A study into the usability of 3GPP technical specifications

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Thesis submitted for examination for the degree of Master of Science in Technology.

Espoo 28.7.2022

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Abstract of the master's thesis

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Title A study into the usability of 3GPP technical specifications

Degree programme ICT Innovation

Major Human-Computer Interaction and Design **Code of major** SCI3020

Supervisor Prof. Janne Lindqvist

Advisors M.Sc. Siddharth Rao, M.Sc. Gabriela Limonta

Date 28.7.2022 **Number of pages** 66+51 **Language** English

Abstract

Technical specifications are documents which provide detailed descriptions of technical requirements for a product, service, system or material. The Third Generation Partnership Project (3GPP) is a collaboration driven organisation which emits technical specifications for cellular telecommunications technologies.

This thesis aims to study the main usability issues of 3GPP technical specifications. It also investigates the prevalence of each of the usability issues identified. The research considers two user groups. The first group is that of specifications consumers, who use the technical specifications as part of their daily work tasks. The second is that of specifications producers, who contribute to the creation of the technical specifications. A mixed methods approach is used to answer the research question. Ten interviews are conducted, followed by a survey which over the course of two weeks received 85 responses.

The main contribution of this thesis is that it uses scientific research methods to study the usability of 3GPP technical specifications. 29 usability issues are identified from the interview data via an affinity diagram. A subsequent survey investigates the prevalence of each of these issues. The findings suggest that specification producers are mostly hindered by 3GPP governance processes which impact their work and productivity. Specification consumers are more affected by the contents of the actual technical specifications, highlighting pain points such as a lack of illustrations and difficulty understanding the contents of the documents.

Keywords usability, user research, technical specifications, 3GPP

Preface

I would like to thank Prof. Janne Lindqvist, my critical observer Dr. Bob Schadenberg and the whole Network Security team at Nokia Bell Labs for their continuous support, advice and guidance. I would like to especially thank my advisors M.Sc. Sid Rao and M.Sc. Gabriela Limonta who went above and beyond to support my academic development.

Finally, I would like to express my deepest gratitude to my parents, Corina and Adrian, and close friends, Karina, Maria and Vanessa, who constantly encouraged and supported me throughout an exciting and challenging time in my life.

Helsinki, 28.7.2022

Flavia-Denisa Veres

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Abbreviations

3G	3^{rd} Generation Cellular Communications Technology
3GPP	3^{rd} Generation Partnership Project
4G	4^{th} Generation Cellular Communications Technology
5G	5^{th} Generation Cellular Communications Technology
6G	6^{th} Generation Cellular Communications Technology
API	Application Programming Interface
CFA	Confirmatory Factor Analysis
CR	Change Request
CT	Core Network and Terminals
EFA	Exploratory Factor Analysis
GDPR	General Data Protection Regulation
IETF	Internet Engineering Task Force
IPR	Intellectual Property Rights
ISO	International Organisation for Standardisation
ITU	International Telecommunications Union
KPI	Key Performance Indicator
MTMM	Multitrait-Multimethod Matrix
PCG	Project Co-ordinator Group
PSSUQ	Post Study System Usability Questionnaire
R&D	Research and Development
RAN	Radio Access Network
SA	Service and Systems Aspects
SUMI	Software Usability Measurement Inventory
SUPR-Q	Standardized User Experience Percentile Rank
SUS	System Usability Scale
TR	Technical Report
TS	Technical Specification
TSG	Technical Specification Group
UMUX	Usability Metric for User Experience
WG	Working Group

1 Introduction

Technology has become a ubiquitous part of human lives. People currently enjoy a smooth usage of interconnected technologies, such as controlling home temperatures while commuting from work or seamlessly making calls and accessing the internet on mobile phones across the globe. This is possible due to a rich set of technical standards which mobile network operators and device manufacturers need to comply with, ensuring that everyday consumers can enjoy a satisfying experience when using devices or services.

Technical standards are defined as published documents which establish a norm via technical specifications, outlining best practices regarding product development, services, methods or materials [1]. The organisations that create the standards are called standards bodies. Some examples of global standards bodies are the International Telecommunications Union (ITU) [2] and the International Organisation for Standardisation (ISO) [3].

Technical specifications are a component of standards and provide a detailed description of the technical requirements of the product, service, system or material [4]. The 3^{rd} Generation Partnership Project (3GPP) [5] and the Internet Engineering Task Force (IETF) [6] are well known organisations which produce industry accepted specifications, however they are not official standards bodies.

The 3^{rd} Generation Partnership Project (3GPP) is a global partnership which brings together organisational partners to create reports and technical specifications for cellular telecommunications technologies. Nokia is a global telecommunications company which contributes significantly to 3GPP. Nokia is also funding and advising on this thesis, thus the following research will focus only on 3GPP technical specifications.

3GPP technical specifications tend to be very long documents. There are also a substantial number of technical specifications within 3GPP, as the organisation has been contributing to the evolution of telecommunications technologies since 1998. The length and volume of documents raises the question as to whether their usability is hindered.

1.1 Problem statement

3GPP technical specifications have a reputation for being convoluted. Furthermore, the contribution process to the specifications has its own complexities. It involves the cooperation and coordination of many parties which need to reach consensus in order for the technical specifications documents to be approved. The complexity of the process may be reflected in the technical specifications which may decrease their usability. This raises the need to evaluate the perceived usability of specifications and uncover their main areas in need of revision, as a first step towards addressing the challenge of improving them.

Perceived usability studies currently rely on widely used metrics such as the System Usability Scale (SUS) [7] [8]. However, using such a generic scale is not enough to study technical specifications. SUS, as well as other well known scales, do

not consider various other aspects that can affect usability, specific to this context. An example is the negotiations and compromises needed in a contribution based partnership project such as 3GPP. An alternative is to use surveys/questionnaires [9, 8] or interviews [10] of the researcher's choice, which can capture the desired dimensions specific to the context of use.

The motivation for the thesis came from a user centered security angle. The term user centered security was coined in 1996 by Zurko and Simon to mean "security models, methods, systems and software which have usability as the primary goal" [11]. It has now become a prolific field of study, bringing together several disciplines, such as human-computer interaction and cybersecurity. Previous work in this domain has focused either on documentation usability [12, 13, 14] or code usability [8, 9, 10]. These works and many others researched the usability of documentation, code or APIs to understand if they introduce unwanted security threats as a direct result of decreased usability. The main contribution of the thesis is that it takes a step back and attempts to address issues which arise from one level before the code and documentation, which is the technical specifications themselves. To the writer's knowledge, there are no other attempts at studying the usability of 3GPP technical specifications. The thesis will not evaluate the effects of the possible usability issues of the technical specifications, such as the possible introduction of bugs or security threats.

1.2 Thesis goals

This thesis aims to:

- **Create a usability evaluation tool tailored for technical specifications.** Having such a tool would help to evaluate 3GPP technical specifications across multiple organisations and guide future usability improvement efforts.
- **Evaluate the usability of 3GPP technical specifications.** Both the output documents and the process surrounding them will be considered when evaluating the usability of 3GPP technical specifications.

The research question posed is: ***What are the main usability issues current 3GPP technical specifications face?***. The related sub-research question is the following: ***What is the prevalence of each of the usability issues identified?***.

The research design uses mixed methods in order to answer the research questions. More specifically, a sequential exploratory strategy is adopted [15]. When using a sequential exploratory strategy, researchers collect and analyse qualitative data, and afterwards collect and analyse quantitative data [16]. The strategy is helpful when checking the findings from the qualitative study on a larger scale. In the case of this thesis, results from qualitative semi-structured interviews are used to inform the creation of a survey/questionnaire (quantitative data).

1.3 Scope and constraints

The study focuses on two main user groups (archetypes) in relation with the technical specifications: consumers and producers. The consumers are people who use or refer to technical specifications as part of their work. Example job titles include but are not limited to software architects, developers, testers, and technical product managers. The producers are 3GPP delegates. They are employees of 3GPP organisational partners authorised to represent the partner company in 3GPP meetings. The producers contribute to the creation of the technical specifications.

As previously stated, the thesis will only consider 3GPP technical specifications, however future work could investigate whether the conclusions from this work can be applied to other technical specifications.

In order to study the usability of 3GPP technical specifications, a first decision needed to be made regarding which definition of usability to use, according to the various ISO standards. The goal of this thesis is to evaluate the usability of technical specifications when they are used by people. This aligns best with standards of ergonomics in human system interaction (ISO 9241). The standard identifies effectiveness, efficiency and satisfaction as sub-dimensions of usability [17].

Furthermore, evaluating usability can be done using several methods (see subsection 2.3), however this thesis will use usability inquiry. Early informal research into the specifications domain revealed its complexity, thus it was clear that performing any sort of controlled tests (i.e., usability testing) would exclude important contextual factors which influence the usability of technical specifications. In addition, the thesis aims to understand people's opinions and points of view. As such, the best suited evaluation method is that of usability inquiry.

1.4 Thesis structure

The rest of this thesis is organized as follows. Section 2 presents background information on 3GPP as an organisation, defines usability and describes usability evaluation methods; Section 3 describes the initial direction for the thesis, presents the work done during this time and motivates why it was abandoned; Sections 4 and 6 describe each of the two research methods used (interviews and survey); Sections 5 and 7 describe the results of the conducted analysis for the data collected using each of the aforementioned methods; finally, Section 8 reflects on the work done and discusses future work, and Section 9 summarises the thesis and its findings.

2 Background

2.1 3GPP and technical specifications

This thesis will focus solely on 3GPP, thus the technical specification creation process described in this subsection will be specific to the 3^{rd} Generation Partnership Project.

3GPP structure

3GPP stands for 3^{rd} Generation Partnership Project and was founded in 1998 to produce *technical specifications (TS)* and *technical reports (TR)* for the 3G mobile network system. The difference between technical reports and technical specifications lies in the nature of the deliverable, with the technical reports containing informative elements whereas the technical specifications contain normative ones. With the evolution of technologies and consumer demands, 3GPP expanded their scope to include 4G and 5G work.

3GPP technical reports and technical specifications are contribution driven by member companies, developed in *working groups (WG)* and approved at the *technical specification group (TSG)* level. The working groups meet regularly and during the technical specification group plenary meeting, present their work for information, discussion and approval [5].

The Third Generation Partnership Project (3GPP) Working Procedures document [18] describes in detail the structure and working procedures of 3GPP, with Figure 1 showing an overview of the working structure of the organisation. These are also elaborated on in the following paragraphs.

The *Project Co-ordinator Group (PCG)* oversees the activities of each of the three technical specifications groups: *TSG RAN (Radio Access Network)*, *TSG SA (Service and Systems Aspects)*, *TSG CR (Core Network and Terminals)*. The PCG has responsibilities such as handling appeals, as well as proposing and approving modifications to working procedures. The technical specifications groups (TSGs) contain in their sub-ordinance 4 to 6 working groups, however more can be created or removed according to organisational needs. Their purpose is to prepare, approve and maintain the technical specifications and technical reports.

3GPP contains five types of participants: partners, individual members, ITU representatives, observers and guests. For a more detailed overview of the different participants please see Table 1. Organizational partners have the authority to publish standards within their designated jurisdictions based on the 3GPP agreed technical specifications. Here lies an important distinction between 3GPP and other standards setting bodies: 3GPP produces technical specifications. It is the standards bodies who then transpose them into standards.

Plenary meetings for each of the TSGs (RAN, SA and CT) occur quarterly, during one week. The last plenary meeting is that of the TSG SA, which is responsible for the overall coordination and monitoring of the technical work. Working group level meetings happen more regularly and the calendar for the meetings can be seen on the 3GPP website [20]. The chair of the group announces during each meeting that each 3GPP partner organization must declare any IPRs (Intellectual Property Rights)

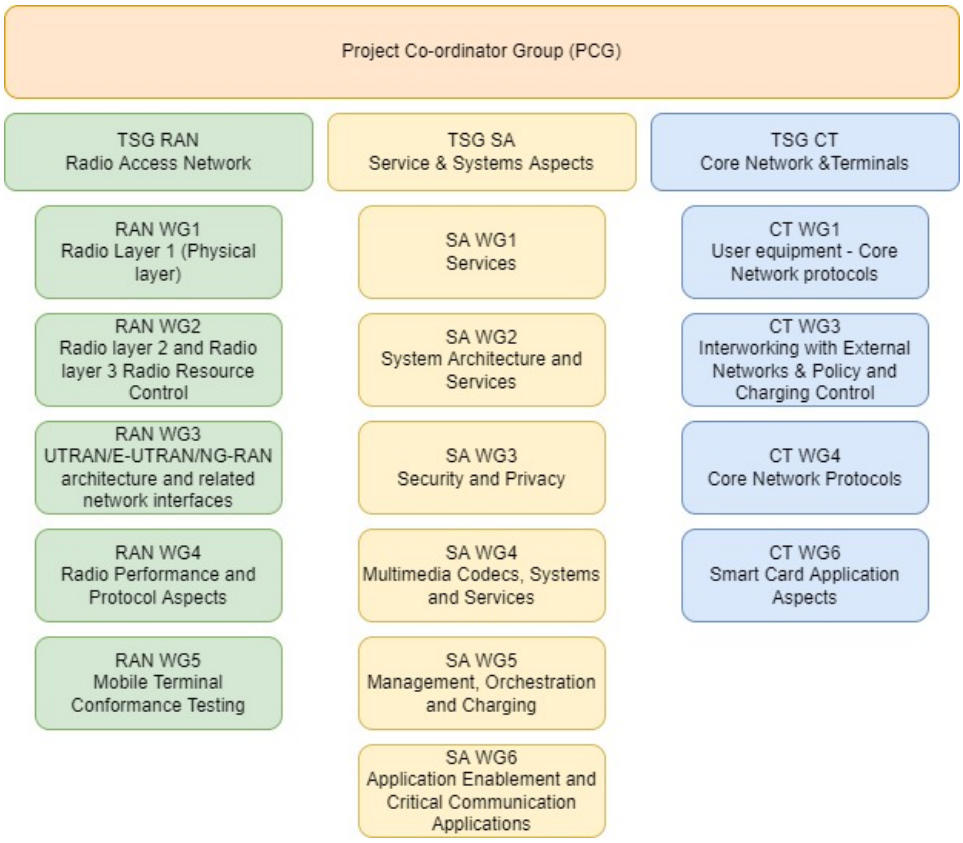


Figure 1: 3GPP technical specification groups as described in [19]

owned which are or will likely become essential to the work of 3GPP. Delegates must hence check if their organization or another owns these IPRs and notify the other organizational partners [20]. Once standards are created from the technical specifications, the standards bodies will be the ones responsible for enforcing IPR policies.

The specifications conception process

The inner workings of how specifications are produced and maintained are described in [21] and summarised below.

New specifications are created using a three step methodology, to which a step 0 and step 4 are often added but not compulsory.

- *Stage 0: A feasibility study is performed.*
- Stage 1: A high level service description is created from the user's point of view.
- Stage 2: The architectural view of the service is specified.
- Stage 3: The service is described in detail.

Table 1: 3GPP participants

Participant Title	Description
Organizational Partner	Any standards organization with capability and authority to define, publish and set standards within the 3GPP scope.
Market Representative Partner	Organisation which offers market advice and a consensus view of market requirements.
Individual Member	Member of an organizational partner which contributes to Technical Specification Groups and uses results of 3GPP work.
ITU Representative	International Telecommunication Union representative.
Observers	Entity which may become a future partner.
Guests	Entity which may become a future individual member.

- *Stage 4: Test specifications are created.*

Before the the feasibility study (Stage 0), outside 3GPP, individual members conduct R&D studies and develop a vision and concept which gets turned into a project proposal [22]. The project proposal is brought forward to 3GPP. If approved by the members during the plenary meetings, then the 3 to 5 stage process described above commences.

The feasibility report is done as part of a *study item*, which studies the feasibility of additional functionality, outputting a technical report. If the report concludes that the functionality is feasible, the new *features* defined as part of the feasibility study get further divided into *building blocks* and *work tasks*. Building blocks are sets of technical functionality usually residing in a single system element. Work tasks are self-contained, well-scoped and well-scheduled sub-divisions of building blocks. Work task outputs can be new or updated specifications, technical reports, or they can conclude that existing specifications already provide the needed functionality or support. All the aforementioned units (study items, features, building blocks and work tasks) are more generally referred to as *work items*.

The following paragraph will detail the work item model, giving the TSG SA as an example [21]. The TSG SA defines the features and services required in the 3GPP specification. SA WG1 will produce the Stage 1 feature requirements and pass them to SA WG2. They can also provide considerations regarding possible architecture and implementation, but it is not within their responsibilities or obligations. SA WG2 defines the architecture and divides features into building blocks. The latter are sent to relevant TSGs and comprising working groups where they are reviewed and discussed until a consensus on the required work is reached. SA WG2, in cooperation

with the TSGs and working groups, also needs to ensure there will be no overlap between the work carried out by working groups. Furthermore, they need to ensure the TSGs evaluate the potential impact of new features. The TSG SA, SA WG1 and SA WG2 are all responsible of ensuring SA WG3 is involved early enough that the security, service and architectural requirements are aligned and communicated.

New specifications are hence created in working groups. A rapporteur is appointed to create the first draft and following revisions, until the specification is deemed stable by the TSG and approved. The working group puts the draft under version control when they consider it is sufficiently stable, and move it to TSG change control. From this moment on, any changes to the specification need to be done with an official change request (CR) approved by the TSG. The TSG may "freeze" a specification, meaning that only essential CRs for correcting errors will be considered. They may also "close" a specification, which means that no more CRs will be considered. They may finally "withdraw" it if it deems that it is obsolete and keeping it available for reading confuses implementation.

Technical specifications are stored on the official 3GPP file servers accessible from the official 3GPP website. They are written in Microsoft Word and stored as .zip files. All previous versions are available to read and a history of changes is displayed, together with other relevant information such as the rapporteur and related technical specifications.

Parallel releases are used, which allows for developers to implement features using a stable set of specifications, whilst work on new functionality is ongoing in the subsequent releases. An illustration of this can be seen in Figure 2. In the figure, Release 17 freezes the work on Stage 3 documents in March 2022, whereas work on Release 18 is at a much earlier stage. Release 18's Stage 3 freeze is instead scheduled for December 2023. When the work is complete, the release is finalized, meaning that all containing features are frozen and ready to be implemented. A full release description is also written up. Furthermore, 3GPP provides a Specification Release Version Matrix [23] listing all the technical specifications and the release they belong to. A table of features by release number is also provided via the 3GPP Work Plan [24]. All 3GPP releases are backwards and forwards compatible, ensuring the smooth operation of existing user equipment, but contributing to the convolution of the actual technical specifications documents.

Each of the partner organisations (e.g., Nokia) holds internal briefings to inform interested parties of the changes incoming with the new releases. Architects are tasked with understanding them and alerting affected teams if the changes impact any of them. Team leads and technical product managers will be made aware of the changes and the technical specialists within each team will identify more in detail the scope of the impact and start appropriate mitigation procedures.

2.2 Usability definition

This thesis focuses on usability, which will be the construct of the survey under development. There are several definitions of usability which can be found in the International Organization for Standardization (ISO) standards. For the purpose of

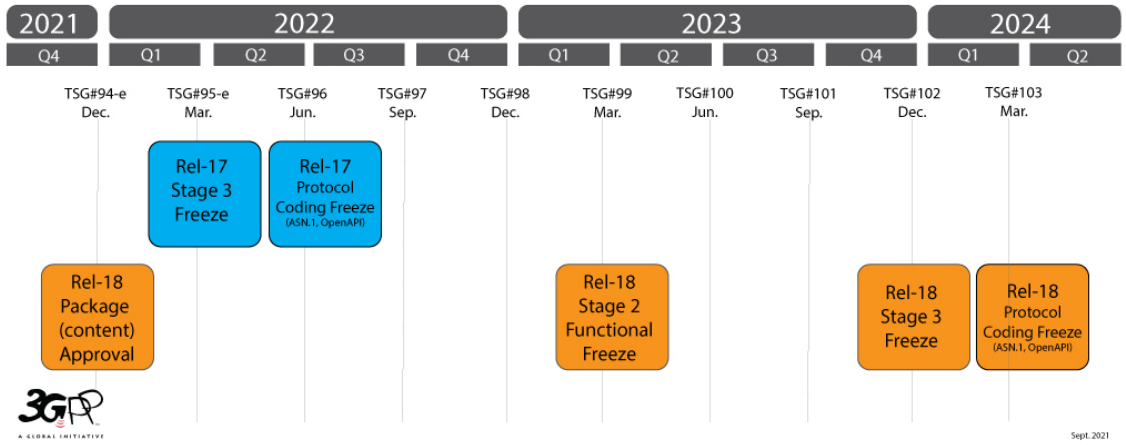


Figure 2: 3GPP release timeline [25]

this thesis, the definitions of usability found in ISO/IEC 9126 and ISO 9241 were used during the initial attempt at generating questions for the scale (see Appendix D). This was because the literature survey also referred to these two standards when defining usability. However, after further consideration, it was decided to go forward with the ISO 9241 definition. ISO 9241 concerns itself with ergonomics in human system interaction whereas ISO/IEC 9126 covers software engineering product quality. The former is more appropriate for this thesis, which aims to evaluate the usability of specification documents, focusing on the people who use them. Thus, for the final set of questions constructed for the survey in Subsection 6.2, only the ISO 9241 definition of usability was be used.

In the following paragraphs, more information is given on the two definitions of usability. Most notably, the sub-constructs of usability are presented according to the ISO 9241 standard.

ISO 9241-11 The ISO 9241 standards cover ergonomics of human system interaction and is composed of several parts, each covering a different area of the topic. For example, part 12 concerns presentation of information, part 14 menu dialogues, and part 11 covers usability: definitions and concepts. The ISO 9241-11:2018 standard defines usability as a function of effectiveness, efficiency and satisfaction [26, 17].

- **Effectiveness** refers to the ability of the user to achieve their tasks with accuracy and completeness;
- **Efficiency** refers to the ability of the user to achieve their tasks in a direct and timely manner;
- **Satisfaction** relates to the cognitive, emotional and physical responses the user has to the product (such as positive attitudes and emotions) [26, 27, 17, 28].

This definition has also been referred to as having the perspective of 'quality-in-use', because it accounts for the nature of the task performed as well as physical and social aspects connected to the product use [29].

ISO/IEC 9126 The ISO/IEC 9126-1:2001 was a standard which covered software engineering product quality. It defined usability as dependent on the software product's ability to be used, understood, liked and learned. This definition corresponds to the 'ease-of-use' perspective which stipulates that the comfort of use is strictly related to the traits of the characteristics of the product, i.e., usability is encapsulated by product quality [29]. This standard has been retired and replaced by ISO/IEC 25010:2011. ISO/IEC 25010 is not described as it was not used for this thesis.

2.3 Usability evaluation methods

Usability evaluation methods can be broken down into three major categories according to [30]: inquiry, testing and inspection. This thesis will use usability inquiry to evaluate the usability of 3GPP technical specifications. Usability inquiry is interested in user perspective and thoughts, and closely involves participants to understand their points of view. This approach is best suited for this thesis which aims to explore perceived usability issues with 3GPP technical specifications. All three evaluation methods will be presented in the following paragraphs.

Usability inquiry Usability inquiry involves uncovering user likes, dislikes, needs and more by talking to, surveying or observing users directly.

Some examples of usability inquiry methods are: questionnaires, surveys, interviews and focus groups. They also include using validated usability questionnaires such as the System Usability Scale [7].

Usability testing Usability testing is a usability evaluation method in which participants complete a series of predefined tasks whilst being observed by facilitators. In many cases, participants are asked to think aloud as they perform the tasks and they are evaluated using metrics like time on task or task success [31].

Some examples of usability testing methods are: lab studies, eye tracking and remote testing.

Usability inspection Usability inspection is a usability evaluation method in which experts evaluate a product or service using a specific set of criteria. This is a quick and inexpensive way to uncover obvious usability issues, however many issues may be missed and it is generally better to also involve end users in evaluation [31].

Some examples of usability inspection methods are: cognitive walkthroughs, heuristic evaluation and feature inspection.

Other usability evaluation methods Bevan and Petrie [32] also distinguish between user-based evaluation, and model- and system-based evaluation. The former

involves end users and they typically perform a task. The latter uses cognitive models which can predict metrics such as time to complete a task without having to recruit participants for the study. Bevan and Petrie [32], and Baxter et al. [31] also expand on user-based methods and differentiate between formative and summative methods. The former focus on user behaviour, intentions and expectations, and are used to shape design more often at the earlier stages of development. Examples include heuristic evaluation and cognitive walkthroughs. The later are performed towards the end of development and evaluate a product or service against a set of metrics, very often based on ISO 9241-11 principles. Examples include eye tracking and remote testing.

3 First Attempt at Developing a Generic User Scale for Evaluating Technical Specifications

This section describes the first attempt made at answering the research question. Only subsection 3.2.2 from this section is relevant for the final work and results for the thesis.

One of the initial aims of this research was to create a generic evaluation tool that could be used to evaluate the usability of any technical specification, regardless of the body that created it. A choice was made to construct a questionnaire (the artefact), drawing inspiration from other evaluation scales such as the System Usability Scale [7]. The questionnaire represented a reusable tool which could have be applied across companies and specifications to evaluate their usability. The flexibility of such a tool would have also allowed to quickly and easily evaluate the usability of technical specifications on a wide scale, providing a more comprehensive overview of the current state of the usability of technical specifications. The goals of the study were to be achieved using the results from the questionnaire, and the artefact evaluated using statistical analysis.

A more detailed description of the methodology to achieve the initial thesis aim follows in subsection 3.1. Subsection 3.2 describes in more detail the work achieved during this initial research direction, and finally 3.3 explains why the decision was made to abandon it.

3.1 Initial research methodology

A literature survey of prior research work involving creation of scales for measuring usability was conducted and used to create a new scale applied to technical specifications. In particular, the scale creation advice in Scaling Procedures from Netemeyer et al. [33] was central to planning the stages of the thesis. The main phases of scale creation described in the book were used to guide this work. The choice to follow the methodology from Scaling Procedures [33] was reinforced by past research into development of evaluation scales, which also used Netemeyer et al. to guide their methodology [34, 35].

The following paragraphs describe each of the phases needed to construct and test the new questionnaire, based on the Scaling Procedures [33] book. Figure 3 provides a visual overview of the scale development phases and informs whether each was completed for this thesis.

Phase 1: Construct definition and content domain Work started with semi-structured expert interviews to better define the target user groups and better understand the context of technical specifications. The user groups identified via internal company enquiry were specifications producers and specification consumers.

The second step was to arrange interviews with user groups (one representative per group and experience level) to better understand the specification consumer group composition and what their current issues and hindrances were when interacting with the technical specifications.

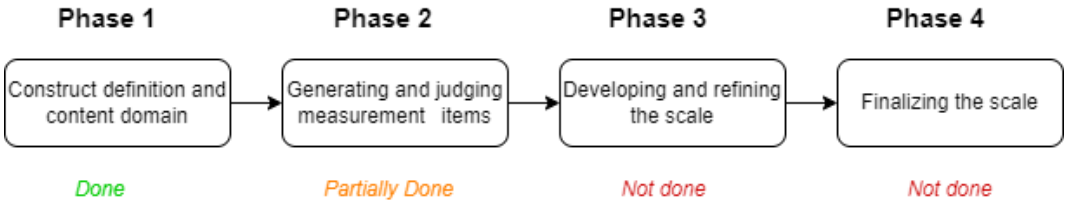


Figure 3: Scale creation phases as presented in [33]

In parallel, literature review and further internal company enquiry was used to define the measured construct (i.e., the ISO definition of usability) and the topics for the questionnaire. The analysed interview data would also feed into the topic development once it was ready. To start with, the following topics and sub-topics were used:

- Process (sub-topics: governance, contribution)
- Contents (sub-topics: technical specifications, presentation)
- Dissemination (sub-topics: distribution, access)

Phase 2: Generating and judging measurement items The second phase started by generating a large number of candidate questions, based on other popular usability questionnaires, adapted to the technical specifications context. In addition, new questions were to be constructed using the information from the interviews conducted in the previous phase. More information on how the questions were crafted can be found in subsection 3.2.1, and Appendix D lists all 188 questions created for this phase.

This phase would have been followed by a content and face validity check done by expert judges. Netemeyer et al. [33] suggest that a minimum of five expert judges need to be used to judge the specificity, clarity and representativeness of the questions. For the thesis, a combination of delegates, architects and human-computer interaction and design experts were to be used. Apart from the qualitative checks mentioned, a quantitative check was also added in the form of consensus amongst them. A small sample from the target user group should also have been used to check if the questions were understood, as part of an early stage pilot.

The feedback from the users and expert judges would have been used to prune the questions.

Phase 3: Developing and refining the scale This phase would have started with the survey being sent to the first group of users. Other studies such as that from Votipka et al. [34] and Faklaris et al. [35] show that anywhere from 120 users to 339 users respectively need to be reached in this phase. Netemeyer et al. [33] present several rules of thumb, such as having a minimum sample size of 100 to 200 or 300, or a sample size of 5 to 10 subjects per question.

The user response data would have been needed in order to perform various statistical checks as well as exploratory factor analysis (EFA) in order to prune the questionnaire further. Long questionnaires have a higher drop-out rate and increase fatigue, which is why this would have been a necessary step. A 'do not understand' answer option would have also been included, and questions with a high number of this response removed. The statistical checks that could have been performed include internal consistency checks via Cronbach's alpha, item-item correlations to evaluate the discriminant characteristics of each item, as well as ceiling and floor effects which help eliminate items with low response variance [34]. Finally, EFA would have been performed using software such as IBM's SPSS [36] over multiple sample sets, in order to prune the questionnaire and uncover any underlying dimensions, maximizing variance and reliability [33].

At the end of this phase, the questionnaire's size should have been further reduced.

Phase 4: Finalizing the scale In the final phase, the questionnaire would have been sent to a new population sample and the new results used to perform Confirmatory Factor Analysis (CFA), establishing that the underlying factor structure identified in the previous phase holds and is reliable. This phase would have pruned the questionnaire further should correlated measurement errors had been detected [33]. The sample sizes used in literature for this phase vary from 120 [34] to 479 [35].

Risks and backup The phases above involved many study subjects (hundreds for phases 3 and 4) which raised the risk of having high dropout rates, especially during the first versions of the questionnaire which would have had a high number of questions. As such, a mitigation plan was put into place, in which the research question of the study would be answered based on the interview data collected alone and the sub-research question dropped. A thorough qualitative study would have been conducted using thematic analysis. Specialized software (such as Atlas.ti [37]) would have been used to do the content analysis, after agreeing on a scheme to categorize answers. Inter-rater agreement would have also be calculated, using Cohen's kappa.

3.2 Work done during the initial direction

The study started by defining the construct and sub-constructs of the questionnaire under development. The construct was chosen to be usability, since the objective of the research was to measure usability of technical specifications. However, usability is made up of individual sub-constructs as described in section 2.2. At this point in the process, both the ISO 9241 and ISO/IEC 9126 definitions of usability were considered, since they were both used in the papers read during the literature review phase.

3.2.1 Generating questions

A total of 188 questions were generated based on five popular usability scales. Herbert et al. [38] and Votipka et al. [34] similarly also looked to popular existing frameworks when they generated the scale items in their work. Netemeyer et al. [33] also advocates for looking at theory and previous studies which dealt with the same construct as sources of information for the item generation phase. The number of questions is advised to be generous, with a focus on quantity not quality, in order to increase the likelihood of having covered relevant aspects of the desired construct [33]. Subsequent phases of the scale creation process would purge the number of questions until they are of a suitable length which would minimise the risk of drop-outs or fatigue. The questions were structured based on the topic and sub-topic they cover, the dimension they addressed (usability sub-construct), the name of the scale and the question number that was used to create the item. The questions can be seen in Appendix D and an excerpt in Table 2.

Table 2: Sample questions generated for the scale

Topic	Sub-Topic	Dimension ISO9241	Dimension ISO9126	Question	Inspiration	Q no.
Contents	Presentation	Satisfaction	Liked	The presentation of the technical specifications is pleasant.	PSSUQ	13
Dissemination	Access	Effectiveness	Liked	I found accessing the technical specifications unnecessarily complex.	SUS	2
Contents	Technical Specs	Effectiveness	Used	The contents of the technical specifications meet my requirements.	UMUX	1

The following paragraphs describe the usability scales which were used as sources for generating the questionnaire items.

UMUX The Usability Metric for User Experience [39] is a subjective metric to measure the usability of products, consisting of four Likert items. Each question corresponds to one component of usability as defined by the ISO 9241-11 standard (efficacy, effectiveness, satisfaction) plus one overall usability question.

SUS The System Usability Scale [7] is a widely used tool to measure system usability. It consists of 10 Likert items and uses the ISO 9241-11 definition of usability. The reason why this scale has remained very popular since its introduction in the 1970s is its ease of use, minimum effort, ability to compare usability across systems due to its generalised questions, and its ability to measure usability as perceived by users.

SUPR-Q The Standardized User Experience Percentile Rank Questionnaire [40] is an 8 item questionnaire which measures usability, trust, appearance, and loyalty and it is aimed at evaluating websites. The authors aimed to create a new measure which was generalizable, multidimensional, brief and normed (creates a database of usability scores for websites, making comparing them easier). In the context of this study, only the items related to usability were considered.

PSSUQ The Post Study System Usability Questionnaire was created at IBM and contains 18 (Version 1) [41], 19 (Version 2) [42] or 16 (Version 3) [43] items and is used to measure perceive satisfaction of a system. For this thesis, the latest version (3) of the questionnaire was used. The questionnaire also contains three sub-scales. Scoring questions 1 to 16 gives the overall usability score, questions 1 to 6 give the system usefulness score, questions 7 to 12 give the information quality score, and 13 to 15 the interface quality score.

SUMI The Software Usability Measurement Inventory (SUMI) [44] is a 50 item questionnaire aimed at assessing usability (using the ISO 9241 definition) of any software. Each question has three answer options: agree, undecided, disagree. It can be used to either compare two products (including versions or the same product), or to compare a product against an average score for state of the art products in the same category (stored in a maintained database). SUMI provides an overall usability score, as well as the scores of affect, efficiency, learnability, helpfulness and control.

3.2.2 Expert interviews

Two expert semi-structured interviews were conducted. Convenience sampling was used within Nokia to recruit the participants. The objectives of the interviews were:

- to better understand who the main producers and consumers of technical specifications are at Nokia
- to better understand the whole technical specifications creation process within 3GPP

These goals were used to focus the creation of the interview questions during a brainstorming session with the two thesis advisors who also acted as supervising researchers. The interview script can be found in Appendix A. The script had minor changes after the first interview, as the questions about governance were not

understood. This could have been avoided with a pilot of the interview, but due to time constraints, a pilot of the script was not done.

The interviews were conducted using Microsoft Teams. They were recorded and a transcript was generated. Both actions used the tool's inbuilt functionality. The auto-transcribed text contained many mistakes and it had to be manually cleaned using the audio recordings. All rules regarding GDPR were followed and non-disclosure agreements were put into place. The participants also received information sheets about the experiment and a consent form to sign. The consent form included a section on agreeing to being recorded and a date by which the data would be destroyed. Each interview had an interviewer and two note takers who also acted as observers. One of the three would also be responsible of ensuring the session was being recorded and automatically transcribed using the video conferencing tool. The observers also asked questions when they required further clarifications.

A debriefing session was held after each of the interviews during which notes were compared, the interview flow was discussed, together with the questions themselves and the information they elicited. The two interviews highlighted the complexity of the technical specifications process and revealed some clear and strong pain points.

No further analysis was done at this stage. However, the interview data contained information on usability issues which came up naturally during the conversation flow. Hence, the expert interviews were included in the affinity diagram exercise described in Section 4.3.

3.3 The pivot

The initial goal of the thesis was to create one measurement tool to compare and quantify the usability of technical specifications. This was an ambitious goal which was deemed achievable at the start of the research. However, after the expert interviews revealed the intricacies of the problem space, it was clearly not going to be reached within the allocated time. In 3GPP, decisions rely on cooperation, agreement and negotiations between partners, adding an extra layer of complexity to the process. Each partner has their own business agendas, such as to include their own patents in the specifications, which contributes to the convolution the documents. Furthermore, some of the features in the specifications never actually get implemented. It thus became clear that it would be more beneficial for this thesis to focus on understanding the 3GPP specific usability issues related to contributing to and using the technical specifications. With targeted and more granular data on where the problems lie, Nokia may use their advantageous position within 3GPP to guide the creation of more usable future specifications.

As such, the new goal was to instead create a more granular tool to discover usability issues in 3GPP technical specifications processes and contents, as well as possible causes and effects. This new goal further constrained the application domain (from technical specifications to 3GPP technical specifications), but also attempted to narrow the scope of the created artefact compared to a generic scale. The new thesis goal would be achieved by collecting information from the targeted user groups and using it to create a survey which would ask a much wider sample to provide

input on whether they have similar issues in the same areas.

The next steps were then to revisit the research methodology and consider if any of the work done thus far could be reused. The data from the expert interviews was the only one that was reused, since it not only provided useful information regarding the target user groups, but it also included usability pain points. The following sections describe the new research methodology and results.

4 Method 1: Interviews

A series of interviews were conducted in order to explore what pain points the two user groups, producers and consumers, face which impede their work. Organising focus groups was considered since it would have sped up the process, however there was a considerable threat of not getting honest answers due to being in the presence of colleagues from other teams (social desirability bias).

This choice of research method was supported by the work of Netemeyer et al. [33]. They suggest looking at the future respondents of a questionnaire as a source of information regarding the contents of the questions, which increases face validity. They go on to give Bearden et al. [45] and Lastovicka et al. [46] as literature examples of scales developed using this technique, with both studies having used exploratory interviews with population sub-samples prior to the item generation phase. Beyond face validity, the subjects can also help with question wording expectations and comprehension, as well as possible response formats for the questions.

4.1 Participants

A total of 8 semi-structured interviews were conducted, of which 2 were 3GPP specifications delegates (specification producers), 2 were architects (specification consumers), 2 were technical project managers (specification consumers) and 2 technical leads (specification consumers). Convenience stratified sampling and snowball sampling were used. Stratified sampling was necessary because this thesis considers two distinct groups of users, that of specification producers and specification consumers. The interview scripts for each user type can be found in Appendices B and C.

4.2 Procedure

The questions were generated following a brainstorming session with the Nokia advisors and based on the points highlighted during the expert interviews. At all times during the generation of the interview questions, the goals of the interviews were kept in mind, which were to further clarify the subjects' extent of involvement with 3GPP technical specifications and to identify their related pain points. During the write-up process for the questions, several guiding points from Baxter et al.'s [31] chapter on interviewing were considered:

- Brevity: Questions were kept short.
- Clarity: Double-barreled, double-negative and vague questions were avoided.
- Bias: Leading, loaded questions and interview prestige bias were avoided.
- Predicting the future: Questions asked participants to talk about past experiences, not the future.
- Inaccessible topics: Interviewees were told at the beginning of the interview as well as before some of the questions when deemed necessary that they were

not being tested and that they could freely say if they did not have experience with something or an opinion on it.

The questions were not tested prior to the interview. The interviews were conducted using Microsoft Teams, as with the expert interviews. Similarly, they were recorded and transcribed using the inbuilt functionality, with manual corrections done to the transcripts where they were incorrect or incomplete. All rules regarding GDPR were followed and non-disclosure agreements were put into place as before, with information sheets and consent forms distributed. During each interview, there was one interviewer and one to two note takers who also acted as observers. The observers also interjected with questions of their own when necessary, adhering to the aforementioned rules for the questions. One of the note takers also ensured the session was being recorded. Debriefing sessions were held with the interviewer and note takers after each interview.

4.3 Analysis

As previously mentioned in subsection 3.2.2, the expert interviews data and user group targeted interviews data was analysed simultaneously. Data analysis was done using an affinity diagram, which is a method of quick qualitative data analysis in which similar concepts are grouped together and themes and patterns from the data are identified [31].

Creating an affinity diagram involves the entire research team (three people in this case), with each researcher going through all the interview data, selecting key quotes, and writing them down on sticky notes. The notes are shuffled and placed on a whiteboard, with similar findings grouped together. This provides a visual form to identify trends in the data, with themes naturally emerging from the groupings [31]. A key consideration when using affinity diagrams is to not have any preconceived themes that the data must fit into, and labels should only be put on the emerging themes at the end of the process. Their common traits would give the label name.

This data analysis technique was chosen for several reasons [31]:

- It is rather fast to perform the analysis.
- It can structure a complex issue, breaking it down into composing categories.
- It highlights issues which cut across multiple categories.
- By using direct user data (such as quotes), it provides traceability to conclusions and decisions made.
- By creating categories of issues, the researchers can address these broader themes rather than focusing on the individual composing issues.
- Fosters innovation and creativity due to lack of a priori categories.

- The whole team is involved in the process and agrees on the outcomes of the analysis. Having multiple points of view reduces any personal biases each of the members may have.

There are a few ground rules to this exercise that Baxter et al. [31] draws attention to and which were followed:

1. Everyone has an equal say in the process.
2. There should be no criticism of ideas.
3. There should be no a priori categories for the data.
4. The groupings can be merged or further broken down as needed.
5. The sticky notes can be duplicated and added to multiple groups.
6. The sticky notes or groups can be moved as needed.

The analysis process took the team of two researchers a total of two days. This time does not include preparing the notes. The third researcher could not participate due to scheduling conflicts. The exercise took place in physical form and pieces of paper (en lieu to sticky notes) with quotes or key summaries extracted from the interview data used. Only semantic information was used, no latent codes were extracted at this point in the analysis. Several iterations over the categories were made and categories changed several times until the researchers agreed on their final form. Over 40 categories were identified during the exercise. They can be seen in Table 3.

Appendix E includes pictures of some of the categories extracted during the affinity diagram exercise. The different colours used for the paper notes are to distinguish between different participants. Their identity is not important, but it may be useful to follow a participant's experience across the various categories which were formed. Furthermore, it was also important to see if one or more categories were formed from the comments of only one person or people who represent the same archetype.

5 Results: Interviews

This section will present the results of the interview data analysis using an affinity diagram.

Affinity diagram results

Table 3 encloses all the categories which were identified during the affinity diagram exercise. 32 categories are usability related, out of which 29 represent usability issues, 3 are non-issues, and a further 17 categories are non-usability related. These latter 17 categories were omitted for the rest of the thesis since they did not support in answering the research or sub-research question. They can be seen in Table 3 coloured in pink. The reader will also notice that there is a general discard category. The information in this category is related to general facts about the specifications documents which was not useful for this study. For example, a technical specification document cannot be standardized while it has an editors note.

Table 3: The list of 32 usability related categories (29 issues; 3 non-issues coloured green) and 17 omitted non-usability related categories (in pink) identified in the affinity diagram

Compliance with standards	Document length	Information spread across multiple specifications	Too many specifications and standards bodies
Amount of contributions	Understandability	Personal contacts/knowing the right people	E-meetings impede progress
Intellectual Property Rights (IPRs)	Competition	Quality (degradation)	Not everything is implemented
Interplay between IPRs and Quality	Interplay between IPRs and Competition	Interplay between Quality and Competition	Interplay between IPRs, Competition and Quality
Vague language in technical specifications	Predicting the future	Lack of supporting information	Delay between 3GPP work and implementation
Side channel negotiations	Consensus is hard	Compromise	Lower quality specifications
Collaborating with other 3GPP working groups	Too many emails	Learning about 3GPP	Time and resource constraints
Information sharing: Proactive/ad-hoc	Information sharing: Meetings	Information sharing: Document updates	Information sharing: Challenges

Interaction between product, delegates and research (feedback)	Delegate goals	Who pays for features	Don't mind/used to/familiar with 3GPP format/ ways of working due to experience
Quality control process	Documents and structure	Deciding on priority of 3GPP work implementation	Facts about 3GPP process
Product side employees overworked and have no time for specifications	Independent interaction with vendors and/or customers (outside 3GPP)	3GPP works at the end of the day	Teams need to refer back to specifications
Technology managers and their team	Role of specification teams	Accessing the specifications	Target audience
Discard pile			

The research question posed in Subsection 1.2 was *'What are the main usability issues current 3GPP technical specifications face?'*. The following list compiles all the usability issues identified in the interviews. It also elaborates on the meaning behind each category name and specifies the usability sub-construct(s) it touches on.

1. Compliance with standards: Checking compliance with the standards and specifications is a manual process that takes time to complete. Aspects such as small changes in very large documents makes it time consuming to check compliance with products as every new standard arrives. (*Efficiency*)

2. Too many specifications and standards bodies: Relates to the previous category. Manually checking several specifications from different specification issuing bodies which often will be similar but with different wording and structure is time consuming and inefficient. (*Efficiency*)

3. Information spread across multiple specifications: Many times, the necessary background information for a feature is found scattered across many different technical specifications. Tracing back this information across specifications is time consuming. (*Efficiency*)

4. IPRs, Competition and Quality (and combinations thereof): The high competition between members of the 3GPP organisation and the high pressure of producing IPR backed contributions to the specifications degrades the quality of the documents (due to compromising). It also creates a tense working environment. (*Effectiveness, Satisfaction*)

5. Compromise: Related to the previous category. In order to reach consensus and approve a specification document, compromise is needed. This can come in the form of introducing several solutions for the same problem (proposed by different companies) which increases the size of the document and decreases its readability. (*Effectiveness, Efficiency*)

6. Consensus is hard: Related to the previous two categories. Since 3GPP works based on consensus between participating organisations agreeing on the final form of a specification, but each company has their own interests, it makes the process of reaching consensus difficult and long. Having a long consensus negotiating process impacts the release time of the specification and the quality of the information that gets added. (*Efficiency*)

7. Side channel negotiations: A big byproduct of having a consensus based organisation is the political implications and lobbying that happens in order for companies to get their IPR backed contributions in a specification. (*Satisfaction*)

8. E-meetings impede progress: Online meetings raise logistical challenges (e.g., timezone differences) which make progress during these meetings slower. (*Efficiency*)

9. Collaborating with other 3GPP working groups: Collaborating with other working groups is a slow process and interviewees reported avoiding it when possible. (*Efficiency, Satisfaction*)

10. Lack of supporting information: Lack of illustrations, figures or background information make understanding the specifications a longer task. (*Efficiency, Satisfaction*)

11. Delay between 3GPP work and implementation: Implementation works with specification releases that can be 3 to 4 years old, which means that there is a required context switch for specification consumers who advise delegates on current specification proposals. Furthermore, delegates will also have a difficult time to find available resources to be assigned to help them with current feasibility studies, jeopardising work completion. (*Effectiveness, Efficiency*)

12. Not everything is implemented: Since many solutions are included in the specifications for the same problem and also many times the specifications are made for emerging technologies, some of the features specified never get implemented. This unnecessarily dilates the size of the document decreasing its readability. (*Effectiveness, Efficiency*)

13. Lower quality specifications: Many of the interviewees reported a decrease in the quality of the specifications compared to its earlier 3G versions. (*Satisfaction*)

14. Learning about 3GPP: None of the interviewees reported ever going to official 3GPP documentation to learn about its working procedures. They rely entirely on internal documentation and learning through practice. (*Satisfaction*)

15. Personal contacts/knowing the right people: Interviews revealed that many people, both specification consumers and producers, rely on other colleagues in order to accomplish their 3GPP related work tasks. (*Effectiveness*)

16. Information sharing - Challenges: Some internal update meetings can be missed due to time constraints, which leads to communication and information gaps that can impact product development and decision making. (*Effectiveness, Efficiency*)

17. Understandability: The specifications are very technical documents and it can sometimes be hard to read or understand them. This means sometimes seeking the help of more technically skilled colleagues. (*Effectiveness, Efficiency, Satisfaction*)

18. Predicting the future: Working on the cutting edge of technology involves teams making predictions on where the industry and the specifications are headed in the future. However, these predictions are not always correct, and sometimes product teams need to make fixes once the specification documents are issued, inducing a financial and time cost. (*Effectiveness, Efficiency*)

19. Vague language in technical specifications: The language of the specifications is intentionally vague at places to allow each of the telecommunications companies to introduce implementation differences which would give them a competitive advantage in the market. However, this comes at the price of making the documents less clear. (*Effectiveness, Efficiency, Satisfaction*)

20. Time and resource constraints: Both specification consumers and producers are faced with time and resource constraints which affect the work they need to do for the 3GPP specifications. (*Effectiveness, Efficiency*)

21. Document length: Techincal specification documents tend to be very long which makes finding specific information as well as navigation harder and time consuming. (*Efficiency, Satisfaction*)

22. Too many emails: One significant quote is that "you can generate around 2500 emails" within two weeks. This makes it time consuming to stay updated and it increases the chances of missing important information. (*Efficiency, Satisfaction*)

The analysis also identified some categories which indicated that there were areas with no issues. These can be seen in Table 3 coloured in green. They are:

1. Don't mind/used to/familiar with 3GPP format/ways of working due to experience: Many interviewees reported that they were used to the processes and ways of working within 3GPP.

2. 3GPP works at the end of the day: This is a direct quote from one interviewee, talking about how despite its issues and areas of needed improvement, 3GPP

works and delivers specifications that are used across the telecommunications industry.

3. Accessing the specifications: During the initial phases of the thesis, accessing the specifications was included as a sub-topic for the scale which was being developed. However, the interviews showed that none of the interviewees had an issue with this.

Summary

A list of 29 usability issues were identified in the interview data via the affinity diagram exercise. The majority of these issues are efficiency related, having an impact on the users' time spent achieving their work tasks. For specification producers, the majority of issues are related to 3GPP processes and politics, such as the heavy focus on patents which creates a highly competitive environment that impedes collaboration. For specification consumers, the issues are more punctual to the contents of the 3GPP technical specification documents, which tend to be harder to read due not only to the complicated technical features they describe, but also to vague language, lack of background information and information not being centralised.

Overall, both groups reported time and resource constrains which make their work harder. The constraints stem from internal sources, such as lack of people available to work on 3GPP tasks, but also from 3GPP and industry pressures caused by a substantial increase in the volume of specifications. Furthermore, both user groups rely on their colleagues when accomplishing many 3GPP related tasks, making the collaboration process within each 3GPP partner company equally important to the collaboration at 3GPP level between the partner companies.

6 Method 2: Survey

Baxter et al. [31] describe how a well designed survey can be used to track user pain points, likes and dislikes on a wide scale. This was a perfect fit for the needs of this thesis, which aimed to confirm whether the usability challenges identified during the interviews resonated on a wider scale in the telecommunications industry.

6.1 Participants

Sampling The survey was distributed internally to Nokia employees, using simple random sampling. Internal mailing lists and Microsoft Yammer groups were used to reach as many relevant participants as possible (i.e., 3GPP technical specifications producers and consumers).

Targeted number of respondents The total number of people within Nokia who work with 3GPP technical specifications as consumers is hard to determine. This is because only a few job roles (e.g., architects) need to access 3GPP technical specifications consistently as part of their work. Others, in development or testing for example, may or may not need to ever open a technical specification. This latter sub-category of consumers usually adhere to a set of requirements which was already produced internally by another colleague or team at Nokia, and would only need to access the specifications in very specific cases (e.g., to check a formula).

That being said, an estimate of the consumer population size can be made based on an internal mailing list. The mailing list contains the email addresses of all those who are involved in the creation and dissemination of new 3GPP specifications for 5G and beyond. There are a total of 712 names on the list, thus the total population size for consumers and producers was estimated to be 712, with 115 producers and 597 consumers. The producers number was extracted from a list of Nokia delegates for 3GPP.

The thesis will not make any claims at obtaining statistically significant results [31] since it estimates the population size. However, it was deemed important to at least set some targets for the number of respondents needed to raise confidence in the results. It is also important to note a distinction is made between producers and consumers because not all questions are common for the two user archetypes (see more in subsection 6.2).

The sample size was computed using Cochran's formula with the correction made for finite sample sizes [47]. Usually a 95% confidence level is used with a marginal error of 5% [48]. This would give a minimum sample size of 89 specification producers and 234 specification consumers. However, as there was a clear difficulty in getting enough respondents for the survey, both the confidence level and marginal error were lowered to 80% and 10% respectively. This brings down the minimum desired sample sizes to 31 specification producers and 39 specification consumers.

6.2 Procedure

Questions Two surveys were created, one for each user group (specification consumer and producer). This was due to some questions being either irrelevant or difficult to answer for the other user group. For example, a delegate knows more about the governance and politics that are involved when working with specifications, but an architect may be shielded from those aspects and only get involved once a document is in Stage 3, i.e., the implementation details specifications document. The two surveys can be viewed in Appendix F and Appendix G. Open ended questions were avoided and no sensitive topics were touched upon in the questions.

The response format varies. There are several multiple choice questions, from which the respondent must select one or more answers. To combat any primacy effect (tendency to pick one of the first answers [31]), the order of the options is shuffled for each respondent. There are also several Likert scale questions using a bipolar 5-point rating scale. Each of the options is labeled.

The questions themselves were generated based on the categories identified in the affinity diagram analysis of the interview data. The first step was to list each of these categories and the most relevant quotes enclosed. At this stage, there were still too many categories and it would have made for too long of a survey to simply ask the participant about whether they agreed that each category represented a usability issue. Through several iterations, the categories were condensed where there was a common theme, and others, such as "not everything is implemented", were turned into a response option for more general usability question (e.g., the users' satisfaction with the quality of the standards). This was done because the supporting quotes for some categories identified in the interviews analysis did not have as many or as varied supporting arguments as others. Please see the affinity diagram categories and corresponding survey questions listed in Table 4.

Table 4: Affinity diagram categories and corresponding survey questions

Affinity Diagram Category	Associated Survey Question(s)
Compliance with standards	I find checking for product compliance with 3GPP technical specifications time consuming
Too many specifications and standards bodies	I find checking for product compliance with 3GPP technical specifications time consuming
Information spread across multiple specifications	I spend a lot of time finding the information I need in the 3GPP technical specifications

IPRs, Competition and Quality (and combinations thereof)	I believe that the effectiveness of the current 3GPP collaboration process can be improved; I believe that the efficiency of the current 3GPP collaboration process can be improved
Consensus is hard	Reaching consensus in a 3GPP meeting can be a time-consuming task
E-meetings impede progress	I find negotiating is more efficient when done face to face
Collaborating with other 3GPP working groups	I find it cumbersome to coordinate with other work groups in 3GPP
Lack of supporting information	I prefer having figures in 3GPP technical specifications
Delay between 3GPP work and implementation	The delay between 3GPP work and implementation has caused issues in my work
Predicting the future	The delay between 3GPP work and implementation has caused issues in my work
Not everything is implemented	Select all the reasons for choosing the level of satisfaction *(included as one of the answer options)*
Lower quality specifications	The quality of the 3GPP technical specifications has decreased in recent years; How satisfied are you with the quality of 3GPP technical specifications; I believe the current 3GPP technical specifications quality assurance process is insufficient
Compromise	Select all the reasons why reaching consensus in a 3GPP meeting can be a time-consuming task. *(included as one of the answer options)*
Learning about 3GPP	How frequently do you refer to the official 3GPP training and guidelines
Personal contacts/knowing the right people	How difficult is it to find the people needed to accomplish tasks related to 3GPP technical specification
Information sharing - Challenges	I find the information sharing process between me and 3GPP delegates to be effective; I find the information sharing process between me and 3GPP delegates to be efficient

Understandability	I find the 3GPP technical specifications hard to read and/or understand
Vague language in technical specifications	The language of the 3GPP technical specifications is vague
Time and resource constraints	I sometimes find it hard to accomplish tasks that involve referring to 3GPP technical specifications; I find the process of staying up to date with the latest 3GPP technical specifications overwhelming
Side channel negotiations	Select all the reasons why reaching consensus in a 3GPP meeting can be a time-consuming task. *(included as one of the answer options)*
Document length	I believe the 3GPP technical specifications documents are too long
Too many emails	I find that 3GPP communications generate too many emails

Table 5 illustrates each of the usability questions created, the usability sub-construct it touches on, the answer options and the user archetype it is addressed to. Each question has a follow-up question depending on the answer given. The role of these follow-up questions is to better understand the source of the issue identified in the question. Please see an example in Figure 4 which shows both the main usability question (about the effectiveness of the collaboration process) and the follow-up related question. All the options for the follow-up questions were extracted from the interviews. These questions also contain an 'other' option. This complicates the analysis process for the survey because it now includes qualitative data, but it was deemed more important to ensure that a complete picture of the motivations and sources of usability issues is obtained from the larger survey population. Each question also displays help text with the definitions of *effectiveness* and *efficiency* whenever they are mentioned (see Figure 4).

Table 5: Survey questions

User Archetype	Sub-construct	Question	Options
Producer	Effectiveness	I sometimes find it hard to accomplish my tasks related to 3GPP technical specifications	5-Point scale (Strongly disagree to Strongly agree)
Both	Satisfaction	I believe the 3GPP technical specifications documents are too long	5-Point scale (Strongly disagree to Strongly agree)

Both	Efficiency	I spend a lot of time finding the information I need in the 3GPP technical specifications	5-Point scale (Strongly disagree to Strongly agree)
Both	Satisfaction	I believe the current 3GPP technical specifications quality assurance process is insufficient	5-Point scale (Strongly disagree to Strongly agree)
Both	Satisfaction	The quality of the 3GPP technical specifications has decreased in recent years	5-Point scale (Strongly disagree to Strongly agree)
Both	Satisfaction	How frequently do you refer to the official 3GPP training and guidelines	5-Point scale (Never to Always)
Producers	Effectiveness	I believe that the effectiveness of the current 3GPP collaboration process can be improved	5-Point scale (Strongly disagree to Strongly agree)
Producers	Efficiency	I believe that the efficiency of the current 3GPP collaboration process can be improved	5-Point scale (Strongly disagree to Strongly agree)
Producers	Efficiency	Reaching consensus in a 3GPP meeting can be a time-consuming task	5-Point scale (Strongly disagree to Strongly agree)
Producers	Efficiency	I find negotiating is more efficient when done face to face	5-Point scale (Strongly disagree to Strongly agree)
Producers	Satisfaction	I find it cumbersome to coordinate with other work groups in 3GPP	5-Point scale (Strongly disagree to Strongly agree)
Producers	Satisfaction	I find that 3GPP communications generate too many emails	5-Point scale (Strongly disagree to Strongly agree)
Producers	Effectiveness	The delay between 3GPP work and implementation has caused issues in my work	5-Point scale (Strongly disagree to Strongly agree)
Both	Efficiency	How difficult is it to find the people needed to accomplish tasks related to 3GPP technical specifications	5-Point scale (Very difficult to Very easy)

Consumers	Satisfaction	How satisfied are you with the quality of 3GPP technical specifications	5-Point scale (Very dissatisfied to Very satisfied)
Consumers	Effectiveness	I sometimes find it hard to accomplish tasks that involve referring to 3GPP technical specifications	5-Point scale (Strongly disagree to Strongly agree)
Consumers	Satisfaction	I find the 3GPP technical specifications hard to read and/or understand	5-Point scale (Strongly disagree to Strongly agree)
Consumers	Satisfaction	The language of the 3GPP technical specifications is vague	5-Point scale (Strongly disagree to Strongly agree)
Consumers	Satisfaction	I prefer having figures in 3GPP technical specifications	5-Point scale (Strongly disagree to Strongly agree)
Consumers	Efficiency	I find checking for product compliance with 3GPP technical specifications time consuming	5-Point scale (Strongly disagree to Strongly agree)
Consumers	Effectiveness	I find the information sharing process between me and 3GPP delegates to be effective	5-Point scale (Strongly disagree to Strongly agree)
Consumers	Efficiency	I find the information sharing process between me and 3GPP delegates to be efficient	5-Point scale (Strongly disagree to Strongly agree)
Consumers	Satisfaction	I find the process of staying up to date with the latest 3GPP technical specifications overwhelming	5-Point scale (Strongly disagree to Strongly agree)

Piloting Before releasing the survey, a small pilot was done using the same participants as for the interviews. Six participants were contacted to fill in the survey, three corresponding to the producer archetype and three to the consumer archetype. A link to the Microsoft Forms survey was sent via email. The form did not collect any personal information. The goals of the pilot were to ensure that the questions were well understood, that the content was relevant for the topic and that there were no technical issues.

The pilot survey ran for exactly one week. The pilot survey had four responses, three from participants who self-identified as consumers and one as producer. There were no major issues reported, apart from a participant who mentioned not receiving a success message after submitting the form. After attempting again this was rectified.

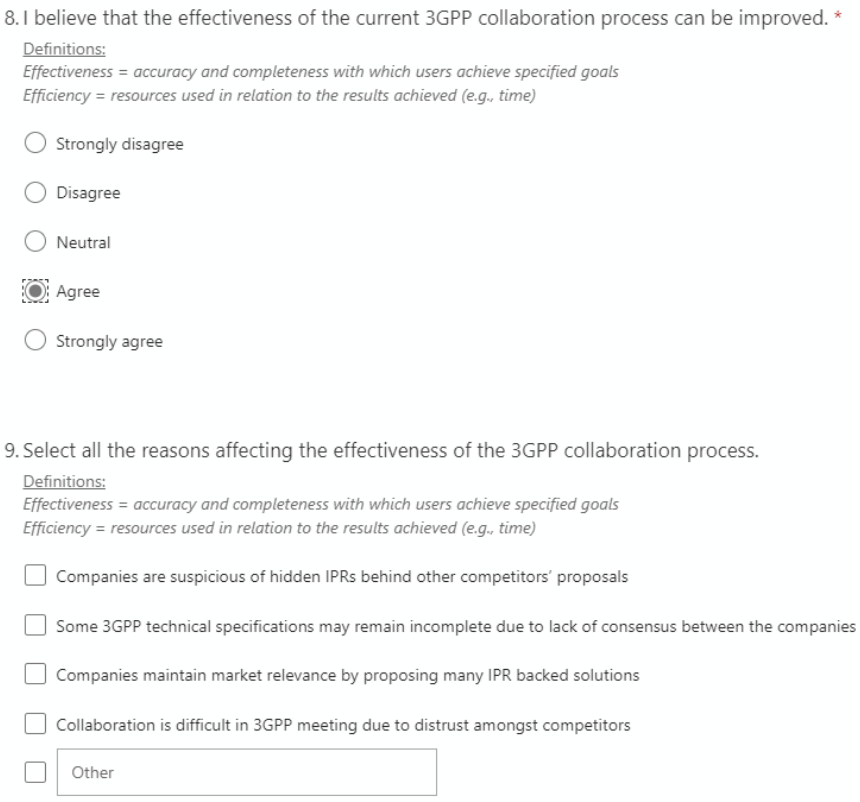


Figure 4: Snapshot of a survey question about the effectiveness of the 3GPP collaboration process and its follow-up question

One participant offered further feedback via email and reported that the survey "collected the most relevant challenges of working in standards, and in particular in 3GPP".

The average time to complete the survey was 08:26 minutes. There were also no questions which upon first inspection generated similar or identical responses, thus a decision was made to not remove any questions.

The survey included the possibility to add 'other' responses. These were analysed and turned into response options for their corresponding questions. They can be seen in Table 6.

Running the survey Only one survey was created in Microsoft Forms, but a first question asked the participant to self identify as either a specification producer or specification consumer (see Table 7). Based on this answer, the subsequent questions which were shown corresponded to the correct user archetype survey. The survey ran for approximately two weeks via Microsoft Forms. Microsoft Forms was used as a platform because it was a familiar tool for Nokia employees and it was also cost effective. Participants were offered a chance to participate in a raffle as an incentive to complete the survey. 10 participants would be selected at random to receive Nokia

Table 6: Information collected from pilot survey

Question	Participants' other responses	Added answer option in the survey
Select all the reasons why the quality of the 3GPP technical specifications has decreased in recent years	Too many features are added, and the overall structure of the specification cannot be adapted to that	The structure of the technical specification document cannot accommodate the large amount of information added
Select all the possible ways that the length of the document has an impact on your work	Opening documents is very slow MS Word is not suitable for huge documents, it stalls often	Opening documents is very slow The length of the document causes my computer/Microsoft Word to hang/stall
Select all the reasons why you prefer having figures in 3GPP technical specifications	Figures make it easier to get an overview and first understanding, and you can use them as "visual anchor"	Figures provide an overview of the feature
Information sharing between me and 3GPP delegates includes the following	I sometimes draft a contribution relating to an IPR I made	Providing information related to my IPR(s)
Select all the reasons why you do not or rarely refer to the official 3GPP training and guidelines	I do not have the need to do so	I do not need to as I am familiar with 3GPP working procedures

internal points which were estimated to value approximately 40 euros. The survey was estimated to take 7 minutes to complete, should all the branching questions also be shown to the participant. Responses were shuffled using the inbuilt Microsoft Forms functionality. The survey was advertised on internal Nokia Yammer groups and via email distribution lists.

6.3 Analysis

Descriptive statistics was used to analyse the results of the survey. When analysing the results, the negative answers and positive answers were grouped together to make the results clearer to read. For example, the percentage of negative responses for a question represents the sum of 'Strongly disagree' and 'Disagree' answers, whereas the positive responses include 'Agree' and 'Strongly agree'. The results were ordered by percentage of positive responses, in descending order. When interpreting the

Table 7: The first question in the survey to distinguish between producer and consumer archetypes

Question	Answer Options
Which of the following describes your job role more accurately in relation to 3GPP technical specifications?	* Specification producer (e.g., a previous or current standards delegate) * Specification consumer (e.g., not a delegate but uses/accesses 3GPP technical specifications as part of their work)

results, a threshold of 55% positive/negative/neutral answers was set for including the question in the discussion. These values are coloured in green in subsequent tables. However, where appropriate, some of the other questions' results were also interpreted.

Number of responses A total of 85 participants completed the survey during the two weeks that the survey was open. 52 of the participants identified as specification producers and 33 as specification consumers. The reason why there were more specification producers is due to the research team contacting them directly via a dedicated emailing list. It was not possible to do so with the specification consumers.

In subsection 6.1 it was stated that in order to achieve a confidence level of 80% and marginal error of 10%, the survey would require 31 specification producers respondents and 39 specification consumers respondents. The survey only gathered 33 responses from specification consumers, which corresponds to a confidence level of 80% and marginal error of 11%. However, 52 specification producers completed the survey which corresponds to a confidence level of 95% and marginal error of 10.2%. This means that there is a much higher likelihood that the survey sample reflects the attitudes of the population of specification producers.

Response times The average response time for the survey was of 66:19 minutes. This number is skewed due to several very large values (e.g., 3076:46 minutes), thus a better measure would be the median which reports 08:03 minutes. The longer responses can be explained by people starting the survey then forgetting about it for up to two days.

7 Results: Survey

This section showcases the results of the survey data analysis. The first two subsections will present the results from each user archetype in more detail. The third subsection will show side by side the common questions between the two user archetypes surveys. The forth subsection will present the results of the survey next to the corresponding usability issue identified in the affinity diagram exercise from section 5. The final subsection summarises the results.

Specification producer results

Table 8 presents the results for the specification producer archetype. It can be seen that the most prevalent issue amongst this user group is that reaching consensus in 3GPP meetings is time-consuming. This is an efficacy issue which interferes with specification producers' ability to create and contribute to 3GPP technical specifications, as a significant amount of time goes to negotiating and compromising to reach consensus. The survey indicates that the reasons behind this are that there are many companies involved, each with their own interests (85.7%). This is followed by having to create alliances and lobby (67.3%), having to negotiate proposals (63.2%) and finally being difficult to prove the superiority of one solution over another (57.1%). Six *other* responses were given for this question, and they raised issues such as e-meetings being inefficient and IPRs hindering the emergence of the superior technical solution.

The next most reported issue was that of negotiating face to face versus online. Over 67% of respondents agreed with each of the response options, i.e., that e-meetings slow down progress and emails are inefficient for reaching consensus and negotiating. However, twelve *other* options were submitted, many touching upon a lack of possibility to build a rapport with fellow delegates as well as reduced non-verbal communication cues. Some more practical matters were also brought up, such as having delegates in different time zones and there being significant delays in getting responses via email which hinders progress and momentum.

73% of respondents found that the efficiency of the 3GPP collaboration process can be improved, and 75% thought its effectiveness could be improved. Looking into the reasons affecting the effectiveness of the collaboration, it can be seen that 61.5% of respondents thought that it causes specifications to remain incomplete due to lack of consensus and that distrust amongst delegates makes collaboration difficult. Furthermore, 71.7% and 82% thought it was due to companies maintaining market relevance via IPRs and being suspicious of solutions including IPRs respectively. In the *other* response box, one third of respondents reported e-meetings again as a reason for the lack of effectiveness. Other reasons were companies following their own KPIs (key performance indicators) and a lack of common goal for the collaborating companies, inconsistent specifications caused by working in isolation, and wasted effort by including features which are never implemented. For reasons affecting the efficiency of the collaboration process, 64.1% of respondents picked that it was related to IPRs and 71.7% reported deadlocks in reaching consensus. The reasons listed in

the *other* response box were very similar to the ones reported for effectiveness.

73% of respondents also found that 3GPP communications create too many emails, with a majority of respondents reporting that they spend too much time reading emails (76.3%) and find it cumbersome to do so (71%). The *other* response box included responses such as having to ignore emails to be productive during the day or the company spam blocker marking them as junk due to their sheer volume (1000-2000 per day during e-meetings). An important point made in these comments was that during face to face meetings, a chair would ensure only one topic is addressed at a time, but emails do not provide the same structure.

The quality related questions as well as the ones with the lowest positive responses will be discussed later in this section, together with the responses from the specification consumer archetype.

It is worth noting that when asking whether it is sometimes hard to accomplish tasks related to 3GPP, it seems that equal proportions of respondents either agree/strongly agree or disagree/strongly disagree. This split could be caused by the different levels of confidence that respondents have regarding achieving work goals which involve 3GPP technical specifications. Confidence comes from experience and how much their job actually involves interacting with the technical specifications on a regular basis. Unfortunately, the survey did not collect demographic data in order to investigate this hypothesis further. These answers could also be biased if respondents did not want to disclose or admit that they sometimes find hard to accomplish tasks related to 3GPP. However, the likelihood of this happening was lowered since the survey was anonymous.

Table 8: Specification producer survey results

Question	Negative	Neutral	Positive
Reaching consensus in a 3GPP meeting can be a time-consuming task	3.8%	1.9%	94.2%
I find negotiating is more efficient when done face to face	5.7%	13.4%	80.7%
I believe that the effectiveness of the current 3GPP collaboration process can be improved	3.8%	21.1%	75%
I believe that the efficiency of the current 3GPP collaboration process can be improved	5.7%	21.1%	73%
I find that 3GPP communications generate too many emails	5.7%	21.1%	73%
The quality of the 3GPP technical specifications has decreased in recent years	9.6%	30.7%	59.6%
I believe the current 3GPP technical specifications quality assurance process is insufficient	15.3%	30.7%	53.8%

I spend a lot of time finding the information I need in the 3GPP technical specifications	30.7%	25%	44.23%
I sometimes find it hard to accomplish my tasks related to 3GPP technical specifications	40.3%	17.3%	42.3%
I believe the 3GPP technical specifications documents are too long	34.6%	28.8%	36.5%
I find it cumbersome to coordinate with other work groups in 3GPP	21.1%	42.3%	36.5%
The delay between 3GPP work and implementation has caused issues in my work	28.8%	40.3%	30.7%
How difficult is it to find the people needed to accomplish tasks related to 3GPP technical specifications	32.6%	46.1%	21.1%
How frequently do you refer to the official 3GPP training and guidelines	46.1%	36.5%	17.3%

Specification consumer results

Table 9 presents the results for the specification consumer archetype. 87.8% of respondents agree to preferring having figures in the technical specification. These are currently rarely found in 3GPP technical specifications. 82.7% prefer them because they are quicker to understand and 79.3% find they provide a helpful overview of the feature. *Other* responses highlight that they can solve ambiguities and prevent misinterpretations.

A high number of respondents find the technical specifications hard to read or understand (72.7%). The reason for this is widespread, however the following four reasons emerge with the most support from participants: the specifications do not include enough background information (70.8%), not enough time to read the entire specification (62.5%), understanding one specification involves understanding many others (83.3%), and the information is scattered across multiple specifications (79.1%). There is a clear theme that can be seen in these answers, which is related to the specifications being very long and being made more complicated due to all the background information which is not centralised in one document.

Next, it can be seen that 66.6% participants find it overwhelming to stay up to date with the 3GPP technical specifications. The main two reason behind this are that it takes too long (59%) and there are too many specifications to check (77.2%).

Finally, it is worth noticing the difference between the positive responses for the question regarding the effectiveness and efficiency of the information sharing process with the 3GPP delegates. 60.6% consider this to be effective, whereas only 48.3% find it efficient. Unfortunately there were no follow-up questions to investigate the reason behind it further, but it should be considered in future work.

Table 9: Specification consumer survey results

Question	Negative	Neutral	Positive
I prefer having figures in 3GPP technical specifications	3%	9%	87.8%
I find the 3GPP technical specifications hard to read and/or understand	18.1%	9%	72.7%
I find the process of staying up to date with the latest 3GPP technical specifications overwhelming	6%	27.2%	66.6%
I find the information sharing process between me and 3GPP delegates to be effective	6.1%	33.3%	60.6%
I spend a lot of time finding the information I need in the 3GPP technical specifications	12.1%	33.3%	54.5%
I sometimes find it hard to accomplish tasks that involve referring to 3GPP technical specifications	27.2%	18.1%	54.5%
I find checking for product compliance with 3GPP technical specifications time consuming	0%	48.4%	51.5%
I find the information sharing process between me and 3GPP delegates to be efficient	9.1%	42.4%	48.3%
I believe the 3GPP technical specifications documents are too long	21.2%	39.3%	39.3%
How satisfied are you with the quality of 3GPP technical specifications	36.3%	30.3%	33.3%
How difficult is it to find the people needed to accomplish tasks related to 3GPP technical specifications	21.2%	45.4%	33.3%
The language of the 3GPP technical specifications is vague	30.3%	39.3%	30.3%
The quality of the 3GPP technical specifications has decreased in recent years	9%	63.6%	27.2%
I believe the current 3GPP technical specifications quality assurance process is insufficient	21.2%	54.5%	24.2%
How frequently do you refer to the official 3GPP training and guidelines	57.5%	33.3%	9%

Common questions

Table 10 compares the results reported for common questions from each of the two user archetypes. For this comparison, the following questions which have slightly different wording but the same meaning behind them were added: 'I sometimes find it hard to accomplish my tasks related to 3GPP technical specifications' and 'I sometimes find it hard to accomplish my tasks that involve referring to 3GPP technical specifications'.

Firstly, it is interesting to see that there is an equal split for both producers and consumers as to whether the document length is an issue. As such, it can be concluded that this should not be an area of focus for improvements.

Secondly, the issue of spending much time finding information in the 3GPP technical specifications also has moderate backing, with approximately 10% more specification consumers considering this an issue. Both groups reported having to browse multiple specifications and finding it challenging to find information from outside their area of expertise as the main underlying issues.

Thirdly, it is worth noting that on the matter of the decrease in quality of specifications and the quality assurance being insufficient, specification consumers were neutral on both accounts whereas specification producers mainly agreed with the statements. 76% of producers consider that the quality assurance is insufficient because many faults are discovered only at implementation time and the companies reviewing the standards in 3GPP do not have technical accuracy as their primary KPI (60.7%). Furthermore, many of the comments in the *other* option box mentioned that quality is not a priority in the high paced and competitive environment that 3GPP operates in. The decrease in the quality of specifications is considered to be due to companies pushing for solutions which use their IPR rather than the best one (87%), and the delegates being overworked (83.8%) with too many contributions to check (83.8%).

Fourthly, both specification producers and consumers rarely refer to the official 3GPP training and guidelines. The main reason for producers is that they do not need them (66.6%), whereas consumers were not aware they existed (73.6%).

On the matter on finding the people needed to achieve tasks related to 3GPP, both user groups reported to be mostly neutral.

Finally, specification producers were split between agreeing and disagreeing that it is sometimes hard to accomplish their 3GPP related tasks. However, for 54.5% of consumers, this was identified as an issue with the main underlying cause being that it was hard to understand the intention behind a specification (83.3%).

Prevelance of usability issues

This thesis posed the sub-research question *What is the prevalence of each of the usability issues identified?*. Section 5 presented the usability issues identified based on the user interviews conducted. Table 11 collates each usability issue from section 5, its corresponding survey question and the results based on the responses collected in the survey. For questions which were common for both user archetypes, the values

Table 10: Survey results for common questions between user archetypes

Question	Specification Producers			Specification Consumers		
	Negative	Neutral	Positive	Negative	Neutral	Positive
I believe the 3GPP technical specifications documents are too long	34.6%	28.8%	36.5%	21.2%	39.3%	39.3%
I spend a lot of time finding the information I need in the 3GPP technical specifications	30.7%	25%	44.23%	12.1%	33.3%	54.5%
I believe the current 3GPP technical specifications quality assurance process is insufficient	15.3%	30.7%	53.8%	21.2%	54.5%	24.2%
The quality of the 3GPP technical specifications has decreased in recent years	9.6%	30.7%	59.6%	9%	63.6%	27.2%
How frequently do you refer to the official 3GPP training and guidelines	46.1%	36.5%	17.3%	57.5%	33.3%	9%
How difficult is it to find the people needed to accomplish tasks related to 3GPP technical specifications	32.6%	46.1%	21.1%	21.2%	45.4%	33.3%
I sometimes find it hard to accomplish my tasks related to 3GPP technical specifications	40.3%	17.3%	42.3%	27.2%	18.1%	54.5%

in the table correspond to the mean based on the results from each archetype. It can be clearly seen that the highest ranking issue is that of reaching consensus, with 94.2% of respondents agreeing that it is a pain point, followed by the lack of illustrations in the document (87.8%) and e-meetings slowing down progress (80.7%). Other usability issues which scored high amongst respondents were those of IPRs and

competition, email volume, understandability of documents and time and resource constraints.

It is also worth pausing to look at the questions which did not have a strong positive or negative response rate. Checking for standards compliance and there being too many specifications and specification setting bodies seem to be issues on which participants are either neutral or see as being issues. However, the proportions are really close, thus it can be interpreted that many have had to accept these as downsides of working with 3GPP specifications which they learned to accept and overcome. Furthermore, these are both issues that are not company or 3GPP specific. Thus, participants may be aware of this and accepted them as 'status-quo' since they will find them when working for other companies or with other technical specifications as well.

The remaining questions have a more equal spread across the three response categories. This shows that there is a lack of consensus on whether the usability issues mentioned in the questions are really issues. It could be said that the two extremes (negative and positive) cancel each other out and the overall outlook on those issues is a neutral one. Thus, the issues with such a split in responses should not be a priority for the usability improvement efforts. Perhaps a better question to ask is whether there is an underlying variable which determines this overall neutral result. The causes could vary greatly, from preference to work style or even work training and previous experience. Taking the document length as an example, someone who works in research would consider that having a 60 page document is acceptable since it needs to cover the specification of a feature in detail. However, someone who is in a management position and is more used to reading executive summaries would find it daunting to have to search for information in such a large document. Future work should continue to investigate these results by conducting focus groups or interviews with participants from each response category to understand where the difference in opinion stems from.

Table 11: Identified usability issues, associated survey question(s) and survey response results

Affinity Diagram Category	Associated Survey Question(s)	Negative	Neutral	Positive
Consensus is hard	Reaching consensus in a 3GPP meeting can be a time-consuming task	3.8%	1.9%	94.2%
Lack of supporting information	I prefer having figures in 3GPP technical specifications	3%	9%	87.8%
E-meetings impede progress	I find negotiating is more efficient when done face to face	5.7%	13.4%	80.7%

IPRs, Competition and Quality (and combinations thereof)	I believe that the effectiveness of the current 3GPP collaboration process can be improved; I believe that the efficiency of the current 3GPP collaboration process can be improved	3.8%; 5.7%	21.1%; 21.1%	75%; 73%
Too many emails	I find that 3GPP communications generate too many emails	5.7%	21.1%	73%
Understandability	I find the 3GPP technical specifications hard to read and/or understand	18.1%	9%	72.7%
Time and resource constraints	I find the process of staying up to date with the latest 3GPP technical specifications overwhelming; I sometimes find it hard to accomplish tasks that involve referring to 3GPP technical specifications	6%; 33.8%	27.2%; 17.7%	66.6%; 48.4%
Information sharing - Challenges	I find the information sharing process between me and 3GPP delegates to be effective; I find the information sharing process between me and 3GPP delegates to be efficient	6.1%; 9.1%	33.3%; 42.4%	60.6%; 48.3%
Compliance with standards	I find checking for product compliance with 3GPP technical specifications time consuming	0%	48.4%	51.5%
Too many specifications and standards bodies	I find checking for product compliance with 3GPP technical specifications time consuming	0%	48.4%	51.5%
Information spread across multiple specifications	I spend a lot of time finding the information I need in the 3GPP technical specifications	21.4%	29.1%	49.3%

Lower quality specifications	The quality of the 3GPP technical specifications has decreased in recent years; How satisfied are you with the quality of 3GPP technical specifications; I believe the current 3GPP technical specifications quality assurance process is insufficient	9.3%; 36.3%; 18.2%	47.2%; 30.3%; 42.6%	43.4%; 33.3%; 39%
Document length	I believe the 3GPP technical specifications documents are too long	27.9%	34.1%	37.9%
Collaborating with other 3GPP working groups	I find it cumbersome to coordinate with other work groups in 3GPP	21.1%	42.3%	36.5%
Delay between 3GPP work and implementation	The delay between 3GPP work and implementation has caused issues in my work	28.8%	40.3%	30.7%
Predicting the future	The delay between 3GPP work and implementation has caused issues in my work	28.8%	40.3%	30.7%
Vague language in technical specifications	The language of the 3GPP technical specifications is vague	30.3%	39.3%	30.3%
Personal contacts/knowing the right people	How difficult is it to find the people needed to accomplish tasks related to 3GPP technical specification	26.9%	45.8%	27.2%
Learning about 3GPP	How frequently do you refer to the official 3GPP training and guidelines	51.8%	34.9%	13.1%

Summary

This section presented the results of the descriptive statistics analysis done on the collected responses from the survey on usability of 3GPP technical specifications. Overall, it is clear that two major themes emerge from the survey, each connected to one of the user archetypes.

Firstly, specification producers mostly highlighted issues related to the processes surrounding 3GPP collaboration, such as reaching consensus, negotiation being difficult online, effectiveness and efficiency improvement needs and high volumes of emails generated. These are issues which will cut across companies and it is something that needs to be addressed from 3GPP itself. Some of these pain points could be solved with simple changes which would bring quick and easy gains. For

example, keeping at least one extraordinary 3GPP delegates meeting in person, where parties can forge connections and negotiate ways forward.

Secondly, specification consumers' major pain points focused on the understandability of the document. Many respondents found it hard to read or understand the specifications and indicated that having figures in the document would make it easier to do so. The power of a good illustration can cut through heavy mathematical formulas or paragraphs of explanations and thus they need to become an integral part of the documents. The addition of figures would help both those who are more technical in their training but also those who are at a higher level of understanding, such as managers. This finding is similar to those of Acar et al. [8, 12], Scheller and Kühn [9] who found in their respective studies that people prefer looking at code examples or pseudocode before reading actual documentation or books, as they provide a quick way to understand the information and assess whether it can help them achieve their tasks. Furthermore, the specification consumer user archetype had issues with being up to date with the latest developments in all the technical specifications. This can be a direct consequence of the documents themselves being hard to digest, but it is also indicative of a wider problem which ties in to another issue, which is that of there being many specifications and many organisations which issue them. The sheer volume of documents makes the task of one person having a good understanding of all this information very hard if not impossible. Most companies have dedicated people or teams who are authorities on specific features or aspects of the specifications, however it still remains an issue for managers for example, who need to have a high level understanding of everything and be aware of any incoming changes which affect their products. This is a wicked problem and one which affects all companies which are dealing with technical specifications, regardless of the organisation which issued them.

8 Discussion

This section discusses the generalisability and significance of findings, followed by limitations of results and methodology. Finally, it reflects on the work done and outlines the direction of future work efforts.

8.1 Generalisability and significance of findings

For this study, the sample of interviewees is very small but the people selected were representative for the user archetype they typify. Each person had varying years of experience within 3GPP, from months to more than 20 years. The survey was also sent to the entire Nokia population which used 3GPP technical specifications or contributed to their creation, by making use of internal communication channels and mailing lists. Whilst there was no one definitive list of those who work with 3GPP technical specifications, a best educated guess was made based on their strong correlation with the latest work on the 5G technology.

This thesis is the first of the author's knowledge to attempt to study the usability of 3GPP technical specifications. The thesis is capitalizing on the learning available within Nokia, who are a major contributor to 3GPP. Having access to this information creates a more authentic picture of the current usability issues 3GPP technical specifications face. Despite some of the findings being 3GPP specific, such as the information being spread across many specifications or the consensus challenges amongst competing members, there are a large number of issues highlighted which can be generalised to other specifications emitting bodies as well. For example, the issue of there being too many specifications and specifications setting bodies is universal as there are many organisations issuing these types of documents. The existence of many specification setting bodies makes feature implementation harder to do, as the relevant technical specifications from all these bodies need to be consulted and checked. Each body will release new or updated specifications which makes it a difficult and time consuming task for the implementing companies to keep up with. Furthermore, the necessary vagueness within the specifications and the need to anticipate where the industry is moving towards applies to all specifications, one for which there is maybe not an immediate solution since the specifications work within a context which requires them to imagine and invent the future.

The results found by conducting this study in Nokia are also highly likely to be found in other 3GPP partners. This is because almost all of the usability issues with higher relevance stem from the working ways of 3GPP (e.g., reaching consensus, slow progress in e-meetings, many emails generated, etc.). Furthermore, it is also highly likely that time and resource constraints related issues raised will also be reflected in other companies, since they also stem from having a very high number of specifications to review and put forward. One suggestion would be for 3GPP to look and learn from younger organisations such as the O-RAN Alliance [49]. Such organisations have the freedom of not having to be backwards compatible with older specifications. However, some of its working procedures could be applied to 3GPP to make online collaboration easier, addressing issues such as the slow progress during

e-meetings or the large volume of emails generated. The O-RAN Alliance has been directly named during interviews on multiple occasions as an example of a better way to run the organisation.

It is important to keep in mind that there were interviewees who considered that despite its flaws, '3GPP worked' and it has been issuing industry leading technical specifications for decades. However, given the increased level of complexity that technological advances contain and the increased number of members in the organisation, it puts high pressures on the scalability of 3GPP as an organisation and its working methods. It is highly likely that other well established organisations similar to 3GPP are experiencing similar issues for the same reasons that led to the problems seen in 3GPP. Thus it is important to confirm this by running the survey on technical specification documents emitted by other standards bodies and follow it up with improvement efforts using a design thinking approach. Design thinking is a human-centered approach to solving non-trivial real-world problems [50]. It has a long tradition of being used in various domains, such as business, management and product innovation.

8.2 Limitations of results

The following subsection will discuss some of the possible limitations in the results reported.

Confidence in specification consumer results As previously mentioned, there were no definite lists of names of people working with 3GPP technical specifications. This was reflected in the lower uptake of the survey in this user group. An educated guess had to be made to estimate the population of specification consumers, and even so these results have 80% confidence and 11% measurement error. Thus, further efforts should be made to increase the confidence in these results and to better target the specification consumer archetype.

Some responses were lost due to bad survey interface design The survey also had a technical difficulty which was reported during the pilot by one participant but labeled as user error with no further action taken at that time. Unfortunately, despite the cause for the error being correct, the end result remained the same and it is estimated that a total of 3 to 5 responses to the survey were lost. This was due to the survey having a final section in which the participant was shown the information and a link on how to enter their name to a separate raffle for the chance to win points. However, the participants also needed to click submit in order for their answers to the survey to be recorded, but they never did (see Figure 5). They considered this final section of the survey as a completion message rather than a set of instructions. To remedy this issue, the survey was changed to only display the link to the raffle with the success message shown after the survey is submitted (see Figure 6).

Risk of incentive seeking respondents A note needs to be made on how the survey was advertised. The initial 5G and 6G Yammer channels used to advertise

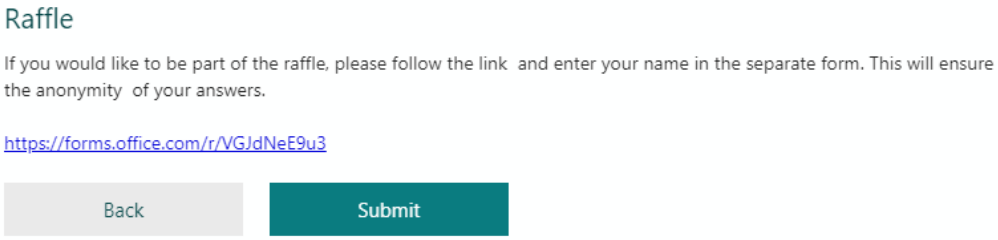


Figure 5: Survey section informing about raffle

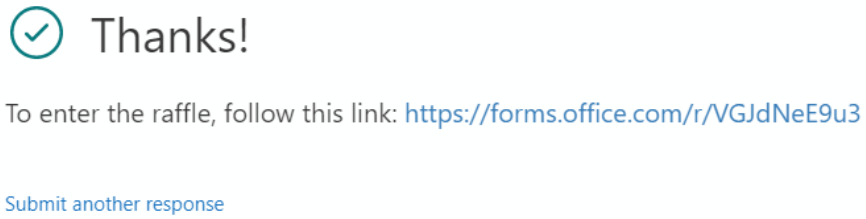
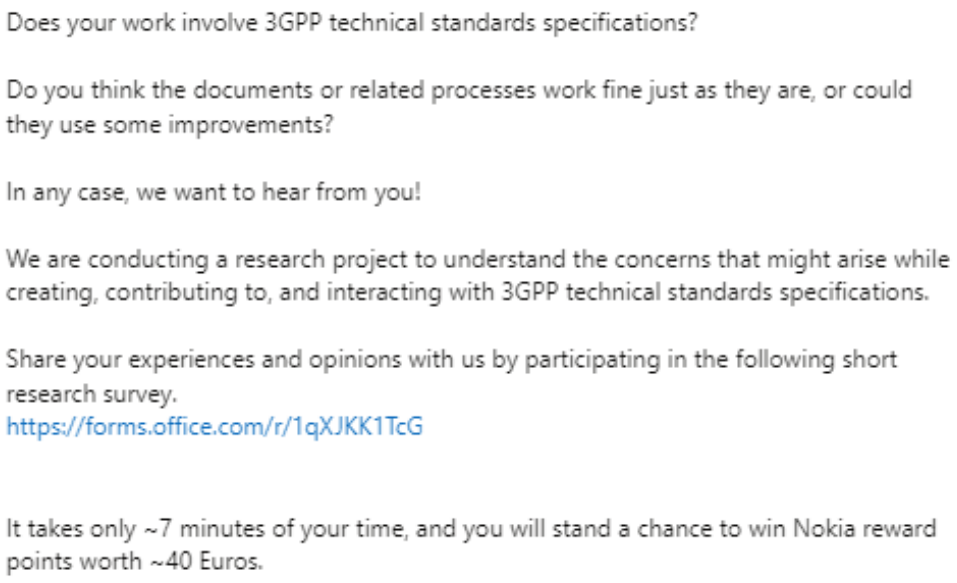


Figure 6: New survey success message

the survey, which had 235 and 622 members respectively, yielded a very poor survey uptake (approximately 15). Further action was taken, with emails sent to previous participants in the interviews, asking them to share the email which contained a link to the survey with their colleagues who worked with 3GPP technical specifications. In addition, a more general Yammer group was used to advertise the survey. This latter advertising medium increased the risk of having participants trying to respond to the survey because of the raffle incentive, despite not having the required knowledge or adhering to the participant criteria (that of being a specification producer or consumer). The advertising post can be seen in Figure 7. A more thorough discussion on the validity threats and implications of the choices of methodology can be consulted in subsection 8.3.

Possible bias in answers One further step was taken when it was noticed that after one week, the number of responses from specification producers was under 10. This was to directly email each of the delegates and invite them to take the survey. This method proved to be by far the most efficient, with the number of respondents increasing almost tenfold. It also brought some direct feedback from

some of the delegates which is worth discussing in the following lines. One first interesting observation was that participants did realise that the questions they were being asked next depended on their previous answers. This was interesting to them and they started trying different combinations with one person replying that it directly influenced their responses as a result. In the future, this survey should be changed to try to prevent this, possibly by using sections in the survey and preventing the possibility to go back after a response for a question is submitted. Second and more concerning, it became clear that there was some suspicion regarding the purpose of the research and how the results could be used. The research goals were stated in the introduction section of the survey and in the communication that was sent advertising it. However, there is an increased risk that the results of the study are skewed as a consequence of the answers not being an accurate depiction of participants' feelings and opinions.


Does your work involve 3GPP technical standards specifications?

Do you think the documents or related processes work fine just as they are, or could they use some improvements?

In any case, we want to hear from you!

We are conducting a research project to understand the concerns that might arise while creating, contributing to, and interacting with 3GPP technical standards specifications.

Share your experiences and opinions with us by participating in the following short research survey.
https://forms.office.com/r/1qXJKK1TcG

It takes only ~7 minutes of your time, and you will stand a chance to win Nokia reward points worth ~40 Euros.

Figure 7: Survey advertisement

8.3 Limitations of methodology and mitigation techniques

As previously mentioned, the research design made use of qualitative and quantitative methods. This subsection is dedicated to presenting the threats to validity separately for each of the methods. By their very nature, the interviews are more aligned with the constructivist philosophical stance, whereas the survey is more aligned with the positivist one [16, 15]. Constructivists believe that knowledge cannot be separated from context and focus on how people make sense of their surroundings. Positivists, on the other hand, believe that knowledge is based on observations, facts and logical inference [16, 15]. A paragraph on biases which need to be considered when conducting interviews and surveys is also included at the end of this subsection.

Interview related validity considerations

Triangulation Triangulation of data and researchers was used, with three researchers from different backgrounds involved in the analysis of the interview data via an affinity diagram exercise.

Member checking This technique implies checking any interpretation of the data with the participants. This was not done for this thesis due to time constraints. However, it was partially achieved by reusing the same participants from the interview as participants for the pilot survey. This was an opportunity for them to provide feedback and one participant wrote that the analysis was "in a good direction" and the most relevant challenges of working with standards were captured in the survey.

Rich, thick descriptions Detailed descriptions of the findings and analysis process were used to make the process as clear and transparent as possible for readers.

Clarify bias Researchers should be honest regarding any personal bias they may carry and reflect on this when reporting the results. This aspect is harder to quantify but the researching team did allocate time at the start of the affinity diagram exercise to discussing any preconceived ideas regarding the usability issues in 3GPP technical specifications which they formed either during the interviews or from previous knowledge.

Report discrepant information Throughout the analysis, all results were reported, regardless of whether they were supporting or contradicting the emerging narrative from the data.

Prolonged contact with participants Two of the researchers had a connection to a small part of the research population spanning a few years, whereas the third researcher was immersed in communicating with and understanding the target groups for one month. Furthermore, each of the interviews conducted started by asking the participant about their role and aimed to reveal their personal angle and involvement within the context of 3GPP technical specifications.

Peer debriefing The process included one peer debriefer, the third researcher, who was not involved in the analysis of the interview data and asked questions regarding the conclusions, their source in the interview data and assumptions made in the reporting.

External auditor The thesis had two external auditors in the form of the supervisor and critical observer who offered constrictive feedback and highlighted any concerns with the methodology or findings.

Surveys related validity considerations

The work of Easterbrook et al. [16] presents from the positivist point of view, to which surveys are a commonly used instrument, that there are four major validity dimensions that need to be addressed. These are internal validity, external validity, construct validity and reliability. The six part series on survey development and best practices from Kitchenham and Pfleeger [51] was also consulted. They dedicate part four to instrument evaluation, also called pretesting, which has the goals of:

- Ensuring questions are understood;
- Assessing response rate;
- Evaluating reliability (reproductibility of results) and validity (measuring the desired construct);
- Ensuring data analysis matches expected responses.

The thesis uses a pilot survey to resolve such possible bugs in the operation of the survey.

In the following paragraphs, the validity and reliability aspects highlighted by Kitchenham and Pfleeger [51] will be examined. Furthermore, any validity dimensions from Easterbrook et al. [16] which were not listed previously will also be reviewed.

Reliability Reliability is an important property of research studies which refers to a study producing the same results when replicated by another team of researchers. For surveys, this means that it yields a similar distribution of results regardless of the number of times it is administered.

Kitchenham and Pfleeger [51] highlight four different reliability perspectives applied to surveys. They are discussed and presented below, however none were applied to this thesis. Due to time constraints, a decision was made that future work could focus more on establishing the reliability and validity of the survey tool, and the current research work would focus on answering the research question.

1. Test-Retest (Intra-observer) Reliability: Implies asking the same participants to take the survey at two different points in time and measuring the correlation of the results. This measure suffers of some drawbacks which applies to the thesis as well, such as time causing responses to change due to increased familiarity with the process the survey refers to or because the participant remembers the answer gave previously so they keep their answers despite their opinion on the matter changing.

2. Alternate form reliability: This method implies creating alternative versions of the survey, either by changing the order of the questions or their phrasing, and calculating the correlation of results as done with the test-retest method. However, this method also suffers from significant drawbacks, risking that the rephrased questions are less understood or misunderstood, or the order of questions itself affecting answers.

3. Internal consistency: This technique uses Chronbach's alpha to measure the internal consistency of the various sub-constructs (e.g. efficiency, effectiveness, satisfaction).

4. Inter-observer (inter-rater) reliability: Measures the agreement between two or more trained respondents who are evaluating (subjective) an external object or process. This does not apply to this thesis since the survey is filled by the users themselves.

Validity Validity is another important property of studies and concerns itself with how accurately the concept under study is measured. Kitchenham and Pfleeger [51] list the following aspects of survey validity, which represent types of internal validity (i.e., confidence that the results stem from the data).

1. Face Validity: This is the weakest form out of all and it implies having untrained users to review the survey items making sure they are clear and understood. This was done in this research during the survey pilot.

2. Content Validity: Another subjective measure involving expert reviewers who ensure the content of the survey is appropriate for the subject of study. Target users are also involved in the process so long as they have knowledge in the study domain. This method is a foundation for more rigorous assessments and it is not concerned with consensus but rather with identifying issues. This was done for this thesis during the survey piloting, in which participants were invited to provide written feedback should any of the questions be either inappropriate or hard to answer.

3. Criterion Validity: Compares the newly created instrument (e.g., survey) with another instrument or predictor. Concurrent criterion validity computes correlation with a "gold standard", such as comparing IQ scores with academic grades. Predictive criterion validity checks if a survey can predict future phenomena, such as predicting time estimates for work tasks and comparing the actual time they took to complete. This was not done in this study.

4. Construct Validity: Is concerned with providing evidence that the construct under investigation is interpreted correctly and the (only) one being (correctly) measured by the instrument. It is composed of convergent construct validity and divergent construct validity. The former investigates whether two related measures of the construct that are theoretically related are also empirically correlated. The later measure checks for dissimilarity. Some measures of construct validity are confirmatory factor analysis (CFA, measures if the data collected by the instrument matches the theoretical understanding of the construct, which usually is provided by exploratory factor analysis or previous research work) or multitrait-multimethod matrix (MTMM, checks convergence and divergence), Bagozzi et al. [52] arguing that CFA is a better choice than MTMM. Since performing CFA would imply having done EFA and due to time constraints, this thesis will not check construct validity.

External validity External validity refers to whether the results of a study can be generalised [16]. Please find an ample discussion on the general applicability of results in sub-section 8.1.

Biases

In their book, Baxter et al. [31] point out a series of possible bias pitfalls that a researcher may fall into. A selection of the relevant ones is listed in the following paragraphs, together with the mitigation techniques used for each.

The following list contains the most common biases when conducting surveys:

- Selection bias: This bias is created when conducting convenience sampling. However, this survey made use of simple random sampling and was sent to the (estimated) entire Nokia work force which is involved with 3GPP, via emailing lists and other internal communication channels.
- Non-response bias: As the name indicates, many of the people contacted for the survey will not respond to it, with Baxter et al. [31] suggesting that a realistic figure is 20% responses. To mitigate this, the questions were kept short, no personal data was collected and a raffle was organised as an incentive in which ten participants had the chance to win points for the internal Nokia rewards platform.
- Satisficing: Baxter et al. [31] describe this decision-making strategy as putting in just enough effort to complete a task, and it happens when a task requires too much cognitive effort. Mitigation techniques in place for this are to keep the survey brief with clear questions that can be answered by the participants, and using an intuitive and familiar survey platform within the company (i.e., Microsoft Forms).
- Acquiescence bias: Describes the tendency of people to agree with a statement. This was mitigated by avoiding leading questions and avoiding binary questions when possible.

The following list contains the most common biases when conducting interviews:

- Selection bias: This is something that has been used for the thesis and it was unavoidable due to scheduling conflicts and availability of interviewees. A mitigation technique for this was to also use stratified sampling and select respondents from each of the main target user groups.
- Social Desirability: Refers to interviewees providing an answer which distorts the truth to make themselves more socially desirable. To encourage participants to be honest, each interview started by stating that this was not a test and recordings would be deleted and transcripts anonymised, as the research studies the processes not the people.

- Prestige response bias: This happens when interviewees select responses that they believe the interviewer wants to hear. It was thus the responsibility of the interviewer to keep neutral and phrase questions in a matter that does not lead the interviewee and encourages honesty.
- Interviewer prestige bias: Happens when an interviewee is informed of the opinion of an expert on a matter and then asked for their own opinion. There were no such questions during the interviews conducted for this thesis.

8.4 Critical reflection and scope for improvement

Interviews and affinity diagram The affinity diagram clearly showed the interplay, complexity and connection between the identified categories of information. However, the choice to use complete quotes did cause the exercise to be more cumbersome and longer to complete. A better option would have been to use both the quotes and summarised quotes, and match them in a pre-step to the analysis to make the iterative category and pattern identification smoother. Furthermore, formal analysis should not have included all the data collected from the interviews, only that related to usability issues. Doing so would have made the affinity diagram exercise more efficient.

Survey The survey created captures the usability issues extracted from the interviews, and maintains the anonymity of the respondents, encouraging them to complete it honestly as there would be no repercussions. However, the survey does not have a demographics section. This would have offered a deeper understanding of the issues identified as it would have allowed the researchers to calculate correlations between experience or job title and responses. One could hypothesise that those who are more experienced do not need to spend much time looking for information in the specifications, or that perhaps an architect would not find understanding the technical specifications difficult, but a manager would.

One interesting observation during the survey pilot was that two of the participants who were interviewed as specification producers self-identified as specification consumers. This could be due to them being delegates in the past but not in their current job. However, this raised the question of whether the survey is disregarding insights that these category of people have, who can express an opinion on both producing and consuming the specifications. It was decided that due to time constraints the most recent experience is more important, so the survey was not modified for this thesis. However, in the future, it would be beneficial to create a combined survey. Creating such a survey does not require much effort since the questions need only be merged from the two specific user archetype surveys.

8.5 Future work

As mentioned in the previous section, the survey could be improved by adding a demographics section and by providing a combined version for those participants

who have experience as both specification producers and consumers. Furthermore, the survey should run for a longer time and more effort should be put into targeting specification consumers to increase confidence in results. Free text responses should also be further analysed and added as response options to the survey based of frequency of occurrence.

Secondly, the findings from this thesis and subsequent related research papers should be summarised and brought forth to 3GPP as a first step towards raising awareness to the most prevalent usability issues and finding solutions.

Thirdly, the survey created, although based on usability issues identified within Nokia, has the potential to help other similar organisations identify usability issues that they face related to 3GPP technical specifications. If patterns of usability issues are identified across organisations, then these could be given a higher priority in the subsequent efforts to solve them. Future work should also look beyond 3GPP and focus on identifying patterns in usability issues that are common to all standards bodies.

Last but not least, it is important to stress the importance of continuing the work started in this thesis.

- First, improving the usability of technical specifications will make them easier to use by the consumers, which will lower the risk of introducing bugs, wasted time and effort and lower the steep learning curve at on-boarding time.

- Second, the delegates will also benefit from improving the usability of specifications, since they will spend less time having to clarify possible misunderstandings.

- Last, if 3GPP can implement usability improvements at their level, then the efforts that each of the individual partner companies are making to overcome these difficulties would be eased, allowing for more time to be spent on the actual implementation and innovation work.

9 Conclusion

This thesis looked at the perceived usability of 3GPP technical specifications. It started by giving an overview of what technical specifications are and how they are created and used, followed by a detailed background into the 3GPP organisation. It then defined usability and presented different ways to measure it.

The main research question posed in this thesis was *What are the main usability issues current 3GPP technical specifications face?* , with the sub-research question *What is the prevalence of each of the usability issues identified?*. To answer them, a mixed-methods approach was used. A series of interviews informed the first research question and a survey assessed the spread of the issues amongst a population of Nokia employees, who work with 3GPP technical specifications either as specification producers or specification consumers.

The research indicates that specification producers are mostly hindered by 3GPP governance processes which impact their work and productivity. Specification consumers are more affected by the contents of the actual technical specifications, highlighting pain points like the lack of illustrations and difficulty understanding the contents of the documents. The results suggest that *reaching consensus* in 3GPP meetings is the most important usability issue, with a proportion of 94.2% of respondents agreeing, followed by the *lack of illustrations* and *e-meetings slowing down progress*. Other notable issues are the impact of *IPRs, competition and quality of the technical specifications* as a result of the current collaboration process, the *high volume of emails generated* and the *understandability* of the 3GPP technical specifications.

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A Experts Interview Script

Questions in bold represent questions which were to be asked in each interview. The rest were for supporting the conversation. When multiple questions are seen on the same line, they are never posed together, but are treated as a follow-up after the interviewee gives their answer.

Introduction: <3m	**Hello and thank you for joining me today.** **This session will be around one hour. If you want to take a break at any point or are not comfortable answering any questions, please let me know. You may also leave at any point. Please also note that this session is being recorded so I can review our conversation and transcribe it for analysis. Is that okay?**
Warm Up: <5m	**Can you start by telling me a bit more about your role. What does that entail?** Are you involved with the technical specifications? How? Are you/have you been involved in the contributions process in a more official capacity? How? If involved in the contributions process, what roles did you have (e.g., editor, rapporteur . . .) How does your role help the delegates?
Body of Session: 30-45m	The contributions process **Would you be able to take us through the process of how specifications are created.** Who are the main groups of people who are involved in the process? Who would you say are the groups of people who interact with the specifications directly? In which capacity? To your knowledge, are there any criteria given when defining specifications? Which are they? Target audience **In your experience, who is the target audience of specifications?** How does this target audience use the specifications? What happens when the specifications are unclear to you or the other target audience? In your experience, is there a process in place to ensure that the target audience understand the specifications, and the specifications are clear and useful to them? In your experience, is feedback sought from the audience with regards to the specifications (for improvement purposes)? What is that process like? Content

	How is a specification born? To your knowledge, how are the goals of specifications defined when adding content to the specifications? What about the problems (identified) and solutions space? Who in your experience would be tasked with identifying or defining them? Is there a proof-reading process? What is that process like? **Are there any other quality checks which the specifications go through?** Governance What do you understand by governance within the context of technical specifications? **Can you tell us a bit about the governance process within the context of the specifications?** Are you exposed to any governance matters when it comes to the technical specifications? What are the main ones that come to mind? Tell me more... Suppose there are conflicting proposals within a working group. How would the governance work in this case? How would consensus be achieved? New proposal versus change request **Under which circumstances does a specification change (when are new versions created)?** Have you been involved with making a new contribution to the specifications? Tell me more about that process. Have you been involved with making a change request to the specifications? Tell me more about that process. So, with that in mind, what are the differences between making a change request and a new contribution as far as your involvement?
Cool Off: <2m	**Is there anything you think we didn't cover today which you think should be brought up?**
Wrap Up: <3m	**Is there anything you would like to ask me?** **Thank you for joining me and have a lovely day.**

B Specifications Producers Interview Script

Questions in bold represent questions which were to be asked in each interview. The rest were for supporting the conversation. When multiple questions are seen on the same line, they are never posed together, but are treated as a follow-up after the interviewee gives their answer.

Introduction: <3m	**Hello and thank you for joining me today.** **This session will be around one hour. If you want to take a break at any point or are not comfortable answering any questions, please let me know. You may also leave at any point. Please also note that this session is being recorded so I can review our conversation and transcribe it for analysis. Is that okay?**
Warm Up: <5m	**Can you start by telling me a bit more about your role. What does that entail?** Are you involved with the technical specifications? How? Are you/have you been involved in the contributions process in a more official capacity? How? How and when did you get involved with specifications? Were there any difficulties in the onboarding process? Can you list some of the materials you used to learn about the inner workings of 3GPP? (If not mentioned specifically, "Are you aware of a 3GPP Working Procedures document? Have you ever viewed it?")
Body of Session: 30-45m	<u>The contributions process</u> **Would you be able to take us through the process of how specifications are created?** Who are the main groups of people who are involved in the process? Who would you say are the groups of people who interact with the specifications directly? In which capacity? What stage of specifications making are you involved in? What pain points do you experience while making contributions in this stage? <u>Target audience</u> **In your experience, who is the target audience of specifications?** How does this target audience use the specifications? **What happens when the specifications are unclear to you or the other target audience?**

	In your experience, is feedback sought from the audience with regards to the specifications (for improvement purposes)? What is that process like? What works particularly well in this process? What about this process is faulty or could be improved? Content To your knowledge, what are the goals of a specification. How are the goals of specifications defined when adding content to the specifications? Who in your experience would be tasked with identifying or defining them? (i.e., the goals) Is there a proof-reading process? What is that process like? **Are there any other quality checks which the specifications go through?** **What are your (as specification producers) personal goals while contributing to a specification? How are these goals set?** **What are the difficulties you face in terms of the content or information contained withing specifications?** Look and feel appeal (i.e., presentation) **What are the difficulties you face with the look and feel appeal of the specifications?** **How do these difficulties impact your day-to-day tasks?** Accessing the specifications **How (or where) do you access the latest or relevant specifications?** **In your opinion, are there any shortcomings to this process of accessing the specifications? Tell me more about it.**
Cool Off: <2m	**Is there anything you think we didn't cover today which you think should be brought up?**
Wrap Up: <3m	**Is there anything you would like to ask me?** **Thank you for joining me and have a lovely day.**

C Specifications Consumers Interview Script

Questions in bold represent questions which were to be asked in each interview. The rest were for supporting the conversation. When multiple questions are seen on the same line, they are never posed together, but are treated as a follow-up after the interviewee gives their answer.

Introduction: <3m	**Hello and thank you for joining me today.** **This session will be around one hour. If you want to take a break at any point or are not comfortable answering any questions, please let me know. You may also leave at any point. Please also note that this session is being recorded so I can review our conversation and transcribe it for analysis. Is that okay?**
Warm Up: <5m	Can you start by telling me a bit more about your role. What does that entail? **Does your job involve 3GPP technical specifications? (If yes) How?** What kind of specifications do you have to refer to? Can you give some examples? Are you/have you been involved in the contributions process in a more official capacity? How?
Body of Session: 30-45m	From specifications to requirements **Could you walk us at a very high level through the process of how specifications get implemented into a product?** How do specifications get translated to requirements document? What is there in the requirements document? How do developers use it? How are requirement documents broken into features? Is there anything else other than the requirement document that the developers refer to? Team **Who else has to refer to the specifications (in your team)?** What are the different roles in your team and how do they use the specifications? Target audience **In your experience, who is the target audience of specifications?** **How does this target audience use the specifications?** **What happens when the specifications are unclear to you or the other target audience?**

	In your experience, is there a process in place to ensure that the specifications are understandable and clear to the target audience? Can you elaborate such processes? **In your experience, is feedback sought from the audience with regards to the specifications (for improvement purposes)? What is that process like? What works particularly well in this process? What about this process is faulty or could be improved?** Interaction with delegates **Do you interact with the delegates directly?** Can you walk us through the process of interacting with the delegates? In which situations do you need to interact with the delegates? (The main intention is to see if they are mere consumers due to complexity of providing input or do they actually provide inputs naturally). If you do provide inputs, can you walk us through the process? General pain points **What are some of the painful aspects of dealing with specifications from your experience?** Have you heard similar or different pain points from your team members? (If yes) Could you elaborate? What are the difficulties you face in terms of the content or information contained withing specifications? **What would you say is currently missing from the specifications? Try to think about content, processes or anything else you think is relevant. (Probe both the content and any processes that involves specifications)** Look and feel appeal (i.e., presentation) **What are the difficulties you face with the look and feel appeal of the specifications?** **How do these difficulties impact your day-to-day tasks?** Accessing the specifications **How (or where) do you access the latest or relevant specifications?** **In your opinion, are there any shortcomings to this process of accessing the specifications? Tell me more about it.**
Cool Off: <2m	**Is there anything you think we didn't cover today which you think should be brought up?**
Wrap Up: <3m	**Is there anything you would like to ask me?** **Thank you for joining me and have a lovely day.**

D Questions Generated for Initial Scale

No	Topic	Sub-Topic	Dimension ISO9241	Dimension ISO9126	Question	Inspiration	Q no
1	Process	Contribution	Satisfaction	Liked	I find the process of making a contribution a frustrating experience.	UMUX	2
2	Dissemination	Access	Satisfaction	Liked	I find accessing the technical specification I want a frustrating experience.	UMUX	2
3	Contents	Technical Specs	Satisfaction	Liked	I find reading the technical specifications a frustrating experience.	UMUX	2
4	Contents	Technical Specs	Effectiveness	Used	The contents of the specifications meet my requirements.	UMUX	1
5	Contents	Presentation	Effectiveness	Used	The presentation of the technical specifications met my requirements.	UMUX	1
6	Contents	Presentation	Satisfaction	Liked	The presentation of the technical specifications is pleasant.	PSSUQ	13
7	Contents	Presentation	Satisfaction	Liked	I like the presentation of the technical specifications	PSSUQ	14
8	Contents	Technical Specs	Effectiveness	Used	The contents of the technical specifications are effective in helping me complete my tasks.	PSSUQ	13

No	Topic	Sub-Topic	Dimension ISO9241	Dimension ISO9126	Question	Inspiration	Q no
9	Contents	Technical Specs	Effectiveness	Used	The information provided by the technical specifications is clear.	PSSUQ	9
10	Process	Contribution	Effectiveness	Understood	The information on how to make a contribution to the technical specifications is clear	PSSUQ	9
11	Process	Governance	Effectiveness	Understood	The information about the governance of the technical specifications is clear.	PSSUQ	9
12	Process	Governance	Satisfaction	Liked	Overall, I am satisfied with the governance process.	PSSUQ	16
13	Process	Contribution	Satisfaction	Liked	Overall, I am satisfied with the contribution process.	PSSUQ	16
14	Contents	Technical Specs	Satisfaction	Liked	Overall, I am satisfied with the technical specifications contents.	PSSUQ	16
15	Contents	Presentation	Satisfaction	Liked	Overall, I am satisfied with the presentation of the technical specifications.	PSSUQ	16
16	Dissemination	Access	Satisfaction	Liked	Overall, I am satisfied with the process of accessing the technical specifications.	PSSUQ	16

No	Topic	Sub-Topic	Dimension ISO9241	Dimension ISO9126	Question	Inspiration	Q no
17	Dissemination	Distribution	Satisfaction	Liked	Overall, I am satisfied with the distribution process of the technical specifications.	PSSUQ	16
18	Contents	Technical Specs	Overall Usaility	Used	It is easy to navigate the technical specifications.	SUPR-Q	2
19	Dissemination	Access	Overall Usaility	Used	It is easy to access the technical specifications.	SUPR-Q	2
20	Process	Contribution	Overall Usaility	Used	It is easy to make a contribution to the technical specifications.	SUPR-Q	2
21	Contents	Technical Specs	Satisfaction	Understood	I feel very confident using the technical specifications.	SUS	9
22	Dissemination	Access	Satisfaction	Understood	I feel very confident accessing the technical specifications.	SUS	9
23	Dissemination	Distribution	Satisfaction	Understood	I feel very confident finding the technical specifications I need.	SUS	9
24	Dissemination	Distribution	Satisfaction	Understood	I feel very confident finding the latest technical specifications I need.	SUS	9
25	Process	Contribution	Efficiency	Learned	I would imagine that most people would learn how to make a contribution very quickly.	SUS	7

No	Topic	Sub-Topic	Dimension ISO9241	Dimension ISO9126	Question	Inspiration	Q no
26	Contents	Technical Specs	Efficiency	Learned	I would imagine that most people would learn how to use the technical specifications very quickly.	SUS	7
27	Contents	Technical Specs	Efficiency	Learned	I would imagine that most people would learn how to navigate the technical specifications very quickly.	SUS	7
28	Dissemination	Access	Efficiency	Learned	I would imagine that most people would learn how to access the technical specifications very quickly.	SUS	7
29	Dissemination	Distribution	Efficiency	Learned	I would imagine that most people would learn where to find the technical specifications they need very quickly.	SUS	7
30	Process	Governance	Efficiency	Learned	I would imagine that most people would learn how the standards organisation governs itself very quickly.	SUS	7

No	Topic	Sub-Topic	Dimension ISO9241	Dimension ISO9126	Question	Inspiration	Q no
31	Process	Contribution	Efficiency	Learned	I would imagine that most people would learn how to follow the status of their contribution very quickly.	SUS	7
32	Process	Contribution	Effectiveness	Understood	I think that I would need the support of a senior person to be able to submit a contribution.	SUS	4
33	Contents	Technical Specs	Effectiveness	Understood	I think that I would need the support of a senior technical person to be able to use/apply the technical specifications.	SUS	4
34	Contents	Technical Specs	Effectiveness	Understood	I think that I would need the support of a senior technical person to be able to navigate the technical specifications.	SUS	4
35	Dissemination	Access	Effectiveness	Understood	I think that I would need the support of a senior person to be able to access the technical specifications.	SUS	4

No	Topic	Sub-Topic	Dimension ISO9241	Dimension ISO9126	Question	Inspiration	Q no
36	Dissemination	Distribution	Effectiveness	Understood	I think that I would need the support of a senior person to be able to find the technical specifications I need.	SUS	4
37	Process	Governance	Satisfaction	Liked	I found the working procedures very cumbersome.	SUS	8
38	Process	Contribution	Satisfaction	Liked	I found the contribution process very cumbersome.	SUS	8
39	Contents	Technical Specs	Satisfaction	Liked	I found navigating the technical specifications very cumbersome.	SUS	8
40	Contents	Technical Specs	Satisfaction	Liked	I found the technical specifications very cumbersome to use.	SUS	8
41	Contents	Presentation	Satisfaction	Liked	I found the technical specifications very cumbersome to read.	SUS	8
42	Dissemination	Access	Satisfaction	Liked	I found accessing the techincal specs cumbersome.	SUS	8
43	Dissemination	Distribution	Satisfaction	Liked	I found the process of finding the technical specifications I am interested in very cumbersome.	SUS	8

No	Topic	Sub-Topic	Dimension ISO9241	Dimension ISO9126	Question	Inspiration	Q no
44	Process	Governance	Effectiveness	Liked	I found the governance system unnecessarily complex.	SUS	2
45	Process	Contribution	Effectiveness	Liked	I found the contribution process unnecessarily complex.	SUS	2
46	Contents	Technical Specs	Effectiveness	Liked	I found the technical specifications contents unnecessarily complex.	SUS	2
47	Contents	Presentation	Effectiveness	Liked	I found the presentation of the specifications unnecessarily complex.	SUS	2
48	Dissemination	Access	Effectiveness	Liked	I found accessing the technical specifications unnecessarily complex.	SUS	2
49	Dissemination	Distribution	Effectiveness	Liked	I found the distribution process of the specifications unnecessarily complex.	SUS	2
50	Process	Contribution	Efficiency	Learned	I needed to learn a lot of things before I could get going with the contribution process.	SUS	10
51	Contents	Technical Specs	Efficiency	Learned	I needed to learn a lot of things before I could get going with the technical specifications.	SUS	10

No	Topic	Sub-Topic	Dimension ISO9241	Dimension ISO9126	Question	Inspiration	Q no
52	Process	Governance	Overall Usaility		It was easy to find the information I needed on governance of the technical specifications.	PSSUQ	10
53	Process	Contribution	Overall Usaility		It was easy to find the information I needed on how to make contributions.	PSSUQ	10
54	Contents	Technical Specs	Overall Usaility		It was easy to find the information I needed in the technical specifications.	PSSUQ	10
55	Dissemination	Access	Overall Usaility		It was easy to find the information I needed on how to access the technical specifications.	PSSUQ	10
56	Dissemination	Distribution	Overall Usaility		It was easy to find the information I needed on where to access the technical specifications.	PSSUQ	10
57	Contents	Technical Specs	Overall Usaility		The technical specifications are easy to use.	SUPR-Q	1
58	Contents	Presentation	Overall Usaility		The technical specifications are easy to navigate.	SUPR-Q	1
59	Contents	Presentation	Overall Usaility		The technical specifications are easy to read.	SUPR-Q	1
60	Dissemination	Distribution	Overall Usaility		The technical specifications are easy to find.	SUPR-Q	1

No	Topic	Sub-Topic	Dimension ISO9241	Dimension ISO9126	Question	Inspiration	Q no
61	Dissemination	Access	Overall Usaility		The technical specifications are easy to access.	SUPR-Q	1
62	Process	Contribution	Overall Usaility		It's easy to make a contribution.	SUPR-Q	1
63	Contents	Presentation	Effectiveness		The organization of information in the technical specifications was clear.	PSSUQ	12
64	Dissemination	Access	Effectiveness		The organization of information related to document access was clear.	PSSUQ	12
65	Dissemination	Distribution	Effectiveness		The organization of information related to document location was clear.	PSSUQ	12
66	Process	Governance	Effectiveness		The organization of information related to document governance was clear.	PSSUQ	12
67	Process	Contribution	Effectiveness		The organization of information related to contributions was clear.	PSSUQ	12
68	Contents	Technical Specs	Effectiveness		The information in the technical specifications was effective in helping me complete my tasks.	PSSUQ	11

No	Topic	Sub-Topic	Dimension ISO9241	Dimension ISO9126	Question	Inspiration	Q no
69	Process	Contribution	Effectiveness		The information on the organisation's website was effective in helping me make and submit a contribution.	PSSUQ	11
70	Dissemination	Distribution	Effectiveness		The information on the organisation's website was effective in helping me find the technical specifications I was interested in.	PSSUQ	11
71	Dissemination	Access	Effectiveness		The information on the organisation's website was effective in helping me access the technical specifications I was interested in.	PSSUQ	11
72	Contents	Technical Specs	Satisfaction		I felt comfortable using the technical specifications.	PSSUQ	4
73	Dissemination	Distribution	Satisfaction		I felt comfortable accessing the technical specifications.	PSSUQ	4
74	Dissemination	Access	Satisfaction		I felt comfortable finding the technical specifications.	PSSUQ	4

No	Topic	Sub-Topic	Dimension ISO9241	Dimension ISO9126	Question	Inspiration	Q no
75	Process	Contribution	Satisfaction		I felt comfortable making a contribution to the technical specifications.	PSSUQ	4
76	Contents	Presentation	Satisfaction		I felt comfortable navigating the technical specifications.	PSSUQ	4
77	Contents	Technical Specs	Efficiency		I was able to complete my tasks quickly using the technical specifications.	PSSUQ	3
78	Dissemination	Distribution	Efficiency		I was able to quickly find the technical specifications I needed.	PSSUQ	3
79	Dissemination	Access	Efficiency		I was able to quickly access the technical specifications I needed.	PSSUQ	3
80	Contents	Technical Specs	Overall Usability		It was simple to use the technical specifications.	PSSUQ	2
81	Contents	Presentation	Overall Usability		It was simple to navigate the technical specifications.	PSSUQ	2
82	Dissemination	Distribution	Overall Usability		It was simple to find the technical specifications.	PSSUQ	2
83	Dissemination	Access	Overall Usability		It was simple to access the technical specifications.	PSSUQ	2

No	Topic	Sub-Topic	Dimension ISO9241	Dimension ISO9126	Question	Inspiration	Q no
84	Process	Contribution	Overall Usability		It was simple to make a contribution to the technical specifications.	PSSUQ	2
85	Contents	Technical Specs	Overall Usability		It was easy to learn to use the technical specifications.	PSSUQ	5
86	Contents	Presentation	Overall Usability		It was easy to learn to navigate the technical specifications.	PSSUQ	5
87	Dissemination	Distribution	Overall Usability		It was easy to learn to find the technical specifications.	PSSUQ	5
88	Dissemination	Access	Overall Usability		It was easy to learn to access the technical specifications.	PSSUQ	5
89	Process	Contribution	Overall Usability		It was easy to learn to make a contribution the technical specifications.	PSSUQ	5
90	Process	Governance	Overall Usability		It was easy to learn how the governance of the technical specifications works.	PSSUQ	5
91	Contents	Technical Specs	Satisfaction		Overall I am satisfied with how easy it is to use the technical specifications.	PSSUQ	1

No	Topic	Sub-Topic	Dimension ISO9241	Dimension ISO9126	Question	Inspiration	Q no
92	Contents	Presentation	Satisfaction		Overall I am satisfied with how easy it is to navigate the technical specifications.	PSSUQ	1
93	Dissemination	Distribution	Satisfaction		Overall I am satisfied with how easy it is to find the technical specifications.	PSSUQ	1
94	Dissemination	Access	Satisfaction		Overall I am satisfied with how easy it is to access the technical specifications.	PSSUQ	1
95	Process	Contribution	Satisfaction		Overall I am satisfied with how easy it is to make a contribution to the technical specifications.	PSSUQ	1
96	Process	Governance	Satisfaction		Overall I am satisfied with the transparency of the governance process for the technical specifications.	PSSUQ	1
97	Contents	Technical Specs	Satisfaction		I like using the technical specifications.	SUS	1
98	Contents	Presentation	Satisfaction		I like navigating the technical specifications.	SUS	1
99	Dissemination	Distribution	Satisfaction		I like looking for the technical specifications I am interested in.	SUS	1

No	Topic	Sub-Topic	Dimension ISO9241	Dimension ISO9126	Question	Inspiration	Q no
100	Dissemination	Access	Satisfaction		I like accessing the technical specifications.	SUS	1
101	Process	Contribution	Satisfaction		I like making contributions to the technical specifications.	SUS	1
102	Process	Contribution			I have to look for assistance most times when I make a contribution to the technical specifications.	SUMI	50
103	Dissemination	Distribution			I have to look for assistance most times when I am trying to find a specific technical specification.	SUMI	50
104	Dissemination	Access			I have to look for assistance most times when I am trying to access a specific technical specification.	SUMI	50
105	Contents	Technical Specs			I have to look for assistance most times when I am trying to understand the contents of technical specifications.	SUMI	50
106	Contents	Presentation			I have to look for assistance most times when I am trying to navigate through the contents of technical specifications.	SUMI	50

No	Topic	Sub-Topic	Dimension ISO9241	Dimension ISO9126	Question	Inspiration	Q no
107	Dissemination	Access			Getting technical specifications in and out of the repository is not easy.	SUMI	49
108	Process	Contribution			The contribution process is really very awkward.	SUMI	47
109	Process	Governance			The governance process is really very awkward.	SUMI	47
110	Contents	Technical Specs			The technical specifications contents are really very awkward.	SUMI	47
111	Contents	Presentation			The presentation of the technical specifications is really very awkward.	SUMI	47
112	Dissemination	Distribution			The distribution of the technical specifications is really very awkward.	SUMI	47
113	Dissemination	Access			Accessing the technical specifications is really very awkward.	SUMI	47
114	Process	Governance			The governance process occasionally works in a way which can't be understood.	SUMI	46
115	Process	Contribution			The contribution process occasionally works in a way which can't be understood.	SUMI	46

No	Topic	Sub-Topic	Dimension ISO9241	Dimension ISO9126	Question	Inspiration	Q no
116	Dissemination	Distribution			The technical specifications distribution process occasionally works in a way which can't be understood.	SUMI	46
117	Dissemination	Access			It is easy to forget how to access the technical specifications.	SUMI	45
118	Contents	Presentation			It is easy to forget how to navigate the technical specifications.	SUMI	45
119	Contents	Technical Specs			It is easy to forget how to use the technical specifications.	SUMI	45
120	Contents	Technical Specs			It is easy to forget how to read the technical specifications.	SUMI	45
121	Process	Contribution			It is easy to forget how to make a contribution to the technical specifications.	SUMI	45
122	Contents	Presentation	Satisfaction	Liked	The technical specifications present themselves in a very attractive way.	SUMI	42
123	Process	Contribution			The contribution process hasn't always worked in the way I was expecting.	SUMI	41

No	Topic	Sub-Topic	Dimension ISO9241	Dimension ISO9126	Question	Inspiration	Q no
124	Process	Governance			The governance process hasn't always worked in the way I was expecting.	SUMI	41
125	Dissemination	Distribution			The distrinbution process hasn't always worked in the way I was expecting.	SUMI	41
126	Dissemination	Access			Accessing the technical specifications hasn't always been done in the way I was expecting.	SUMI	41
127	Contents	Presentation			The presentation of the technical specifications has not always been the way I was expecting.	SUMI	41
128	Contents	Technical Specs			The contents of the technical specifications have not always been what I was expecting.	SUMI	41
129	Process	Governance			I will never learn all the steps involved in the governance process of the standards specificaions.	SUMI	40
130	Process	Contribution			I will never learn all the steps involved in the contribution process.	SUMI	40

No	Topic	Sub-Topic	Dimension ISO9241	Dimension ISO9126	Question	Inspiration	Q no
131	Process	Governance	Satisfaction		I think the governance process has sometimes given me a headache.	SUMI	37
132	Process	Contribution	Satisfaction		I think the contribution process has sometimes given me a headache.	SUMI	37
133	Dissemination	Distribution	Satisfaction		I think that finding the technical specifications I am looking for has sometimes given me a headache.	SUMI	37
134	Contents	Presentation	Satisfaction		I think that looking at the technical specifications has sometimes given me a headache.	SUMI	37
135	Contents	Presentation	Satisfaction		I think that the presentation of the technical specifications has sometimes given me a headache.	SUMI	37
136	Contents	Presentation	Satisfaction		I think that navigating the technical specifications has sometimes given me a headache.	SUMI	37

No	Topic	Sub-Topic	Dimension ISO9241	Dimension ISO9126	Question	Inspiration	Q no
137	Dissemination	Access	Satisfaction		I think that accessing the technical specifications has sometimes given me a headache.	SUMI	37
138	Contents	Technical Specs	Satisfaction		I think that the contents of the technical specifications has sometmes given me a headache.	SUMI	37
139	Dissemination	Access	Efficiency		There are too many steps required to access the technical specifications.	SUMI	36
140	Process	Contribution	Efficiency		There are too many steps required to make a contribution to the technical specifications.	SUMI	36
141	Dissemination	Distribution	Efficiency		There are too many steps required to find the technical specifications.	SUMI	36
142	Contents	Technical Specs			The organisation of the technical specifications contents seems quite logical.	SUMI	33
143	Process	Governance			The organisation of the governance process seems quite logical.	SUMI	33

No	Topic	Sub-Topic	Dimension ISO9241	Dimension ISO9126	Question	Inspiration	Q no
144	Process	Contribution			The organisation of the contribution process seems quite logical.	SUMI	33
145	Dissemination	Distribution			The organisation of the technical specifications distribution process seems quite logical.	SUMI	33
146	Process	Contribution			It is obvious that technical specifications contributors' needs have been fully taken into consideration.	SUMI	31
147	Contents	Technical Specs			It is obvious that technical specifications consumers' needs have been fully taken into consideration.	SUMI	31
148	Process	Contribution	Efficiency		The speed of the contribution process is fast enough.	SUMI	29
149	Contents	Technical Specs	Satisfaction	Liked	Using the technical specifications is frustrating.	SUMI	27
150	Dissemination	Distribution	Satisfaction	Liked	Finding the technical specifications is frustrating.	SUMI	27
151	Contents	Presentation	Satisfaction	Liked	Navigating the technical specifications is frustrating.	SUMI	27

No	Topic	Sub-Topic	Dimension ISO9241	Dimension ISO9126	Question	Inspiration	Q no
152	Contents	Technical Specs	Satisfaction	Liked	Reading the technical specifications is frustrating.	SUMI	27
153	Process	Contribution	Satisfaction	Liked	Contributing to the technical specifications is a frustrating process.	SUMI	27
154	Contents	Technical Specs			There is too much to read before you can start using the technical specifications.	SUMI	25
155	Process	Contribution			There is too much to read before you can make a contribution to the technical specifications.	SUMI	25
156	Process	Contribution		Understood	I can understand and act on the information provided by the specifications emitting body regarding the contribution process to the technical specifications.	SUMI	23

No	Topic	Sub-Topic	Dimension ISO9241	Dimension ISO9126	Question	Inspiration	Q no
157	Contents	Technical Specs		Understood	I can understand and act on the information provided by the specifications emitting body regarding using the technical specifications.	SUMI	23
158	Dissemination	Distribution		Understood	I can understand and act on the information provided by the standards organisation regarding finding the technical specifications I need.	SUMI	23
159	Dissemination	Access		Understood	I can understand and act on the information provided by the specifications emitting body regarding accessing the technical specifications I need.	SUMI	23
160	Contents	Presentation		Understood	I can understand and act on the information provided by the specifications emitting body regarding the presentation of the technical specifications.	SUMI	23

No	Topic	Sub-Topic	Dimension ISO9241	Dimension ISO9126	Question	Inspiration	Q no
161	Process	Governance			I think the governance process is inconsistent.	SUMI	21
162	Process	Contribution			I think the contributions process is inconsistent.	SUMI	21
163	Contents	Presentation			I think the presentation of the technical specifications is inconsistent.	SUMI	21
164	Contents	Technical Specs			I think the contents of the technical specifications is inconsistent.	SUMI	21
165	Dissemination	Distribution			I think the location of the technical specifications is inconsistent.	SUMI	21
166	Contents	Technical Specs			The specifications emitting body's help pages related to the contents of the technical documents are very informative.	SUMI	15
167	Process	Governance			The specifications emitting body's help pages related to the governance of the technical documents are very informative.	SUMI	15

No	Topic	Sub-Topic	Dimension ISO9241	Dimension ISO9126	Question	Inspiration	Q no
168	Process	Contribution			The specifications emitting body's help pages related to the contribution of the technical documents are very informative.	SUMI	15
169	Dissemination	Access			The specifications emitting body's help pages related to accessing the technical documents are very informative.	SUMI	15
170	Contents	Presentation			The way that technical specifications information is presented is clear and understandable.	SUMI	13
171	Process	Contribution			The way that the contribution information is presented is clear and understandable.	SUMI	13
172	Process	Governance			The way that the governance information is presented is clear and understandable.	SUMI	13
173	Contents	Technical Specs	Satisfaction	Liked	Working with the technical specifications is satisfying.	SUMI	12

No	Topic	Sub-Topic	Dimension ISO9241	Dimension ISO9126	Question	Inspiration	Q no
174	Process	Contribution	Satisfaction	Liked	Contributing to the technical specifications is satisfying.	SUMI	12
175	Contents	Presentation	Satisfaction	Liked	Looking at the technical specifications is satisfying.	SUMI	12
176	Contents	Technical Specs			It takes too long to learn how to use the technical specifications.	SUMI	10
177	Process	Contribution			It takes too long to learn how to contribute to the technical specifications.	SUMI	10
178	Contents	Technical Specs			I find that the help information given by the specifications emitting body regarding the technical specifications is not very useful.	SUMI	8
179	Process	Contribution			I find that the help information given by the specifications emitting body regarding contributing to the technical specifications is not very useful.	SUMI	8

No	Topic	Sub-Topic	Dimension ISO9241	Dimension ISO9126	Question	Inspiration	Q no
180	Process	Governance			I find that the help information given by the specifications emitting body regarding the governance of the technical specifications is not very useful.	SUMI	8
181	Dissemination	Access			I find that the help information given by the specifications emitting body regarding accessing the technical specifications is not very useful.	SUMI	8
182	Dissemination	Distribution			I find that the help information given by the specifications emitting body regarding finding the technical specifications I am interested in is not very useful.	SUMI	8
183	Contents	Technical Specs			I enjoy the time I spend using the technical specifications.	SUMI	7
184	Process	Contribution			I enjoy the time I spend contributing to the technical specifications.	SUMI	7

No	Topic	Sub-Topic	Dimension ISO9241	Dimension ISO9126	Question	Inspiration	Q no
185	Contents	Presentation			I enjoy the time I spend looking at the technical specifications.	SUMI	7
186	Contents	Presentation			I enjoy the time I spend navigating the technical specifications.	SUMI	7
187	Contents	Technical Specs			I sometimes don't know what to do next when i use the technical specifications.	SUMI	6
188	Process	Contribution			I sometimes don't know what to do next when i make a contribution to the technical specifications.	SUMI	6

E Affinity Diagram Images

A selection of the categories identified during the affinity diagram exercise can be seen below.

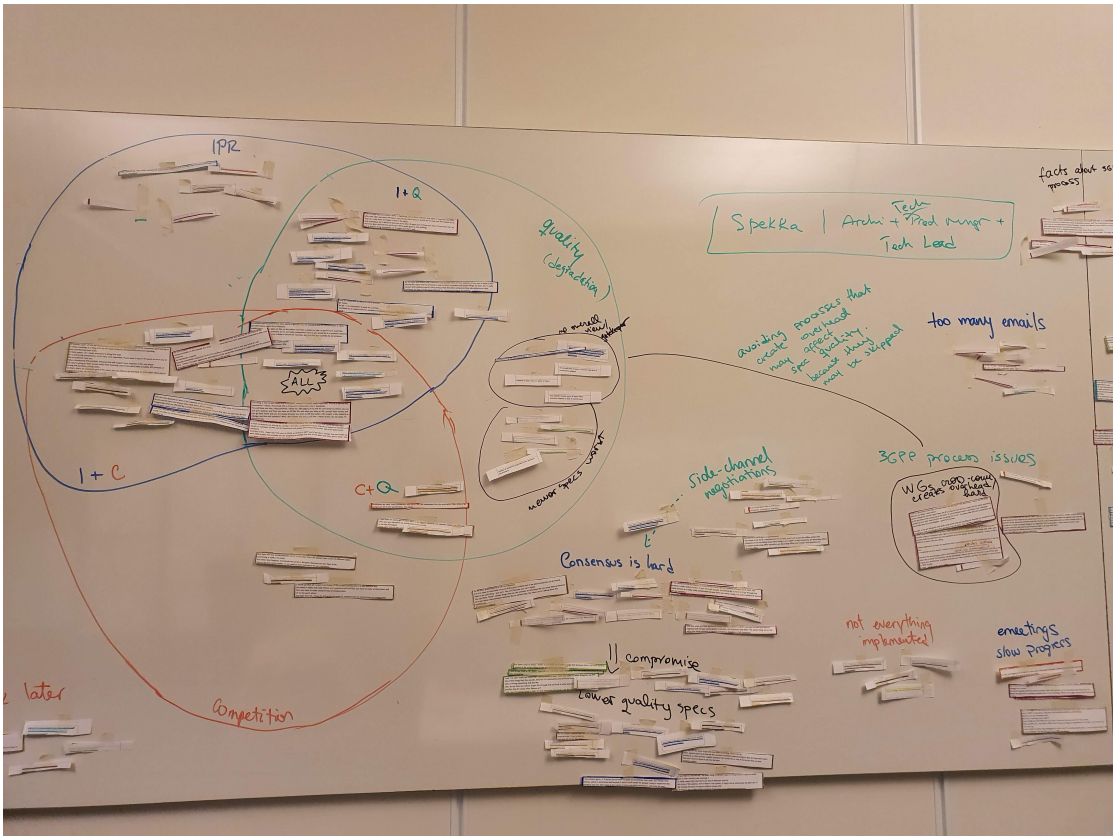

Figure E1: Affinity diagram work - Partial overview

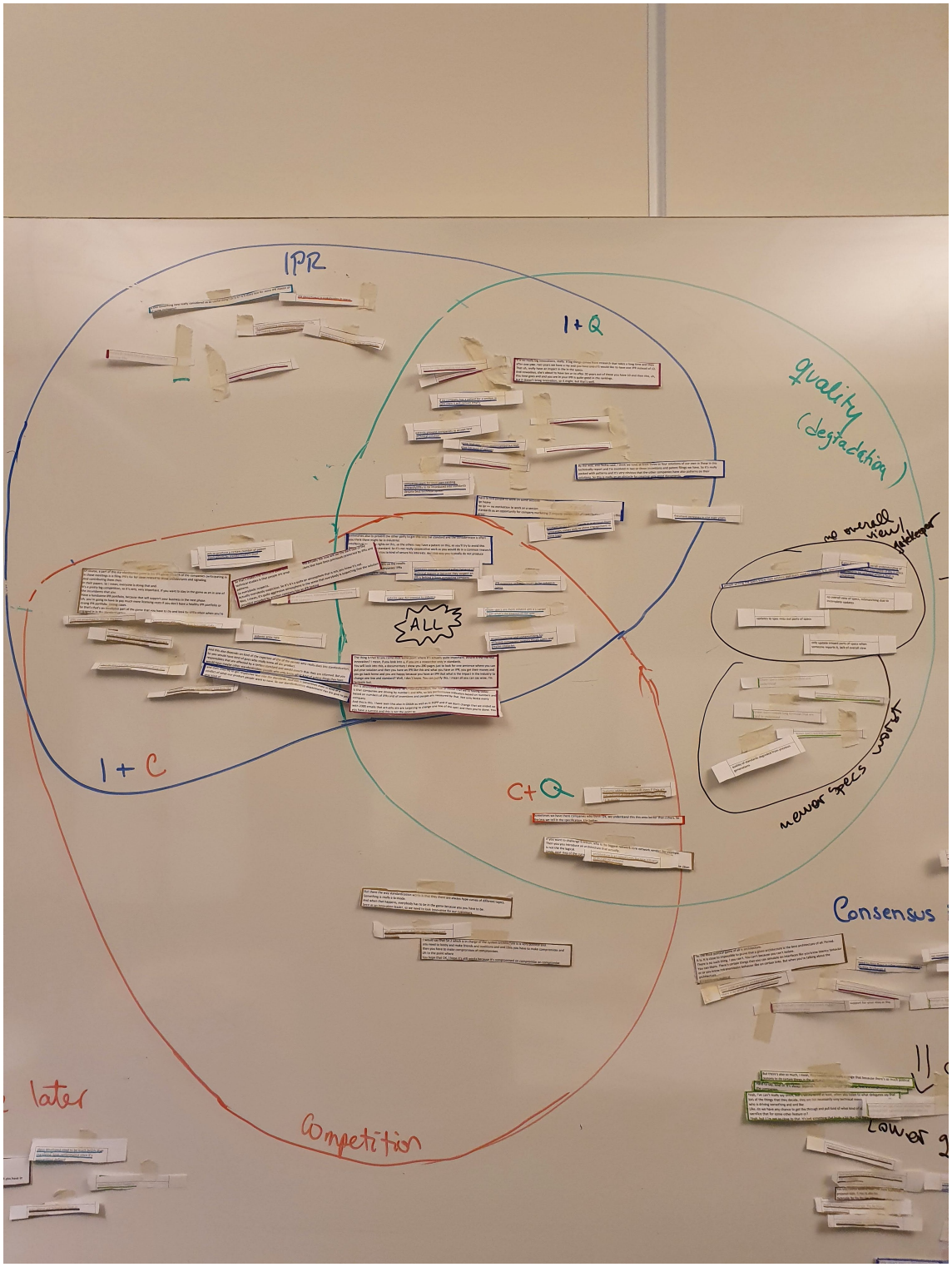

Figure E2: Affinity diagram work - IPRs, quality degradation and competition

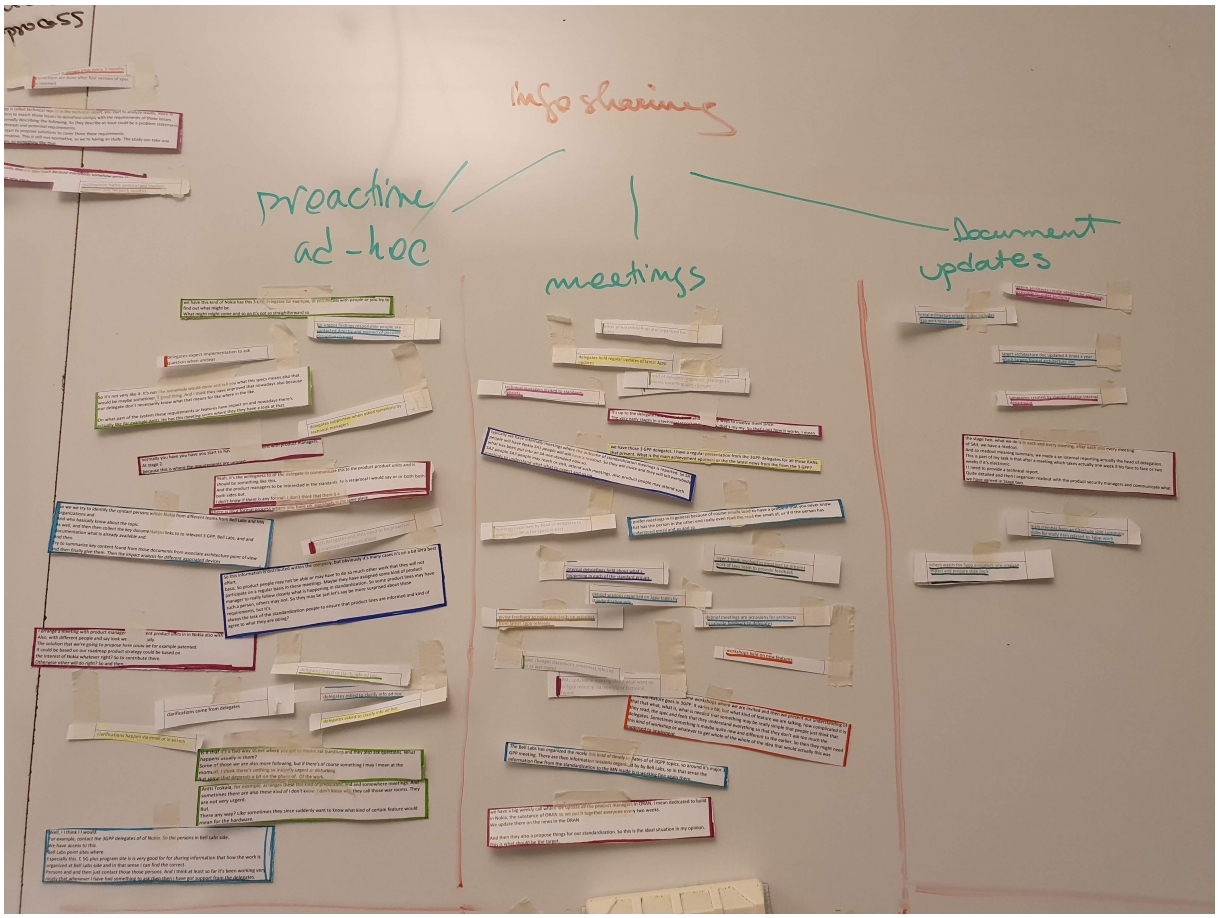

Figure E3: Affinity diagram work - Information sharing

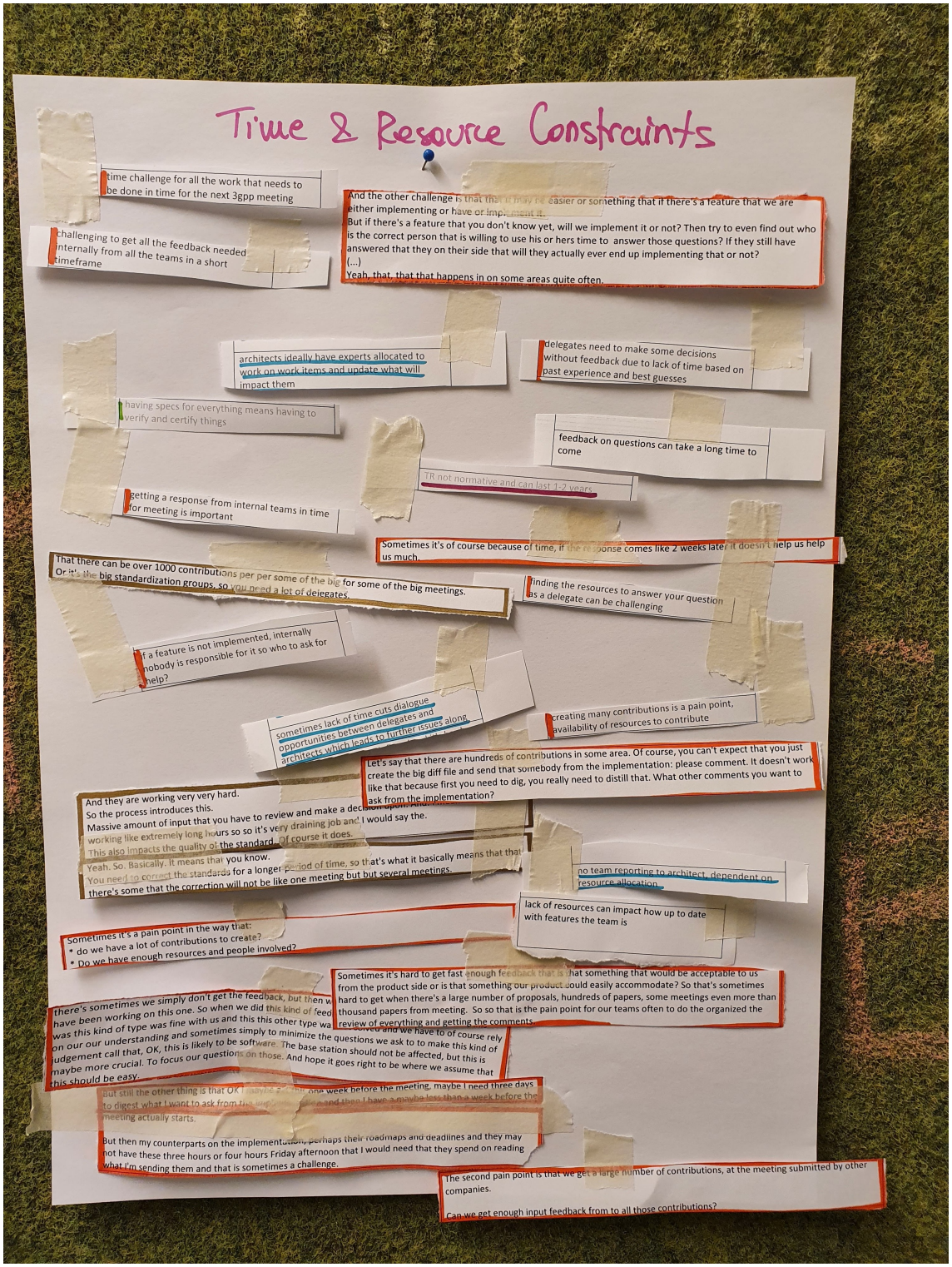

Figure E4: Affinity diagram work - Time and resource constraints

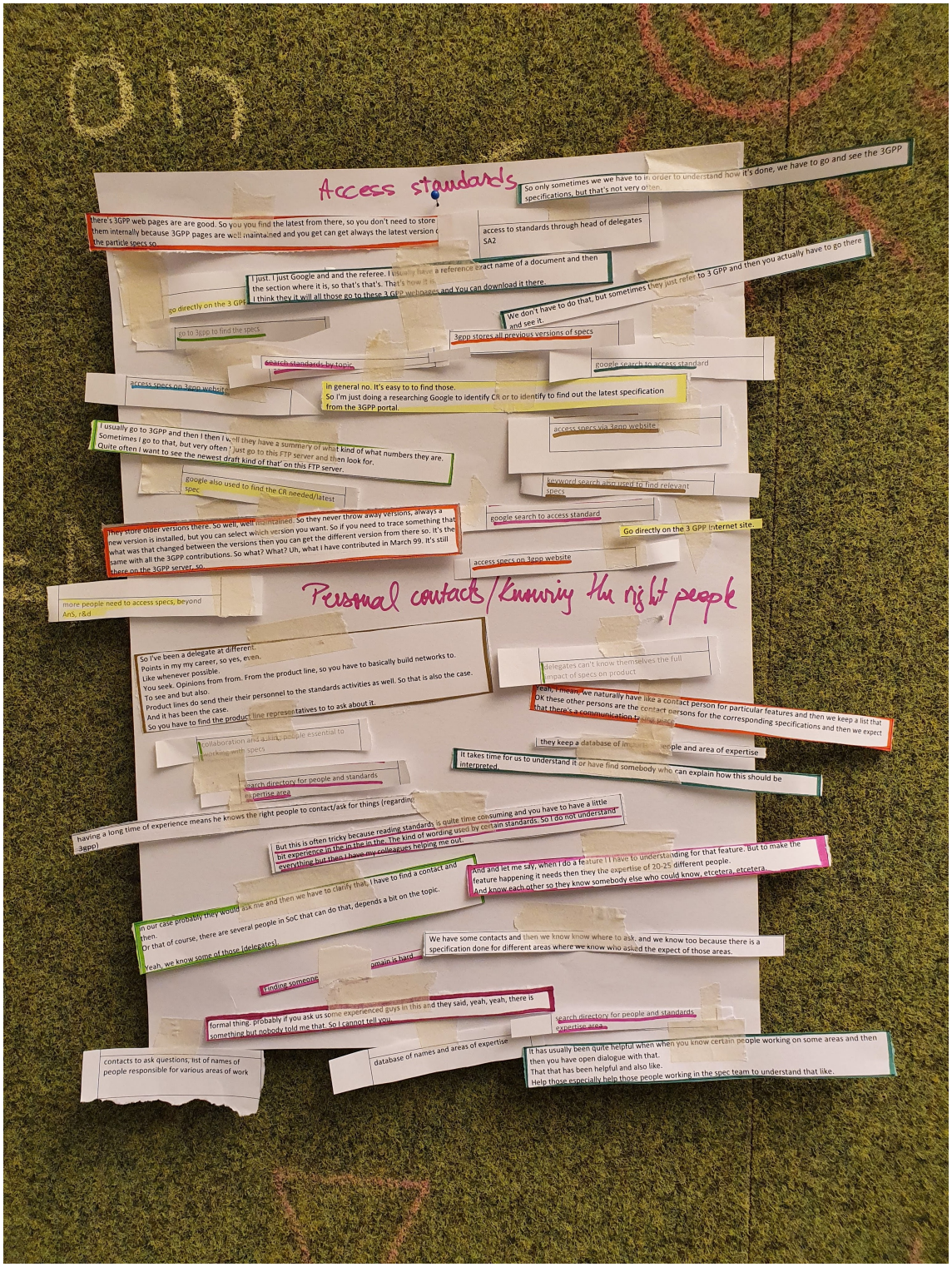

Figure E5: Affinity diagram work - Accessing specifications and personal contacts

F Specification Producers Survey

Which of the following describes your job role more accurately in relation to 3GPP technical specifications?

- Specification producer (e.g., a previous or current standards delegate)
- Specification consumer (e.g., not a delegate but uses/accesses 3GPP technical specifications as part of their work)

I sometimes find it hard to accomplish my tasks related to 3GPP technical specifications.

- Strongly disagree, Disagree, neutral, agree, strongly agree

[IF PREVIOUSLY ANSWERED AGREE, STRONGLY AGREE]
Select all the reasons why you sometimes find it hard to accomplish tasks related to 3GPP technical specifications.

- I have too much work to do in a short time frame.
- I do not receive timely feedback from colleagues.
- I need to work with my best guess due to lack of timely information.
- I am not allocated the needed resources.
- It is hard to find the right person to ask a question or clarify some information.
- Too many contributions to review and submit in a short time frame.
- Lack of discussions internally.
- Not enough time to receive results from internal feasibility studies.
- Other...

I believe the 3GPP technical specifications documents are too long.

- Strongly disagree, Disagree, neutral, agree, strongly agree

[IF PREVIOUSLY ANSWERED AGREE, STRONGLY AGREE]
Select all the reasons you believe impact the length of the 3GPP technical specifications documents.

- Standards are bloated with hyped/trendy but non – essential features.
- Standards are bloated with multiple solutions for the same issue due to IPR reasons.
- Standards are bloated with features that never get implemented.

- Other...

[IF PREVIOUSLY ANSWERED AGREE, STRONGLY AGREE]
Select all the possible ways that the length of the 3GPP technical specifications document has an impact on your work.

- The length of the document causes my computer/Microsoft Word to hang/stall.
- Opening documents is very slow.
- Finding information within the specification is challenging.
- The search function does not meet my needs.
- Other...

I spend a lot of time finding the information I need in the 3GPP technical specifications.

- Strongly disagree, Disagree, neutral, agree, strongly agree

[IF PREVIOUSLY ANSWERED AGREE, STRONGLY AGREE]
Select all the reasons why you spend a lot of time finding the information you need in the 3GPP technical specifications.

- I need to browse multiple 3GPP technical specifications to get the information I need.
- I find navigating the 3GPP technical specifications challenging.
- I find that the current nested referencing system makes the 3GPP technical specifications difficult to read.
- I find that the 3GPP technical specifications are poorly linked between themselves.
- I find it challenging to find the information I need if it is outside my area of expertise.
- Other...

I believe the current 3GPP technical specifications quality assurance process is insufficient.

- Strongly disagree, Disagree, neutral, agree, strongly agree

[IF PREVIOUSLY ANSWERED AGREE, STRONGLY AGREE]
Select all the reasons why you believe the current 3GPP technical specifications quality assurance process is insufficient.

- The review process is too short.

- The review process is too long.
- Quality assurance relies on other companies reviewing specifications which do not always have technical accuracy as a prime driver.
- Many faults are discovered only at implementation time.
- Other...

The quality of the 3GPP technical specifications has decreased in recent years.

- Strongly disagree, Disagree, neutral, agree, strongly agree

[IF PREVIOUSLY ANSWERED AGREE, STRONGLY AGREE]
Select all the reasons why the quality of the 3GPP technical specifications has decreased in recent years.

- There are too many contributions to check.
- There are too many organizations involved.
- The delegates are overworked.
- Updating a feature is challenging due to information being spread across multiple 3GPP technical specifications.
- Companies push for solutions that use their own IPRs and not necessarily the best technical solution.
- The structure of the technical specification document cannot accommodate the large amount of information added.
- Other...

How frequently do you refer to the official 3GPP training and guidelines?

- Never, Rarely, Sometimes, Often, Always

[IF PREVIOUSLY ANSWERED NEVER, RARELY]
Select all the reasons why you do not or rarely refer to the official 3GPP training and guidelines.

- The 3GPP training and guidelines documents are too long.
- In the 3GPP training and guidelines documents, the information insufficient.
- In the 3GPP training and guidelines documents, the information is difficult to find.
- I was not aware of such materials, or they are not easily accessible.
- I prefer asking colleagues.

- I prefer to refer to internal (company) resources.
- I do not need to as I am familiar with 3GPP working procedures.
- Other...

I believe that the effectiveness of the current 3GPP collaboration process can be improved.

- Strongly disagree, Disagree, neutral, agree, strongly agree

[IF PREVIOUSLY ANSWERED AGREE, STRONGLY AGREE]
Select all the reasons affecting the effectiveness of the 3GPP collaboration process.

- Companies are suspicious of hidden IPRs behind other competitors' proposals.
- Companies maintain market relevance by proposing many IPR backed solutions.
- Collaboration is difficult in 3GPP meeting due to distrust amongst competitors.
- Some 3GPP technical specifications may remain incomplete due to lack of consensus between the companies.
- Other...

I believe that the efficiency of the current 3GPP collaboration process can be improved.

- Strongly disagree, Disagree, neutral, agree, strongly agree

[IF PREVIOUSLY ANSWERED AGREE, STRONGLY AGREE]
Select all the reasons affecting the efficiency of the 3GPP collaboration process.

- Companies are suspicious of hidden IPRs behind other competitors' proposals.
- Companies maintain market relevance by proposing many IPR backed solutions.
- Deadlocks in reaching consensus are a frequent occurrence.
- Other...

Reaching consensus in a 3GPP meeting can be a time-consuming task.

- Strongly disagree, Disagree, neutral, agree, strongly agree

[IF PREVIOUSLY ANSWERED AGREE, STRONGLY AGREE]
Select all the reasons why reaching consensus in a 3GPP meeting can be a time-consuming task.

- Many companies are involved, each with their own interests.
- It is difficult to prove the technical superiority of one solution over others.

- Proposed solutions need to be negotiated with other member companies.
- Getting support for ideas involves establishing alliances, lobbying and making compromises.
- Other...

I find negotiating is more efficient when done face to face.

- Strongly disagree, Disagree, neutral, agree, strongly agree

[IF PREVIOUSLY ANSWERED AGREE, STRONGLY AGREE]
I find negotiating is more efficient when done face to face because:

- I think that e-meetings slow down the work progress in 3GPP.
- I think that emails are inefficient for negotiating.
- I think that emails are inefficient for reaching consensus.
- Other...

I find it cumbersome to coordinate with other work groups in 3GPP.

- Strongly disagree, Disagree, neutral, agree, strongly agree

[IF PREVIOUSLY ANSWERED AGREE, STRONGLY AGREE]
Select all the reasons why your work is affected by the coordination process with other 3GPP work groups.

- I find that it slows down my work
- I avoid involving the other working groups whenever I can.
- I may overlook important details by avoiding communication with other working groups.
- Other...

I find that 3GPP communications generate too many emails.

- Strongly disagree, Disagree, neutral, agree, strongly agree

[IF PREVIOUSLY ANSWERED AGREE, STRONGLY AGREE]
Select all the ways in which you are affected by the fact that 3GPP communications generate too many emails.

- I spend too much time reading emails.
- I miss emails which may hold important information.
- I find it cumbersome to go through the emails.

- Other...

The delay between 3GPP work and implementation has caused issues in my work.

- Strongly disagree, Disagree, neutral, agree, strongly agree

[IF PREVIOUSLY ANSWERED AGREE, STRONGLY AGREE]
Select all the reasons why the delay between 3GPP work and implementation has caused issues in your work.

- It slowed down feedback on current 3GPP work.
- Some new 3GPP features slipped unchecked by our internal team which caused issues later on.
- Some internal decisions relied on guesswork which we needed to rectify later.
- Other...

How difficult is it to find the people needed to accomplish tasks related to 3GPP technical specifications.

- Very difficult, Difficult, Neutral, Easy, Very Easy

[IF PREVIOUSLY ANSWERED DIFFICULT, VERY DIFFICULT]
Select all the ways in which the difficulty of finding the needed people to accomplish tasks related to 3GPP technical specifications affects your work.

- I need to make best guesses when commenting on change requests.
- My tasks are not completed on time.
- I lose time identifying relevant people for the task.
- Other...

G Specification Consumers Survey

Which of the following describes your job role more accurately in relation to 3GPP technical specifications?

- Specification producer (e.g., a previous or current standards delegate)
- Specification consumer (e.g., not a delegate but uses/accesses 3GPP technical specifications as part of their work)

How satisfied are you with the quality of 3GPP technical specifications?

- Very dissatisfied, Dissatisfied, Unsure, Satisfied, Very satisfied

[IF PREVIOUSLY ANSWERED DISSATISFIED, VERY DISSATISFIED]
Select all the reasons for choosing the level of satisfaction.

- Inconsistencies or conflicting information in 3GPP technical specifications.
- Mismatch between interconnected 3GPP technical specifications.
- Formulas are too long.
- 3GPP technical specifications are bloated with too much information.
- Some features are kept for several generations but never implemented.
- Other...

[IF PREVIOUSLY ANSWERED DISSATISFIED, VERY DISSATISFIED]
Select all the effects the quality of the 3GPP technical specifications has on your work.

- It takes me longer to read the 3GPP technical specifications.
- It is more complicated to understand the 3GPP technical specifications.
- It does not affect my work.
- Other...

I sometimes find it hard to accomplish tasks that involve referring to 3GPP technical specifications.

- Strongly disagree, Disagree, neutral, agree, strongly agree

[IF PREVIOUSLY ANSWERED AGREE, STRONGLY AGREE]
Select all the reasons why you sometimes find it hard to accomplish tasks that involve referring to 3GPP technical specifications.

- I have too much work to do in a short time frame.
- I do not receive timely feedback from colleagues.

- I am not allocated the needed resources.
- It is hard to find the right contact to ask questions or clarify details about the 3GPP technical specifications.
- I have to give feedback for too many 3GPP contributions in a short time frame.
- Lack of time to conduct feasibility studies for the upcoming 3GPP features.
- I have to make assumptions regarding future trends.
- I have to rectify incorrect guesses made earlier when the specifications were in preliminary phase.
- It is hard to understand the intention behind a specification.
- Other...

I spend a lot of time finding the information I need in the 3GPP technical specifications.

- Strongly disagree, Disagree, neutral, agree, strongly agree

[IF PREVIOUSLY ANSWERED AGREE, STRONGLY AGREE]
Select all the reasons why you spend a lot of time finding the information you need in the 3GPP technical specifications.

- I need to browse multiple 3GPP technical specifications to get the information I need.
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- Strongly disagree, Disagree, neutral, agree, strongly agree

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- Companies push for solutions that use their own IPRs and not necessarily the best technical solution.
- The structure of the technical specification document cannot accommodate the large amount of information added.
- Other...

I find the 3GPP technical specifications hard to read and/or understand.

- Strongly disagree, Disagree, neutral, agree, strongly agree

[IF PREVIOUSLY ANSWERED AGREE, STRONGLY AGREE]
Select all the reasons why you find the 3GPP technical specifications hard to read and/or understand.

- The 3GPP technical specifications are too technical.
- The 3GPP technical specifications do not include enough background information.
- 3GPP technical specifications are incoherent due to too many edits and editors.
- I have no time to read the entire 3GPP technical specification.

- 3GPP technical specifications are too long.
- The language used in 3GPP technical specifications is hard to understand.
- Understanding one 3GPP technical specification requires the understanding of too many other related 3GPP technical specifications.
- The information I need is scattered across multiple 3GPP technical specifications.
- Lack of executive summary for 3GPP technical specifications.
- Formulas are hard to read and/or understand.
- Other...

The language of the 3GPP technical specifications is vague.

- Strongly disagree, Disagree, neutral, agree, strongly agree

[IF PREVIOUSLY ANSWERED AGREE, STRONGLY AGREE]
Select all the reasons why the vagueness of the 3GPP technical specifications language impacts your work.

- It is hard to understand which features are mandatory.
- It is time consuming to get clarifications from the delegates.
- It is time consuming to get clarifications from other colleagues.
- It is difficult to get clarifications.
- It makes the implementation process more difficult.
- There are inconsistencies between Stage 2 and Stage 3 documents.
- I rely on others to understand the technical specifications.
- My work may be blocked whilst I wait for help from more technically able colleagues.
- Other...

I believe the 3GPP technical specifications documents are too long.

- Strongly disagree, Disagree, neutral, agree, strongly agree

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- The length of the document causes my computer/Microsoft Word to hang/stall.

- Opening documents is very slow.
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- The search function does not meet my needs.
- Other...

I prefer having figures in 3GPP technical specifications.

- Strongly disagree, Disagree, neutral, agree, strongly agree

[IF PREVIOUSLY ANSWERED AGREE, STRONGLY AGREE]
Select all the reasons why you prefer having figures in 3GPP technical specifications.

- Figures are easier to understand.
- Figures are quicker to understand.
- Figures provide a deeper understanding of the technical specification.
- Figures provide an overview of the feature.
- Other...

I find checking for product compliance with 3GPP technical specifications time consuming.

- Strongly disagree, Disagree, neutral, agree, strongly agree

[IF PREVIOUSLY ANSWERED AGREE, STRONGLY AGREE]
Select all the reasons why you find checking for product compliance with 3GPP technical specifications time consuming.

- There are too many 3GPP technical specifications to check.
- It is hard to understand which features from a 3GPP technical specification are mandatory.
- It is hard to understand which features in the 3GPP technical specifications are important from a commercial point of view.
- Other...

Information sharing between me and 3GPP delegates includes the following:

- Attend debriefing meetings.
- Read internally created summaries.
- Read power point slides.
- Receive updates via email.

- Ask colleagues directly.
- Attend company workshops.
- Providing information related to my IPR(s).
- Other...

I find the information sharing process between me and 3GPP delegates to be:

- Effective : Strongly disagree, Disagree, neutral, agree, strongly agree
- Efficient : Strongly disagree, Disagree, neutral, agree, strongly agree

I find the process of staying up to date with the latest 3GPP technical specifications overwhelming.

- Strongly disagree, Disagree, neutral, agree, strongly agree

[IF PREVIOUSLY ANSWERED AGREE, STRONGLY AGREE]
Select all the reasons why you find the process of staying up to date with the latest 3GPP technical specifications overwhelming.

- It takes up much of my time.
- There are too many specifications to check.
- I need to follow too many standards bodies each with their own set of distinct standards and specifications.
- It involves interacting with too many different people.
- It is time consuming to understand the similarities and differences between relevant standards and specifications from different standards bodies due to the use of different wording.

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- Never, Rarely, Sometimes, Often, Always

[IF PREVIOUSLY ANSWERED NEVER, RARELY]
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- I lose time identifying relevant people for the task.
- Other...