Enhancing the obsolescence management of tester equipment

Lappeenranta–Lahti University of Technology LUT

Master's thesis in Electrical Engineering

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ABSTRACT

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In this thesis, the existing obsolescence management practices related to tester equipment in the company considered in this thesis are improved. Relevant information about obsolescence management and related standards are gathered and presented in the form of a literature review. The company's existing obsolescence management practices are identified and reviewed based on the gathered information. Improvements are proposed to the existing practices, which are reviewed via a questionnaire survey. The improved practices are formed into an obsolescence management framework and then developed into a comprehensive obsolescence management process.

The management process is partially tested in this thesis via a case-study example, in which an obsolete piece of tester equipment is replaced. The purpose is to examine the existing replacement procedure and to identify areas of improvement. The replacement procedure is evaluated based on its practicality and improvements are proposed to address any issues identified. Remaining steps of the obsolescence management process will be tested as future work after the publication of this thesis.

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Testerilaitteiston ikääntymisen hallinnan parantaminen

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Tässä diplomityössä kehitetään yrityksen nykyisiä testerilaitteiston ikääntymisen hallinnan toimintatapoja. Merkityksellistä tietoa ikääntymisen hallinnasta ja siihen liittyvistä standardeista kerätään ja esitetään kirjallisuuskatsauksen muodossa. Työssä tunnistetaan ja arvioidaan yrityksen nykyiset ikääntymisen hallinnan toimintatavat. Nykyisiin toimintatapoihin esitetään parannuksia ja niiden toiminnallisuutta arvioidaan kyselytutkimuksen avulla, joka lähetetään ylläpitotiimin jäsenille. Parannetuista toimintatavoista muodostetaan testerilaitteiston ikääntymisen hallintaa kohdennettu viitekehys, jonka pohjalta muodostetaan ikääntymisen hallinnan prosessimalli.

Hallintaprosessia testataan osittain suorittamalla laitteen korvaamistoimenpide, jossa ikääntynyt testerilaite korvataan toisella laitteella. Tämän tarkoituksena on sekä tutustua nykyiseen korvaamistoimenpiteeseen ja tunnistaa siitä parannuskohteita. Laitteiden korvaamiseen tarkoitettujen toimenpiteiden käytännöllisyyttä arvioidaan ja esitetään parannuksia ongelmakohtiin. Loput testerilaitteiston ikääntymisen hallintaprosessin vaiheista on tarkoitus testata tulevaisuudessa työn julkaisemisen jälkeen.

SYMBOLS AND ABBREVIATIONS

Abbreviations

ATS	automated test set
BOM	bill-of-materials
COTS	commercial-off-the-shelf
CTE	calibration and testing engineering
CTM	calibration and testing maintenance
DMSMS	diminishing manufacturing sources and material shortages
EOL	end-of-life
EOLA	end-of-life announcement
FMEA	failure mode and effects analysis
IPR	intellectual property rights
ISO	international standardization organization
JIRA	software development tool used for issue tracking and project management
MTBF	mean time between failure
MTTR	mean time to repair
NCE	non-recurring engineering
OEM	original equipment manufacturer
OMP	obsolescence management plan
PCN	product change notice
PDCA	plan do check act
POMS	proactive obsolescence management system
UUT	unit under test

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1 Introduction

Obsolescence management is an important process when concerning sustainment-dominated systems, which include avionics, military systems, and industrial equipment [1]. These systems have longer life cycles than their constituent parts, but the systems require to be sustained and kept operational even after their constituent parts become unavailable due to obsolescence [1]. Regular consumer products often have a lifespan of only a few years, such as smartphones. In contrary, products in aerospace and defense sectors are produced and supported for decades [2]. A typical challenge for companies that specialize in manufacturing products with long life cycles is to ensure the continuation of production even after a certain component used in the product becomes unavailable due to obsolescence. Managing the component obsolescence of products is crucial, but in addition to that, also the test systems which are used to test the products require to be managed for obsolescence. According to [2] test engineers in aerospace and defense industry spend at least 50 percent of their time actively dealing with obsolescence in their automated test sets (ATSs).

Product's life cycle typically consists of six main stages which are presented in Fig. 1. In this example of stage-classification, the last stage of product's life cycle is called obsolescence. Obsolescence has been defined as "the condition of no longer being used or useful" in [3] and as "the loss or impending loss of original manufacturers of items or suppliers of items or raw materials" in [4]. *In industrial domain, obsolescence also includes the cessation of production of a component if there are no other manufacturers for that specific component* [5]. In the context of managing obsolescence of tester equipment, obsolescence often happens due to product discontinuation. The topic of this thesis is industry-driven, and the company considered in this thesis uses a variety of tester equipment at their test stations. This thesis will focus on improving the obsolescence management procedures related to tester equipment, which are used at the testing phase of the company's production chain. A literary survey is conducted in this thesis to provide information about existing obsolescence management processes and about standards related to management processes. Based on the gathered information and a questionnaire survey, the existing management procedures related to resolving obsolescence issues of tester equipment will be improved. The improved management process will be partially tested via a case-study example in which obsolete tester equipment is replaced.

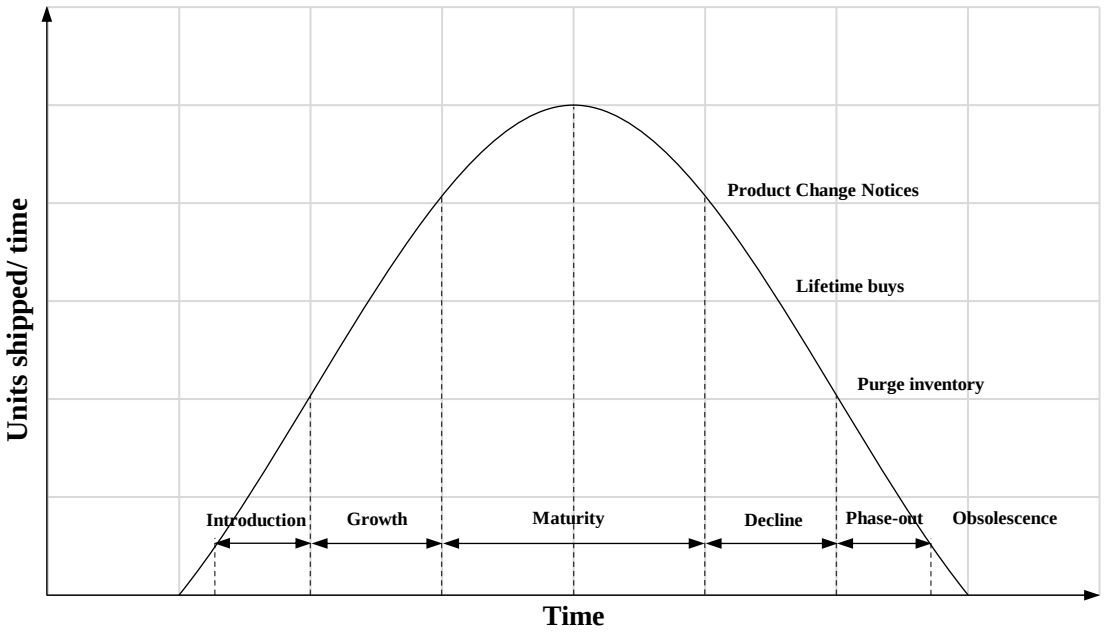

Figure 1. Example of part life cycle curves [6]. The six main stages are introduction, growth, maturity, decline, phase-out and obsolescence.

1.1 Background

The company focused on in this thesis, is testing their products at test stations, which are built from various mechanical, electronical, pneumatical parts and devices. Typically, once a product has been manufactured and assembled, its functionality needs to be tested. In similar fashion within the company considered in this thesis, testing is done after products and parts have been manufactured and assembled. Company considered in this thesis uses tester equipment such as electronical measuring instruments at test stations to measure different electrical quantities during automated test sets. Test stations require to maintained and kept operational for the entire life cycle of specific products or product families. A product is usually updated throughout its entire life cycle, and because of this, the test stations often require to be updated as well. Updates to test stations happen on both hardware and software level. Systems with life cycles of multiple decades have been noted to be challenging to maintain in [2] as test engineers need to maintain test stations based on legacy or even obsolete equipment.

Tester equipment and other electronical devices used at test stations degrade over time, due to different degradation mechanisms such as mechanical wear, humidity, electrical stress,

and fatigue. As a result of degradation, electronical devices may lose their ability to function accurately. Impacts of degradation include, e.g., changes in equipment signals or response times, accuracy and reproducibility degradation, calibration drift or loss of output data [7]. Therefore, effects of degradation and ageing can cause a device to not function according to its original specification. If tester equipment is not functioning according to its original specification, it may compromise the functionality of the test station and result as products not passing certain tests. Preventive maintenance has been put in place to counter most effects of degradation, but sudden obsolescence can still occur, since certain effects of degradation are difficult to prevent.

All tester equipment will eventually become obsolete, but end of life announcements (EOLA) made by the manufacturers allow customers to prepare before their products become obsolete. An EOLA takes places at the end of product's life cycle, and it is followed by last time buys which are referred to as lifetime buys in Fig. 1. It's worth noting that a product can also become obsolete before the product has reached its expected obsolescence stage. Premature obsolescence is unexpected, for example, changes on the employee level can cause a lack of know-how regarding a specific device [8]. In worst case, this can result as inability to produce, maintain, or repair the device, which will render the device obsolete. Different types of obsolescence are presented and discussed later in Section 2 of this thesis.

1.2 Objectives of the study

The objective of this study is to gather relevant information related to obsolescence management, which is then used to improve the existing practices used for managing issues that are caused by obsolete or soon-to-be obsolete tester equipment within the company of this thesis. The existing management practices will be identified and reviewed based on the gathered information. An additional review of the existing management practices is conducted via a questionnaire survey. Based on the results of the two reviews, improvement recommendations to the management practices are proposed and then developed into a comprehensive management process.

The second objective of this study is to partially test the improved management process by carrying out a replacement procedure for an EOL piece of tester equipment. The replacement procedure will function as a case-study example, and it is presented in Section 4 of this

thesis. The case-study will examine the existing practices used in the company and provide information about the practicality, agility, and issues related to the replacement procedure. Additional improvements and changes to the management process are expected to take place after this study. A conclusion of results will be presented in Section 5 and potential future changes to the management process will be discussed. This information allows the company of this thesis to modify the management process in the future.

1.3 Research questions

In this thesis, an attempt is made to provide answers to the following research questions (**RQ**):

RQ 1: How is obsolescence management conducted in practice? This thesis will examine a process example gathered from the literature to understand how the management should be done. Additionally, the thesis will break down the management process found from literature into specific process steps.

RQ 2: What standards are available for obsolescence management related to industrial and tester equipment? The research will explore different standards related to obsolescence management. If suitable standards are found, how could these standards be applied to existing management processes. The applicability of relevant standards to different stages of management processes will be evaluated.

RQ 3: How is the company of this thesis currently managing issues that are caused by obsolete or soon-to-be obsolete tester equipment? Does the current management process have similarities to obsolescence management process gathered from the literature review? The current management practices will be identified and evaluated by comparing them with management processes gathered from literature.

RQ 4: Which parts of the existing management practices should be improved? The existing management practices will be reviewed in two stages. The first stage will consist of reviewing the management practices by comparing it to information gathered from the literature survey. Based on the results of the review, improvement recommendations will be proposed to address the issues. The second review will consist of a questionnaire survey, in which

both the existing management practices and suggested improvements will be reviewed. The survey will be sent to employees who are managing issues caused by EOL tester equipment.

RQ 5: What is the existing replacement procedure and which parts should be improved about the procedure? The replacement procedure will be examined to this thesis to appropriate extent from the company's point of view. Improvements will be proposed but they will be implemented outside of this thesis.

RQ 6: Which are the parts of the improved management process and replacement procedure that should be further improved as future-work? The results of the thesis will be analyzed and discussed to provide ideas for future-work.

It is worth remarking that the problem statement of the research topic addressed in this thesis is defined by six main research questions and supporting sub-questions. These questions are strongly interlinked and will be answered in sequential manner, as answers to the first question support the following question and so on. These questions also guide and define the scope of the topics considered in this thesis.

2 Obsolescence management processes and standards

In this chapter, a literary review is conducted on obsolescence management processes. Additionally, a standardized way of managing obsolete equipment in an industrial setting will be researched. The purpose of this literary review is to gather necessary information so that the existing obsolescence management practices related to tester equipment can be improved within the company considered in this thesis. The purpose of researching standards related to obsolescence management is to discover if a standardized way of management exists. The benefit of using standardized practices is to assure that chosen practices are done in uniform way. In addition, the use of standardized practices in any process enhances the quality, consistency, and safety of the process [9].

First, in Section 2.1, an example of obsolescence management process is presented. The process example gathered from the literature is broken down into smaller process steps and each step is studied. This section will answer to **RQ1** introduced in Section 1. After general understanding of obsolescence management processes have been gathered, different standards related to management of industrial equipment will be analyzed. The company providing this thesis topic is interested in improving their obsolescence management of tester equipment used at test stations. Hence, examples of standards related to test and industrial equipment management will be presented, and potential standards are chosen based on practical evaluation. The Section 2.2 will answer to **RQ2** introduced in Section 1.

2.1 Existing obsolescence management processes

Obsolescence management processes are used in different industries and are especially important in arms, aviation, and nuclear industries [10]. These industries don't have much control over when a given manufacturer decides to discontinue supporting or manufacturing replacement parts or components. Obsolescence is defined as "the loss or impending loss of original manufacturers of items or suppliers of items or raw materials" in [10]. To counter the effects of obsolescence, industries have established obsolescence management processes. For example, in Finnish nuclear power plants at Loviisa and Olkiluoto, proactive obsolescence management systems have been implemented [11]. A part of these

management systems was to establish dedicated groups with necessary disciplines to take care of various obsolescence activities for managing nuclear power plants' spare parts.

The main goal of obsolescence management is to ensure that obsolescence is managed throughout the product's life cycle to minimize financial and availability impacts [12]. Minimizing financial impacts is often achieved on the production level by eliminating downtime. To emphasize the cost of downtime, survey made by Siemens concludes that a single hour of downtime in modern automotive industry can cause losses up to $2,000,000 [13]. The cost of a single hour of downtime may not be as massive for the company when considering the product case that is considered in this thesis, but excessive downtime will still cause financial losses. One reason for production downtime within the company of this thesis, is due to a piece of tester equipment breaking down or not functioning according to its original specification. These two causes are considered as mechanical and technological obsolescence [3]. Replacing an obsolete device may introduce the possibility of extended production stoppage if there is no validated replacement device available.

Clarification between terms EOL and obsolescence is done before continuing this chapter. EOL and obsolescence are often used synonymously but the terms still share differences. A product will become EOL when the manufacturer discontinues its production. Manufacturers also consider their discontinued products to be obsolete. The customer however can consider a product to be obsolete even when it's still in production, for example if the product does not meet the demands of the customer anymore. The differences between discontinuance and obsolescence have been explained in [6]. The root cause of obsolescence determines the type of obsolescence, which include mechanical, technological, psychological, economic, incompatibility, and premature obsolescence [3]. When considering the company case in this thesis, the most common reason for obsolescence is due to product discontinuance but also mechanical, incompatibility, premature, and technological obsolescence occur.

Next, an example of obsolescence management process is provided with the support of relevant literature. Additional obsolescence management processes are presented in [14] and [15], these processes were studied but are not examined in this section.

2.1.1 Example process for product obsolescence management

A basic obsolescence management process was formed in [16] to provide guidance for establishing and implementing proactive obsolescence management program for nuclear power plants. The basic process for managing equipment and part obsolescence is presented in Fig. 2. This example process was selected due to the lack of available information regarding obsolescence management processes used in industries more relevant to the company case considered in this thesis. The principles of obsolescence management, however, are expected to remain similar regardless of the industry type. In Fig. 2, three foundational process steps are presented, in addition to two inputs from organizational interfaces and available resources which shape the contents of the process. The scope of the obsolescence management process can therefore either increase or decrease depending on available resources and organizational interfaces. Available resources include both internal and external resources which include e.g. methods and tools used for managing assets that are facing obsolescence. Additionally in Fig. 2, eight major process elements required for establishing proactive obsolescence management process are presented. Next, the eight major elements are examined to provide information about how each element could be performed in the company considered in this thesis.

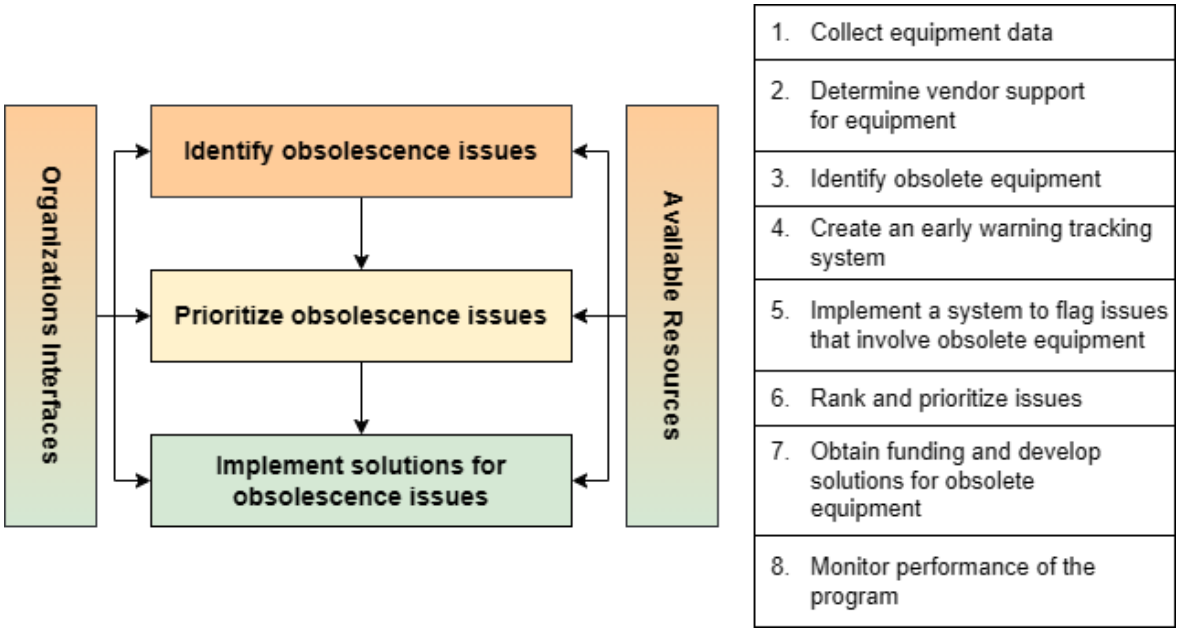

Figure 2. A generic proactive obsolescence management process with three foundational steps on the left-hand side, and eight major elements of an effective proactive obsolescence program on the right [16].

The first element of the proactive obsolescence program is to collect equipment data, as shown in Fig. 2. Collecting equipment data entails compiling a list of equipment used in the factory. Collecting equipment data is already performed in the company considered in this thesis via the use of equipment management tool and equipment database. However, if information in the database is not current, correct, or complete for the equipment, then obsolescence statuses cannot be determined accurately. *The minimum information required for determining if an item is obsolete consists of manufacturer and model information* [16]. Typically, obsolescence issues are resolved and mitigated by using either reactive or proactive approach [14]. Items that are not selected for proactive obsolescence management, should be managed in reactive manner.

The number of available resources is limited in the company's case, which will limit the number of items that can be selected for proactive obsolescence management. This is because the number of resources required to implement the following element in Fig. 2, which is called determining vendor support for items, is proportional to the number of selected items. One method for selecting relevant items for proactive obsolescence management program is presented in [8], and it is based on heuristic life-cycle estimation. Applying heuristics is supposed to separate items into three different categories: 1) items to definitely monitor, 2) items not to monitor, and 3) items for which not enough is known to determine the need for monitoring. Further analysis may be conducted on items in category 3) to determine whether items should be monitored or not. A ranking scheme is presented in [16] for items to rank equipment, which considers factors such as:

- *Equipment criticality*
- *Maintenance and demand history of stocked items*
- *Remaining inventory*
- *Severity of failure if replacement is not available*
- *Availability of existing solution*
- *Priority of scheduled work*
- *Other relevant factors*

Suitable ranking factors could be used for items in category 3) to determine if these items should be monitored or not.

Determining vendor support for selected items is the following element in Fig. 2, which provides information about the item's availability. This element can be considered as obsolescence monitoring. For commercial-off-the-shelf (COTS) assemblies, recommended ways to analyze availability are through vendor surveys, phone calls, e-mails, and vendor websites [8]. Therefore, the method for obsolescence monitoring on tester equipment level could involve regularly checking product change notices (PCN) from the original equipment manufacturers' (OEM) and vendors' websites. Additionally, *obtaining life cycle information requires establishing a cooperative relationship and good communication with suppliers* [2]. The monitoring should therefore also consist of contacting the suppliers of selected equipment. The data collected via monitoring requires to be processed and made accessible to the equipment management tool.

Following process step in Fig. 2 is to identify obsolete equipment, which can be accomplished by setting flags or codes for every obsolete equipment found in the equipment information system. In the company's case this could be performed by manual data entry process using the equipment management tool and equipment database. Additionally, this method would allow any employee to determine the life cycle status for given item in equipment database and to identify its obsolescence status manually. The use of flags would allow the equipment data to be filtered, enabling any employee with access to equipment database to identify obsolete and soon-to-be obsolescent equipment. The flags or codes should be used to represent whether an item is already obsolete, obsolescent, or available. A commercial third-party tool designed for managing asset obsolescence is presented in Fig. 3, which uses green, yellow, and red colored flags to present the availability status of items. In addition, every item in Fig. 3 has fields for information such as identification code, model type, status, risk, strategy, and priority. Similar types of flags and information could be integrated into company's existing equipment management tool.

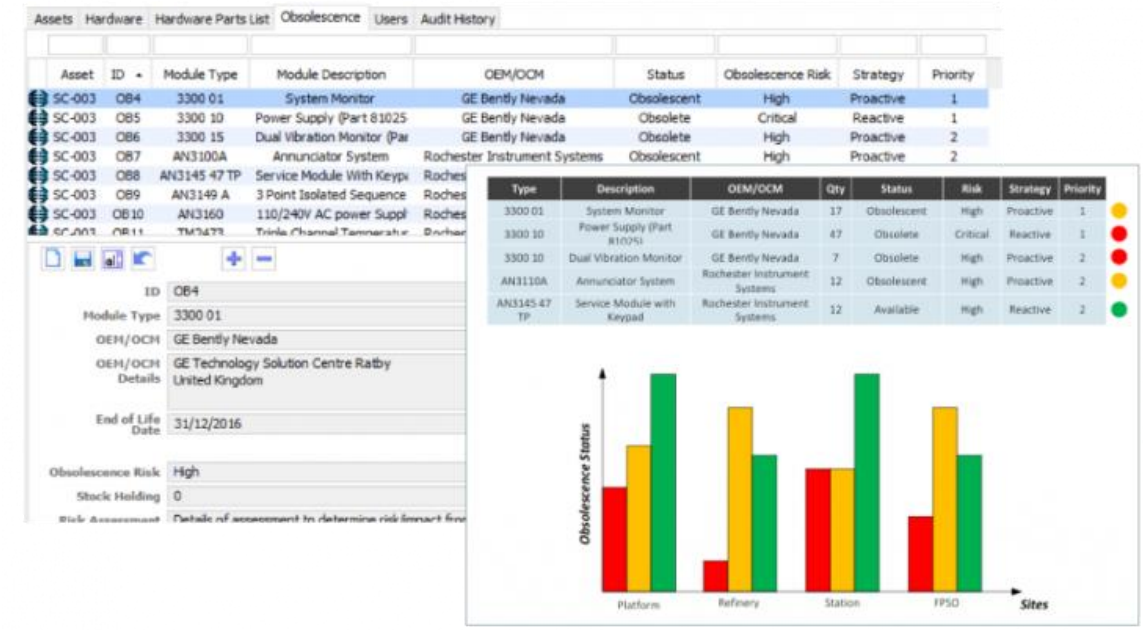

Figure 3. User interface of the Obsolescence Manager application [17]. The components and their status along with risk level and managing strategy are listed.

Creating an early warning system is advised in [16] to provide early warning signs of obsolescence, which is the fourth element in Fig. 2. The benefit of an early warning system is that precursors for obsolescence can be tracked on daily basis without having to contact the vendors. Examples of precursors for obsolescence are presented in [16], which include e.g. increased lead times and prices. Establishing an early warning system requires collecting and analyzing precursor data. The processed data could be used as an input to the following process step in Fig. 2, which concerns the implementation of processes for flagging obsolescence issues. Due to limited resources, creating an early warning system will not be examined further, but a concept of early warning tracking system could potentially be developed as future work.

Implementing processes for flagging obsolescence issues is the next element in Fig. 2. These processes are supposed to establish methods for identifying and communicating obsolescence issues. The objective of these processes is to allow both flagging and elevating the importance of obsolescence issues. In the company's case, suitable methods could be integrated into daily activities of each organization working on the operations level. For example, the maintenance personnel could flag and communicate obsolescence issues if the

equipment they are working on turns out to be obsolete. All obsolescence related issues could be combined into monthly or quarterly obsolescence health reports that would allow measuring the progress and performance of the obsolescence management program. Also, existing processes that can be enhanced by incorporating obsolescence information into them should be identified [16]. In company's case, the current information system however requires to be modified before it can facilitate flagging obsolescence issues. Therefore, the processes for flagging obsolescence issues should be established and integrated to existing processes after the current information systems are ready to facilitate them.

After obsolescence issues have been identified and flagged, all issues need to be ranked and prioritized. When issues are prioritized, the most critical obsolescence issues can be mitigated first. Issues can be prioritized by assessing the risk related to the obsolescence issue. Examples of risk criterion which help assessing the risk for a given item are the likelihood and the impact of obsolescence. *The recommended method of conducting the risk assessment is the use of the triplet of Probability, Impact and Cost as described by IEC 62402:2007. The result of this assessment will determine the category of risk (low, medium or high)* [12]. In [12] following considerations are advised to be considered when risk assessment is conducted:

a. What would be the impact of product being unavailable due to lack of spares?
b. What would be the impact of performance degradation due to alternative components?
c. What would be the impact on product due to material obsolescence?
d. What would be the likely cost of premature replacement?
e. What would be the likely cost of other measures to circumvent obsolescence?
f. What is the probability of obsolescence occurring due to advances in technology?
g. What is the probability of obsolescence occurring due to the introduction of new legislation?
h. What would be the consequences of the loss of the relevant knowledge and skill base sets?
i. What would be the impact of lack of documentation?
j. What would be the impact of loss of access to intellectual property rights (IPR)?
k. What would be the impact to the product due to changes in environmental legislation?

The company considered in this thesis has already established equipment risk-mapping in which critical equipment is identified. Therefore, the obsolescence risk assessment should be either integrated into the existing critical equipment mapping process or alternatively an additional obsolescence risk assessment could be performed in parallel with the existing process. The results of risk assessment could be then manually entered as data entries for

each item in the equipment database using the equipment management tool. A similar view as in Fig. 3 could be achieved by incorporating necessary modifications to the company's equipment management tool.

After risk assessment has been conducted for each equipment, a resolution needs to be selected or developed. This process step is supposed to obtain funding and develop solutions for obsolescence issues, as shown in Fig. 2. Examples of different resolution and mitigation options included in reactive and proactive approaches are presented in Fig 4. Obsolescence issues that cannot be mitigated proactively will have to be resolved using same options as in reactive approach, but with more time available for implementation. Resolution options in Fig. 4 are ordered in cost order where 'Existing Stock' has the lowest non-recurring engineering (NRE) costs and 'Major Redesign' has the highest NRE cost, the cost of 'Last Time Buy' is not included.

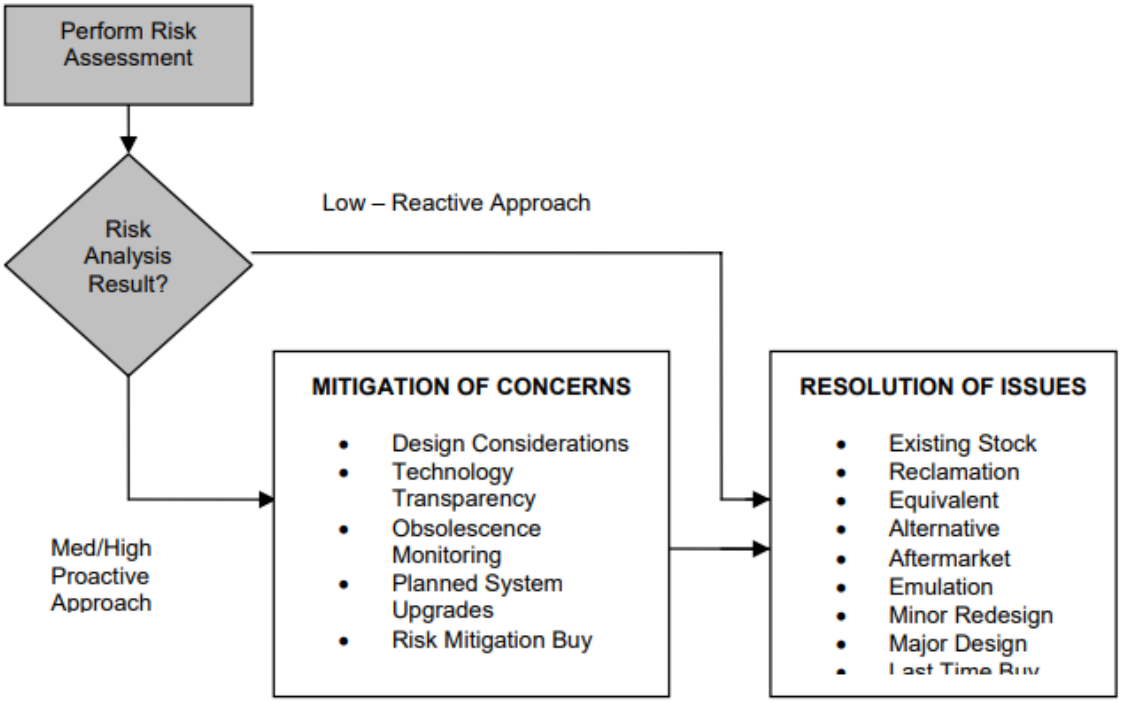

Figure 4. Examples of different options for mitigating and resolving obsolescence issues using reactive and proactive approach based on the result of risk analysis [12].

The final element in the obsolescence management process is to monitor performance of the program. Obsolescence health reports were mentioned previously in this chapter as health reports provide an effective tool for measuring the performance of the program.

Obsolescence could also be incorporated as a parameter to equipment or system health reports if such reports are generated. Different metrics are presented in [16] that can help monitoring the program's performance, such as system unavailability caused by obsolescence, cost of downtime due to obsolescence and quantity of obsolete equipment that have no known solution. The initial obsolescence management process is likely to change when it is started based on user experience. In the company considered in this thesis, measuring performance of the obsolescence process through health reports and metrics could be implemented once the obsolescence management process has matured and is proven functional. Therefore, the implementation of this element should be performed as future work once the company has a functional obsolescence management process.

2.2 Review of standards related to obsolescence management

The secondary target of the literary review considered in this thesis is to research different standards related to obsolescence management. The research yielded information about multiple standards that could applied to obsolescence management. However, only the most relevant standards were selected for further examination. The selection was based on author's estimation of each standards' usefulness to the needs of the company case considered in this thesis. In the following chapters, further evaluation is conducted on how the selected standards could be applied on a general level to the company's existing practices. The evaluation will be based on estimations of how much effort would the implementation of standardized practices require and how compatible is the standardized practice with the company's existing practices. The evaluation will also consider the company's existing organizational interfaces and available resources that could be leveraged if the selected standard was implemented.

2.2.1 IEC 62402:2019 Obsolescence management standard

IEC 62402:2019 standard is selected for further examination as it provides guidelines for establishing an obsolescence management process. The management process presented in this standard is shown in Fig. 5. The standard defines obsolescence as *the transition of an item from available to unavailable from the manufacturer in accordance with the original specification* [14]. Product discontinuance is an example of obsolescence which fits the definition given in this standard. The management process requires to be tailored to fit the requirements and needs of the organization considered. Next, all activities presented in the management process will be studied and evaluated. The evaluation will be conducted on a general level to determine the compatibility of different activities with the company's existing processes and practices. The author has been familiarized with the company's existing processes and practices on a general level.

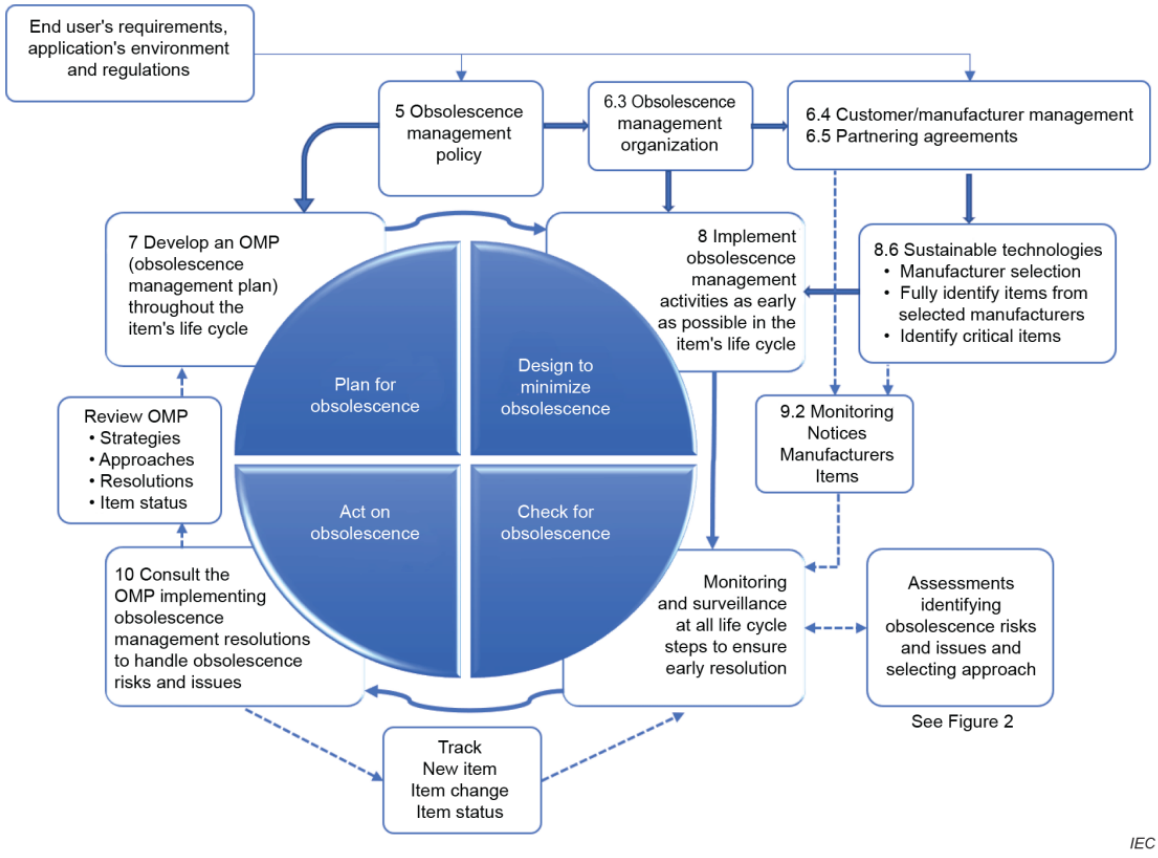

Figure 5. Obsolescence management process in [14].

The obsolescence management process shown in Fig. 5 is divided into four main segments: I) plan for obsolescence, II) design to minimize obsolescence, III) check for obsolescence, and IV) act on obsolescence. These four segments form the overall obsolescence management process, which consist of individual activities surrounding the four segments. The foundation for the management process is established with the four upper most activities in Fig. 5 and these activities are examined next.

The first activity in Fig. 5 is called end user's requirements, application's environment and regulations. This activity is supposed to set requirements and context for the management process so that it meets the organization's needs. To fulfil the end user's requirements, enough resources require to be allocated to the management process. Therefore, if the number of available resources is limited, it will also limit how many of the requirements can be fulfilled. The application's environment is related to the organizational interfaces mentioned in the management process presented in Section 2 in Fig. 2. The outcome from this activity is used in the following activities in which management policy, organization, customer and manufacturer partnering agreements are established.

The second activity in Fig. 5 is called obsolescence management policy. This activity is supposed to establish a policy which organizes obsolescence management by identifying required roles, responsibilities, infrastructure, skills, and operational procedures. The policy is supposed to define necessary practices related to executing and updating both the policy and the obsolescence management plan (OMP). The standard defines the output of the obsolescence management process as continuously evolving OMP, although the development of an OMP is performed in a separate activity. Practicality of obsolescence management policy is hard to evaluate, but it provides a structural base for managing obsolescence. However, due to limited number of resources and time, an overarching obsolescence management policy will not be implemented in this thesis.

The third activity in Fig. 5 is called obsolescence management organization, which is supposed to establish an organization for executing the policy. In this activity, an obsolescence manager or management team is appointed for managing, monitoring, evaluating, and coordinating activities of the obsolescence management process. A separate management organization will not be established during this thesis due to limited number of resources available. Existing operational procedures and responsibilities will likely have to be redefined when an obsolescence management process is designed later in this thesis.

The fourth activity is called customer and manufacturer management and partnering agreements. The end user of test station is the company considered in this thesis, and test stations are used mainly by operators and maintenance personnel. The company can be considered as the customer, which acquires tester equipment and components used in custom built tester equipment from suppliers. In this activity, the customer is supposed to establish relationships with manufacturers or suppliers so that they can provide information regarding product obsolescence. Requirements for implementing this activity would be to first identify the personnel who is currently communicating with suppliers and manufacturers regarding tester equipment, and what kind of organizational interfaces are being used for communication. Then existing methods could be improved so that suppliers and manufacturers would be requested to send information related to tester equipment obsolescence to selected personnel. The information would have to then be communicated within the company so that it reaches the relevant personnel who is supposed to maintain test stations and their tester equipment.

The four main segments and their activities are examined next. These activities take place after the foundational activities have been performed. The activities of the four main

segments take place in different stages in the item's life cycle. Time frames for different activities within each segment during product's life cycle are presented in Fig. 6.

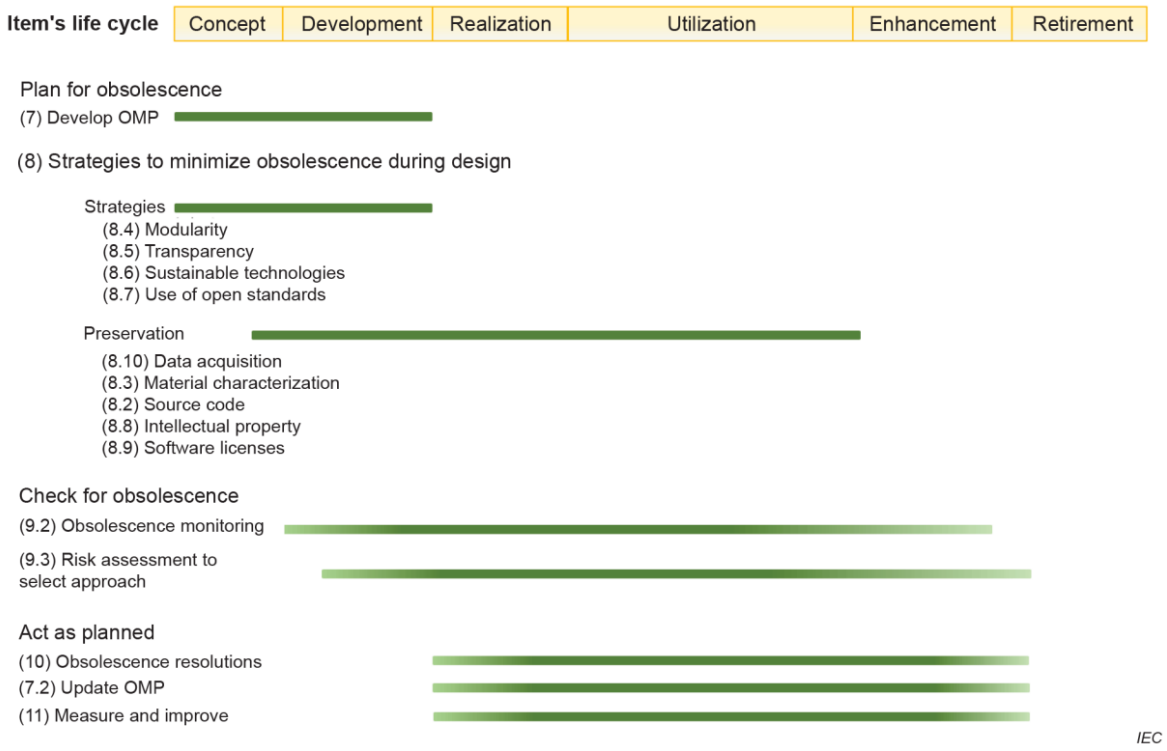

Figure 6. Obsolescence management activities' time frames during item's life cycle [14].

The first segment in the management process is called I) plan for obsolescence, which is shown in both Fig. 5 and Fig. 6. This segment includes an activity for developing OMP, which allows the company to prepare for obsolescence in advance. Test stations are developed to last for the entirety of product's life cycle as already mentioned in Section 1.1. The life cycle of the product being manufactured often exceeds the life cycle of tester equipment used at the test station, which results as the tester equipment becoming obsolete before production is discontinued. An OMP is supposed to mitigate this issue by having a predefined approach and resolution for handling the issue caused by tester equipment obsolescence. During the conceptualization and development phases of test station, an obsolescence management plan could be designed as suggested in Fig. 6. OMPs would also have to be developed for existing test stations, which are in the realization and utilization stages in their life cycles. OMPs could also be developed only for specific tester equipment that multiple test stations utilize, instead of developing OMPs for each test station.

The second segment in the obsolescence management process is II) design to minimize obsolescence. Majority of tester equipment utilized at test stations are manufactured and designed by other companies, and therefore the company has very little control over minimizing obsolescence by design. Different strategies for minimizing obsolescence are presented in Fig. 6 and these should be considered at test station development stage. Following strategies are mentioned in the standard that could be applied to reduce obsolescence risk of tester equipment: selecting tester equipment that has long-term production life and is available from multiple manufacturers, improving modularity of test stations by making tester equipment exchangeable between test stations. In addition to these strategies, data acquisition of relevant information related to tester equipment could be used to predict upcoming obsolescence. This strategy is similar to the early warning tracking system mentioned in Section 2.1.1.

The third segment in the obsolescence management process is III) check for obsolescence. The main activity of this segment is monitoring obsolescence throughout the item's life cycle. Obsolescence management standard explains obsolescence monitoring as follows: *"Obsolescence monitoring involves tracking items and their manufacturers, to determine the item's current availability status and, where possible, when the item will become obsolete."* [16]. In practice, the monitoring activity should be formed into a comprehensive sub-process. Monitoring activity is dependent on having the items selected which are to be monitored. Similar discovery was made when the first example process was examined in Section 2.1.1, where point was also made about the importance of data integrity. In the company considered in this thesis, most items can be monitored since items have already been listed to equipment database, but the integrity of data in equipment database should be verified. However, not all equipment can be selected for monitoring due to limited number of resources. Items selected for monitoring need to be assessed for risks related to the items and most suitable approach and resolution should be chosen. The standard also provides guidelines for performing risk assessment related to obsolescence, which is similar to the risk assessment presented in Section 2.1.1.

The final segment in Fig. 5 is IV) act on obsolescence. The standard advises that obsolescence risks and issues are handled by implementing planned mitigation resolutions listed in the OMP. The standard contains a list of example resolutions for proactive and reactive approaches, which are similar to resolution options presented in Fig. 4. When obsolete items

are replaced in test stations, equipment data in relevant information systems need to be updated. If information is not updated, then obsolescence monitoring process continues monitoring the obsolete item instead of the new item. The contents of OMP also needs to be updated as shown in Fig. 6. The final activity in this segment consists of measuring and improving the management process, which was also the final activity in the process presented in Section 2.1.1.

2.3 Review of other standards

Standards found during the research conducted in Section 2.2, which were not selected for further examination, are presented in this section. While these standards are only partially related to obsolescence management, they provide useful information for understanding obsolescence management at a higher level.

2.3.1 ISO 31000:2018 Risk management

ISO 31000:2018 standard provides guidelines for establishing a risk management process [18]. Risk management process already exists in the company and due to management's iterative nature, any existing risk criteria can be updated when necessary. Currently risks related to production equipment are assessed based on risk criteria which has different risk factors and weighing. The ISO 31000 standard defines risk assessment as the overall process of risk identification, risk analysis and risk evaluation in [18]. Safety of EOL production equipment should be considered the most important factor for risk criteria, but safety related risks are already handled by other departments in the company. Ways of treating risks related to EOL production equipment could be mentioned in obsolescence management plan if one is created for managing production equipment obsolescence.

2.3.2 IEC 60300-1:2014 Dependability management

Dependability management standard provides guidance on dependability, reliability, supportability and maintainability of products, systems, processes, or services [19]. It is worth remarking that during this study, no free access was available for this standard. Based on the

basic details of the main contents of this standard, the author did not find this standard useful enough to acquire a digital copy of it. However, this standard could potentially aid in providing understanding of different dependability related procedures and techniques. If dependability is considered as important factor, then tester equipment's dependability should be further investigated, and this standard would serve as a good starting point.

2.3.3 ISO 22383:2020 Authenticity, integrity and trust for products and documents

ISO 22383:2020 provides guidelines for authenticating materials' integrity via different anti-counterfeiting technologies [20]. It gives guidance on implementing a suitable authentication solution for chosen item. Similar standards which relate to avoidance of counterfeit materials exist; SAE AS5553D [21], JESD243A [22]. These standards could provide insight to authentication technologies and methods. If the integrity of replacement parts needs to be verified, suitable authentication procedures could be added to the obsolescence management policy. Purchasing parts from sources other than the OEM or authorized aftermarket sources, increases the risk of counterfeit parts [23]. Counterfeit electronical devices may not meet the specifications set by the original manufacturer. Also, counterfeit products can introduce vulnerabilities that have been deliberately added to the product. EOL tester equipment and replacement parts that are unavailable for purchase from the OEM are still often available from unauthorized third-party sources. Tester equipment and replacement parts sold by unauthorized distributors often represent their products as new, although they can in fact be unused, refurbished or reclaimed. The risk of counterfeit parts should be acknowledged if unauthorized or unknown sources are used.

2.3.4 IEC 61010-1:2017 Safety requirements for electrical equipment for measurement, control, and laboratory use

IEC 61010-1:2017 standard specifies safety requirements for electrical test and measurement equipment and electrical laboratory equipment. Test stations are likely designed to be safe to use by following general safety requirements specified in this standard. This standard could provide useful information for operators and maintenance team about detecting electrical equipment that doesn't fulfil safety requirements. Safety improvements to existing

electrical equipment could also be derived by inspecting equipment with the standard safety requirements in mind. Electrical equipment may fulfill the safety requirements when it's deployed, but when devices must be repaired or replaced, equipment may not fulfill its safety requirements afterwards. The safety angle would be more important in EOL devices which are not supported by manufacturers anymore.

2.3.5 Summary of key findings from standards

The applicability areas for different standards to the company's existing obsolescence management related processes are evaluated in Table 1. Based on the study, the obsolescence management standard IEC 62402:2019 could be applied to all parts of the obsolescence management. However, this thesis will focus on improving the existing obsolescence management practices with limited number of resources available. Therefore, the obsolescence standard should be used as a reference when improvement recommendations to existing practices are proposed. Dependability management standard was evaluated to be potentially applicable to processes in which new tester equipment is purchased. The other standards are applicable to processes that are closely related to obsolescence management, such as the replacement procedure.

Table 1. The applicability areas for different standards to the obsolescence management and related processes.

Standard	Applicability
IEC 62402:2019 Obsolescence management standard	All parts of the obsolescence management process
ISO 31000:2018 Risk management	Existing critical equipment mapping process
IEC 60300-1:2014 Dependability management	Test station development should consider tester equipment's dependability and make such designs that minimize the level of dependability.
ISO 22383:2020 Authenticity, integrity and trust for products and documents	When new suppliers for tester equipment are chosen their authenticity should be verified
IEC 61010-1:2017 Safety requirements for electrical equipment for measurement, control, and laboratory use	Part of replacement procedure. After a device has been replaced on a test station, its safety should be verified

3 Improving the obsolescence management of tester equipment

The company considered in this thesis has noted that their existing obsolescence management practices for tester equipment should be improved to include more standardized and proactive measures. All existing procedures of the obsolescence management will be first identified in Section 3.1. Also, the responsibilities for each procedure will be identified. This section will answer to **RQ3** and **RQ4** introduced in Section 1. Once the existing procedures have been fully identified, the procedures will be reviewed in two stages. The first review is performed by comparing the existing obsolescence management procedures against the process steps of the example process presented in Section 2.1.1. The first review is expected to reveal deficiencies in the existing management practices. Also, the strengths and the issues related to each existing procedure are analyzed. Solutions will be proposed in a form of improvement recommendations that address the issues found from the first review. The proposed solutions will be based on the standardized way of performing obsolescence management presented in Section 2.21 and refined by internal discussions with the supervisor of this thesis.

The second review is performed via a questionnaire survey that will be sent to the personnel performing the management procedures. The responses to the survey will provide feedback about the existing management's state and provide a channel for the personnel to suggest improvements. The initial improvements to the existing practices are also reviewed in the questionnaire survey. Every response will be individually analyzed, and most practical improvements will be integrated to the new management framework which is designed in Section 3.4. The specifications for the improved management framework will be set based on results of both reviews. An obsolescence management process will be formed based on the proposed management framework, which will be partially tested via a selected case-example in Section 4.

3.1 Identification of the existing obsolescence management procedures

Identification of the existing obsolescence management procedures for tester equipment is done under the guidance of the supervisor of this thesis, B.Sc. Teemu Loman. At the

company, he is responsible for managing the execution of calibration and testing engineering (CTE) team's obsolescence related management procedures for tester equipment and has a broad understanding of the existing management practices. As the goal of this thesis is to improve the existing practices for managing obsolete or discontinued tester equipment, the current procedures need to be identified first. Currently, the management is performed via different procedures performed by the CTE-team, but no clearly defined management process exists.

The tester equipment of a test station requires to be managed through-out the lifespan of the test station. The expected life cycle of a test station nearly always exceeds the expected life cycle of the tester equipment. The shorter lifespan of tester equipment will mean that the tester equipment is required to be replaced at least once or multiple times before the test station reaches the end of its life cycle. Optionally, the test stations can occasionally undergo renewal projects, in which a renewed copy of the existing test station is developed. These projects are carried out by the tester development team and often within these projects, obsolete or soon-to-be obsolete tester equipment is replaced with new tester equipment. Renewal projects make the choosing of replacement tester equipment easier for the maintenance team, as the renewed test stations utilize fully tested and validated tester equipment.

The existing obsolescence management procedures related to tester equipment during test station's life cycle are presented in Fig. 7. At the final stage of the test station development project, the ramp-up phase of the test station finishes. During the ramp-up phase, tester equipment is listed to equipment as shown in Fig. 7. After the ramp-up is completed, the responsibility for updating and maintaining the test station is transferred from the development team to the maintenance team. At this point, the test station is considered to be introduced to production testing use as shown in Fig. 7. The maintenance of test stations consists of multiple different processes and procedures, which are not all presented in this section. Only the procedures related to obsolescence management of tester equipment are focused on in this section.

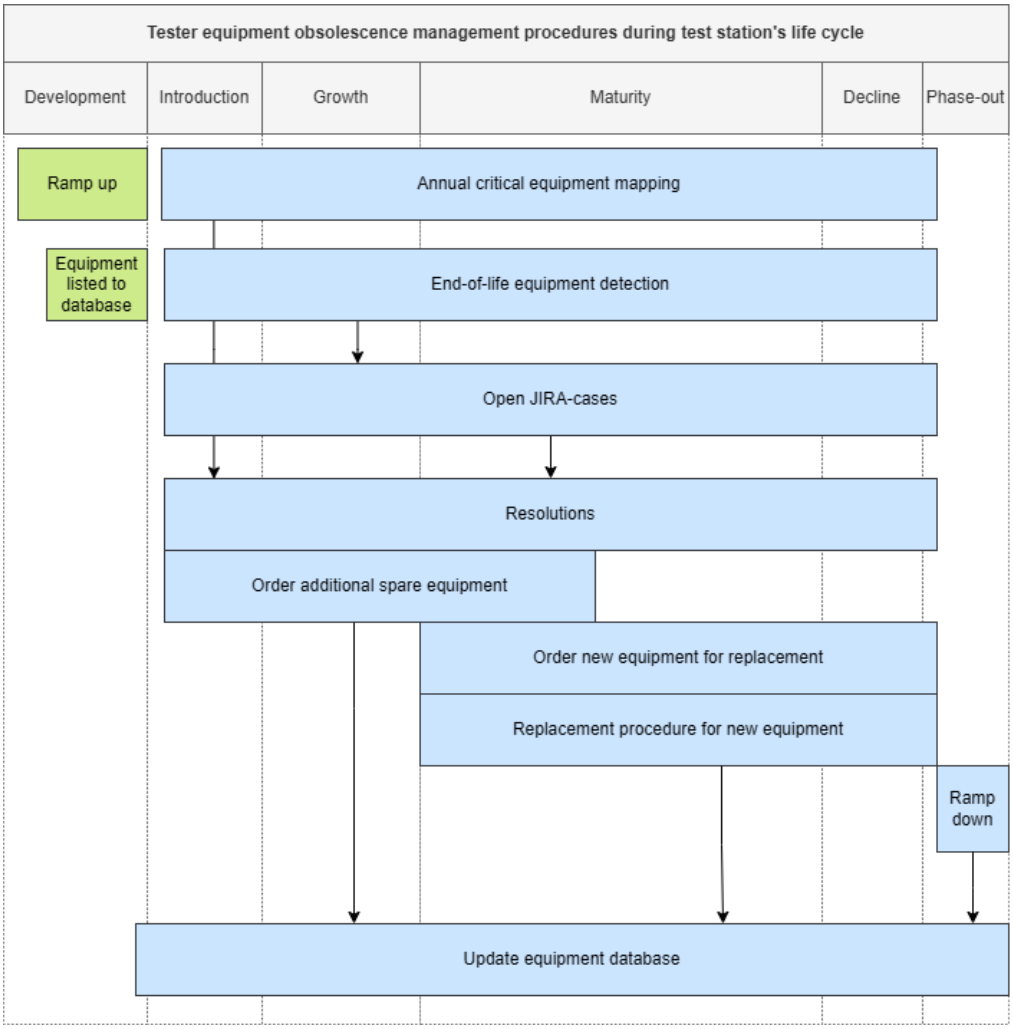

Figure 7. Flowchart presentation of the existing procedures for test equipment obsolescence management during test station's life cycle. Colours indicate responsibilities: Light green for tester developer team and light blue for maintenance team.

In the existing obsolescence management practice, the main procedure for tracking obsolete tester equipment is identified as annual critical equipment mapping. Additionally, the company considered in this thesis has noted that employees occasionally detect that the life cycle status of a device has reached its EOL status. These two procedures for monitoring the life cycle status of tester equipment are shown at the top of the flowchart in Fig. 7. During the annual critical equipment mapping process, every test station's equipment is evaluated with the help of pre-defined risk criteria. The evaluation of risks yields a score for each piece of equipment. The score represents the criticality of the piece of equipment in case it malfunctions or breaks. A case is opened for every piece of equipment which has been identified as critical to mitigate the risk. In similar way, if an employee detects that a piece of tester equipment has reached its EOL status or is about to reach it, the employee can open a case

about the issue. Cases are prioritized and assigned to maintenance team members, who then begin to resolve the cases.

The resolutions for resolving the cases are generally performed by maintenance team members. In cases, where an obsolete piece of tester equipment must be replaced, a replacement device is searched firstly from the company's own recommended device list. If the replacement device is not found in the recommended device list, then a suggestion for a new replacement device is made, and its suitability is evaluated together with a tester developer. After a replacement device is selected, purchased and available for testing, it will be added to the equipment database. The test station needs to be made compatible with the replacement device on both hardware and software level. Once compatibility is achieved then the obsolete device can be replaced with the replacement device. The test station's functionality requires to be tested and validated next. The company's validation procedure is extensive and classified; therefore, its contents are not opened here. After the test station, which is utilizing the replacement device has passed the validation process, then a final update to the equipment database is made to ensure that all information is correct.

In the company considered in this thesis, this can be considered as the existing practice of managing obsolete tester equipment related issues.

3.2 Initial review of the existing obsolescence management of tester equipment

The initial review of the existing activities for managing tester equipment obsolescence is performed in collaboration with the supervisor of this thesis. Both the strengths and the issues related to each activity are identified. Existing activities are analyzed by comparing each activity to the process steps of the process example found in Section 2.1.1. Each activity is expected to have a corresponding process step in the example process and vice versa. If no corresponding activity exists for the process steps, then a deficiency is discovered from the existing management activity. Based on the initial review; responsibilities, deficiencies, strengths, and issues are identified for each activity. Results of the initial review are presented in Table 2. It's worth noting that the resolutions procedure in Table 2, consists of multiple different activities which can differ based on the case, therefore individual activities related to resolutions are not listed.

Table 2. Current procedures and responsibilities are listed along with corresponding process steps found from example processes. The deficiencies, the strengths and the issues of each procedure are also listed.

Example process' procedure	**Company's existing procedure and responsibility**	**Strengths of current procedure**	**Issues of current procedure**
Collect equipment data.	Tester equipment is collected to equipment database in final stages of test station development. Update equipment database. Test development team Equipment specialist	Data is listed to equipment database. Relevant data is listed for each equipment.	Not every item is listed to equipment database. Equipment database has no field for life cycle status of items. Updating item status in equipment database must be remembered.
Determine vendor support for equipment and parts.	Annual critical equipment mapping, Employee notices EOL tester equipment. Maintenance team	Critical items are identified. Employees are aware of importance of equipment EOL.	Critical equipment mapping does not always detect all obsolete or soon-to-be obsolete items. No possibility for reactive measures.
Identify obsolete equipment.	Scan for opened cases related to obsolete equipment. Maintenance team	-	Obsolescence status of an item should be easily identifiable.
Early warning tracking system.	-	No extra resources required.	No possibility for predicting obsolescence.
Flag issues related to obsolete equipment.	JIRA-case is opened. Maintenance team Process engineers	Standard process for opening cases.	Case is not progressing, or case is opened too late.
Rank and prioritize issues.	JIRA-case is prioritized Maintenance team Process engineers	Issues can be prioritized.	Case is prioritized incorrectly.
Obtain funding and develop solutions for obsolete equipment.	Resolutions are developed when cases are worked on. Maintenance team	Reactive solutions.	No consistent procedure for replacing obsolete equipment. Lack of information about obsolete equipment replacement related subjects. Testing and validating replacement items is done using test stations, which are meant for production testing use.
Monitor performance.	Overall performance of maintenance team is measured. Maintenance team managers	Some metrics are available.	No metric for measuring performance of obsolescence management.

Improvement recommendations are proposed to fix the issues presented in Table 2. The review of the initial improvements will be included to a questionnaire survey, which will be sent to the maintenance team members. The survey and its results will be presented in Section 3.3. The initial problematic issues from the company's point of view were chosen from Table 2, which are:

- Obsolete items are not always detected.
- No possibility for proactive measures.
- Lack of information related to obsolete equipment replacement related subjects.
- Not every item is listed to equipment database.
- No consistent procedure for replacement work.
- Equipment database has no information about the life cycle status of items.

Certain activities share identical issues, as shown in Table 2. Therefore, improvements should be proposed for every activity that is linked to the six main issues listed above. The improvements to each activity linked with a problematic issue are presented next. Multiple issues were identified from the activity called *Resolutions* in Table 2. Under the guidance of the supervisor of this thesis, following improvement recommendation was proposed for making the *resolutions* procedure clearer when tester equipment is replaced:

Improvement 1:

- Before existing tester equipment becomes reaches end of its life cycle, the replacement device's or part's compatibility and functionality should be verified in advance. The replacement procedure could consist of following steps: Choosing a replacement device or part together with test developer. Ordering the device and creating a station specific solution for the replacement device, which is used to validate device's compatibility and functionality with the test station. If there are multiple of same devices in other test stations which must be replaced, then the station's reliability should be validated for at least 2 months. If needed, a platform level solution is created, together with a roll-out plan for replacing all EOL devices.

As all tester equipment is not added to equipment database during the activity called *Tester equipment is collected to equipment database* in Table 2, all equipment cannot therefore be

monitored. Following improvement recommendation was proposed for mitigating the issue:

Improvement 2:

- The monitoring should only cover important tester equipment which has been collected or will be collected to equipment database. Not all tester equipment can be monitored for availability changes due to resource limitations.

Information about life cycle status of tester equipment should be visible in equipment database. Obsolete equipment is not therefore easily identifiable as shown in Table 2. Following improvement recommendation is proposed to address this issue:

Improvement 3:

- Add a data field which indicates the EOL date or life cycle status for items in the equipment database, to which the information could be manually entered if known.

The life cycle status of tester equipment is not consistently determined via activities called *Annual critical equipment mapping* and *Employee notices EOL tester equipment*. Following improvement recommendation is proposed to address this issue:

Improvement 4:

- Life cycle status monitoring should be performed by contacting manufacturers and suppliers and requesting them to send notifications to the maintenance team about tester equipment's life cycle status changes. If there is no possibility for notifications, then tester equipment's life cycle status should be periodically checked by contacting manufacturers.

The proposed placements of these improvements to the existing management practices are presented in Fig. 8. Improvement recommendations 1–4 will be reviewed by the maintenance team in Section 3.3 via a questionnaire survey. The responsibilities and actual procedures for the improvement recommendations 1–4 will be determined based on these two reviews in Section 3.4.

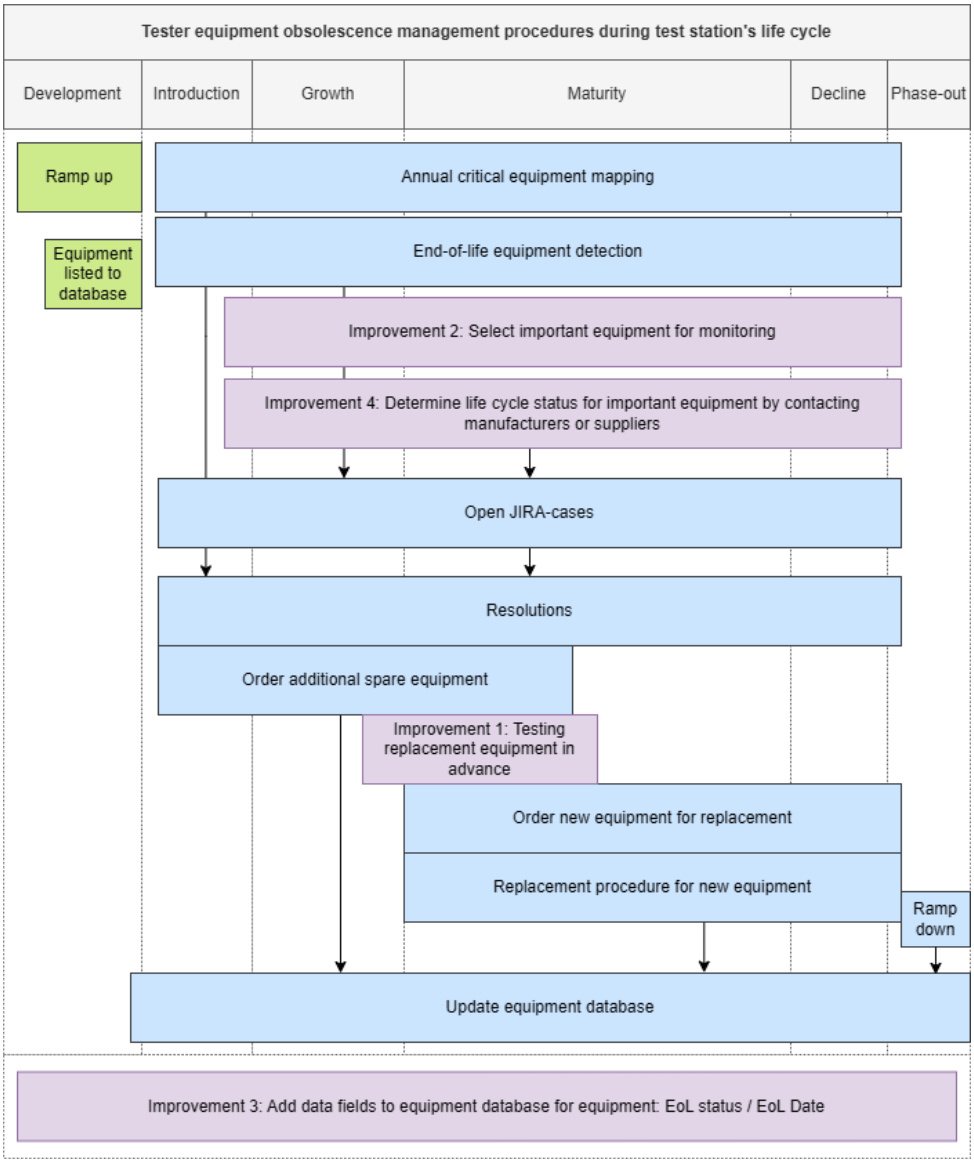

Figure 8. Flowchart presentation of the existing procedures including the placements of improvement recommendations 1–4 for tester equipment obsolescence management. Colors indicate responsibilities: light green for tester developer team, light blue for maintenance team and violet for open responsibility.

3.3 Questionnaire review of the existing obsolescence management of tester equipment

The purpose of the questionnaire survey is to gather feedback about the current state of obsolescence management activities and the initially proposed improvement recommendations 1–4, and to provide a platform for the maintenance team to suggest additional improvements. The target group for the survey consist of 24 employees, and similar number of responses is

expected to the survey. The target group has been familiarized with the on-going thesis topic during an internal meeting where the topic was presented. As multiple issues were discovered from the initial review done in Section 3.2, the respondents are expected to be motivated to provide feedback and improvements.

Before the questionnaire survey was created, a general understanding of question and survey design was gathered from literature. The better the questions and their order are optimized, the more accurate and useful information the responses will provide [24]. Guidelines for creating optimized questionnaires are presented in [24], and these guidelines were generally followed during the creation of the questionnaire survey. The questionnaire's questions are presented in Appendix 1. The structure of the questionnaire follows an order, in which after every rating question, there is a follow-up question for the respondents to provide additional feedback relating to the topic of the rating question.

The questionnaire survey gathered total of six responses from the maintenance team members, therefore the number of responses was lower than expected. The average rating of all responses to the questionnaire's rating questions Q1, Q3, Q5, Q7, Q9 and Q11 are presented in Fig. 9. The responses to the follow-up questions Q2, Q4, Q6, Q8, Q10 and Q12, are presented and briefly analyzed in this section.

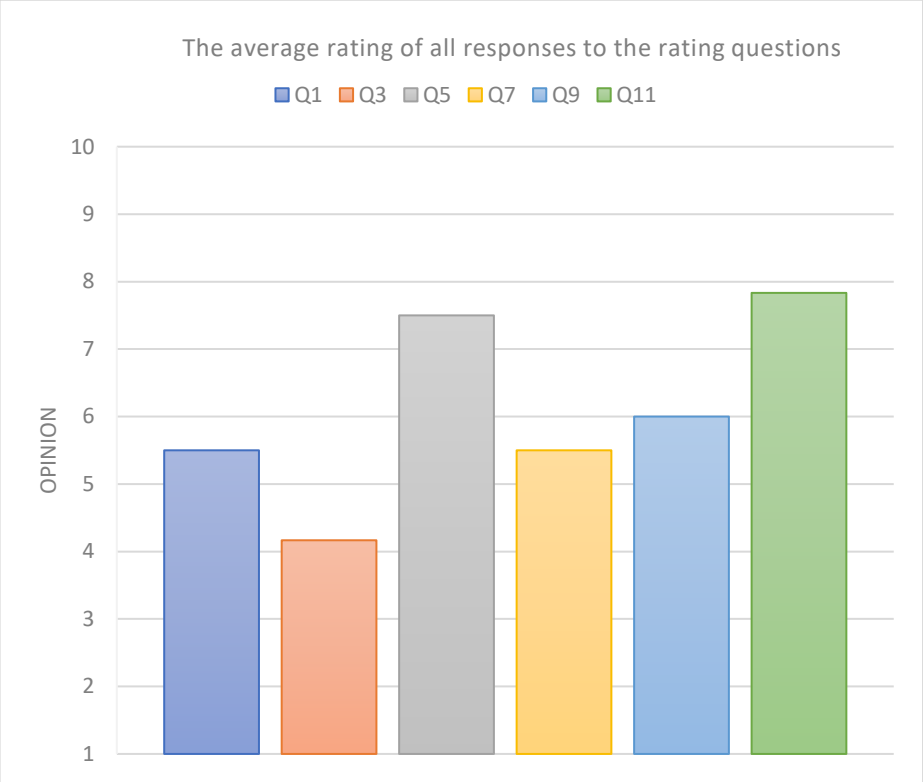

Figure 9. The average rating of all responses to the questionnaire's six rating questions. Y-axis represents the rating scale used in the rating questions, which corresponds to respondent's opinion.

The first rating question (Q1) concerned the opinion of the respondent on the functionality of existing practices relating to EOL tester management. In the first question, possible answers were presented using a rating scale from 1 to 10, where number 1 corresponded the opinion of "Not working at all", and number 10 corresponded the opinion of "Working perfectly". The responses to the questionnaire showed that the opinion on the functionality of existing practices among the maintenance team differs significantly. Half of the respondents are satisfied with existing practices related to managing EOL tester equipment, while the other half is dissatisfied. The average rating of all responses to the question was 5.5, as seen in Fig. 9. The rating question (Q1) was followed by an open-ended follow-up question (Q2), in which the respondents were proposed to identify any strengths or issues with the existing practices relating to EOL tester equipment management. The key strengths of the existing practices were timely reactions, core of maintenance team has remained the same and ability to take advantage of existing networks. As the core of maintenance team has remained the same, many devices have been memorized which then helps to identify devices that are not

listed to the equipment database. The strength of having team members that have memorized equipment may also be considered as an issue. The key issues were identified from the responses and are presented in Table 3.

Table 3. The key issues identified from the responses to the questionnaire's question Q2, in which the respondents were asked to identify strengths and issues related to the existing way of EOL tester equipment management.

Key issues of existing EOL tester equipment management
Reactive based activities. End of life devices may not have a backup device.
Lack of information about which devices will become EOL. And even if the information is available, no action takes place. It's not always clear who is supposed to act, as EOL notices don't always require any reaction from the team.
The decision-making process regarding EOL considerations is based on a predefined fixed lifespan. Consequently, the equipment is utilized in various environments, ranging from highly controlled clean rooms to ordinary shop floors. For example, the workload of the same type of equipment varies, but this factor is not typically accounted for in calculations.
We don't always have enough documentation. Some parts may not be available anymore, because they are custom made within the company. Or parts are unavailable because of other reasons.
I'm not receiving information about tester equipment, which is EOL. I've believed that the management level personnel are receiving information about EOL related subjects and will forward it to us when necessary.

The second rating question (Q3) concerned the respondent's opinion on the sufficiency of the existing practices for replacing tester equipment which has already reached its EOL stage. The possible answers were presented using a rating scale from 1 to 10, where number 1 corresponded the opinion of "Completely disagree", and number 10 corresponded the opinion of "Completely agree". The responses to this question differed significantly, as did the responses to the first rating question. Two of the respondents nearly completely disagreed,

and one respondent nearly completely agreed with the sufficiency of existing practices. In the follow-up question (Q4) the respondents were asked to suggest ideas for improving the existing practices for replacing tester equipment and parts that have already reached EOL stage. The additional improvements are presented in Table 4.

Table 4. The responses to the survey's question Q4. Number of responses was six, which are shown on the left column, and the responses are on the right column. The responses were translated from Finnish to English.

	Suggested improvements for replacing existing EOL tester equipment
1	Certain tester equipment should be added to the equipment database since they are not listed anywhere. The management of this type of tester equipment should not be based on memorizing them.
2	EOL date must be known for tester equipment. Every tester equipment should have a responsible person. And when the tester equipment becomes or is soon to become EOL, this person would be responsible for finding a solution.
3	Responsibilities for following things should be clarified: Who performs the replacement procedure, who decides which replacement device is suitable, who is testing and validating the replacement device?
4	Using condition monitoring to find out the parts accuracy and functionality.
5	At the halfway of the product's life cycle, both the product and its test stations should undergo a "mid-life refit" process. With this process, both the product and its test stations would be updated if necessary. Tester development team would redesign the test station.
6	The maintenance team members should be added to the list of people who receive information about EOL announcements.

The initial improvement recommendations 1–4 were reviewed in the questionnaire via corresponding rating questions (Q5, Q7, Q9, Q11). The purpose of reviewing the initial improvement recommendations was to discover how many of the respondents disagree with the improvements. The respondents that disagree with a specific improvement, are expected to have more information relating to the topic. From the improvements which the respondents agree with, a conclusion can be made that the respondents are willing to accept the idea. The improvements were presented as claims and the respondents were able to answer if they agreed with the claim by selecting a number on a rating from 1 to 10, where number 1 corresponds completely disagreeing and number 10 corresponds completely agreeing. The responses to the rating questions are presented in Fig. 9. The respondents that disagreed with any of the initial improvements will be discussed with during the design part in Section 3.4,

so that the new improved process meets the needs of the maintenance team. The responses to the follow-up questions (Q6, Q8, Q10 and Q12) of the rating questions were analyzed together internally with the supervisor of this thesis. The feedback to the improvement recommendations 1–4 suggested by the respondents will be presented next.

Feedback to improvement recommendation 1:

The rating question Q5, in which the improvement recommendation 1 was reviewed, received the second highest level of agreement, as seen in Fig. 9. In the follow-up question Q6, a respondent shared their concern about the improvement recommendation 1. The concern was that the improvement recommendation 1 could introduce a new limitation problem, as it could limit the use of the existing spare device pool. The issue arises from the fact, that the existing device pool would not be compatible with the test station which utilizes the new replacement device. Vice versa, the replacement device would not be compatible with any test station utilizing the device of the current device pool. A solution for replacing a specific device type was provided by the respondent: a tester development process could be started for replacing specific device type. During this process, the tester development team would choose the replacement device and do all the necessary work for ensuring the functionality of the test stations. Supposedly, the maintenance team would then just have to install the replacement devices and take the updated testing software to use, which is provided by the tester development process.

Another flaw in the improvement recommendation 1 was pointed out by a respondent, which was that the developer of the test station is rarely involved with the choosing of replacement devices. The original developer may not be employed by the company anymore, or the developer may not remember the reasons for choosing a specific device, as the test station development process may have taken place over a decade ago. Therefore, it could be beneficial to keep the core of tester development team as the same as long as possible. As the core of maintenance team has remained the same for long period of time, this was pointed out to be one of the strengths previously in this section. If the maintenance team was to choose the replacement device, then any technical information regarding why a specific device has been chosen for the test station could make it easier for choosing more reliable replacement devices.

Additional improvements suggested by the respondents for what kind of proactive measures should be taken before tester equipment becomes EOL included:

- Every test station should be designed to be compatible with two different devices or two different models of the device.
- There should be more communication with the suppliers and manufacturers. Sometimes replacement devices can be acquired for testing purposes from the suppliers without a fee.
- Generating fact-based data and analysis.
    - For complex equipment: Using condition monitoring technics like data analysis on vibration, thermal behavior, calibration parameter's change and number of failures.
    - For simple parts: doing regular inspections
- Around half-way in product's and test station's life cycle, a mid-life refit should be done.
- After an EOL device has been replaced, it should be sent to calibration for the last time to ensure the quality of the last production batch.

Feedback to improvement recommendation 2:

The rating question Q7 received the least amount of agreement, in which the improvement recommendation 2 was reviewed. The purpose of the follow-up question Q8 was to identify all necessary tester equipment and parts, to which life-cycle status monitoring and proactive measures should be targeted at. The responses include:

- Specific type of tester equipment
- All equipment and parts if their malfunctioning can cause a production stoppage
- Calibrated measuring instruments
- Identifying critical parts via the use of criticality definition table or failure mode and effects analysis (FMEA).
- Certain type of tester equipment and custom parts made by the company
- All equipment and parts should be monitored.

Feedback to improvement recommendation 3:

The rating question Q9, in which the improvement recommendation 3 was reviewed, received the second lowest amount of agreement from the maintenance team. The purpose of the follow-up question Q10 was to gather feedback and improvements to the equipment database's information fields for listed items. Feedback and improvements included:

- The impact to the production process in case a device becomes unavailable or breaks. Example of different types of impacts: stops the production of low or high volume product. Stops the production of a key product or reduces the product's production capacity by half.
- The device pools which are soon to be obsolete should have an indication for it in equipment database. Also, similar indicator should be added for devices which cannot be purchased anymore.
- Updating the equipment database with EOL related information a minor thing since the EOL information can be looked up from other places by anyone. The following steps after the EOL announcement has been received are more important.
- Adding replacement policy and procedure to registration.
- Life-cycle information is difficult to implement to equipment database

Feedback to improvement recommendation 4:

The rating question Q11 received the greatest amount of agreement, in which the improvement recommendation 4 was reviewed. The purpose of the follow-up question Q12 was to gather feedback and improvements to the information fields in the equipment database for listed items. Feedback and improvements included:

- EOL tester equipment should be made more visible, so they are remembered, and risks are acknowledged.
- Manufacturers could be polled during annual critical equipment mapping. Making a list of all tester equipment in use and send requests to their manufacturers if they could provide us an estimation of product's life cycle or changes in availability. This information could be added to equipment database. The polling should be done by a separate person or a group.

- Using failure data and analysis of some maintenance indexes like mean time between failures (MTBF), mean time to repair (MTTR), etc.
- Every part of a test station should be managed the same way that product's components are managed.
- Monitoring life-cycle status changes of tester equipment and parts should be done by component managers.

Based on the responses to the survey, similar issues were detected by the respondents as were found during the initial review of the current management practices in Section 3.1. The main issues detected by the respondents were:

- Responsibilities and tasks are unclear for resolving EOL related issues.
- All tester equipment and parts are not listed anywhere.
- EOL announcements and dates are not always known.
- Lack of information about the impact of EOL equipment.
- Reliance on reactive measures.
- Lack of documentation related to EOL related issues.

Additional issues were detected from the current management practices by the respondents, which were not detected during the initial review, these additional issues were:

- Unavailability of components which are used in custom made tester equipment built by the company.
- The decision-making process regarding EOL considerations does not consider the workload of tester equipment which can vary.
- Information about EOL related issues is not reaching everyone.

Both the main issues and additional issues discovered by the respondents will be addressed in Section 3.4, where the design part of improved management process takes place.

3.4 Design of the improved obsolescence management process

The design for the improved tester equipment obsolescence management process will be done in two separate parts. In the first part, a framework will be designed that is based on the proposed improved obsolescence management which was presented in Fig. 8. The key issues which were discovered via the survey review are presented in Table 3, and these issues will be addressed first. If the issues cannot be resolved by the improvement recommendations 1–4, then additional solution is proposed. The feedback gathered from the survey indicated that the improvement recommendations 1–4 require changes. Therefore, solutions are proposed by either changing the initial improvement recommendations 1–4 or by generating an additional improvement.

The second part of the design will consist of shaping the improved management framework into a management process. Improvements will be turned into individual process steps and then combined into a management process. The literature review done in Section 2.2 will aid in defining standard-like management process steps. The management process is formed by taking example from the process example model presented in Section 2.2. The management process will be internally reviewed to ensure that existing processes support it and vice versa. The benefit of the two-part design process is that the initial state is known and documented from which the management process originates from. This allows the company considered in this thesis to trace the origin of each process step and this should make it easier to improve the management process in future.

3.4.1 Framework design for improved management practices

The key issues which were discovered via the questionnaire survey are addressed first. Both the issues and proposed solutions to the issues are presented in Table 5.

Table 5. Key issues identified from the responses to the questionnaire survey on the left. The proposed solution to each issue on the right.

Key issue	Proposed solution
Reactive based activities. EOL devices may not have a backup device.	Improvement 4 enables proactive activities. Additional improvement for defining proactive strategies for items. Acquiring a backup device when the device is still available for purchase is considered as a proactive strategy.
Lack of information about which devices will become EOL. And even if the information is available, no action takes place. It's not always clear who is supposed to act, as EOL notices don't always require any reaction from the team.	Improvement 2 selects most crucial tester equipment for availability monitoring. Additional improvement for clarifying the procedures and responsibilities for the replacement process.
The decision-making process regarding EOL considerations is based on a predefined fixed lifespan. Consequently, the equipment is utilized in various environments, ranging from highly controlled clean rooms to ordinary shop floors. For example, the workload of the same type of equipment varies, but this factor is not typically accounted for in calculations.	When the most crucial tester equipment is selected by using improvement 2, the workload and environment of tester equipment should be considered. The workload and environment of test station should affect the number of backup equipment. The sufficiency of available backup equipment for test stations with high workload should be evaluated.
We don't always have enough documentation. Some parts may not be available anymore, because they are custom made within the company. Or parts are unavailable because of other reasons.	Old test stations are not always well documented but new test stations are. The state of documentation could be reviewed for older test stations, but this should be considered as future work. Existing custom-made devices with EOL components should be redesigned with components that are available. This should also be considered as future work as it requires all components to be identified and tracked for availability changes, which should be done at the development stage.
I'm not receiving information about tester equipment, which is EOL. I've believed that the management level personnel are receiving information about EOL related subjects and will forward it to us when necessary.	Improvements 3 and 4 are supposed to address this issue. The personnel receiving the information about availability changes will forward the information accordingly. Additional improvement is required for easy access to availability information.

Additional improvement for verifying the correctness of equipment database information for selected tester equipment

The data entries for tester equipment are entered manually to equipment database, which can result as incorrect data due to human error. Additionally, the status and location for each tester equipment is manually updated, which may result as incorrect status or location information. The correctness of data in equipment database needs to be verified because the listing method relies on up-to-date data in equipment database. The status and location data for each tester equipment in equipment database can be checked and corrected during annual critical equipment mapping process.

Additional improvement for checking the availability of all selected items

The availability of multiple items which are manufactured by the same manufacturer should be checked by contacting the supplier or the manufacturer once. This way the number of times required to contact the manufacturer or supplier is minimized. Additionally, the manufacturers or suppliers should be requested to send the information about availability changes to maintenance team's shared email. The availability status of each item could then be updated to the equipment database as soon as availability information is available. Recommended availability statuses for items were presented in Fig. 3, which were: 1) Available, 2) Obsolescent, and 3) Obsolete. The naming of the three availability statuses could be simplified by using: "available", "available till (date)" and "not available". The availability checking should be performed by a specific employee or group. The availability status of available items can change at any point, so the availability status needs to be checked periodically.

Additional improvement for determining priority for tester equipment:

Once availability of all important items is visible in the equipment database then the priority should be determined for each item. The priority is supposed to indicate for which items cases are opened first. Priority is not required if cases are opened for all items which are not

available. Items which are available may not require prioritization. The priority of an item could determine the opened JIRA-case's priority.

Additional improvement for determining appropriate strategy for each item:

After a JIRA-case has been opened for resolving the obsolescence issue, an additional planning checklist could be filled by case assignee before case is continued. The idea of the checklist is to gather all necessary information relating to the test stations utilizing the item and select the most appropriate strategy for resolving the case. Different strategies for resolving obsolescence issues related to tester equipment include:

1. Ordering additional spare items before the item becomes unavailable for purchasing,
2. Activating a renewal project that will test and validate replacement items,
3. Waiting for completion of a renewal project to provide tested and validated replacement items.
4. Waiting for the completion of ramp-down project to provide a spare item,
5. Testing and validating a replacement item in advance the replacement procedure.
6. Testing and validating a replacement item during the replacement procedure.
7. Carrying out a replacement procedure with a tested and validated replacement item.
8. Carrying out replacement procedure to a specific test station to provide spare item for remaining test stations.
9. No action required.

The applicability of strategies 1–9 based on item's availability status is identified in Table 6.

Table 6. Strategies 1–9 on the left column and ‘x’ presenting the applicability of the strategy to item with availability status “Unavailable” or “Available till (date)”

Number of Strategy	**Applicability of strategy based on availability status**	
	Unavailable	Available till (date)
1.		x
2.	x	x
3.	x	
4.	x	
5.		x
6.	x	
7.	x	
8.	x	
9.	x	x

The strategy could be chosen based on the information provided by the checklist and the item’s availability status. Additional strategies should be added to the list of available strategies as future work if needed. The checklist is supposed to provide the assignee with most appropriate strategy for resolving the case. Following factors will also affect the selection of most appropriate strategy for the item:

- Number of test stations utilizing an item with same model type,
- Number of spare items in storage or otherwise available,
- Remaining lifespan of test stations utilizing the item (renewal / ramp-down),
- Duration of renewal project completion,
- Does a ramp-down project provide spare items,
- Has replacement item been tested or validated,
- Has replacement item been ordered or is it already in storage,
- Has replacement item been selected,
- Does replacement item meet the requirements of other test stations which utilize an item with same model,
- Does test stations require hardware changes,
- Does test stations require software changes,
- Where is the replacement item tested,
- Workload of the test stations utilizing the item,

Responsibilities are clarified after the checklist is completed. Procedure for completing the checklist and selecting most suitable strategy must be defined. Responsibilities need to be determined for selecting, ordering, testing, and validating the replacement device. The planning checklist should also include following actions:

- Determining contact person from maintenance or tester development team, who has the most experience with the item or test station.
- Gathering information about on-going plans for the item and test stations affected.
- Choosing the strategy together with contact person and tester development team.
- Determining if renewal projects or ramp-down projects provide spare items.
- Checking the recommended list of devices if replacement device is selected.
- Selecting replacement item together with contact person.
- Ensuring that replacement item's specifications meet the requirements of test station.
- Ensuring the compatibility of replacement item with test station.
- For custom tester equipment, a renewal project for designing new custom device should be opened.
- Determining the hardware and software changes required.
- Ordering the device.
- Determining what preparations can be done before device arrives.

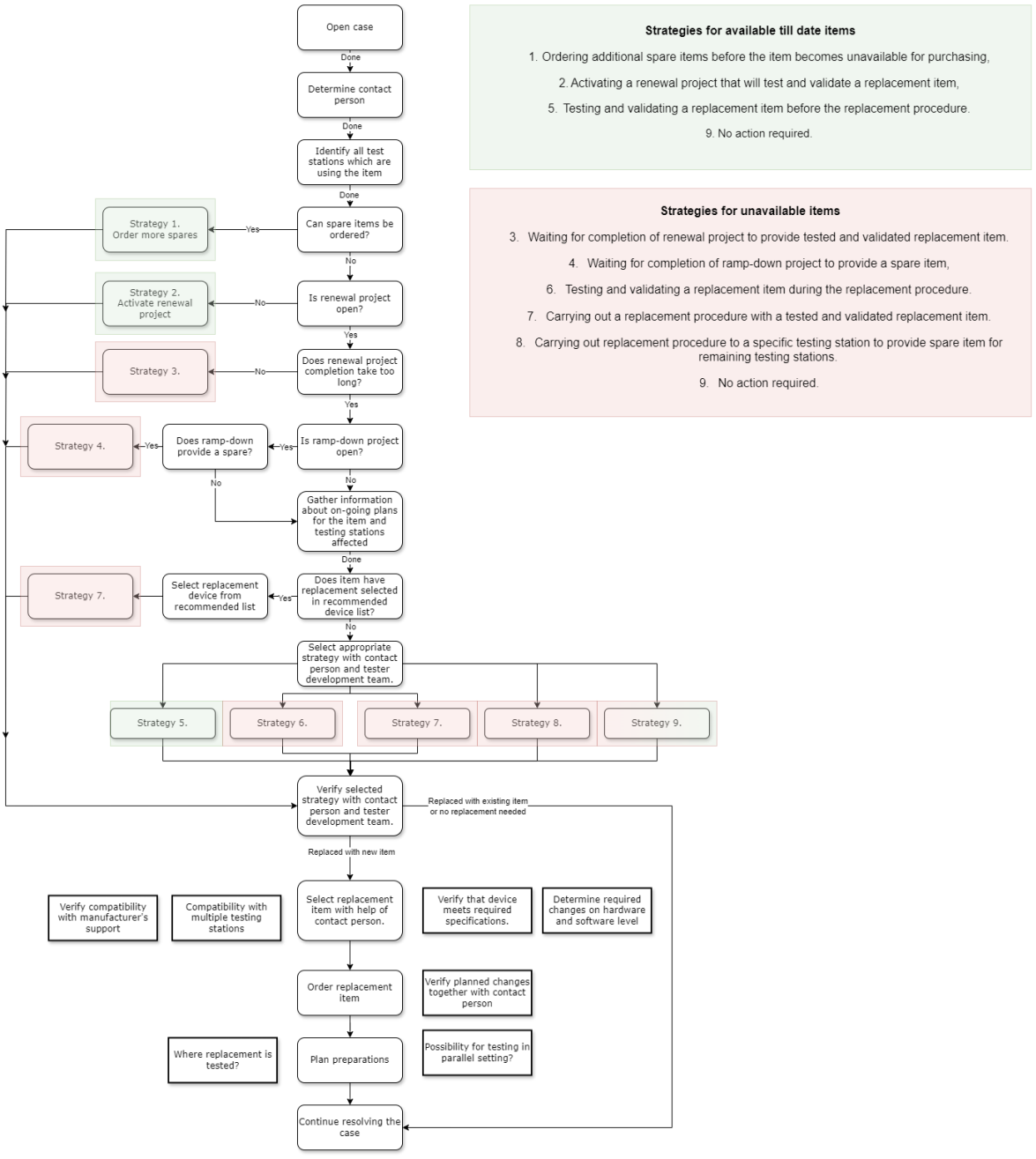

Figure 10. Flowchart presentation of the planning checklist. The light green color indicates strategies for items that are still available for purchasing, while light red color indicates strategies for items that are not available for purchasing anymore.

The planning checklist is presented in Fig. 10, and it is considered as the first version of the checklist. The checklist is most likely to change when it is tested for the first time in Section 4 when considering the planned proof-of-concept case.

Additional improvement for clarifying the procedures and responsibilities for the replacement process.

Before a process for carrying out a replacement procedure can be formed, the current replacement procedure needs to be identified. The case-study in Section 4 will examine how replacement procedures are carried out in the company considered in this thesis.

The improvement recommendations 1–4 and the additional improvements are integrated to the management framework that was presented in Fig. 8. Based on those improvements a new framework for tester equipment obsolescence management is presented in Fig. 11. The proposed management framework encapsulates the improvements into four new activities: 1) verifying correctness of equipment database information, 2) equipment availability monitoring, 3) selecting appropriate strategy using a checklist and 4) continuous improvement of the replacement procedure.

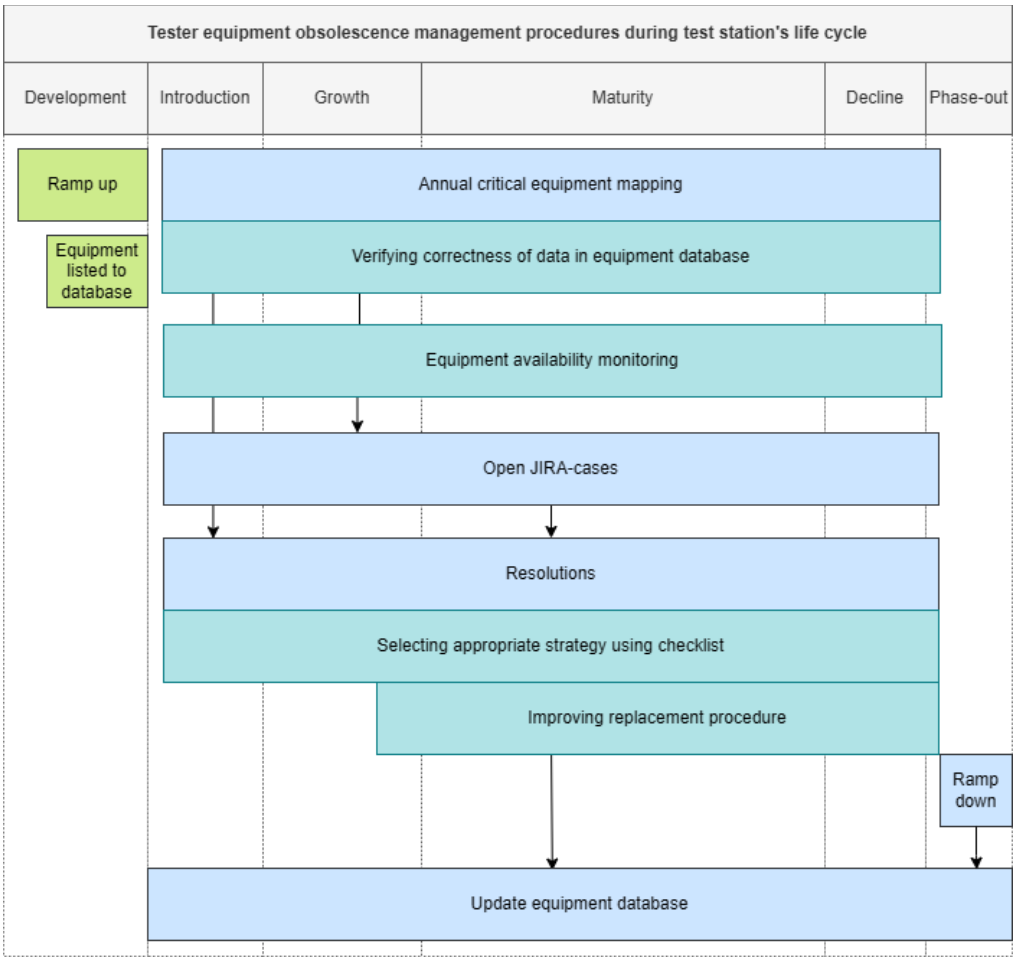

Figure 11. Flowchart presentation of the improved test equipment obsolescence management framework from the development stage to the decline stage in test station's life cycle. New proposed activities in cyan color.

3.4.2 Process formation based on the designed framework

The existing annual critical equipment mapping process is supposed to remain as a separate process from the obsolescence management process. However, additional improvement is proposed to the critical equipment mapping process for verifying correctness of data in equipment database as shown in Fig. 11. *Improvement recommendations 2* and *4* and relevant additional improvements are proposed to be integrated into the new activity: equipment availability monitoring which is presented in Fig. 11. *Improvement recommendation 3* and additional improvements related to equipment database tool are supposed to add life cycle status and priority information for the equipment in the equipment database. These

improvements are not considered as recurring activities as they require to be implemented to the equipment database tool just once. Since the obsolescence management will be dependent on the equipment database tool, it's recommended to consider equipment database tool related changes as part of the obsolescence management at the beginning. Equipment database tool related improvements should be tested and validated by the equipment database tool owner. *Improvement recommendation 1* consists of multiple smaller improvements relating to the replacement procedure, these improvements should be gradually integrated as part of the replacement procedure. Additional improvement was proposed for selecting the most appropriate strategy to mitigate obsolescence issues, which is proposed to become as part of the resolutions activity as shown in Fig. 11. Based on these considerations, an obsolescence management process for tester equipment is formed and it is presented in Fig. 12.

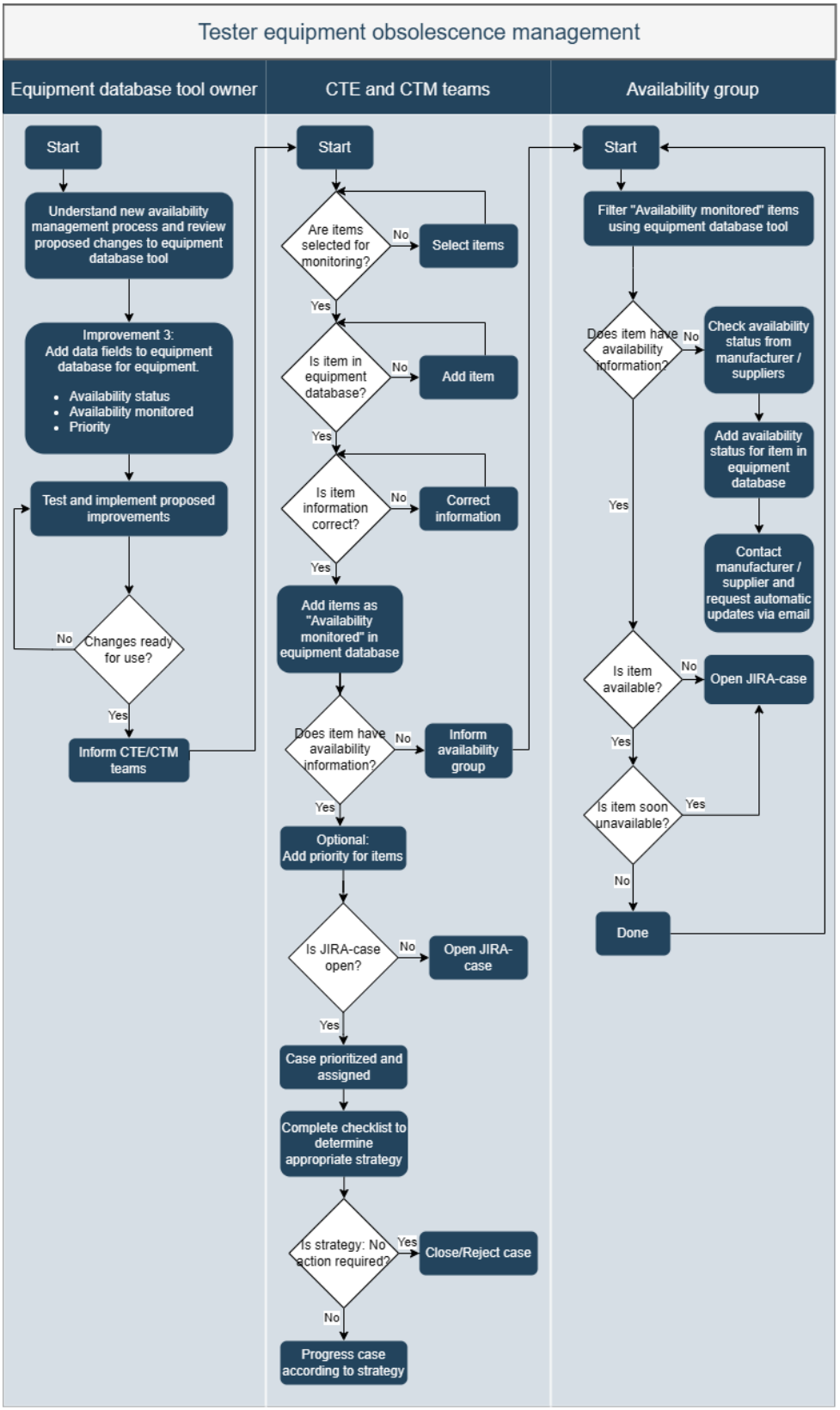

Figure 12. Flowchart of the obsolescence management process and proposed responsibilities for different activities. Responsibilities are equipment database owner, testing and calibration maintenance and engineering teams and availability group members.

Activities in Fig. 12 have been divided for three different responsibility groups: the equipment database tool owner, the calibration and testing maintenance (CTM) and CTE teams, and the availability group. Equipment database related changes are supposed to be completed before the activities of both the maintenance team and the activity group can be performed. Calibration and testing maintenance and engineering teams are supposed to select the tester equipment for availability monitoring and then inform the availability group to perform continuous availability status checking for each selected tester equipment. The obsolescence management process is supposed to support the resolutions activity by determining the most appropriate strategy to mitigate the obsolescence issue. Each of the mitigation strategies presented in Fig. 9 should be tested to identify their practicality. Additional instructions for performing strategies 1–8 could be created as future-work. It was decided during the design part, that the existing replacement procedure will be examined and improved gradually as future-work. The replacement process will be formed after the completion of case-study.

4 Case study for replacing obsolete tester equipment

The goal of this section is to partially test the improved obsolescence management process via a case study example and examine the existing replacement procedure of the company. Initial results of the replacement case will be presented and analyzed in this section briefly as the replacement case is planned to finish after the publication of this thesis. Therefore, the existing replacement procedures will be improved as future work. Meaningful improvements to the existing procedures require the procedures to be fully identified and evaluated through first-hand experience. This section will answer to **RQ5** and **RQ6** introduced in Section 1.

The obsolescence management process presented in Fig. 12 requires changes to the equipment database tool before it can be performed. Changes to the equipment database require to be planned, tested, and implemented together with the equipment database tool owner. Therefore, the equipment availability monitoring will be tested as future work. The life cycle status is already known for the item which is to be replaced in this case study. The device is not available anymore as it has reached its EOL phase. The planning checklist presented in Fig. 10 will be tested via this case study.

4.1 Replacement for chilled mirror dewpoint hygrometer

The case study's goal is to carry out a replacement procedure in which a chilled-mirror dew point hygrometer is be replaced with a new model. Chilled-mirror dew point hygrometers are used to measure the dew point temperature of gases containing water vapor. The device contains an optical module which consists of LED light source and a photodiode light detector. The device measures the temperature of a chilled mirror at the point when gas begins to condense to its surface as shown in Fig. 13. The surface of the mirror is reflective, and when gas condensates to its surface, the reflective properties of the surface change. The LED is directed at the mirror's surface and the amount of light scattered varies on the thickness of the condensation layer.

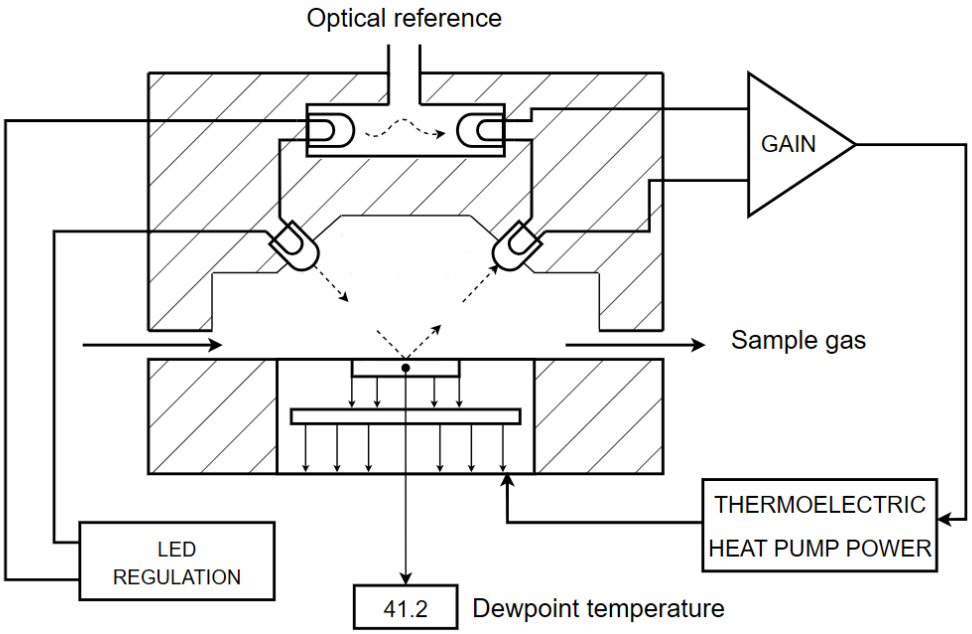

Figure 13. Schematic of chilled mirror sensor, adapted from [25].

The replacement procedure which was performed during this thesis is presented next. The R&D department of the company considered in this thesis had selected the replacement device based on their professional experience, therefore the replacement device was not selected based on the checklist presented in Fig. 10. However, the compatibility and required hardware changes to the relevant test stations were identified during this replacement procedure. The new device had also been ordered and added to equipment database before replacement procedure had begun.

The first step in the replacement procedure was to identify technical differences between the new and old device. Technical differences between the devices would normally be identified during the obsolescence management process when potential replacement device is being selected. Technical differences were identified by comparing device specifications and listing similarities and differences side by side to an excel spreadsheet. Additionally, all test stations which utilize the device were identified with the help of equipment database. Next, it was verified that new device met the specifications of each test station.

The second step was to read manuals of both devices and perform experimental testing with both the new and old device to become familiar with devices' functionalities. Testing was performed with a personal laptop, to which the device was connected via serial

communication adapter. Galvanically isolated adapter was used because it protects connected devices by preventing the generation of ground loops. Relevant test stations were then studied to help identify if hardware level changes are required to accompany the new device, which resulted as no need for hardware changes.

Next, the test software and test sequence were studied to understand how the test software communicates with the device and which operations the device is supposed to perform during execution of test sequence. The communication between test software and the device had been implemented with a device specific driver. Therefore, additional driver for the new device required to be implemented and validated during the replacement procedure. The command references of old and new device only had minor differences but due to these differences, the old driver won't function correctly with the new device. The structure of the old driver was used as a template for the new driver, from which the parts which don't function with the new device were identified. The new device has additional functionalities which the old device doesn't have, therefore the implementation for new functionalities needs to be added to the new driver.

The driver was initially tested by running test software with a custom test sequence which contained all necessary operations identified previously. Afterwards the driver was tested on an actual test station using the original test sequence. Testing required that test station was reserved for testing when there was no production testing on test station. Experimental testing revealed issues which were resolved by modifying both the driver and test sequence until the test sequence executed without issues.

Next step in the replacement procedure is to run test sequence multiple times on both the old and new device to provide validation data. Validation runs are still on-going and will finish after the publication of this thesis. The steps performed to carry out the replacement procedure in this case-study should provide a general idea for the required steps for the replacement process that will be formed as future work.

4.2 Improvements to the replacement procedure

In this case study, the replacement device had been selected by the R&D department. The selection process for a replacement device should be standardized to ensure that the selected

replacement device meets the needs of both existing and up-coming test stations. The selection should follow a process in which the relevant departments within the company are consulted or actively collaborated during replacement item selection in Fig. 10. Information about the selected replacement devices and on-going replacement procedures should also be visible to all relevant personnel.

Technical differences between the old and the new device need to always be identified during the replacement procedure. Therefore, a template which contains general technical information applicable to most devices could be helpful. An excel spreadsheet was used during this case-study to present the differences between the old and the new device. Identifying the test stations that utilize the device that is to be replaced is easy with the equipment database tool, but it requires that the test stations have been listed to the equipment database. A list of test stations utilizing a specific device model could be added to the template for technical differences. Test stations that utilize same devices often have different specifications, which is a crucial piece of information when the suitability of replacement device is evaluated. However, the suitability of the replacement device should be evaluated earlier when the device is being selected.

Familiarizing the assignee with both the old and the new device is crucial part of the replacement procedure in order to identify functional differences between devices. However, there are multiple different devices and employees have different amount of experience with each device. Maintenance and engineering teams could have named specialists for each type of device or test station, which would speed up the familiarizing part. Having specialists for each type of test stations would also speed up familiarizing the assignee with test station specific software and test sequence.

In this case study testing the replacement device was performed on a production test station. The problem with this approach is that a suitable test station is often unavailable because production units need to be tested on it. If the maintenance team needs to carry out a replacement procedure and the test station is unavailable, a development station should be used instead. However, the development station may also be unavailable because tester developer team is using it. Ideally every type of test station would have a copy of them for development purposes and replacement devices could be tested on development stations without having to use production test station.

5 Conclusions

This study focused on gathering and analyzing relevant information related to obsolescence management with a key target to propose improvements to existing practices used by the company. To support the analysis, a literature review about obsolescence management processes and key standards was conducted. Based on the analysis, an improvement plan was proposed for the tester equipment obsolescence management, which was evaluated through a questionnaire survey. The feedback from the survey helped define the proposed improvements and identified possible areas of further improvement. Based on the results of the literature analysis and the survey feedback, a final improvement plan was proposed and from which an obsolescence management process for tester equipment was derived.

The existing practices related to tester equipment obsolescence management used in the company served proof of concept for this thesis. However, due to limited possibilities to finalize the analysis, the practical evaluation of proposed improvement plan remains incomplete at this stage. Practical evaluation of the improvement plan has been discussed with the supervisor of this thesis and the remaining improvements will be evaluated as future work prior to the deployment of the improvement plan which includes the obsolescence management process.

Possible problems related to the deployment of the improvement plan may arise when changes to the equipment database tool are implemented. Any unidentified limitations of the management tool may require redefining the proposed changes. Executing the equipment availability monitoring may also require additional training for the designated availability group members. Future improvements will be targeted at the different strategies for resolving obsolescence related issues. The strategies in which replacement devices are selected and replacement procedures are carried out will be refined through internal discussions with R&D and engineering teams.

Enhancing the obsolescence management of tester equipment is a continuous process for the company. This work will enable the use of proactive measures for mitigating obsolescence issues and serves as a stepping stone towards standardized obsolescence management practices. This study contributes a concrete example for enhancing obsolescence management of industrial equipment in an industrial setting. It is important to notice that the proposed

improvement plan was tailored to fit the end requirements of the company considered in this thesis. Existing organizational interfaces and available resources heavily impact the scope of the obsolescence management as mentioned in [13].

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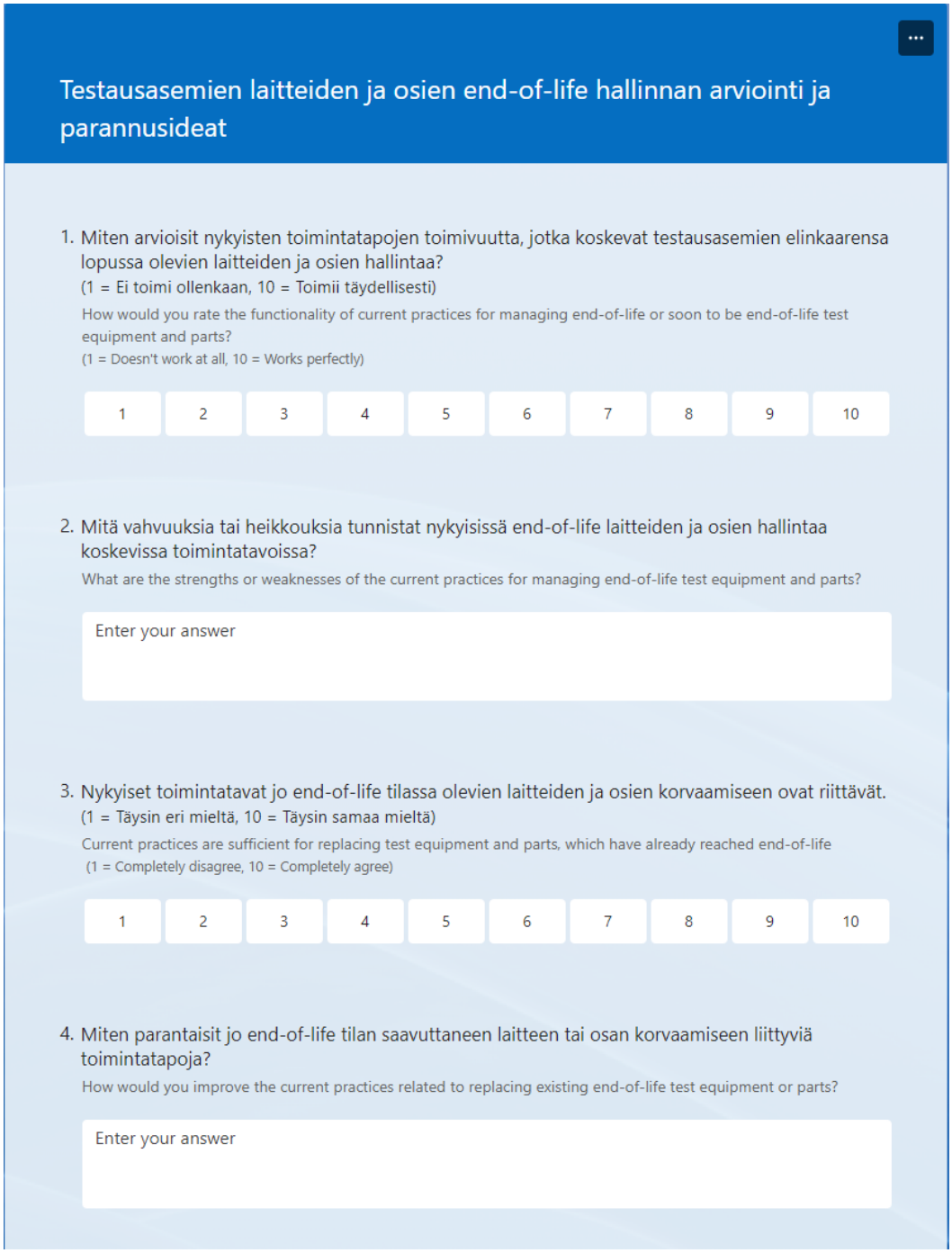
Appendix 1.

Questionnaire survey: “Rating the end-of-life management of test stations' tester equipment and parts, and collecting improvements”.



Testausasemien laitteiden ja osien end-of-life hallinnan arviointi ja parannusideat

1. Miten arvioisit nykyisten toimintatapojen toimivuutta, jotka koskevat testausasemien elinkaarensa lopussa olevien laitteiden ja osien hallintaa?
(1 = Ei toimi ollenkaan, 10 = Toimii täydellisesti)
How would you rate the functionality of current practices for managing end-of-life or soon to be end-of-life test equipment and parts?
(1 = Doesn't work at all, 10 = Works perfectly)

1 2 3 4 5 6 7 8 9 10

2. Mitä vahvuuksia tai heikkouksia tunnistat nykyisissä end-of-life laitteiden ja osien hallintaa koskevissa toimintatavoissa?
What are the strengths or weaknesses of the current practices for managing end-of-life test equipment and parts?

Enter your answer

3. Nykyiset toimintatavat jo end-of-life tilassa olevien laitteiden ja osien korvaamiseen ovat riittävät.
(1 = Täysin eri mieltä, 10 = Täysin samaa mieltä)
Current practices are sufficient for replacing test equipment and parts, which have already reached end-of-life
(1 = Completely disagree, 10 = Completely agree)

1 2 3 4 5 6 7 8 9 10

4. Miten parantaisit jo end-of-life tilan saavuttaneen laitteen tai osan korvaamiseen liittyviä toimintatapoja?
How would you improve the current practices related to replacing existing end-of-life test equipment or parts?

Enter your answer

5. Ennen kuin testausaseman laitteen tila muuttuu end-of-lifeksi, korvaavan laitteen yhteensopivuus ja toiminta kannattaisi varmistaa ennakkoon esimerkiksi näin:

    1. Valitaan korvaava laite yhdessä aseman kehittäjän kanssa. Tilataan laite ja luodaan yksittäinen asemakohtainen ratkaisu, jonka avulla validoidaan korvaavan laitteen toiminnallisuus testausasemassa. Jos laitekannassa on useampi korvattava laite, tarkastellaan validoinnissa myös korvaavan laitteen luotettavuutta esim. 2 kuukauden ajan.
    2. Tarvittaessa luodaan korvaavalle laitteelle platform-tason ratkaisu ja tehdään suunnitelma kaikkien laitteiden korvaamista varten.

    (1 = Täysin eri mieltä, 10 = Täysin samaa mieltä)

    Before test equipment becomes end-of-life, the replacement device/part's compatibility and functionality should be verified in advance, for example by:

    1. Choosing a replacement device/part together with test developer. Ordering the device and creating a station specific solution for the replacement device, which is used to validate device's compatibility and functionality with the testing station. If there are multiple of same devices which have to be replaced, then station's reliability should be validated for 2 months, for example.
    2. If needed, a platform level solution is created, together with a roll-out plan for replacing all end-of-life devices.

    (1 = Completely disagree, 10 = Completely agree)

1	2	3	4	5	6	7	8	9	10

6. Mitä muita ennakoivia toimia ehdottaisit, ennen kuin laitteen tai osan tila muuttuu end-of-lifeksi?
    Which other proactive measures would you suggest, before test equipment or parts become end-of-life?

    Enter your answer

7. Testausasemien laitteistosta kannattaisi valita vain tärkeät laitteet ja osat, joiden elinkaarentilaa valvotaan, ja kohdistaa ennakoivia toimia vain näihin laitteisiin ja osiin, kun päivämäärä elinkaaren lopusta on selvillä. (1 = Täysin eri mieltä, 10 = Täysin samaa mieltä)
    Only important pieces of test equipment and parts should be selected for life cycle status monitoring. Proactive measures should be only targeted at them, once the end-of-life date is known.
    (1 = Completely disagree, 10 = Completely agree)

1	2	3	4	5	6	7	8	9	10

8. Mihin laitteisiin ja osiin elinkaaritilan valvontaa ja ennakoivia toimia kannattaisi kohdistaa?
    Which test equipment and parts should be monitored for life cycle status changes, and proactive measures should be targeted at?

    Enter your answer

9. Laiterekisterissä (Indysoft) olisi hyvä näkyä laitteiden ja osien elinkaarentila, josta selviäisi onko laitetta tai osaa enää saatavilla ja mahdollisesti mihin päivämäärään saakka.
    (1 = Täysin eri mieltä, 10 = Täysin samaa mieltä)
    Test equipment's life cycle status should be visible in Indysoft, to clarify whether a piece of test equipment is still available for purchasing or not. (1 = Completely disagree, 10 = Completely agree)

1	2	3	4	5	6	7	8	9	10

10. Mitkä muut tiedot laiterekisterissä auttaisivat hallitsemaan laitteita ja osia end-of-lifen varalta?
What other information in Indysoft would be helpful to manage test equipment and parts for end-of-life?

Enter your answer

11. Elinkaaritilan valvontaa kannattaisi toteuttaa ottamalla yhteyttä valmistajiin ja toimittajiin, ja pyytää heitä lähettämään ilmoituksia elinkaaritilan muutoksista meidän sähköpostiimme. Jos mahdollisuutta ilmoitusten lähettämiseksi ei ole valmistajan puolelta, niin laitteiden ja osien elinkaaritila pitäisi varmistaa säännöllisesti ottamalla yhteyttä valmistajaan. (1 = Täysin eri mieltä, 10 = Täysin samaa mieltä)
Life cycle status monitoring should be performed by contacting manufacturers and suppliers, and requesting them to send us notifications about tester equipment's life cycle status changes to our e-mail. If there is no possibility for notifications, then tester equipment's life cycle status should be periodically checked by contacting manufacturers. (1 = Completely disagree, 10 = Completely agree)

1	2	3	4	5	6	7	8	9	10

12. Keksitkö muita tapoja laitteiden elinkaaritilan valvonnan toteuttamiseksi?
Can you come up with other ways to implement tester equiment's life cycle status monitoring?

Enter your answer