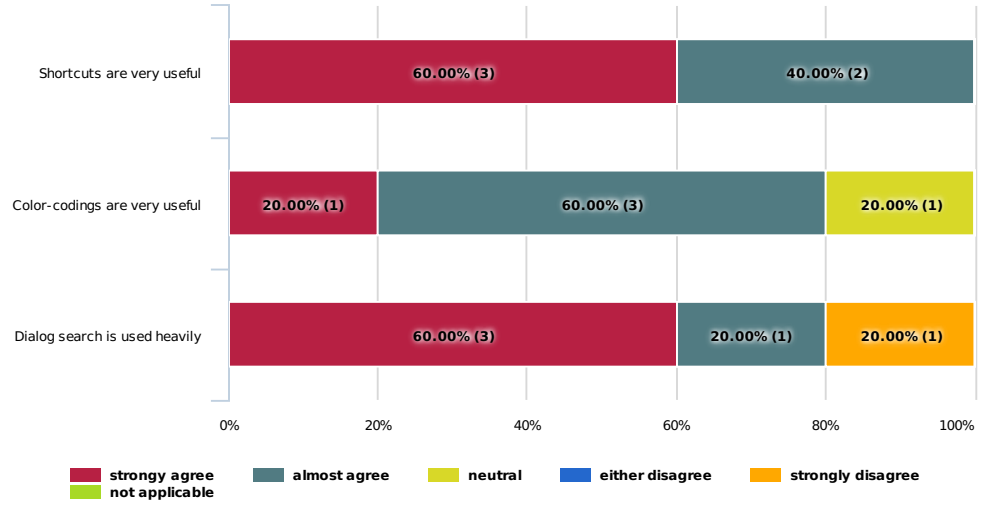
Remarks to the question *0*

There are no text answers yet.

17. Question page: User Experience – User Support
13. Question 5

Please give us feedback whether WAMAS 5 provides user support sufficiently:

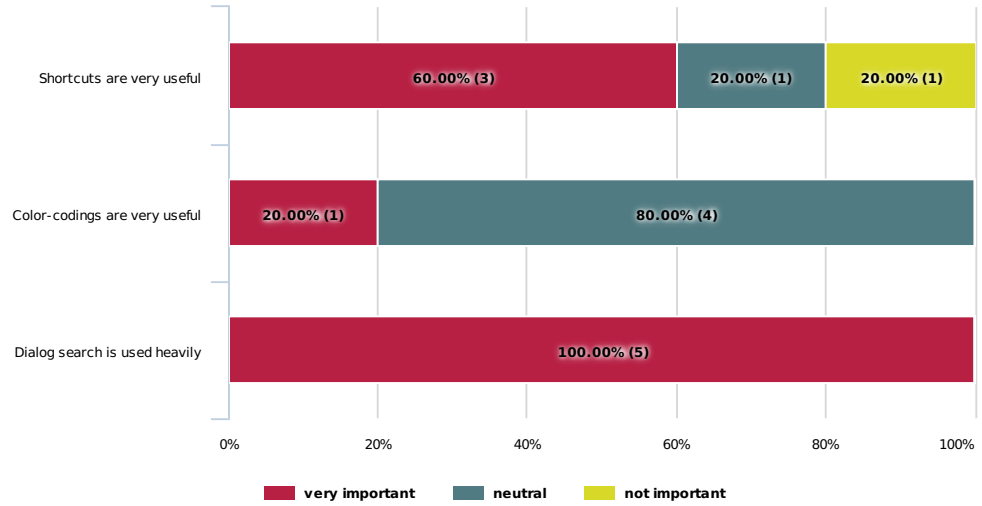
* exactly one answer for both ratings is required



	strongy agree	almost agree	neutral	either disagree	strongly disagree	not applicable	ø	
Shortcuts are very useful	60.00% 3	40.00% 2	0.00% 0	0.00% 0	0.00% 0	0.00% 0	**1.40**	5
Color-codings are very useful	20.00% 1	60.00% 3	20.00% 1	0.00% 0	0.00% 0	0.00% 0	**2.00**	5
Dialog search is used heavily	60.00% 3	20.00% 1	0.00% 0	0.00% 0	20.00% 1	0.00% 0	**2.00**	5
							1.80	

Please give us feedback whether WAMAS 5 provides user support sufficiently:

Second ratings:



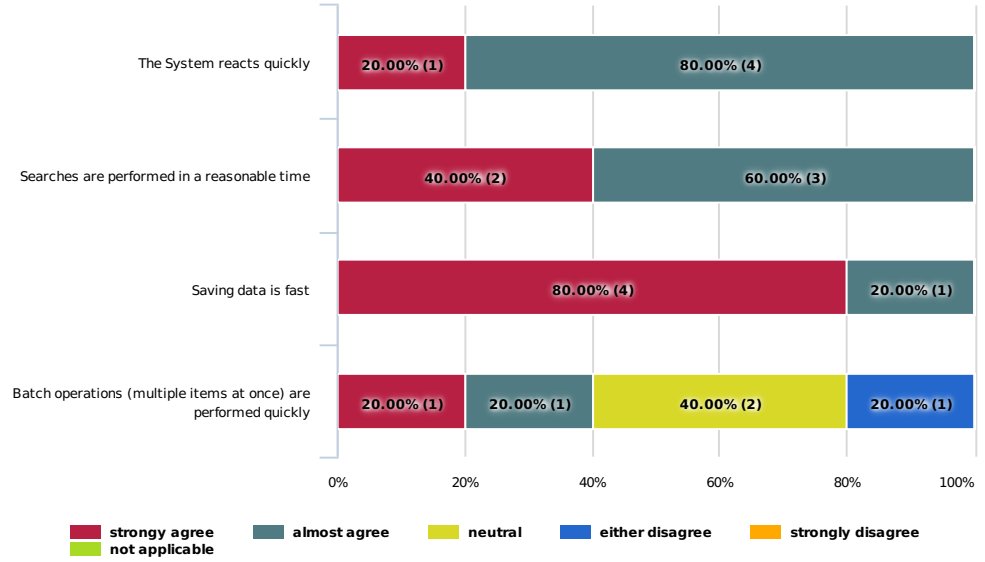
	very important		neutral		not important		ø	
Shortcuts are very useful	60.00%	*3*	20.00%	*1*	20.00%	*1*	**1.60**	*5*
Color-codings are very useful	20.00%	*1*	80.00%	*4*	0.00%	*0*	**1.80**	*5*
Dialog search is used heavily	100.00%	*5*	0.00%	*0*	0.00%	*0*	**1.00**	*5*
							1.47	

Remarks to the question	*0*
There are no text answers yet.	

18. Question page: User Experience – Performance
14. Question 5

In order to estimate whether WAMAS 5 performs in time and efficiently please address the statements:

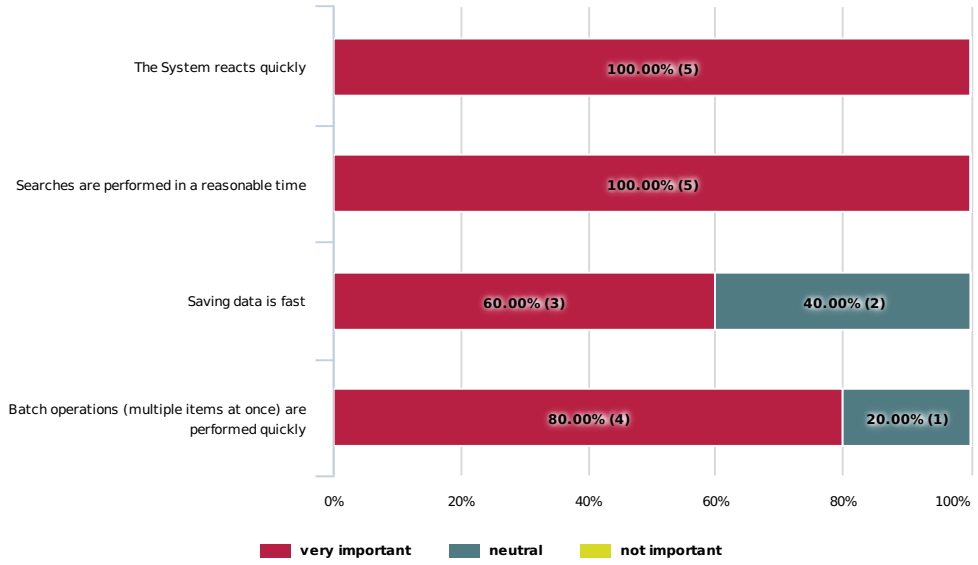
* exactly one answer for both ratings is required



	strongy agree	almost agree	neutral	either disagree	strongly disagree	not applicable	ø	
The System reacts quickly	20.00% 1	80.00% 4	0.00% 0	0.00% 0	0.00% 0	0.00% 0	**1.80**	5
Searches are performed in a reasonable time	40.00% 2	60.00% 3	0.00% 0	0.00% 0	0.00% 0	0.00% 0	**1.60**	5
Saving data is fast	80.00% 4	20.00% 1	0.00% 0	0.00% 0	0.00% 0	0.00% 0	**1.20**	5
Batch operations (multiple items at once) are performed quickly	20.00% 1	20.00% 1	40.00% 2	20.00% 1	0.00% 0	0.00% 0	**2.60**	5
							1.80	

In order to estimate whether WAMAS 5 performs in time and efficiently please address the statements:

Second ratings:



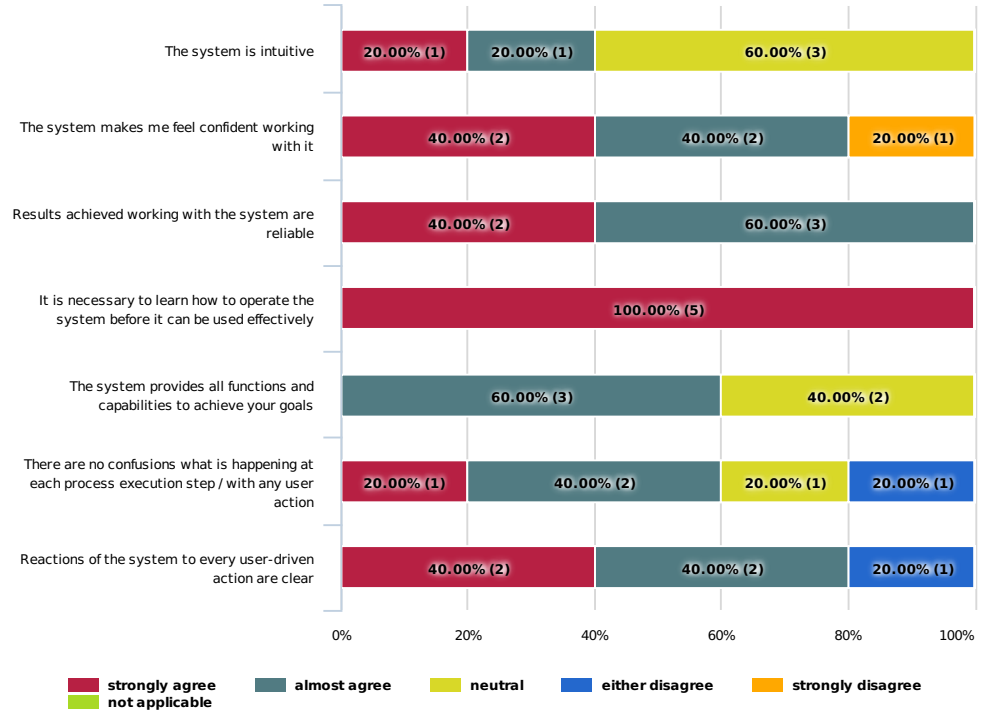
	very important		neutral		not important		ø	
The System reacts quickly	100.00%	*5*	0.00%	*0*	0.00%	*0*	**1.00**	*5*
Searches are performed in a reasonable time	100.00%	*5*	0.00%	*0*	0.00%	*0*	**1.00**	*5*
Saving data is fast	60.00%	*3*	40.00%	*2*	0.00%	*0*	**1.40**	*5*
Batch operations (multiple items at once) are performed quickly	80.00%	*4*	20.00%	*1*	0.00%	*0*	**1.20**	*5*
							1.15	

Remarks to the question	*0*
There are no text answers yet.	

20. Question page: General Questions
15. Question 5

Common feeling when solving tasks with the help of WAMAS 5:

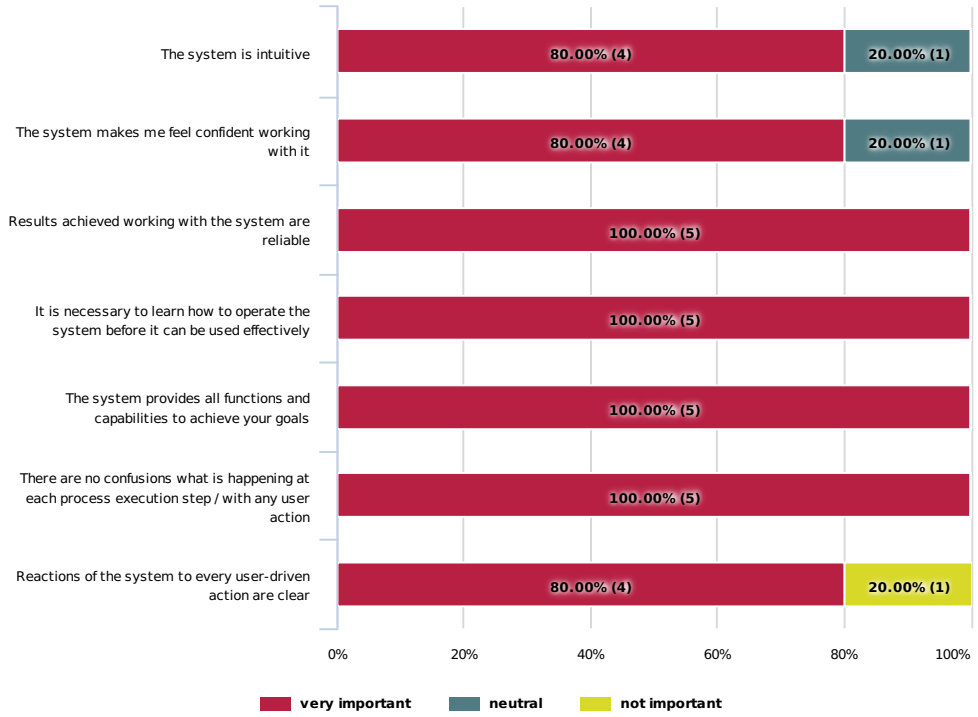
* exactly one answer for both ratings is required



	strongly agree	almost agree	neutral	either disagree	strongly disagree	not applicable	ø	
The system is intuitive	20.00% 1	20.00% 1	60.00% 3	0.00% 0	0.00% 0	0.00% 0	**2.40**	5
The system makes me feel confident working with it	40.00% 2	40.00% 2	0.00% 0	0.00% 0	20.00% 1	0.00% 0	**2.20**	5
Results achieved working with the system are reliable	40.00% 2	60.00% 3	0.00% 0	0.00% 0	0.00% 0	0.00% 0	**1.60**	5
It is necessary to learn how to operate the system before it can be used effectively	100.00% 5	0.00% 0	0.00% 0	0.00% 0	0.00% 0	0.00% 0	**1.00**	5
The system provides all functions and capabilities to achieve your goals	0.00% 0	60.00% 3	40.00% 2	0.00% 0	0.00% 0	0.00% 0	**2.40**	5
There are no confusions what is happening at each process execution step / with any user action	20.00% 1	40.00% 2	20.00% 1	20.00% 1	0.00% 0	0.00% 0	**2.40**	5
Reactions of the system to every user-driven action are clear	40.00% 2	40.00% 2	0.00% 0	20.00% 1	0.00% 0	0.00% 0	**2.00**	5
							2.00	

Common feeling when solving tasks with the help of WAMAS 5:

Second ratings:



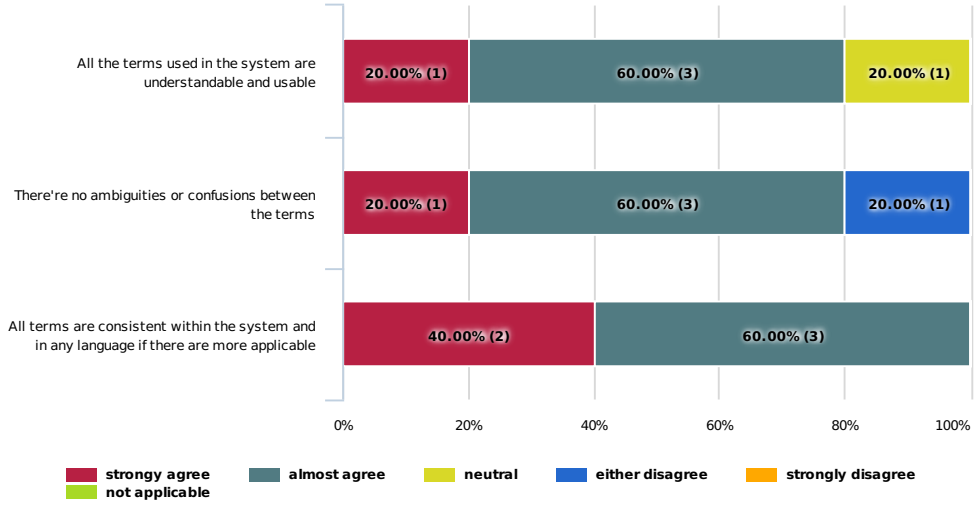
	very important		neutral		not important		ø	
The system is intuitive	80.00%	*4*	20.00%	*1*	0.00%	*0*	**1.20**	*5*
The system makes me feel confident working with it	80.00%	*4*	20.00%	*1*	0.00%	*0*	**1.20**	*5*
Results achieved working with the system are reliable	100.00%	*5*	0.00%	*0*	0.00%	*0*	**1.00**	*5*
It is necessary to learn how to operate the system before it can be used effectively	100.00%	*5*	0.00%	*0*	0.00%	*0*	**1.00**	*5*
The system provides all functions and capabilities to achieve your goals	100.00%	*5*	0.00%	*0*	0.00%	*0*	**1.00**	*5*
There are no confusions what is happening at each process execution step / with any user action	100.00%	*5*	0.00%	*0*	0.00%	*0*	**1.00**	*5*
Reactions of the system to every user-driven action are clear	80.00%	*4*	0.00%	*0*	20.00%	*1*	**1.40**	*5*
							1.11	

Remarks to the question	*0*
There are no text answers yet.	

21. Question page: General Questions
16. Question 5

Evaluation of the following statements will help to understand how well the terminology is used in WAMAS 5:

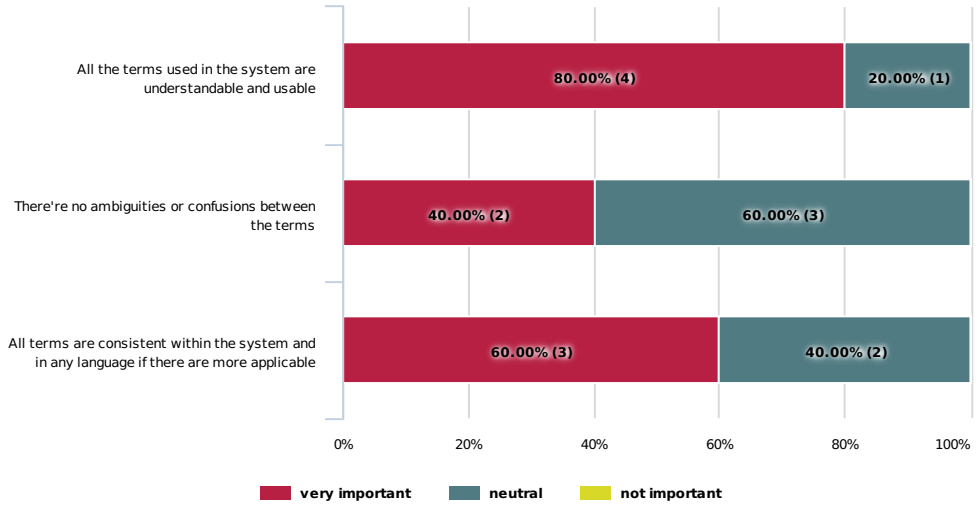
* exactly one answer for both ratings is required



	strongy agree	almost agree	neutral	either disagree	strongly disagree	not applicable	ø	
All the terms used in the system are understandable and usable	20.00% 1	60.00% 3	20.00% 1	0.00% 0	0.00% 0	0.00% 0	**2.00**	5
There\'re no ambiguities or confusions between the terms	20.00% 1	60.00% 3	0.00% 0	20.00% 1	0.00% 0	0.00% 0	**2.20**	5
All terms are consistent within the system and in any language if there are more applicable	40.00% 2	60.00% 3	0.00% 0	0.00% 0	0.00% 0	0.00% 0	**1.60**	5
							1.93	

Evaluation of the following statements will help to understand how well the terminology is used in WAMAS 5:

Second ratings:



	very important		neutral		not important		ø	
All the terms used in the system are understandable and usable	80.00%	*4*	20.00%	*1*	0.00%	*0*	**1.20**	*5*
There\'re no ambiguities or confusions between the terms	40.00%	*2*	60.00%	*3*	0.00%	*0*	**1.60**	*5*
All terms are consistent within the system and in any language if there are more applicable	60.00%	*3*	40.00%	*2*	0.00%	*0*	**1.40**	*5*
							1.40	

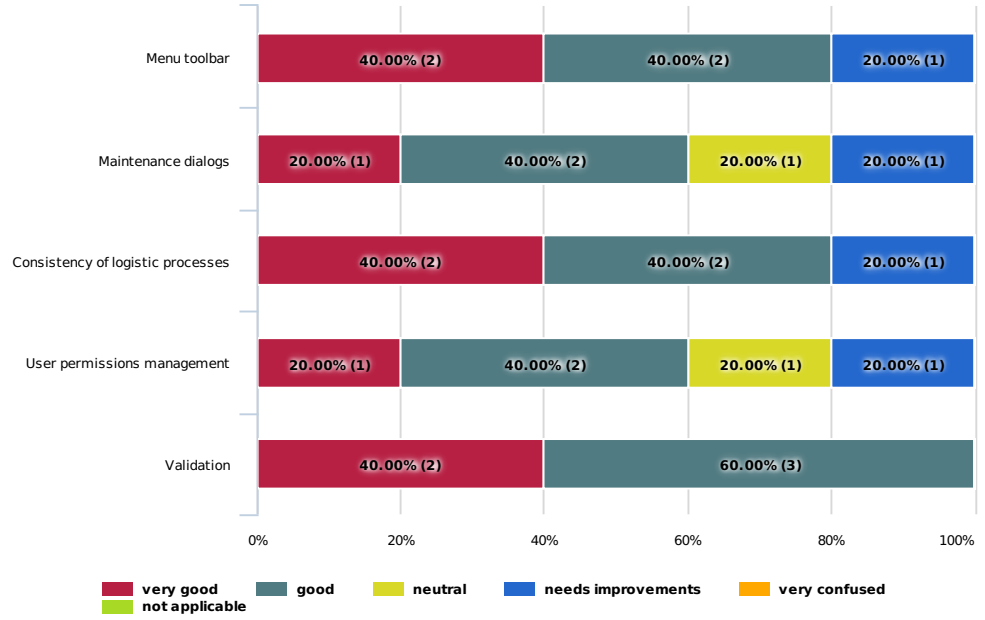
Remarks to the question *0*

There are no text answers yet.

22. Question page: General Questions
17. Question 5

Please rate the following areas:

* exactly one answer per line is required



	very good	good	neutral	needs improvements	very confused	not applicable	ø	
Menu toolbar	40.00% 2	40.00% 2	0.00% 0	20.00% 1	0.00% 0	0.00% 0	**2.00**	5
Maintenance dialogs	20.00% 1	40.00% 2	20.00% 1	20.00% 1	0.00% 0	0.00% 0	**2.40**	5
Consistency of logistic processes	40.00% 2	40.00% 2	0.00% 0	20.00% 1	0.00% 0	0.00% 0	**2.00**	5
User permissions management	20.00% 1	40.00% 2	20.00% 1	20.00% 1	0.00% 0	0.00% 0	**2.40**	5
Validation	40.00% 2	60.00% 3	0.00% 0	0.00% 0	0.00% 0	0.00% 0	**1.60**	5
							2.08	

Remarks to the question 1

user permissions: some permissions of superuser should be ablt to be defined also for "normal" users

23. Question page: General Questions
18. Question 1

Which areas could and should be improved from your perspective?

* optional survey input

_____	100.00% 1	

mass order creation (manually in system) should be improved
permission system should be imporoved (permissions from superuser should be made possible for other users per definition in um004)
online help is needed

1

24. Question page: And last but not the least…
19. Question

If there is still something it wasn\'t asked about or you just want to tell something, please do it here. Suggestions, feedback, and critical remarks are gladly accepted.

* optional survey input

This question has no answers.