European Commission

Repair Score Study: Product specific application to Smartphones and Tablets

Second Draft Report

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Contents

List of abbreviations and definitions

ADEME	Agency for Ecological Transition
CEAP	Circular Economy Action Plan
CEN	European Committee for Standardization
CENELEC	European Committee for Electrotechnical Standardization
DDi	Disassembly Depths
DG ENV	Directorate General for Environment
DG GROW	Directorate General for Internal Market, Industry, Entrepreneurship and SMEs
ETSI	European Telecommunications Standards Institute
EU	European Union
f_c	Correction factor
ICT	Information and Communications Technology
ITU	International Telecommunication Union
JRC	Joint Research Centre
KU Leuven	Katholieke Universiteit Leuven
MSAs	Member State Authorities
OEMs	Original Equipment Manufacturers
RRU	Reparability, Reusability and Upgradeability
TU Delft	Technische Universiteit Delft
TWG	Technical Working Group

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The two teams from KU Leuven (Braquené Ellen, Laps Emma and Van Moeseke Tine) and TU Delft Sagar Dangal, Julieta Bolanos Arriola, Bas Flipsen, Jeremy Faludi and Ruud Balkenende) have contributed to the calibration and validation processes described in Chapter 3 and Chapter 4.

Introduction

The new Circular Economy Action Plan (CEAP)[1] announced regulatory measures for electronics and ICT including mobile phones, tablets and laptops under the Ecodesign Directive so that these devices are designed for energy efficiency and durability, reparability, upgradability, maintenance, reuse and recycling.

In this context, DG GROW is currently leading work on smartphones and tablets, with the view to establish an implementing measure under the Ecodesign Directive and possibly an energy label under the Energy Labelling Framework Regulation[2].

In support of a possible introduction of product reparability scoring in the EU policy, the JRC developed, in the period 2018-2019, a repair scoring methodology (hereinafter "General Method"). The methodology development included a stakeholder consultation process. A Technical Working Group (TWG) was set up to facilitate this process. Background information and initial input from stakeholders were gathered at the beginning of the study via a questionnaire. Moreover, two meetings were organised in order to obtain feedback and input directly from the TWG. The final output of this process was a report published in 2019 (Cordella et al., 2019) in which such a system is described. In the General Method, scoring criteria are set out to rate the extent to which products are reparable or upgradable. The assessment of reparability focuses on a number of priority product parts and technical parameters, which cover product design characteristics and relevant operational aspects, related to the repair and upgrade of products. The General Method was built on a draft of standard EN 45554[3] for the assessment of reparability, reusability and upgradeability (RRU) of energy related products, developed under standardisation mandate M/543 as one of the actions under CEAP.

Following this JRC study, different formats of a label to depict reparability scores were tested in a consumer study published in 2021 (Directorate-General for Environment, 2021). It analysed the effects of reparability scoring and how to effectively communicate this information to consumers. Overall, the study showed that providing reparability information is effective in guiding product choices towards more reparable products.

In parallel to the work at the EU level, a reparability scoring scheme has been introduced at the national level in France, and Spain is considering the instruction of such a system as well[4]. Moreover, several mobile phone operators launched an industry-wide harmonised labelling scheme for mobile phones[5], while iFixit also present reparability scores on their website[6].

In this context, DG ENV has requested the JRC to conduct a follow up study, which entails the development of product specific methods and the application of a developed reparability scoring system on models of smartphones and tablets available on the EU market. This study serves as a methodological basis for the possible introduction of the scoring system for these product groups.

The study uses the aforementioned JRC method developed in 2019, follows the methodological steps and proceeds with the choices that are deemed appropriate for these product groups. In order to ensure the applicability of the method in a real-life context, the study also includes the calibration of the scale of reparability scoring and the validation of the results.

The scoring system presented here incorporates aspects that determine the reparability of the products in question. However, it is worth noting that these aspects are also relevant for reuse and upgrade, two concepts also compatible with circular economy and with extending product lifetime. For example, the ability to disassemble a product and replace parts influences its ability to be repaired, but also to be reused and upgraded

It is important to note that, although this repair score does not aim to measure the environmental benefits from repairable design, there is clear correlation between extending lifecycle and environmental impacts reduction for electronic products like smartphones and tablets. According to Cordella et al. 2020, a significant GWP reduction can be achieved by extending the lifetime of smartphones from 2 years to 3 or 4 years (-29% and -44%, respectively). Even in scenarios where the extension of the lifetime is associated to the replacement of priority parts as display or battery, the benefits, in term of carbon footprint, are still very high and the repair scenario is still a more sustainable option than substitution. At the ecodesign and energy labelling consultation

[1] Circular Economy Action Plan (COM/2020/98 final). Available at this link

[2] Ecodesign preparatory study on mobile phones, smartphones and tablet. Available at this link. Initiative- Designing mobile phones and tablets to be sustainable-Ecodesign. Available at this link

[3] The standard was later published as EN 45554:2020.

[4] Consulta pública sobre la futura regulación del índice de reparabilidad de los aparatos eléctricos y electrónicos. Available at this link

[5] https://www.ecoratingdevices.com

[6] https://www.ifixit.com/Teardown

forum held on the 28th of June 2021, stakeholders have been notified of the new JRC study. A dedicated stakeholder meeting took place on the 7th of September 2021. In the following month the stakeholders have been provided the opportunity to send their written comments. A summary of the comments received is provided in Annex III.

1 Definitions

The following definitions are applied in this report:

Part: hardware, firmware or software constituent of a product [Source: EN45554:2020]

Spare part: a separate part that can replace a part with the same or similar function in a mobile phone, cordless phone or tablet. The part is considered necessary for use if the mobile phone, cordless phone or tablet cannot function as intended without that part. The functionality of the mobile phone, cordless phone or tablet is restored or is upgraded when the part is replaced by a spare part; [Source: draft ecodesign regulation, 2021]

Disassembly: process whereby a product is taken apart in such a way that it could subsequently be reassembled and made operational [Source: EN45554:2020]

Additional notes from the JRC Repair Score 2019: Disassembly has to be reversible, i.e. to enable re-assembly without causing damages to functional parts of the product. Destructive disassembly (also referred to as "dismantling") does not count towards this parameter.

Step: A step consists of an operation that finishes with the removal of a part, and/or with a change of tool [Source: JRC, 2019; French Score, 2020].

Fasteners: A hardware device that mechanically or magnetically connects or fixes two or more objects, parts or pieces. A fastener is generally non-permanent, i.e., it can be easily removed or disassembled without damaging the objects, parts or pieces connected or fixed together (e.g., screws or clips). Welds and some glues are, in contrast, permanent fixings [Source: French Score, 2020].

Reusable Fasteners: An original fastening system that can be completely re-used, or any elements of the fastening system that cannot be re-used are supplied with the new part for a repair, re-use or upgrade process [Source: EN45554:2020].

Removable Fasteners: an original fastening system that is not reusable, but can be removed without causing damage or leaving residue which precludes reassembly (in case of repair or upgrade) or reuse of the removed part (in case of reuse) for the repair, reuse or upgrade process [Source: EN45554:2020].

Security updates means operating system updates with the main purpose to provide enhanced security for the device [Source: draft Commission Regulation laying down ecodesign requirements for smartphones, cordless phones and tablets].

Functionality updates means operating system updates with the main purpose to implement new functionalities, corresponding to the latest version of this operating system available in the market; a functionality update may include a security update [Source: draft Commission Regulation laying down ecodesign requirements for smartphones, cordless phones and tablets].

2 Methodology

The method described below is based on the general method for assessing the reparability and upgradability of generic products placed on the market developed by the JRC in 2019 (Cordella et al. 2019). As shown in Figure 1, this general method is founded on three pillars

I) Priority parts;

II) Key parameters for repair and upgrade;

III) Scoring framework.

This general approach developed by JRC can be tailored for the application to specific products, as was illustrated in 2019 for the case studies on washing machine, vacuum cleaners and laptops.

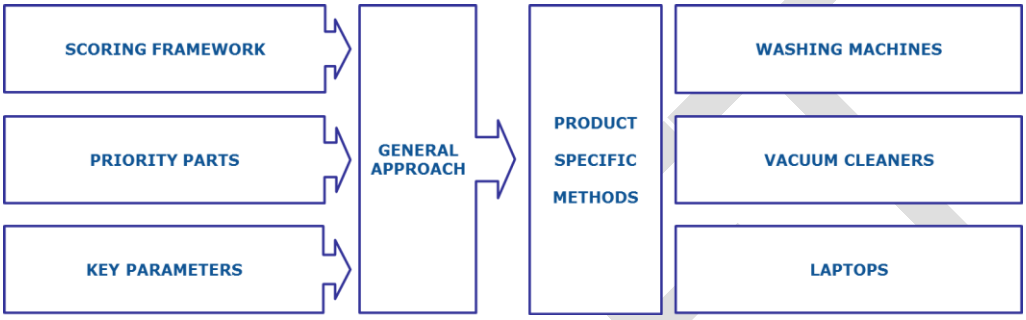

Figure 1. From general to product specific approaches

However, in addition to the aforementioned pillars, the development of a product specific scoring method also requires a consideration of calibration and validation aspects, as described below.

2.1 General outline of the product specific method

This study consists of the steps presented in Figure 2 below.

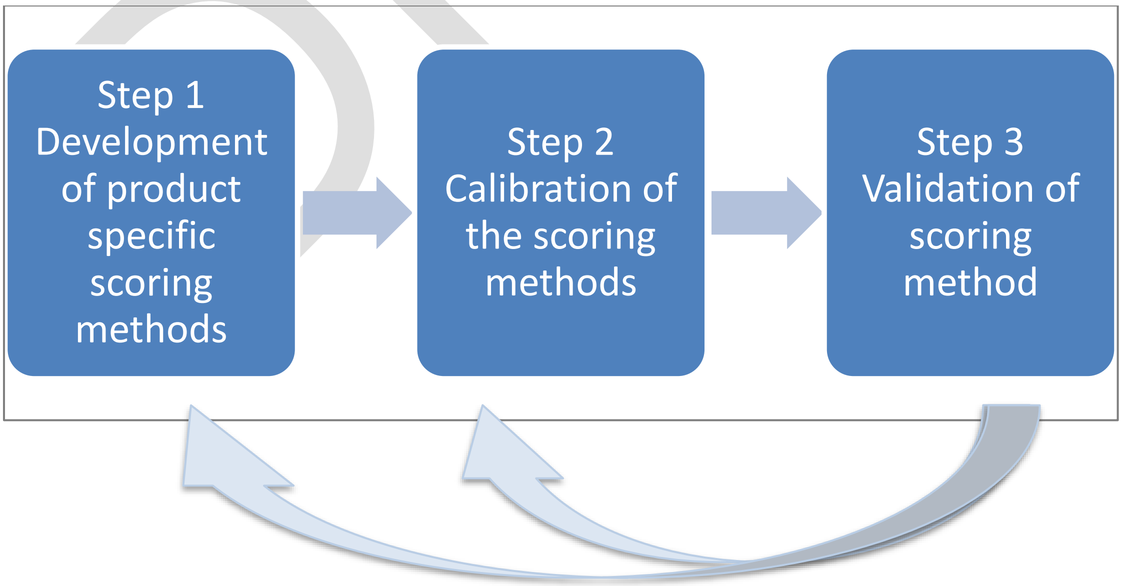

Figure 2. Outline of the different steps of the study

STEP 1: Development of product specific scoring methods

The development of a product specific method will mainly rely on the JRC General Method and includes the following steps:

1. Selection and justification of the selected priority parts (section 2.2)
2. Selection and justification of the choice of key parameters (section 2.3)
3. Definition of the scoring criteria (section 2.4)
4. Definition of the weighting factors and the aggregation of the scoring parameters (section 2.5)
5. Draft a guidance for calculation / verification procedure, including an excel sheet (Annex I and Annex II)

STEP 2: Calibration of the results

1. Select an X number of devices that are representative of the market at the time of the study, including price (e.g. low-end, mid-range, high-end), or different design architectures.
2. Apply the scoring system on the selected products. Review of product documentation may be used in order to assign scores.
3. Calibrate the results based on: status on the market and the results, also considering outliers (rugged / niche application devices). This step may be revisited after the validation stage and re-calibrate if necessary.

STEP 3: Validation

The aim of the validation exercise is to verify whether the scoring system methodology is suitable for the intended use. In particular, we aim to verify:

1. The technical reproducibility of the scoring assessment by different teams applying the method in parallel;
2. The most important methodological challenges encountered by the experts in the application of the methodology;
3. Consistency with other systems currently in place, such as the French reparability index, (keeping in mind the differences in scope and application);
4. Correlation of scoring results vs. product costs and scoring results vs. repair cost

Other Scoring Systems

A French reparability index[7] was introduced on 1 January 2021 as a part of the French law No. 2020-105 of 10 February 2020 relating on the fight against waste and the circular economy for electrical and electronic products[8]. The French Ministry of Ecological Transition and the Agency for Ecological Transition (ADEME) together with external specialist sources such as Spareka and other stakeholders, developed this mandatory reparability index not only for smartphones but also for other products such as laptops, television, washing machines and electric lawnmowers. The index that will gradually be extended to other electrical and electronic equipment is based on the scores assigned to the 5 different criteria, listed below:

- Documentation: score determined by the producer's commitment to make technical documents available free of charge, in number of years, to repairers and consumers.

- Disassembly and accessibility, tools, fasteners: score determined by the ease of the disassembly of the product, the type of tools required and the characteristics of the fasteners.

- Availability of spare parts: score determined by the producer's commitment to the availability of spare parts and the time taken to deliver them.

[7] https://www.indicereparabilite.fr/

[8] https://www.legifrance.gouv.fr/jorf/id/JORFTEXT000041553759?r=TMq5JqJCco

- Price of spare parts: score determined by the ratio of the selling price of spare parts to the price of the product.

- Specific: score determined by sub-criteria specific to the product category concerned.

The final reparability index is the results of the calculation of the scores assigned to the different criteria, reduced to a score out of 10.

Article 16-I of the abovementioned anti-waste law establishes the mandatory display of the reparability index which must be placed both online and in the shop. Retailers are obliged to make the details available to consumers by any appropriate means (e.g. directly on the product or its packaging, via a terminal in the shop, a QR code, a table available on a web page, etc.).

Another initiative that raises consumers' awareness of making informed and more sustainable choices and helps preserve the natural resources necessary for the products production is the Eco Rating initiative[9]. The consortium behind this initiative lead to the development of an industry-wide Eco Rating labelling scheme, which involves five of Europe's leading mobile operators: Deutsche Telekom, Orange, Telefónica, Telia Company and Vodafone. The consortium is open to other mobile operators and also includes the participation of more than 16 phone manufacturers who have contributed to Eco Rating providing data for their devices.

In this initiative, the evaluation of the final score is done considering not only reparability but also other material efficiency indicators including durability, recyclability, etc. Moreover, beside material efficiency aspects, the environmental performances of mobile phones through the whole life cycle are considered.

The life cycle covers production, transport, use and end-of-life disposal and includes 13 environmental indicators such as climate change, ozone depletion, acidification, resource use, eutrophication and others. The calculation of the life cycle impact was carried out according to the Environmental Footprint method developed for the European Product Environmental Footprint initiative[10]. The analysis of material efficiency aspects was based on the standards developed by CEN and CENELEC under mandate 543 of the European Commission, and also on other criteria drawn from various guidelines, standards and ecolabels (e.g. ETSI, ITU, etc.).

This methodology considers an overall score on a scale from 1 to 100, meaning that the closer the score is to 100, the better the sustainability performance of the device. The Eco Rating label with the calculated score should be displayed on the device information at the point of sale.

The EU Horizon2020 project PROMPT[11] is tackling the same challenges by establishing an independent testing programme for premature obsolescence. This programme will support the assessment of the longevity of consumer products when they are put on the market.

The testing programme will cover major aspects related to longevity. It has the goal to enable testing bodies, consumer organisations, market surveillance authorities and other interested stakeholders to rely on tangible definitions and to methodically assess premature obsolescence. It will contribute to ongoing and future standardisation efforts and provide designers and policymakers with recommendations on improving durability and reparability of products, empower consumers to make informed choices, and create awareness on market conditions. The consortium has identified component reliability, product design features concerning repair and reuse and user and market-related factors as the most critical categories to be analysed. The consortium interacts regularly with all relevant stakeholders, including the JRC team working at the development of this repair score. Finally, in the field of the repair scoring systems, it is important to mention the iFixit scores for smartphones[12], tablets[13] and laptops[14]. The evaluation of iFixit is based on aspects like the difficulty to open the device, easy-to-swap modular parts, prioritized access to often-replaced components, while upgradeability is also considered a positive feature. The score is provided in a 0-to-10 scale and some qualitative description of the reparability / upgradability characteristics is also provided.

Where relevant, these examples were taken into account in the development of the scoring system for smartphones and tablets. Unlike the other schemes described in this section, this JRC study focuses exclusively on reparability measures for smartphones and tablets. The design of the method developed to assign the repair score will be presented in detail in the following sections.

[9] https://www.ecoratingdevices.com/
[10] https://ec.europa.eu/environment/eussd/smgp/ef_pilots.htm
[11] https://prompt-project.eu/
[12] https://www.ifixit.com/smartphone-repairability
[13] https://www.ifixit.com/tablet-repairability
[14] https://www.ifixit.com/laptop-repairability

Disclaimer: The selections and the definition of the scoring system as proposed below are based on the regulatory provisions of the June 2021 draft regulation laying down ecodesign requirements for mobile phones, cordless phones and tablets. In the case of changes in the draft regulation, the following section may also be changed.

2.2 Selection of Priority Parts

According to the JRC General Method (Cordella et al., 2019), a selection of relevant priority parts is made in order to maintain the complexity in the assessment at a reasonable level. The parameters used for the identification of those parts are primarily the functional importance of the part (i.e. the extent to which a part is necessary for the delivery of primary or secondary functions of the product), and the frequency of failure of a given part.

The parts listed in the following Table 1 have been identified as priority parts for smartphones and tablets respectively, and are proposed for spare part availability (and other requirements) by the ecodesign preparatory study on mobile phones, smartphones and tablets (Fraunhofer IZM et al, 2021d). For the purposes of this study, it is therefore appropriate to select the same priority parts, in order to ensure compatibility and complementarity between the draft ecodesign and energy labelling regulations on one hand, and the scoring system on the other. Considering this approach, the list of priority parts could be subject to changes to reflect changes in the regulatory text.

Table 1 List of parts identified as priority parts for smartphones and tablets in the preparatory study and the draft ecodesign regulation on mobile phones, smartphones and tablets

Smartphones	**Tablets**
Battery	Battery
Display assembly	Display unit
	Front panel digitizer unit
Charger	Charger
Back cover or back cover assembly	Back cover or back cover assembly
Front-facing camera	Front-facing camera
Rear-facing camera	Rear-facing camera
External connectors	External connectors
Buttons	Buttons
Microphone	Microphone
Speaker	Speaker
Hinge assembly	Hinge assembly
Mechanical display folding mechanism	Mechanical display folding mechanism
Mechanical display rolling mechanism	Mechanical display rolling mechanism

The parts listed in Table 1 are not all subject to the same level of regulatory requirements. For example, in the case of smartphones, spare parts for the battery and the display assembly shall be available to both professional repairers and end-users[15], while the other listed parts shall be available to professional repairers only. A similar distinction between listed parts is made with regards to disassembly, whereby different requirements are proposed for the battery, the display assembly, and the rest of the listed parts, with regards to the removability/reusability of fasteners are connectors, the necessary of tools, working environment and skill level for a repair. For the purposes of implementing such scoring system on products placed on the EU market, only products that meet those minimum requirements are assessed. Therefore, the scoring system has been designed in a way that minimum regulatory requirements constitute the minimum scores that can be assigned to a product.

Apart from differences stemming from regulatory requirements, those parts also differ in terms of their functional relevance to the product and also their failure rate. Those part characteristics are used as input for the determination of the appropriate weighting for each part within the scoring system.

This relationship is presented in Figure 3 and further specified in section 2.5.2.

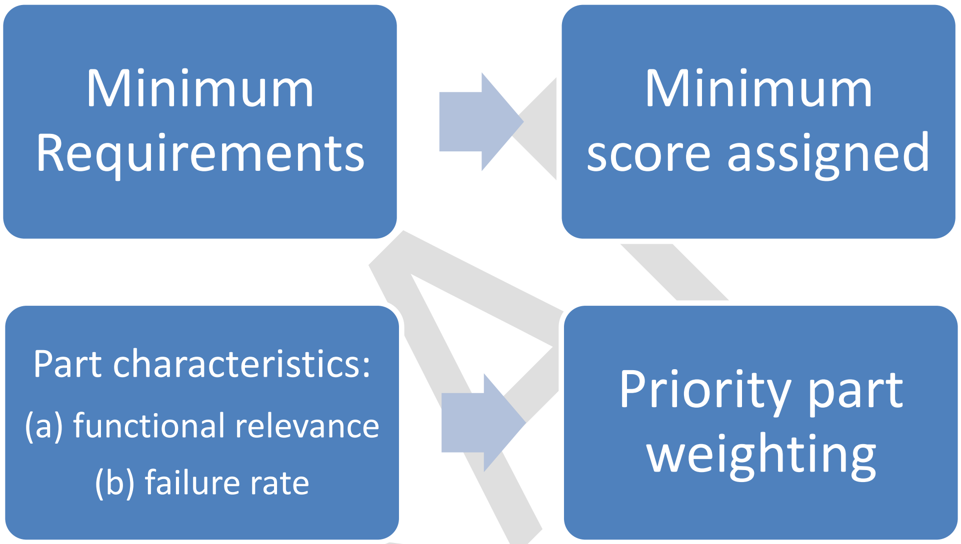

Figure 3. Relationship between ecodesign regulation and scoring system for priority parts

Some devices may consist of multiple parts of the same type, such as two batteries or two screens (Fraunhofer IZM et al, 2021c). In such cases, both parts are assessed, so that the part from which the lowest score is derived for a given parameter is considered in the calculation.

Finally, the part "charger" identified by the draft regulation is not considered relevant for the purposes of developing a repair scoring system: even though charging a smartphone or tablet are essential for the functionality of the device, the charger constitutes a part which is external to the main device (in both the case of a smartphone and a tablet), and therefore does not influence the ability of a device itself to be repaired.

Main changes compared to the first draft of the method

No changes from the previous version. However, the validation step (Chapter 4) has highlighted some challenges are attributed to the lack of specific definitions for each priority part, including unclear limits for assemblies and for bundling. The comments raised by stakeholders (see Annex III) will be shared with the Ecodesign team. The list of priority parts could be subject to changes to reflect those that might take place in the regulatory text.

[15] This requirement is conditional in the draft ecodesign regulation, with an alternative compliance criterion specified: *"or shall ensure that the battery endurance in cycles achieves a minimum of 1000 full charge cycles, and after 1000 full charge cycles the battery must, in addition, have in a fully charged state, a remaining capacity of at least 80 percent of the rated capacity"*

2.3 Selection of scoring parameters

The second step of the JRC General Method is the selection of parameters relevant to the repair and upgrade of the product, on which scores will subsequently be assigned. Similarly to the case of priority part selection described in section 2.2., the parameters considered are, on one hand, related to the draft regulation but also going beyond, in order to ensure both the scoring systems' compatibility with and the complementarity to the regulation.

The parameters identified as relevant to rate for smartphones and tablets are the following:

- Disassembly depth (first considered per part)
- Fasteners (type) (first considered per part)
- Tools (type) (first considered per part)
- Spare parts (target group) (considered for whole product)
- Software updates (availability over time) (considered for whole product)
- Repair Information (considered for whole product)

The parameters which are first considered per part are then aggregated at product level as described in the aggregation section 2.5.

All six parameters selected above are also identified by the JRC General Method as suitable for reparability assessment.

2.3.1 Disassembly Depth

The disassembly depth is the number of steps required to remove a part from a product[16], without damaging the product. The analysis of disassembly depth is fundamental to assess the effort required to access and/or replace priority parts (Cordella et al., 2019). Disassembly depth is identified as a key parameter for ease of repair and upgrade also in standard EN45554:2020 (CEN/CENELEC, 2020). Finally, the reparability index effective in France[17] also considers disassembly depth and proceeds with assigning scores based on the number of steps necessary to disassemble a given part.

The draft ecodesign Regulation addresses ease of disassembly as a means to reflect the reparability of a product, for both smartphones and tablets. Specifically, depending on the product part, criteria are established related to fasteners and connectors, tools, the working environment and the skills level for repair. It also specifies that joining, fastening or sealing techniques do not prevent the disassembly of certain parts. However, it does not define a maximum number of disassembly steps as a threshold. Therefore, for the purposes of the scoring system, the parameter of disassembly depth here is considered.

2.3.2 Fasteners (type)

Fasteners are another parameter related to disassembly. More specifically, fasteners influence on reparability can be assessed in terms of their number, their type, as well as their visibility, as considered in EN 45554:2020 (CEN/CENELEC, 2020). According to the same standard, in terms of type, fasteners can be characterised by their reusability or removability. However, the consideration of other reparability parameters such as the disassembly depth (described above) in the scoring system, and the availability of repair information and instructions both in the regulation and the scoring system, deem the separate consideration of fastener number and fastener visibility (respectively) obsolete. Therefore, for the purposes of this scoring system (and as is the case in the draft ecodesign regulation), only the type of fasteners is considered additionally, which provides a more qualitative assessment of a component's disassembly compared to the quantitative focus of the disassembly depth parameter. Similarly, the French reparability index limits this assessment to fastener type.

For smartphones, the draft ecodesign regulation specifies that fasteners and connectors for battery replacement shall be reusable[18], while for the display assembly replacement, fasteners and connectors shall be

[16] The counting of the steps for each part, starts from the product fully assembled.

[17] https://www.indicereparabilite.fr

[18] This requirement is conditional in the draft ecodesign regulation, with an alternative compliance criterion specified: *"or shall ensure that the battery endurance in cycles achieves a minimum of 1000 full charge cycles, and after 1000 full charge cycles the battery must, in addition, have in a fully charged state, a remaining capacity of at least 80 percent of the rated capacity"*

removable. For tablets, the draft ecodesign regulation specifies that fasteners and connectors for battery replacement shall be reusable[18], while for the display unit and front panel digitizer unit replacement, fasteners and connectors shall be removable. Finally, in the case of both products, the joining, fastening or sealing techniques shall not prevent the disassembly of a number of parts using commercially available tools. These regulatory requirements are again used here as a minimum basis in the scoring system to define scoring criteria.

2.3.3 Tools (type)

The tools necessary to disassemble a part for repair is another parameter relevant to reparability. Different types of tools are defined in EN 45554:2020 on the basis of their availability, and on the principle that the wider access to a specific tool, the more probable it is that a repair will be carried out. More specifically, EN 45554:2020 distinguishes between repairs without any need for tools, those that can take place with basic tools, product-group specific tools, other commercially available tools, proprietary tools, and repair not feasible with any tools. The approach followed here is consistent with the standard, with the addition of further granularity, such as distinguishing between basic tools, tools supplied with a spare part and those supplied with the product at purchase, to reflect ease of access to tools and a material efficiency principle.

The draft ecodesign regulation specifies criteria on the basis of tool type for both smartphones and tablets. For smartphones, battery replacement shall be feasible with the use of no tool, or a tool or set of tools that is supplied with the product or spare part, or basic tools[18], while for the display assembly replacement, repair shall be feasible with commercially available tools. For tablets, battery replacement shall be feasible with the use of no tool, or a tool or set of tools that is supplied with the product or spare part, or basic tools[18], while for the display unit and front panel digitizer unit replacement, repair shall be feasible with commercially available tools. Once again, for the purposes of the scoring system, these requirements are used as a minimum basis for the scoring. The French reparability index also includes the Tools parameter in the assessment on the basis of tool type.

2.3.4 Spare Parts (target group)

The availability of spare parts is a paramount parameter to ensure that a repair/upgrade process can take place (Cordella et al., 2019). Spare part availability can refer to various sub-parameters, specifically:

i) Availability to various target groups;

ii) Availability over a specific period of time;

iii) Delivery time;

iv) Price.

The draft ecodesign regulation proposes requirements related to all sub-parameters listed above.

The present scoring system complements it by further considering sub-parameter (i) of availability to various target groups, as later described in section 2.4.

With regards to sub-parameter (ii) on the period of availability, spare parts for all parts listed in the regulation shall be available until five years after placing the last unit of the model on the market in the case of smartphones, and until six years in the case of tablets. This period is considered to already sufficiently capture a reasonable product lifetime of smartphones and tablets as estimated in Task 7 of the preparatory study to the ecodesign regulation, even after considering increased durability and reparability scenarios (Fraunhofer IZM et al., 2021d).

Similarly, with regards to sub-parameter (iii), a regulatory requirement on delivery time of the spare parts within 5 working days after having received the order is also considered to be capturing a reasonable period of time without introducing a bias related to the place of delivery.

Finally, with regards to sub-parameter (iv) on price of spare parts, the draft ecodesign regulation sets the requirement that the maximum pre-tax price of spare parts shall be disclosed and not raised later on when the product is placed on the market.

For that reason, only the sub-parameter of target group is considered as a differentiating factor for a scoring exercise. The ecodesign regulation introduces requirements for the availability of spare parts to either both end-users and professional repairers (in the case of the part of display assembly), or professional repairers only (in the case of the rest of products listed in Table 1). Additional granularity is introduced in the scoring assignment described in section 3.3 below. It is worth noting that the French reparability score assesses also spare parts availability for spare parts retailers, a target group which is not considered as adding value for consideration in this scoring system (since both professional repairers and end-users are already considered).

2.3.5 Software Updates (availability over time)

The availability of security and functionality updates constitutes a paramount parameter for reparability of some products, especially ICT such as smartphones and tablets (Cordella et al., 2019). The French reparability index does consider the parameter of availability of software updates, albeit only assessing (scoring) whether information of that availability exists or is absent. The draft ecodesign regulation introduces the requirement of ensuring the availability of security updates for at least 5 years and the availability of functionality updates for at least 3 years, at no costs. These duration periods are expanded in the scoring assignment described in section 3.3. below.

In the initial version of the method, this parameter was not considered due to its coverage by minimum requirements until 5 years and 3 years for security and functionality updates respectively. However, after evaluating the availability of security updates already present in the market for a considerable amount of devices[19], an expansion of the duration beyond 5 and 3 years is appropriate.

2.3.6 Repair Information

The provision of information is necessary to support the repair/upgrade operation and should recollect all the information mentioned in the other parameters (e.g. through user manuals) (Cordella et al., 2019). Types and availability of information may refer to:

- the comprehensiveness of the information;
- the availability to various target groups;
- the duration of that availability;
- the price at which access to information is provided.

The French reparability index also considers the parameter of repair information, including all sub-parameters listed above.

The draft ecodesign regulation addresses all four sub-parameters to a different extent. With regards to comprehensiveness, the following list of repair and maintenance information shall be available to professional repairers until seven years after placing the last unit of the model on the market and for a fee that is reasonable and proportionate:

i. the unequivocal appliance identification;
ii. a disassembly map or exploded view;
iii. wiring and connection diagrams, as required for failure analysis;
iv. electronic board diagrams, as required for failure analysis;
v. list of necessary repair and test equipment;
vi. technical manual of instructions for repair;
vii. diagnostic fault and error codes (including manufacturer-specific codes, where applicable);
viii. component and diagnosis information (such as minimum and maximum theoretical values for measurements);
ix. instructions for software and firmware (including reset software);
x. information on how to access data records of reported failure incidents stored on the device (where applicable);
xi. software tools, firmware and similar auxiliary means required for full functionality of the spare part and device after repair, such as remote authorisation of serial numbers.

[19] https://www.which.co.uk/reviews/mobile-phones/article/mobile-phone-security-is-it-safe-to-use-an-old-phone-a6uXf1w6PvEN

Repair instructions for battery and display assembly replacement in the case of smartphones, and battery replacement in the case of tablets, shall be provided on a free access website until seven years after placing the last unit of the model on the market. A duration of availability longer than seven years is not considered relevant for the product groups in question.

Therefore, accounting for the above minimum requirements, granularity for a scoring system is considered for the sub-parameters of target groups and price, as described in section 2.4. below, on the basis of a seven-year long provision of the full list of information (points i-ix above)

2.3.7 Other relevant parameters not selected

The cost of repair is considered a relevant parameter for reparability and a determining factor of whether repairs take place in practice (Cordella et al., 2019). The draft ecodesign regulation does not define minimum requirements for the overall cost of repair, however it does introduce requirements related to price of repair information and an information requirement on spare part price; both of which parameters influence the overall cost of repair. The present scoring system remains consistent with that approach, accounting for price on the basis of those sub-parameters. The price of spare parts is considered to be too volatile a parameter, both in terms of variability over regions and over time, to be considered in the scoring system, potentially hindering the method's robustness and making verification challenging.

Other parameters considered in the JRC General Methodology are those related to Data management (transfer and deletion) and Password reset and restoration of factory settings. Classification tables for those parameters are also provided in EN 45554:2020. Both those parameters are important in enabling reuse by giving confidence to a first and a second user of the device with regards to data privacy. However, the draft ecodesign regulation already includes the provision that devices shall encrypt user data by default and that they include a software function that resets the device to its factory settings and erases by default the encryption key. Therefore, it is considered that those parameters are well covered by requirements without the need of further consideration in a scoring system.

Finally, the provision of guarantee is another parameter considered in the JRC General Methodology, as it can enable the execution of a repair operation. However, as already specified there, commercial guarantee does not directly address the reparability/upgradability of products but can be rather seen as a complementary measure. Therefore, it is not considered in the context of this scoring system.

Main changes compared to the first draft of the method

Based on the comments received from the stakeholders, the new parameter Software Updates (availability over time) has been added to the methodology. Other parameters have been proposed by the stakeholders and further discussed by the study team as presented in Annex III.

2.4 Definition of the Scoring Criteria

The JRC General Method proposes a hybrid system that combines:

a) Pass/fail criteria that products must fulfil in order to be eligible for the repair/upgrade rating;

b) A scoring framework based on scoring criteria, indicating to what extent/ how much a product is reparable or upgradable.

As described in section 2.2., the repair score is proposed within an ecodesign / energy labelling regulatory process, and is, therefore, meant to complement a set of minimum reparability requirements. In this context all the devices fulfilling the potential minimum ecodesign requirements will be considered eligible for the repair/upgrade rating.

Based on the methodology described in section 2.1., the selection of priority parts and parameters, follows the definition of **scoring/rating criteria**, in order to evaluate single parameters in relation to the entire product or in relation to a specific priority part.

Points are assigned at priority part level for the first three parameters (#1 Disassembly Depth, #2 Fasteners (type), #3 Tools (type) and at product level for the #4 Spare Parts (target group), #5 Software Updates and #6 Repair Information. Points ranging from 1 to 5 have been assigned to the different rating classes. 1 corresponds to the case in which repair/upgrade is purely compliant with minimum reparability requirements. Points above 1 have been set to conditions further facilitating the repair/upgrade of products, with 5 being the maximum.

The following scoring criteria are proposed.

2.4.1 Disassembly Depth (DD)

A score is assigned for each priority part based on their disassembly depths (DDi). A discrete rating is proposed. Points are assigned at priority part level:

Rating Class I) DDi ≤ 2 steps = 5 pt.

Rating Class II) 5 ≥ DDi > 2 steps = 4 pt.

Rating Class III) 10 ≥ DDi > 5 steps = 3 pt.

Rating Class IV) 15 ≥ DDi > 10 steps = 2 pt.

Rating Class V) DDi > 15 steps = 1 pt.

At the initial version of the report the steps assigned to each Rating Class differed according to priority part (specifically, different assignment for the back cover and battery parts). However, the number of steps for each Rating Class were harmonised across all priority parts to account for differences in product design and the fact that different parts may be the first ones to be removed along a disassembly pathway.

2.4.2 Fasteners (type)

(Same scoring criteria applied for smartphones and tablets)

A score is assigned for each priority part according to the level of removability and reusability of the fasteners used in the device assembly. Points ranging from 1 to 5 have been assigned to the different rating classes. A score of 1 point corresponds to the case in which repair/upgrade is purely compliant with the minimum ecodesign requirements (i.e. removable fasteners).

Points are assigned at priority part level:

Rating Class I) Reusable Fasteners[20] = 5 pt.

Rating Class II) Removable Fasteners =1 pt.

The assessment of the type of fasteners is based on the disassembly process to remove the specific priority part, starting from the previous priority part in disassembly sequence already removed.

In case different types of fasteners are encountered in the disassembly of a priority part, the worst score should be considered.

Main changes compared to the first draft of the method

In the first draft of the methodology the concept of "same reusable fasteners", meaning the use of the same type (model) of fastener to fasten a priority part to the rest of the product, was included and rewarded. However, this point was later re-considered due to the significant overlap with the concept of disassembly depth. In other words, if different types of fasteners are used for a given priority part, the complexity this adds to the disassembly is already considered as additional step(s). The scope of the assessment for this parameter has been clarified, being limited to the part removal starting from the previous part in the disassembly sequence already removed.

2.4.3 Tools (type)

(Same scoring criteria applied for smartphones and tablets)

A score is assigned for each priority part according to the complexity and availability of the tools needed for its replacement repair/upgrade: Points ranging from 1 to 5 have been assigned to the different rating classes. 1 corresponds to the case in which repair/upgrade is purely compliant with minimum ecodesign requirements (i.e. C fasteners)

Points are assigned at priority part level:

Rating Class I) No Tools = 5 pt.

[20] Please note that the definition of reusable fasteners includes also fastening system that cannot be re-used are supplied with the new part for a repair, re-use or upgrade process, as defined in the EN45554:2020.

Rating Class II) Basic Tools[21] = 4pt.

Rating Class III) A set of tools that is supplied (or offered to be supplied) with the spare part = 3 pt.

Rating Class IV) A set of tools that is supplied (or offered to be supplied) with the product = 2 pt.

Rating Class V) Commercially Available Tools =1

The assessment of the type of tools is based on the disassembly process to remove the specific priority part, starting from the previous priority part in disassembly sequence already removed.

In case different types of tools are needed for the disassembly of a priority part, the worst score should be considered.

Main changes compared to the first draft of the method

In the first draft of the method 3 points were assigned to the following options "basic tools", "tools provided with the product" or "tools provided with the spare parts". The new proposal assign different scores to these different options based on material efficiency principles. This approach, in JRC view, does not contradict the EN45554:2020 standard, as it only adds further granularity to the assessment. The scope of the assessment for this parameter has been clarified, being limited to the part removal starting from the previous part in the disassembly sequence already removed.

2.4.4 Spare Parts (target group)

Points ranging from 1 to 5 have been assigned to the different rating classes. 1 corresponds to the case in which repair/upgrade is purely compliant with minimum ecodesign requirements: it means that in case of smartphone all the priority parts available to professional repairers + display assembly available to end-users). Points above 1 have been set to conditions further facilitating the repair as the wider availability of spare parts, in terms of target group.

Points are assigned at product level as follows:

Smartphones:

Rating Class I) Spare parts for all priority parts are available to end users = 5 pt.

Rating Class II) Spare parts for display assembly, battery, back cover (or back cover assembly) and cameras are available to end users; spare parts for all other parts are available to professional repairers = 4 pt.

Rating Class III) Spare parts for display assembly, battery and back cover (or back cover assembly) are available to end users; spare parts for all other parts are available to professional repairers = 3 pt.

Rating Class IV) Spare parts for display assembly and battery are available to end users; spare parts for all other parts are available to professional repairers) = 2

Rating Class V) Spare parts for display assembly are available to end users: spare parts for all other parts are available to professional repairers) = 1

Note: Spare parts for hinge assembly, mechanical display folding mechanism and mechanical display rolling mechanism are to be available only in case of foldable/rollable smartphones respectively[22].

Tablets:

Rating Class I) Spare parts for all priority parts are available to end users = 5 pt.

Rating Class II) Spare parts for display unit, front panel digitizer unit, battery, cameras and back cover (or back cover assembly)are available to end users; spare parts for all other parts are available to professional repairers = 4 pt.

Rating Class III) Spare parts for display unit, front panel digitizer unit, battery and back cover are available to end users; spare parts for all other parts are available to professional repairers = 3 pt.

[21] According to the reference list of basic tools available in Table A.3 of the standard EN45554:2020, as long as the process remains a non-destructive disassembly and compliant with minimum regulatory provisions

[22] Devices with foldable and rollable displays are described in Ecodesign preparatory study on mobile phones, smartphones and tablets, Task 4 Report, Fraunhofer IZM, Fraunhofer ISI, VITO, 2021, pp. 105-106.

Rating Class IV) Spare parts for display unit and front panel digitizer unit and battery are available to end users; spare parts for all other parts are available to professional repairers = 2 pt.

Rating Class V) No spare parts are available to end users; spare parts for all other parts are available to professional repairers = 1 pt.

Note: Spare parts for hinge assembly, mechanical display folding mechanism and mechanical display rolling mechanism are to be available only in case of foldable/rollable tablets respectively.

Main changes compared to the first draft of the method

Minor changes have been introduced to better align the assessment of the two product groups.

2.4.5 Software updates (availability over time)

(Same scoring criteria applied for smartphones and tablets)

The rating of this parameter is based on the duration of the minimum guaranteed availability of operating system functionality updates free of charge, where ‘functionality updates’ means operating system updates with the main purpose to implement new functionalities, corresponding to the latest version of this operating system available in the market: and where a functionality update may include a security update;

Rating Class I) minimum guaranteed availability of security updates for 7 years, and operating system functionality updates for 6 years = 5 pt.

Rating Class II) minimum guaranteed availability of security updates for 6 years, and operating system functionality updates for 5 years = 4 pt.

Rating Class III) minimum guaranteed availability of security updates for 5 years, and operating system functionality updates for 6 years = 3 pt.

Rating Class IV) minimum guaranteed availability of security updates for 5 years, and operating system functionality updates for 4 years = 2 pt.

Rating Class V) minimum guaranteed availability of security updates for 5 years, and operating system functionality updates for 3 years =1 pt.

Main changes compared to the first draft of the method

This parameter was not present in the first draft of the method.

2.4.6 Repair Information

(Same scoring criteria applied for smartphones and tablets)

The rating of this parameter is based on the target group of repairers, on the cost of the repair and maintenance information and on the content.

Points are assigned at product level:

Rating Class I) Public availability of repair information at no additional cost for end users (see Note below); availability of all information at no additional cost for professional repairers = 5 pt.

Note: electronic board diagrams are exempted from the assessment at end user level.

Rating Class II) Available at no additional cost to registered professional repairers = 3 pt.

Rating Class III) Available at reasonable price to registered professional repairers = 1 pt.

Main changes compared to the first draft of the method

Compared to an initial proposal for this method, the provision of electronic board diagrams to end users is excluded from Rating Class I), as it is considered to not add significant value for the purpose of end user repair. Amongst the models evaluated as part of the calibration and validation exercise (see section 3 and 4 below) by KU Leuven, none was accompanied by a provision of electronic board diagrams.

2.5 Definition of the Weighting Factors and aggregation

2.5.1 Introduction

The next step of the methodology entails the definition of weighting factors that allow the evaluation of the relevance of each rated criterion / priority parts and allow tailoring the scoring system in order to reflect the specificities of the product group.

Weighting factors are introduced at 2 different levels:

- Weight of the different priority parts (described in section 2.5.2)
- Weight of the different parameters (described in section 2.5.3)

A description of an aggregation mechanism, which consists of mathematically combining the scores achieved for each parameter and priority part, concludes in section 2.5.4.

2.5.2 Weighting factors for different priority parts

As described in section 2.2., priority parts are functionally relevant parts that are associated with typical failures for that product group. However, priority parts can have different failure likelihood and functional relevance and these differences can be translated in the scoring system in terms of different weights assigned to such parts.

Data from a 2019 survey among smartphone users in Germany (Clickrepair 2019)[23], (Wertgarantie 2020)[24] gives insights in most frequent defects of smartphones. More than two thirds of the defects were related to display damages, followed by casing and battery issues. Other studies also confirm that the highest failure rate is associated to the display, mainly due to drops / shocks / scratches (Cordella et al., 2021). Similarly to smartphones, data on tablet defects demonstrate that displays are the most frequent part to get damaged after a drop occurs (two out of three cases), followed by the casing and the camera (Wertgarantie, 2018)[25].

Similarly also the back cover can experience similar damages. However, the back cover can be considered less relevant from a functional perspective, as in many cases these are aesthetic damages and do not affect the primary functionality of the device.

Battery issues are also reported as highly frequent, mainly due to aging mechanisms (Cordella et al., 2021). According to a recent online survey in Germany, batteries represent 36% of all the failures for tablets (Stiftung Warentest, 2020)[26].

Cameras are also reported as relevant sources of failures (Clickrepair 2019)[27] (Wertgarantie 2020)[28], Cordella el al., 2021). In the case of connectors, is not fully clear whether the high failure rates reported in some studies refer only to the devices or to the cables as well.

The other priority parts are less relevant in terms of failure likelihood, but still highly relevant in terms of functionality.When considering foldable devices, no statistics have been found due to the currently lower market uptake, but still a qualitative assessment is possible. According to some device reviews[29] there's limited-to-no water resistance, susceptibility to screen scratches, a risk of things getting stuck in the hinge, and the mechanism itself being a potential trouble spot. There are also very limited choices in protective cases for these devices so far.

Further information regarding smartphone part repairs are offered by data from the Open Repair Alliance[30] demonstrating that most repairs are related to displays and batteries, followed by ports, software updates, buttons and cameras.

The data referenced above can offer useful insights towards determining the failure likelihood of various parts. However, in terms of establishing appropriate weighting factors for those parts in the context of the repair scoring, the data need to be considered with caution:

[23] https://www.presseportal.de/download/document/627427-clickrepair-smartphone-reparatur-studie-2019.pdf
[24] https://www.wertgarantie.de/sites/default/files/2021-03/wertgarantie-smartphone-repair-study-2020.pdf
[25] https://www.wertgarantie.de/sites/default/files/2020-08/wertgarantie-tablet-repair-study-2018-final-en.pdf
[26] https://www.test.de/Ergebnisse-Reparatur-Umfrage-Erfahrungen-von-10000-Teilnehmern-ausgewertet-5587855-0/
[27] https://www.presseportal.de/download/document/627427-clickrepair-smartphone-reparatur-studie-2019.pdf
[28] https://www.wertgarantie.de/sites/default/files/2021-03/wertgarantie-smartphone-repair-study-2020.pdf
[29] https://www.digitaltrends.com/mobile/folding-phones-durability-problem/
[30] https://openrepair.org/open-data/insights/mobiles/

– Data often refer to (attempted) repairs rather than overall failures. Therefore, there might be a bias against failures for which repair was not attempted or was not sought in the first place;

– Data generated from surveys often do not refer to a finite list of parts (or refer to combination of failures), whilst, as described in section 2.2, it is reasonable to establish a list of priority parts on which the reparability assessment takes place. Such data can, therefore, offer useful indications, but a one-to-one correspondence between the failure rate of a part and a weighting factor would have its own disadvantages;

– While contemporary data need to be considered, an approach that ensures a future-proof method and one which still accounts for a number of parts and their importance within the device is deemed appropriate.

For that reason, rather a qualitative assessment considering failure likelihood and functional relevance is conducted in order to identify appropriate weighting factors for the priority parts identified by the draft ecodesign regulation.

Table 2. Classification of priority parts by their functional relevance and failure likelihood.

Relevance value		Failure Likelihood		
		Low	Medium	High
Functional relevance	Low			
	Medium		Front-facing camera Rear-facing camera	Back cover (assembly)
	High	External connectors Buttons Microphone Speaker	Hinge assembly or mechanical display folding mechanism mechanical display rolling mechanism	Battery Display assembly[31]

The assessment above is used for the determination of weights. Specifically,

- High functional relevance / High failure likelihood (in green) = 30%
- High functional relevance / Medium failure likelihood (in beige) = 20%
- Medium functional relevance / High failure likelihood (in orange) = 10%
- Other combinations (in blue) = 5%

In this context the failure likelihood is somehow considered a less relevant aspect whenever associated to spare parts with lower functional relevance (e.g. back cover vs mechanical display folding mechanism).

However, the parts of hinge assembly or mechanical display folding/rolling mechanism are not present in all devices. In the case of such part(s) are present in the device, the sum of the priority part weightings would exceed 100% (and equal to 120%), therefore an adjustment is introduced in order to maintain the same balance of importance between parts. Specifically:

Scenario A: In the case, the part(s) of hinge assembly or mechanical display folding/rolling mechanism is not present, the initial assessment weights are applied:

- High functional relevance / High failure likelihood (in green) = 30%
- Medium functional relevance / High failure likelihood (in orange) = 10%
- Other combinations (in blue) = 5%

[31] For tablets, the equivalent of display unit and front panel digitizer

Scenario B: In the case, the part(s) of hinge assembly or mechanical display folding/rolling mechanism is present, the initial assessment weights are adjusted using a correction factor f_c = 1/120 %, as follows[32]:

- High functional relevance / High failure likelihood (in green) = 30% * f_c = 25%
- High functional relevance / Medium failure likelihood (in beige) = 20% * f_c = 17%
- Medium functional relevance / High failure likelihood (in orange) = 10% * f_c = 9%
- Other combinations (in blue) = 5% * f_c = 4%

In order to reflect the different weighting of priority parts and codify the way priority parts are considered from a weighting and minimum score perspective, the parts are also categorised in Levels as shown in Table 3 below. Sublevels are also introduced to describe other differentiations of parts that are within the same level. Specifically:

- Sub-levels 1a for display and 1b for battery are reflecting different minimum reparability requirements in the draft regulation, and therefore a different minimum point basis in the scoring system

Sub-levels 4a and 4b are defined to reflect the different applicability of the part list to different types of design (4a for foldable smartphone / tablets and 4b for rollable smartphone / tablets).

Table 3. Classification of priority parts into levels and assignment of weighting factors for each level

Level	Sublevel	Part – Smartphone	Part – Tablet	Scenario A Weighting	Scenario B Weighting
LEVEL 1	1a	Display assembly	Display unit*	30%	25%
			Front panel digitizer unit*		
	1b	Battery	Battery	30%	25%
LEVEL 2	2	Back cover	Back cover	10%	9%
LEVEL 3	3	Front camera	Front camera	5%	4%
	3	Back camera	Back camera	5%	4%
	3	Connectors	Connectors	5%	4%
	3	Buttons	Buttons	5%	4%
	3	Microphones	Microphones	5%	4%
	3	Speakers	Speakers	5%	4%
LEVEL 4	4a	Hinge assembly or Fold mechanism	Hinge assembly or Fold mechanism	N/A	17%
	4b	Roll mechanism	Roll mechanism	N/A	17%

*Note: for the sublevel 1a of tablets the weighting factor is divided between the two components: display unit and front panel digitizer unit, both with a 15% weighting in Scenario A and 12.5% weighting in Scenario B.

Main changes compared to the first draft of the method

A dynamic approach for the weighing of rollable /foldable design options has been introduced and replaced the previous approach based on the replacement of priority parts.

[32] For simplicity, the calculated weightings are rounded.

2.5.3 Weighting factors for different parameters

In section 2.3., the parameters relevant to rate reparability for smartphones and tablets have been identified. As in the case for priority parts, these parameters can also have different levels of relevance. More specifically, the inclusion of a minimum ecodesign requirement already sufficiently covering the specific repair parameter can reduce its relevance as a scoring parameter. Table 4. below provides the proposed applicable weights for the selected parameters.

Table 4. Weighting of selected parameters

Parameter	Weight	Justification
Disassembly Depth	25%	Key parameter for ease of repair and upgrade, not addressed by a minimum requirement.
Fasteners (type)	15%	Key parameter for ease of repair and upgrade, partially addressed by a minimum ecodesign requirement.
Tools (type)	15%	Key parameter for ease of repair and upgrade, partially addressed by a minimum ecodesign requirement.
Spare Parts (target group)	15%	Key parameter for ease of repair and upgrade, partially addressed by a minimum ecodesign requirement.
Software Updates (duration)	15%	Key parameter for ease of repair and upgrade, partially addressed by a minimum ecodesign requirement.
Repair Information	15%	Key parameter for ease of repair and upgrade, partially addressed by a minimum ecodesign requirement.

Disassembly depth is established as the highest weighted parameter. That is deemed appropriate for several reasons:

- Compared to the other identified parameters, disassembly depth is a parameter which is not directly considered via means of minimum requirements in the draft ecodesign regulation. As such, the repair scoring system is acting as complementary to the minimum regulatory requirements;
- Disassembly depth provides a good proxy for other reparability-related concepts that are considered challenging to account for and verify directly, such as the disassembly time, the disassembly effort, and the repair cost
- Disassembly depth constitutes a technical and objective parameter for reparability.

The remaining four parameters selected are assigned an equal weighting of 15%. It is important to note here that this weighting does not represent the importance of those parameters as a whole, but rather the sub-elements of these parameters that are then considered in the scoring. For example, spare part availability as a general concept constitutes a key parameter and precondition for the feasibility of repair, However, as elements of spare part availability are already considered in the draft ecodesign regulation (e.g. duration of repair), only some aspects of spare part availability (i.e. target audience) are considered for scoring and therefore weighted at 15%. The same principle was used to weigh the parameters of fasteners, tools and repair information.

Main changes compared to the first draft of the method

The weight for the Disassembly Depth parameter has been reduced from 40% to 25%. The weight for the new parameter “Software Updates” is 15%.

2.5.4 Scoring Aggregation

The final score (defined as Overall Reparability Index) can be calculated using the formula described in Table 5 below. Partial scores are first calculated at priority part level and then aggregated at parameter level using the weighting factors of priority parts. Finally the parameter scores are aggregated in an Overall Reparability Index, based on the different parameter weighting factors.

Table 5. Calculation of the Overall Reparability Index

Parameter	**Score for priority part i [1-5]**	**Weight for priority part i [%]**	**Parameter Score [1-5]**	**Parameter Weight [%]**	**Final Score [1-5]**
#1 Disassembly depth	$S_{1,i}$	$\omega_{1,i}$	$S_1 = \sum_{i=1}^{N} S_{1,i} \cdot \omega_i$	W_1	**Overall Reparability Index** $\mathbf{R} = \sum_{j=1}^{6} S_j \cdot W_j$
#2 Fasteners (type)	$S_{2,i}$	$\omega_{2,i}$	$S_2 = \sum_{i=1}^{N} S_{2,i} \cdot \omega_i$	W_2	
#3 Tools (type)	$S_{3,i}$	$\omega_{3,i}$	$S_3 = \sum_{i=1}^{N} S_{i} \cdot \omega_i$	W_3	
#4 Spare parts (target group)	…	…	S_4	W_4	
#5 Software updates (duration)	…	…	S_5	W_5	
#6 Repair Information	…	…	S_6	W_6	

Where:

- **R** is the overall reparability score
- **S** is the score (per spare part or parameter)
- **ω** is the priority part weight
- **W** is the parameter weight
- **i** is a specific priority part,
- **N** is the N of priority parts
- **J** is a specific parameter

Each parameter will score between 1 and 5, reflecting (from low to high) the performance of the device in each of the reparability aspects covered by the scoring system.

Main changes compared to the first draft of the method

The new parameter "Software Updates" has been added to the formula.

2.6 Assessment and verification

In this section, guidance on the assessment and verification for the repair scoring system is provided.

Assessment

Original Equipment Manufacturers (OEMs) should declare the repair score of each smartphone and tablet model placed on the market covered by the ecodesign regulation. For the purposes of verification (described below), the OEM should provide to Member State Authorities (MSAs) on request:

- The analytical calculation of the final score per parameter in the format that is provided in the Excel file, accompanied by the technical parameters specified below.
- A disassembly map and disassembly protocol that describe all the disassembly steps considered necessary to replace each of the priority parts (as defined in the Scoring System Report), including an indication of the tools needed and the types of fasteners to be removed.

The protocol should clearly ensure that the disassembly is reversible (so that the product is operational after re-assembly) and include the steps needed for the reassembly of the device. The assessment of the disassembly parameters (disassembly depth, tools and fasteners) should be strictly based on the disassembly protocol described by the OEM. The self-assessment should be conducted in a workshop environment by an expert.

The OEM should also declare the list of parts available for professional repairer and/or consumer as well as a detailed description of the information provided for professional repairer and/or consumer.

Table 6 below summarises the technical parameters of the models to be declared by the OEM as part of the analytical calculation of the repair score.

Table 6. Technical parameters of the model and their declared values

Parameter	Unit	Value
#1 Disassembly Depth	$[n_i]$	DDi (to be declared for each and every priority part i of the product) Where i is a specific priority part,
#2 Fasteners		Removable/ Provided with the spare part / Reusable / Same Reusable (to be declared for each and every priority part of the product)
# 3 Tools		Commercially available / Provided with the product / Provided with the spare part / Basic tools / No tools needed (to be declared for each and every priority part i of the product)
#4 Availability of spare parts		End users / Professional Repairers
#5 Software updates	Years	≥ 5-7 years for security updates; ≥ ≥3-6 years for functionality updates Free-of-charge
#6 Repair Information	[€]	End users / Professional Repairers Fee applied (if any)

Verification

The MSA shall verify one single unit of the model and verify that each of the scoring parameters are correctly assessed by the OEMs. The verification implies a mix of different methods, including physicals, documental and market checks as summarised in the Table 7 below.

Table 7. Methods of verification by parameter

Parameter	Measure	Method of verification
#1 Disassembly Depth	N° of disassembly steps	Physical check (disassembly test)
#2 Fasteners	Types of fasteners used	Physical check (disassembly test)
#3 Tools	Types of tools used	Physical check (disassembly test)
#4 Availability of spare parts	Ability of certain users to access certain spare parts Y/N.	Check online / via manufacturer. Procurement process check The procedure for ordering them (for both end users and professionals) shall be publicly available on the free access website of the manufacturer, importer or authorised representative, at the latest two years after the placing on the market of the first unit of a model and until the end of the period of availability of these spare parts; During this period the manufacturer, importer or authorised representatives shall ensure the ordering and delivery of these spare parts to MSA as part of a market surveillance process.
#5 Software updates	Numbers of years from the product launch up to the last operating system updated available for the model Y/N.	Check information provided by the manufacturer / check the availability of the software update, free of charge. Check that the functionality implemented are corresponding to the latest version of this operating system available in the market.
#6 Repair Information	• Ability of certain users to access certain information Y/N. • Ratio of fee to access information in relation to cost of product*	Documentation check (with product and/or online)

*This parameter is relevant to ensure that fees (if any) charged by manufacturers, importers or authorised representatives for access to the repair and maintenance information (or for receiving regular updates of this information) are reasonable and proportionate.

According to the ecodesign proposal a fee is reasonable if it does not discourage access by failing to take into account the extent to which the professional repairer uses the information.

More specifically, the verification of parameters #1, #2 and #3 should be based on a physical disassembly and recording of the operations needed. The disassembly of the device should be conducted in a "workshop environment" by an expert. The MSA should follow the disassembly protocol (made available by the OEM) and check the results of the scoring system claimed by the OEM. The MSA verification should include a full reassembly of the device and verification of correct functioning of the device. In particular, after exposure to a disassembly test, the MSA should verify that the device is able to:

1. Operate normally:
   - No noticeable operational faults when using standard software applications.
   - No major damage to the product that does not allow for standard usage.
2. Not create hazards to end user:
   - No case or display cracking or other sharp points generated during the disassembly process that could injure a user.
   - No electrical component failures or access that could result in a user safety issue.

The MSA should also verify that all relevant spare parts (#4), software updates (#5) and repair information (#6) are made available to the target group of repairers (professional/ end-users) as for the OEM declaration.

The verification of the availability of spare parts (#4) can include also a procurement process check, beyond the check of the OEMs websites. MSAs can check that the list of spare parts and the procedure for ordering them are publicly available, order one or more, and check that the part delivered corresponds to the order. Checks can be carried out online or via direct contact with the manufacturer.

The availability of the repair information (#6) can be verified via a documentation check.

Finally the MSA should also verify that the weighting factors and aggregation formulas are correctly applied according to the formula provided by the legal text.

Further technical guidance is provided by parameter in Annex II.

Main changes compared to the first draft of the method

The new parameter "Software Updates" has been added to the assessment and verification guidance.

3 Calibration

The aim of the calibration exercise is to investigate how models already placed on the market are positioned in the proposed scoring range (expressed numerically in scores 1 to 5) and in the proposed classification (expressed alphabetically in classes A to G), in order to determine whether adjustments are necessary and to allow for a fair and future-proof scoring system. For that purpose, studies were conducted by the universities of KU Leuven and TU Delft, and involved an independent assessment of the reparability of a selection of smartphones and tablets. The assessment was carried out according to the repair score methodology proposed by the JRC in September 2021 and involved the actual disassembly of selected models. Devices were selected by the universities based on a number of criteria:

- the reparability assessment would be done on at least 10 different smartphone models;
- at least two smartphone models would be selected from each of the following ranges:
  - Low-end purchase price, x <200 €
  - Mid-range purchase price, 200 € < x < 600 €
  - High-end purchase price, x > 600 €

The figures below demonstrate the results observed by KU Leuven (Figure 4) and TU Delft (Figure 5) respectively in the case of smartphones.

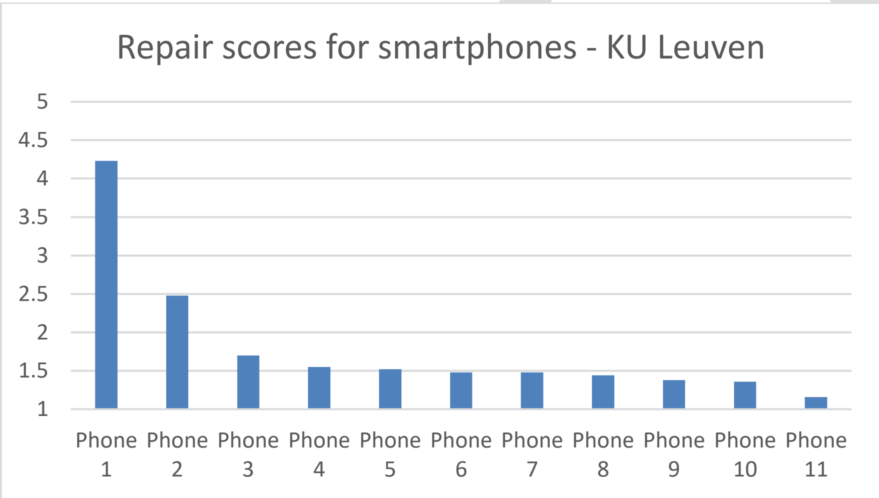

Figure 4. Repair scores for smartphones – KU Leuven

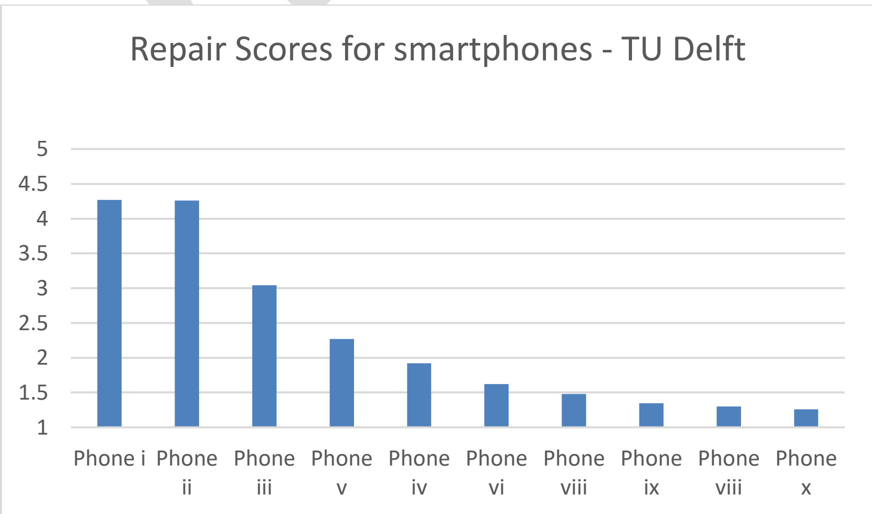

Figure 5. Repair scores for smartphones – TU Delft

The results indicate a wide range for total scores, ranging from 1.16 to 4.27. The same cannot be said about the variance of those scores, as 82% of devices tested by KU Leuven and 60% of devices tested by TU Delft have total scores lower than 2.0.

This can be explained by the following:

- For most devices tested, there were no spare parts available and no repair information available. This is also understandable due to the lack of minimum requirements currently on the market related to these parameters. Nevertheless, in the scores presented above, the assumption was made that minimum requirements are established in the context of an ecodesign regulation, and therefore minimum points were awarded in those cases.
- Similarly, most devices were awarded minimum scores related to fasteners and tools.

Despite the lack of variance in the total scores observed for the device tested, the wide range demonstrates a high improvement potential. It is therefore argued that the score range of 1-5 can be maintained so as to allow for a future-proof scoring system, and for grasping that potential once established.

The scoring system also proposes a classification system of A-G as presented in Table 8[33]:

Table 8. Classification system for the representation of reparability scores

Repair Score Class	Repair Score Range
A	x ≥ 4.00
B	4.00 > x ≥ 3.50
C	3.50 > x ≥ 3.00
D	3.00 > x ≥ 2.50
E	2.50 > x ≥ 2.00
F	2.00 > x ≥ 1.50
G	1.50 > x ≥ 1.00

The figures below demonstrate the distribution of the above scored devices into classes for the KU Leuven results (Figure 6) and the TU Delft (Figure 7) results respectively.

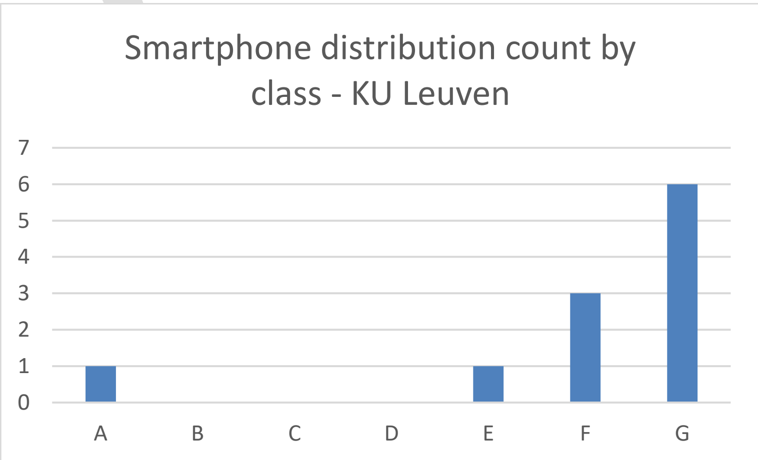

Figure 6. Smartphone distribution count by class – KU Leuven

[33] In an earlier version of the report presented on 7 September 2021, an initial classification system was proposed, calibrated on a score range of 0-5. This was then corrected and adjusted as in Table 8 to account for a scoring range of 1-5.

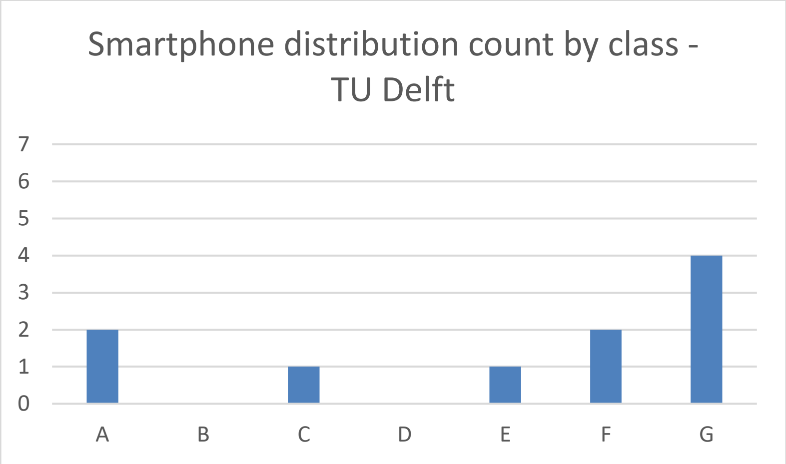

Figure 7. Smartphone distribution count by class – TU Delft

The results between the two sources demonstrate similarity and once again the good range, but uneven distribution, with most devices falling in the bottom two classes. At the same time, some, but few, devices achieved class A, which allows for sufficient improvement potential.

A similar reparability assessment was conducted for tablets (see Figure 8 and 9). Considering the small sample used for this assessment (3 and 2 tablets respectively), no reliable conclusions can be drawn with regards to calibration. However, observed disassembly approaches and challenges provide useful input in terms of validation (e.g. method suitability) discussed in section 4 below.

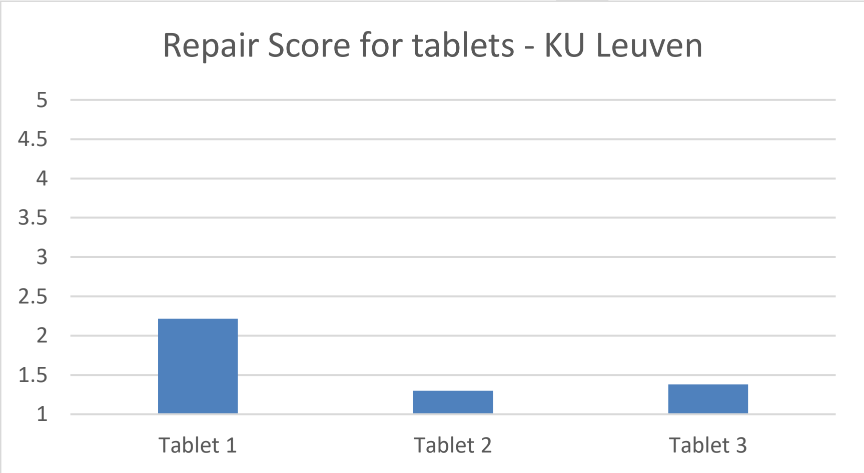

Figure 8. Repair scores for tablets – KU Leuven

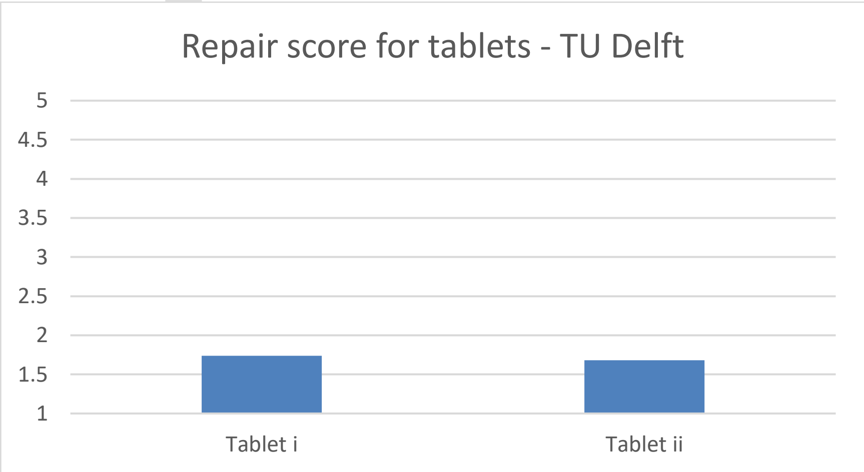

Figure 9. Repair scores for tablets – TU Delft

Similarly to smartphones, low scores here can be explained by minimum scores awarded for the parameters of spare part availability and repair information availability, as well as for the fasteners and tools parameters. High improvement potential is therefore also observed for this product group.

It is difficult to draft many conclusions from that sample size, however the classification initially proposed has similar characteristics to that in the case of smartphones. Therefore, a similar re-calibration to that proposed for smartphones is proposed for tablets too. .

4 Validation

The aim of the validation exercise is to verify whether the scoring system methodology is suitable for the intended use. In particular, we aim to verify:

1. The technical reproducibility of the scoring assessment and results by different teams applying the same method in parallel;
2. The most important methodological challenges encountered by the experts in the application of the method;
3. Consistency with other systems currently in place, in this case the French reparability index (keeping in mind the differences in scope and application);
4. Correlation of scoring results vs. product costs and scoring results vs. repair cost

This validation process is based on an independent and parallel application of the repair score method. Two research groups from the Universities “KU Leuven” and “TU Delft” applied the scoring method independently and without consultations. The assessment was carried out according to the repair score methodology proposed by the JRC in September 2021 and involved the actual disassembly of selected models.

4.1 Reproducibility of the method

Six "same models" of smartphones and “one same tablet” were disassembled and tested by both research teams (see Table 9). In general the scoring results demonstrate a very good reproducibility of the method. The variation of the scoring results from the two research teams is always lower than one full class (0.5 points). More specifically, the maximum deviation between the two assessments is 0.185 points for smartphones (see Smartphone A) and 0.34 points for the only tablet tested by the both teams. It means that in most of the cases the two independent assessments resulted in the same scoring class, and the classification of some devices in different classes is mainly due to products that are very close to the limits between the two classes (see smartphone C, D, and E). Nevertheless, the differences are also due to methodological challenges that have been highlighted by the study teams and are discussed in the following sections of this chapter.

Table 9. Results of the overall reparability scoring for six models evaluated by both KU Leuven and TU Delft

Model	Research Team	Score (1-5 range)	Class (A-G range)
Smartphone A	KU Leuven	1.16	G
	TU Delft	1.345	G
Smartphone B	KU Leuven	1.38	G
	TU Delft	1.26	G
Smartphone C	KU Leuven	1.48	G
	TU Delft	1.62	F
Smartphone D	KU Leuven	1.48	G
	TU Delft	1.60	F
Smartphone E	KU Leuven	1.52	F
	TU Delft	1.48	G
Smartphone F	KU Leuven	4.23	A
	TU Delft	4.26	A
Tablet A	KU Leuven	1.30	F
	TU Delft	1.74	G

Methodological challenges highlighted in the application of the method

Definition of a disassembly map

In the absence of publicly available disassembly maps and repair information from the OEMs for many of the devices tested, the study teams had to develop their own disassembly paths (an example in Figure 10). This process comes with some subjective choices (tools used, steps needed) which could sometimes differ or from the ones applied by a different study team, and from the ones that OEMs would suggest for the device.

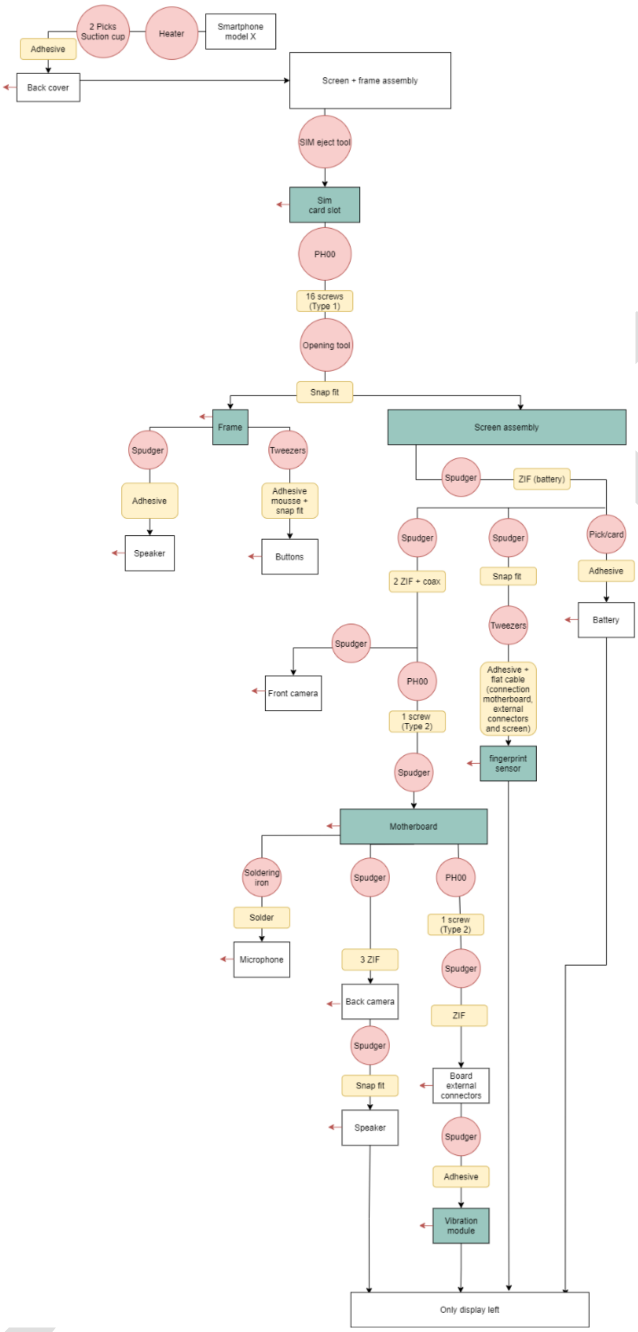

Figure 10. Example of a disassembly map developed by KU Leuven

Interpretation of the definition of some priority parts

Some priority parts are not clearly defined, which leaves room for different interpretations. One example is “buttons”: this priority part could be interpreted in different ways, including the assembly with the electronic part, or even only the mechanical part.

Interpretation of bundling

It is critical to address and clarify in the scoring system, to what extent products can be designed to have multiple priority parts bundled within a single module. In the draft ecodesign regulation there is no explicit clarification that bundling is allowed. However, during the validation exercise, multiple priority parts have been found attached with non-removable fasteners (i.e., soldered or encased in a module) from which further disassembly requires de-soldering or destructive disassembly.

Evaluation of parallel actions carried out with different tools

In some situations, several tools have to be used at the same time (e.g. spudger and screwdriver). The methodology did not initially clarify whether a change of tools should be counted as one step or based on the number of tools used.

Fasteners and Tools:

The study teams did not found fully clear whether the assessment of the type of fasteners and tools is "path based" or "part based". In the path-based scenario, the fastener and tools used to reach the target part along the entire disassembly process determine the score of this parameter. On the contrary, applying a part-based approach, only the fasteners/tools used starting from the previous priority part already removed are taken into consideration in the score. The method was later clarified to follow a part-based approach, so as to avoid a significant overlap with the criterion of Disassembly Depth.

Methodological challenges specific for tablets.

The methodological challenges highlighted above for the smartphones appear also to be relevant for tablets. However, the main methodological difference between repair scoring of tablets and smartphones is the distinction between "Display unit" and "Front panel digitizer unit" as independent priority parts to be disassembled. The study teams found that, while these parts might be separable in theory, in practice isolating the digitizer come with high risk of cracking the screen due to the heavily applied glue between the layers. In some cases, separating the digitizer from the display did not seem feasible at all.

4.2 Comparison with the French Score Index

The scoring results based on the proposed EU Scoring System cannot be fully compared with the French Score Index, mainly for the following reasons:

- The proposed EU repair score is developed in conjunction with and expanding on the minimum requirements proposed in the draft ecodesign regulation, while the French Index was developed without the same minimum reparability requirements in place
- The different methodological choices applied in terms of parameters. In particular, the French system assigns only 20% of the total repair score weight to disassembly related parameters such as disassembly depth, fasteners and tools (Critère 2) while these parameters (#1,#2 and #3) are much more relevant in the first JRC methodological proposal (W1 + W2 + W3 = 70%).

Nevertheless, it is still relevant to analyse the correlation of single parameters of the scoring system that are addressed by both scoring systems. The graph below (Figure 11) shows the differences between the normalised DD score calculated by TU Delft according to the JRC Method and the DD score declared by OEMs under the French Score. These results show a good correlation between the two methods except for the last model, that is a foldable smartphone. Probably, the weighting approach proposed for the first draft of the JRC method favours too much this design in terms of DD as the calculation does not cover connectors, speaker, microphone and buttons, parts normally quite deep in the disassembly process.

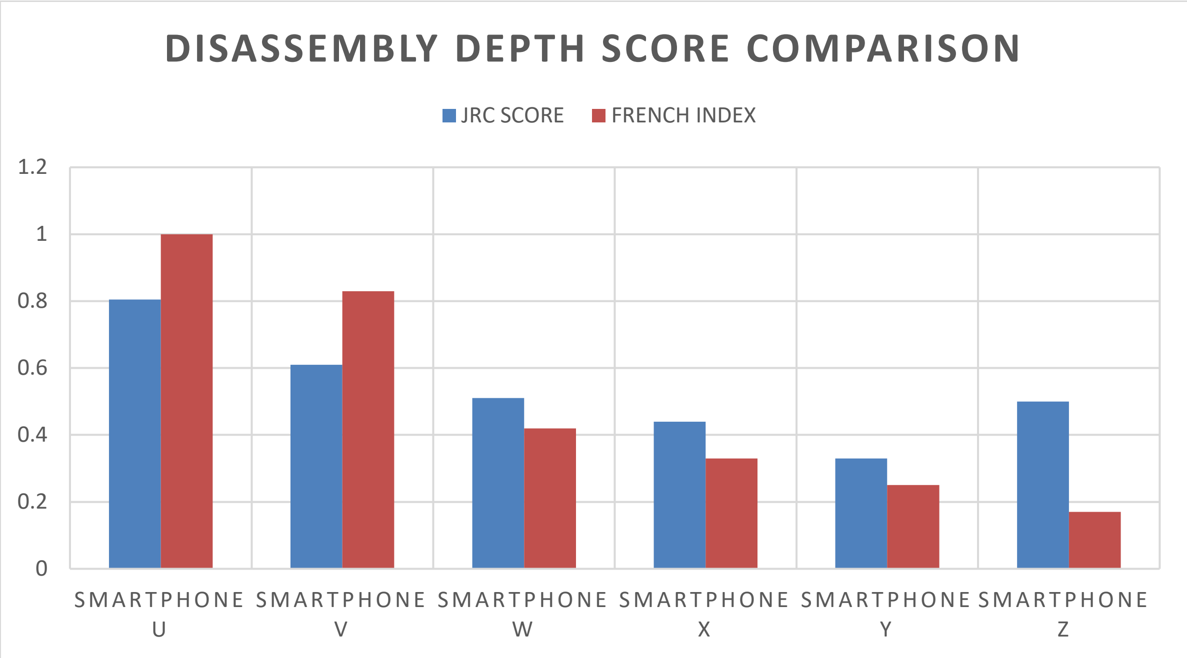

Figure 11: Normalised Disassembly depth under the JRC Repair Score and the French Index

4.3 Correlation of scoring results vs. repair cost

The correlation of these two aspects is still difficult to verify, mainly because most of the devices are in the same lowest class. However, it is interesting to remark, that the best scoring smartphone is the one with the lowest ratio between repair and device cost, mainly due to the fact that the repair does not require high level of skills and the end user can simply buy the spare part and carry out some simple disassembly operations by themselves. For this model, the display assembly spare part is available for a 15% of the smartphone purchase price, while the battery and back cover cost about 5% of the smartphone purchase price.

5 Conclusion

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List of figures

List of tables

Annex I: Calculation sheet

A Repair Score calculator is provided as a separate file in .xls format.

Annex II: Guidance for users

This annex provides further technical guidance for the assessment of the repair score parameters.

Disassembly depth

The disassembly depth is defined as the number of steps needed to remove a target part from a product (which might include getting access to fasteners).

According to the definition of step reported in the section 1 of this document, a step consists of an operation that finishes with the removal of a part, and/or with a change of tool. This definition is illustrated in the green box on the right in Figure 12. In the example below, the first step ends with the removal of a part; from there the second step starts by grabbing a tool, includes the removal of a fastener and ends with the release of this tool. The third step starts by grabbing a different tool, includes the removal of a fastener and ends with a removal of a part (in this case a subset).

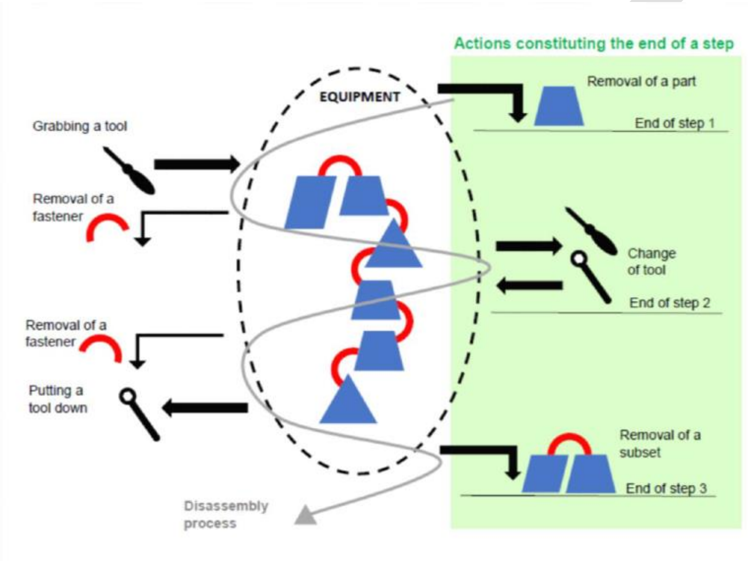

Figure 12. Description of the procedure for counting the steps needed to remove parts. [Source: French Score Manual] Note: the term "subset" in figure refers to a "bundle" i.e. two parts assembled together (multi-part component).

The only actions that constitute the end of a step are the removal of a part, the removal of a bundle (or subset)[34] or a change of tool. The removal of a fastener is not considered a step unless it involves a change of tool or the removal of a part. Note that the fastener is not considered as a part. Moreover, the hand is not considered as a tool, but if the use of the hand leads to the removal of a part of the device, then this action must be considered as a step without the use of tools ("no tools").

In some repair scenarios, multiple tools may need to be used simultaneously (e.g. spudger and screwdriver). In this case the grabbing of each tool should be accounted as a separate step (e.g. in the case of two tools, counting two steps) in order to properly consider the complexity of such process.

Specific disassembly scenarios are discussed below.

Considering that the counting of the disassembly steps begins with the fully assembled device whereas the end of disassembly takes place when the part is dissociated and extracted, in the case of a multi-part component (bundle) including more than one priority parts the disassembly depth is completed when the target part of the bundled component is separated and individually accessible.

The disassembly sequence include also the access and removal of fasteners. In the case where the extraction of a part requires the consecutive removal of several fasteners that can be removed with the use of the same tool, the process is counted as a single step (as illustrated in Figure 13 below).

[34] https://www.indicereparabilite.fr/

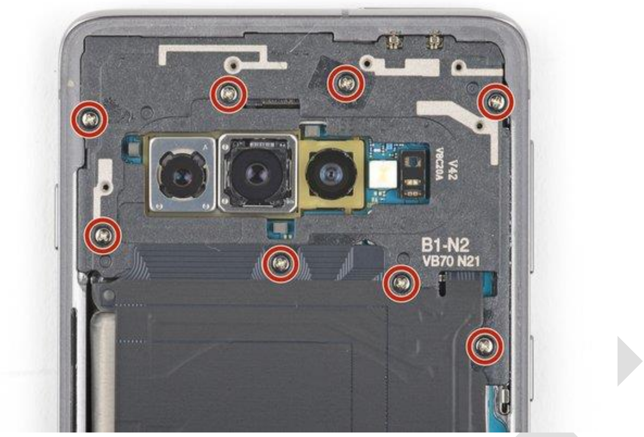

Figure 13. Removal of eight 4 mm Phillips screws securing the top midframe to the smartphone, counted as a single step. [Source: iFixit.com]

In case a device includes multiple parts of the same type, such as two displays or two batteries, both are assessed in the scoring system but only the part with the worst score is considered for the final calculation. For instance, if the device has two displays (display A and display B) and for the disassembly the display A requires a sequence of 15 steps while display B only needs 7, display A is considered in the final scoring system calculation

Connectors with mechanical and electrical function

During the disassembly process there are some connectors with both mechanical and electrical function that might need to be disconnected (see Figure 14). In such case, these connectors should be treated as equivalent to fasteners in this repair score framework. It means that the consecutive disconnection of several connectors with the same tool should be treated as 1 step.

Figure 14. Example of connector's disconnection in 2 different models of smartphone. [Source: iFixit.com]

Other disassembly-related actions

In cases where remote notification or authorisation of serial numbers are necessary for the full functionality of the spare part and the device, these actions need to be counted as additional disassembly steps. For example, the use of software to successfully complete the replacement of a part in a repair process, counts as a step in the disassembly depth evaluation of this part.

Fasteners

As described in the definitions, a fastener is a hardware device that mechanically or magnetically connects or fixes two or more objects, parts or pieces. Some fasteners are generally non-permanent, i.e. they can be easily removed or disassembled without damaging the objects, parts or pieces connected or fixed together (e.g., screws or clips). However, welds and some glues are, in contrast, permanent fixing techniques.

In the context of this repair score, different types of fasteners applied to smartphones and tablets can be classified within two broad classes: **removable** and **reusable**.

The draft ecodesign regulation requires that fasteners shall be removable for some priority parts and reusable for others. Therefore, the use of fasteners which are **neither removable nor reusable** is not allowed. A fastening/fixing techniques can be identified as "neither removable nor reusable" in case the priority part cannot be removed without causing damage or leaving residue which preclude reassembly (in case of repair of upgrade) or reuse of the removed part (in case of reuse) for the reuse, repair and upgrade process (EN45554:2020).

The assessment of the type of fasteners is based on the disassembly process to ***remove*** the specific priority part, starting from the previous part in disassembly sequence already ***removed***.

Connectors with both mechanical and electrical function (e.g. see Figure 14) should be treated and assessed as fasteners in this context.

Removable Fasteners

This class corresponds to the Class B according to the EN45554:2020. Adhesives are in general considered removable (but non-reusable) fasteners unless new ones are supplied with the spare part and in this case, the adhesive can be considered reusable. During the process of removal of adhesives, different types of fractures can occur. In order to facilitate the replacement of adhesive in a repair process, the “adhesive fracture on one substrate” is the most favourable option (see Figure 15below).

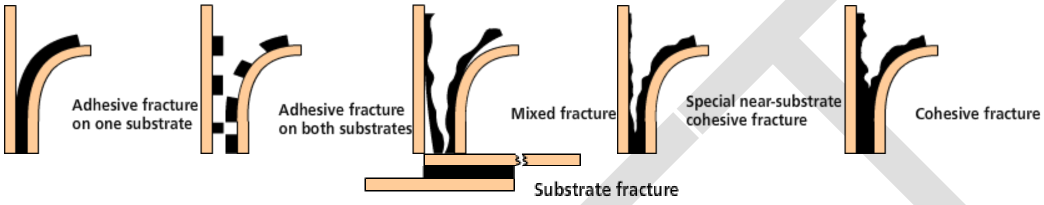

Figure 15. Types of fractures occurring in adhesives. Source: Fraunhofer IFAM: Adhesive Bonding – the Right Way. https://leitfaden.klebstoffe.com/en/6-4-fracture-pattern-evaluation/

Whenever the removal mode of the adhesive is different from “adhesive fracture on one substrate”, it would mean that traces on adhesive remain on the surface of the device, making necessary additional steps for cleaning operation (including the use of tools for such cleaning that would count as steps). This operation should be taken in to account in the disassembly depth counting and the scoring of the Tools parameter. In case the residue cannot be removed with commercially available tools with a reasonable level of effort and permanently precluding the reassembly of the product, they should considered as “not removable”. The adhesive should be also classified as “not removable” whenever its removals process, with the use of commercially available tools, embeds a high risk of damaging the device. This is the case for some fastening techniques that are mainly meant for being permanent as welds and some glues.

Pull-tabs are a special type of Pressure Sensitive Adhesive (removable fastener) with the benefit of an easy linear removal during disassembly (see Figure 16). These stretch-release adhesives lose their tack when stretched, allowing for the lifting out of the part (in this case the battery) with ease.

Figure 16. Example of “removable” pull-tab adhesive [Source: iFixit.com]

Reusable fasteners

Screws and other connectors such as snap-fits and clips should be classified as **reusable** fasteners unless they are damaged during the disassembly/reassembly process in a way that makes impossible their reuse.

Reusable fasteners should be able to resist mechanical stresses that can be induced under a disassembly and reassembly process, therefore ensuring multiple reuses. However, it is not part of this repair score methodology the definition of how many reuse cycles must be ensured.

In the case of snap-fits or clips any damages to the fastener would affect not only the fastener reusability but the entire product/spare part making the product not compliant with the proposed ecodesign minimum requirement. Figure 17 shows a snap-fit fastening technique applied to a smartphone back-cover.

Tools

The evolution of joining and fastening techniques applied by smartphones and tablets manufacturers have also affected the types of tools used for repair. Tools needed during a repair process can go beyond some common screwdrivers and include tools for opening operations (e.g. prying levers, spudgers, suction cup pliers), tools for product inspection (e.g. magnifying glasses) for cleaning, for heating operations (e.g. in order to detach the adhesives).

Points are assigned at priority part level based on the availability of these tools (according to the scoring classes defined in the EN45554:2020 for the parameter "tools". However, further granularity is introduced, aiming to further reward repair processes that are feasible without the use of tools.

Below further clarifications are provided on the scoring classes:

No tools: the disassembly is feasible by only using hands, which are not considered tools in the context of this scoring system. Figure 17 below, presents an example of back cover removal with the use of hands and no tools.

Figure 17. Example of back cover with a "reusable" snap-fit fastening system and replaceable with "no tools" [Source: iFixit.com]

Basic tools: the disassembly of a specific priority part (i) is feasible with the use of a reference list of basic tools that available in Table A.3 of the standard EN45554:2020, as long as the process remains a non-destructive disassembly and compliant with minimum regulatory provisions.

Tool supplied (or offered to be supplied) with the product: the disassembly of a specific priority part (i) is feasible with the use of tools supplied (or offered to be supplied) with the product (at the time of purchase). The disassembly of a specific priority part (i) is feasible with the use of tools provided by the OEM with the device. The availability of a purchase option with "part + tool(s)" needs to be ensured by the OEM (e.g. a specific screwdriver necessary for the disassembly of the battery is available in the device box).

Tools supplied (or offered to be supplied) with the spare part: the disassembly of a specific priority part (i) is feasible with the use of tools supplied by the OEM with the spare part. The availability of a purchase option with "part + tool(s)" needs to be ensured by the OEM (e.g. a specific screwdriver necessary for the disassembly of the battery is available with the spare battery).

Commercially available tools: the disassembly of a specific priority part (i) is feasible with the use of other commercially available tools. In order to define commercially available tools, an important aspect to consider is the distinction between commercially available tools and proprietary tools as presented in the Table 9 below. The draft ecodesign proposal does not permit the use of fastening techniques for which proprietary tools are needed for disassembly.

Table 10. How to distinguish between proprietary tools and commercially available tools.

Proprietary Tools	**Commercially available tools**
These are tools that are not available for purchase by the general public or for which any applicable patents are not available to licence under fair, reasonable and non- discriminatory terms	Non-proprietary tools

Spare Parts

The authorities can check that the list of key spare parts and the procedure for ordering them are publicly available, order one or more, and check that the part delivered corresponds to the order. Checks can be carried out online or via direct contact with the manufacturer.

Repair Information

Among the repair information assessed by the scoring system, some aspects are considered to be more relevant for professional repairers and only partially relevant for end-users. For this reason aspects as the electronic board diagrams are exempted from the assessment.

Table 11. List of required repair information per target group

Repair information	Target Group	
	Professional Repairers	End users
The unequivocal appliance identification;	x	x
A disassembly map or exploded view;	x	x
Wiring and connection diagrams, as required for failure analysis;	x	x
Electronic board diagrams, as required for failure analysis;	x	
List of necessary repair and test equipment;	x	x
Technical manual of instructions for repair;	x	x
diagnostic fault and error codes (including manufacturer-specific codes, where applicable);	x	x
Component and diagnosis information (such as minimum and maximum theoretical values for measurements);	x	x
Instructions for software and firmware (including reset software);	x	x
Information on how to access data records of reported failure incidents stored on the device (where applicable);	x	x
Software tools, firmware and similar auxiliary means required for full functionality of the spare part and device after repair, such as remote authorisation of serial numbers.	x	x

Software Updates (length)

This parameter is related to the updates of the operating system. The aim is to keep the product with functionalities corresponding to the latest version of this operating system available on the market.

The length of the support duration should be evaluated based on a transparent declaration of the Minimum guaranteed availability of operating system updates (until): DD MM YYYY.

Annex III: Summary of stakeholder comments

Priority parts

Different stakeholders proposed to consider assembly and bundling of priority parts. A number of proposals were made such as limiting bundling to level 3 parts (initially including cameras, connectors, buttons, microphones and speakers) and setting a limit to the number of parts involved. Alternative proposals concern the inclusion of assembly as a combination of different Levels of priority parts or even considering assembly through the concept of functions or through a similar failure rate.

A Member State commented on the reason why in case a device includes multiple priority part of the same type, only the part with lower reparability score is considered for the final calculation, without considering the frequency of failure. The consideration of all parts was proposed.

JRC opinion:

Considering that the selection of priority parts was based on the draft ecodesign regulation, a discussion on bundling should be addressed at both ecodesign regulation and scoring system levels. Concerning the existence of multiple parts of the same type, it is proposed that the one yielding the lowest reparability score is selected in order to avoid higher complexity and uncertainty in terms of assessment and verification.

Parameters

One of the aspects raised by stakeholders was the addition of other parameters.

Several stakeholders suggested the inclusion of **the price of spare part** in the repair scoring system. Other industry representatives suggested the inclusion of **repair services (return option)**. Regarding the latter, the proposed criterion is based on density of manufacturer supported repair service network, proximity, availability of mail in repair service and repair hotline provided by manufacturers. An additional parameter proposed by different stakeholders was the **software updates** also to ensure that the spare parts' functionality is maintained after disassembly and reassembly. A proposal on the rating classes was made considering the combination of different years of availability of the security and functionality updates, starting from the draft minimum ecodesign requirements. Concerning **part pairing and serialisation**, several stakeholders pointed out the need to address it in the scoring system either by counting it as a step in the disassembly depth or by integrating it as a 'Freedom from part pairing' parameter.

Some stakeholders also suggested considering **disassembly time** alongside disassembly depth as a parameter that can factor in the difficulties involved in removing a part.

Other comments concerned the modification of some of the parameters already selected for the repair scoring system, are described in the next section.

JRC opinion:

On the price aspect, no concrete solution was proposed, and challenges remain related to variability over regions and time, and to the verification process. Similarly, the repair service parameter is associated with verification difficulties and the variability of service level in different Member States, areas, time and cost. As the inclusion of these parameters may undermine the robustness and implementation of the scoring method, they were not included. Both parameters were, already considered not suitable for the repair score, according to the JRC general methodology. On the other hand, the parameter of software updates (duration) was added and the proposed scoring criteria are reported in section 2.4 of this report.

With regards to the part pairing and serialisation comment, a clarification was added to Annex II of the report, specifying that processes requiring actions relevant to the disassembly such as remote notification or authorisation of serial numbers for full functionality of the spare part and device during repair, need to be counted as additional repair steps. For example, the need to use a software to recognise the use of a new part introduced in the product during a repair process, counts as a step in the evaluation of this part.

Finally, due to complexity in the verification, the disassembly time is not directly added in this product specific application of the repair score system, however it is considered that parameters (disassembly depth, type of fasteners) already included provide proxies and to an extent represent disassembly time.

Scoring criteria and weighting factors

Disassembly Depth: some stakeholders proposed to harmonise the number of steps in each rating class of the disassembly depth across all the spare parts, in order to not introduce bias towards certain product designs over others.

With regards to fasteners, some stakeholders disagreed with considering supplied fasteners as “reusable” instead of “removable” and also asked for clarification of the difference between “reusable” and “same reusable” fasteners. Other stakeholders proposed to remove the scoring criteria “same removable” as this is not an option defined under the EN45554:2020 and triggering some double counting. It was also suggested to define how many times a “reusable fastener” can be actually reusable and to consider in the scoring system the residues that some reusable fasteners may leave.

Tools. Some industry representatives suggested not differentiating between "no tools" and "basic tools" because they are both captured in class A of EN45554:2020. On the other hand, different stakeholders proposed to consider separate scoring classes for "basic tools", tools supplied with the product and tools supplied with spare parts. In their proposal, the score should increase from commercially available tools, to tools supplied with the product, tools supplied with spare parts, basic tools and finally no tools with the highest score.

With regards to the **availability of spare parts** parameter, a stakeholder proposed to aggregate a specific time period from 5 to 7 years availability. Another stakeholder suggested the redistribution of the rating classes and inclusion of an additional one to cover also the availability of the cameras.

A Member State suggested the addition of “marking of individual steps" to the list of **repair information**, while a stakeholder suggested that the repair information should be considered at part level instead of at product level.

With regards to **weighting of parts** some stakeholders argued against the exclusion of level 3b parts (initially including connectors, buttons, microphones and speakers) from the scoring system when the level 4 parts of folding/rolling mechanisms are present in the devices, and proposed an alternative weighting system. In this proposal, all priority parts are always considered by adjusting the weighting with a correction factor. Some stakeholders also commented that priority parts weighting should better reflect parts that fail most often (displays and batteries).

JRC opinion:

Some of the proposal have been accepted. In particular:

- the harmonisation of number of steps for all spare parts in the disassembly depth
- the deletion of “same removable” from the scoring criteria
- the separation of the rating classes for “basic tools”, “tools supplied with the part” and “tools supplied with the products”
- the inclusion of the cameras in the availability of spare part parameter.

The changes applied to the scoring criteria are also described in section 2.4 of this report.

The list of repair information was selected on the basis of the provisions included in the draft ecodesign regulation and, in order to avoid further complexity in the method, disassembly parameters are evaluated at part level while service-related parameters at product level. For this reason, this proposed change was not included.

Fasteners supplied with the product/part are considered as reusable according to EN45554:2020, therefore it was decided to maintain this principle in this study.

The meaning of same reusable fasteners is related to the use of the same type and model of fastener used for fastening a priority part. In the revised version of the scoring system the concept of "same reusable" fasteners has been reconsidered as explained in section 2.4 of the report. As regards how many times a fastener can be reused, this is an aspect difficult to assess and verify and it is not the scope of the repair score. Finally, the removal of fastener residue is considered a step in the disassembly process as reported in annex II.

The differentiation between "no tools" and "basic tools" is considered to introduce additional granularity into the scoring system without contradicting the provisions of the standard. This distinction not only reflects the aspect of tool access, but also repair time and effort and material efficiency benefits.

The dynamic weighting for priority parts has been considered and implemented in the scoring system in case the folding/rolling mechanism is factored in, as shown in section 2.4.

Aggregation and final scoring

Some stakeholders commented on the modification of the weighting factor of the different parameters. Some of them suggested equal weighting while others proposed adjustments for some parameters, e.g. the reduction of the disassembly depth weight.

JRC opinion:

The differentiation in weighting of Disassembly Depth have been justified from the fact that minimum requirements have been provided by the ecodesign proposal for all the Scoring Criteria except the Disassembly Depth. Nevertheless, the weight of this parameter has been reduced from 40% to 25%, keeping all the other parameters at a 15% weight.